



CITY OF THORNTON, COLORADO

PROJECT NO. 12-777XP

SOURCE WATER PUMP STATION

TECHNICAL SPECIFICATIONS

ISSUED FOR BID

VOLUME 2 OF 7

DIVISIONS 01-46

MAY 2026





CITY OF THORNTON, COLORADO
THORNTON WATER PROJECT (12-777XP)

SOURCE WATER PUMP STATION

TABLE OF CONTENTS

VOLUME 2 OF 7

SECTION NO. TITLE

DIVISION 01 - GENERAL REQUIREMENTS

01_11_00	SUMMARY OF WORK
01_20_20	MEASUREMENT AND PAYMENT
01_31_19	PROJECT MEETINGS
01_32_21	SCHEDULES AND REPORTS
01_32_34	PHOTOGRAPHIC AND VIDEOGRAPHIC DOCUMENTATION
01_33_00	SUBMITTAL PROCEDURES
01_35_73	DELEGATED DESIGN PROCEDURES
01_41_00	REGULATORY REQUIREMENTS
01_43_39	MOCKUPS
01_45_17	CONTRACTOR QUALITY CONTROL PLAN
01_45_24	REGULATORY QUALITY ASSURANCE
01_50_00	TEMPORARY FACILITIES AND CONTROLS
01_60_01	PRODUCT REQUIREMENTS
01_71_23	FIELD ENGINEERING
01_75_17	COMMISSIONING
01_75_19	WATER LEAKAGE TEST FOR CONCRETE STRUCTURES
01_78_24	OPERATION AND MAINTENANCE MANUALS
01_78_36	WARRANTIES AND BONDS
01_81_50	DESIGN CRITERIA

DIVISION 03 - CONCRETE

03_11_07	CONCRETE FORMWORK
03_15_00	CONCRETE ACCESSORIES
03_20_00	CONCRETE REINFORCING
03_21_17	ADHESIVE-BONDED REINFORCING BARS AND ALL THREAD RODS IN CONCRETE
03_30_00	CAST-IN-PLACE CONCRETE
03_31_26	SELF-CONSOLIDATING CONCRETE REQUIREMENTS
03_35_29	CONCRETE FINISHES
03_48_53	POLYMER CONCRETE ELECTRICAL HANDHOLES
03_60_00	GROUTING
03_63_01	EPOXIES
03_63_02	EPOXY RESIN/PORTLAND CEMENT BONDING AGENT

SECTION NO. TITLE

03_64_24	EPOXY INJECTION SYSTEM
03_70_30	THERMAL CONTROL OF CONCRETE

DIVISION 04 - MASONRY

04_05_17	MORTAR AND MASONRY GROUT
04_05_18	ADHESIVE BONDING REINFORCING BARS AND ALL THREAD RODS IN MASONRY
04_05_23	MASONRY ACCESSORIES
04_22_00	CONCRETE UNIT MASONRY

DIVISION 05 - METALS

05_05_24	MECHANICAL ANCHORING AND FASTENING TO CONCRETE AND MASONRY
05_12_00	STRUCTURAL STEEL FRAMING
05_14_05	STRUCTURAL ALUMINUM
05_21_19	OPEN WEB STEEL JOIST FRAMING
05_31_00	STEEL DECKING
05_50_00	METAL FABRICATIONS
05_51_50	LADDERS

DIVISION 06 - WOOD, PLASTICS, AND COMPOSITES

06_10_00	ROUGH CARPENTRY
06_16_00	SHEATHING

DIVISION 07 - THERMAL AND MOISTURE PROTECTION

07_11_00	DAMPPROOFING
07_41_15	SOFFIT PANELS
07_42_13	FORMED METAL WALL PANELS
07_60_00	FLASHING AND SHEET METAL
07_61_13	STANDING-SEAM METAL ROOF PANELS
07_72_00	ROOF ACCESSORIES
07_72_53	SNOW GUARDS
07_84_00	FIRESTOPPING
07_92_00	JOINT SEALANTS

DIVISION 08 - OPENINGS

08_11_13	HOLLOW METAL DOORS AND FRAMES
08_31_14	FLOOR ACCESS DOORS
08_33_23	OVERHEAD COILING DOORS
08_45_01	TRANSLUCENT WALL PANELS
08_71_00	DOOR HARDWARE
08_91_00	LOUVERS

SECTION NO. TITLE

DIVISION 09 - FINISHES

09_84_12	METAL FACED ACOUSTICAL PANELS
09_96_01	HIGH-PERFORMANCE COATINGS
09_99_97	STEEL PIPELINE COATINGS

DIVISION 10 - SPECIALTIES

10_14_00	SIGNAGE
10_28_00	TOILET, BATH, AND LAUNDRY ACCESSORIES
10_44_00	FIRE PROTECTION SPECIALTIES

**DIVISION 23 - HEATING, VENTILATING, AND
AIR CONDITIONING (HVAC)**

23_05_00	COMMON WORK RESULTS FOR HVAC
23_05_93	TESTING, ADJUSTING, AND BALANCING FOR HVAC
23_07_13	DUCTWORK INSULATION
23_09_13	INSTRUMENTATION AND CONTROL DEVICES FOR HVAC
23_31_13	METAL DUCTWORK
23_34_01	FANS
23_81_14	AIR CONDITIONING UNITS
23_81_44	HEAT PUMPS
23_83_01	HEATING UNITS

DIVISION 26 - ELECTRICAL

26_05_00	COMMON WORK RESULTS FOR ELECTRICAL
26_05_03	UTILITY COORDINATION
26_05_10	MEDIUM VOLTAGE MOTORS
26_05_13	MEDIUM VOLTAGE CABLES
26_05_18	600-VOLT OR LESS WIRES AND CABLES
26_05_20	FIBER OPTIC CABLE AND APPURTENANCES
26_05_21	LOW VOLTAGE WIRE CONNECTIONS
26_05_22	MEDIUM VOLTAGE CABLE CONNECTIONS
26_05_26	GROUNDING AND BONDING
26_05_29	HANGERS AND SUPPORTS
26_05_33	CONDUITS
26_05_34	BOXES
26_05_44	DUCT BANKS
26_05_53	IDENTIFICATION FOR ELECTRICAL SYSTEMS
26_05_74	ELECTRICAL SYSTEM STUDIES
26_06_01	CONDUIT SCHEDULE
26_08_50	FIELD ELECTRICAL ACCEPTANCE TESTS
26_09_13	ELECTRICAL POWER MONITORING
26_12_20	LIQUID FILLED PAD MOUNTED TRANSFORMERS
26_13_01	5-KILOVOLT MEDIUM VOLTAGE METAL CLAD SWITCHGEAR

SECTION NO. TITLE

26_13_02	15-KILOVOLT MEDIUM VOLTAGE METAL CLAD SWITCHGEAR
26_13_05	PROTECTIVE RELAYS
26_18_42	MEDIUM VOLTAGE VARIABLE FREQUENCY DRIVE
26_22_14	DRY-TYPE TRANSFORMERS
26_24_15	INDIVIDUALLY MOUNTED CIRCUIT BREAKER SWITCHBOARDS
26_24_16	PANELBOARDS
26_24_20	LOW VOLTAGE MOTOR CONTROL CENTERS
26_27_26	WIRING DEVICES
26_28_01	LOW VOLTAGE MOLDED CASE CIRCUIT BREAKERS
26_28_17	DISCONNECT SWITCHES
26_29_05	MOTOR STARTERS
26_33_01	BATTERY SYSTEMS
26_33_54	UNINTERRUPTIBLE POWER SUPPLIES 10 - 30 KVA
26_36_24	TRANSFER SWITCHES
26_41_01	LIGHTNING PROTECTION
26_42_13	CATHODIC PROTECTION
26_43_14	SURGE PROTECTIVE DEVICES
26_50_10	LIGHTING: LED LUMINAIRES

DIVISION 28 - ELECTRONIC SAFETY AND SECURITY

28_10_00	ELECTRONIC ACCESS CONTROL AND INTRUSION DETECTION
28_23_29	VIDEO SURVEILLANCE REMOTE DEVICES AND SENSORS
28_46_13	FIRE ALARM SYSTEMS

DIVISION 31 - EARTHWORK

31_00_00	EARTHWORK
31_05_15	SOILS AND AGGREGATES FOR EARTHWORK
31_10_00	SITE CLEARING
31_23_18	ROCK REMOVAL
31_23_19	DEWATERING
31_23_24	CONTROLLED LOW STRENGTH MATERIAL (CLSM)
31_23_35	TRENCHING
31_32_18.04	STABILIZATION FABRIC
31_36_02	RIPRAP AND GABIONS EROSION AND SEDIMENTATION CONTROL
31_50_00	EXCAVATION SUPPORT AND PROTECTION
31_63_30	DRILLED CONCRETE PIERS

DIVISION 32 - EXTERIOR IMPROVEMENTS

32_16_14	CONCRETE CURBS, GUTTERS, AND SIDEWALKS
32_17_23	PAVEMENT MARKINGS
32_31_00	FENCES AND GATES
32_92_19	SEEDING

SECTION NO. TITLE**DIVISION 33 - UTILITIES**

33_05_01.01 WELDED STEEL PIPE AND FITTINGS

DIVISION 40 - PROCESS INTEGRATION

40_05_00.01 COMMON WORK RESULTS FOR GENERAL PIPING
40_05_00.03 PIPE IDENTIFICATION
40_05_00.09 PIPING SYSTEMS TESTING
40_05_06.01 PIPING SPECIALTIES
40_05_06.03 PIPE COUPLINGS
40_05_07.01 PIPE SUPPORTS
40_05_07.03 PREFORMED CHANNEL PIPE SUPPORT SYSTEM
40_05_17.05 COPPER WATER TUBE: SEAMLESS, ASTM B88
40_05_19.01 DUCTILE IRON PIPE: AWWA C151
40_05_23.01 STAINLESS STEEL PIPE AND TUBING
40_05_24.01 STEEL PIPE: EXPOSED
40_05_31.17 POLYVINYL CHLORIDE (PVC) PIPE: SCHEDULE TYPE
40_05_51.01 COMMON WORK RESULTS FOR VALVES
40_05_57.13 MANUAL ACTUATORS
40_05_57.24 ELECTRIC ACTUATORS
40_05_57.43 HYDRAULIC POWER SUPPLY SYSTEMS
40_05_57.65 HYDRAULIC CYLINDER ACTUATORS
40_05_59.33 CAST-IRON SLIDE GATES
40_05_62 PLUG VALVES
40_05_63 BALL VALVES
40_05_64 BUTTERFLY VALVES
40_05_65.01 GATE VALVES
40_05_65.24 CHECK VALVES
40_05_67.37 PRESSURE CONTROL VALVES
40_05_67.40 AIR AND VACUUM RELIEF VALVES
40_61_00 COMMON WORK RESULTS FOR PROCESS CONTROL AND
INSTRUMENTATION SYSTEMS
40_61_16.10 SPECIFIC CONTROL STRATEGIES
40_64_01 CONTROL SYSTEMS: PROGRAMMABLE LOGIC CONTROLLERS
40_64_21 CONTROL SYSTEMS: LOCAL OPERATOR INTERFACE (LOI)
40_66_01 CONTROL SYSTEMS: NETWORK MATERIALS AND EQUIPMENT
40_66_71 CONTROL SYSTEMS: WIRELESS COMMUNICATIONS - CELLULAR
40_67_01 CONTROL SYSTEMS: PANELS, ENCLOSURES, AND PANEL
COMPONENTS
40_67_26 CONTROL SYSTEMS: UNINTERRUPTIBLE POWER SUPPLIES 10 KVA
AND BELOW
40_71_15 FLOW MEASUREMENT: MAGNETIC FLOWMETERS
40_71_79 FLOW MEASUREMENT: SWITCHES
40_72_76 LEVEL MEASUREMENT: SWITCHES

SECTION NO. TITLE

40_73_13	PRESSURE/VACUUM MEASUREMENT: GAUGES
40_73_23	PRESSURE/VACUUM MEASUREMENT: DIRECT
40_73_63	PRESSURE/VACUUM MEASUREMENT: DIAPHRAGM AND ANNULAR SEALS
40_73_64	PRESSURE/VACUUM MEASUREMENT: INSTRUMENT VALVES
40_73_65	PRESSURE MEASUREMENT: SUBMERSIBLE
40_75_13	ANALYZERS: PH
40_75_14	ANALYZERS: ORP
40_75_53	ANALYZERS: TURBIDITY
40_80_01	COMMISSIONING FOR INSTRUMENTATION AND CONTROLS
40_96_15	SCHEDULES: I/O LIST

DIVISION 41 - MATERIAL PROCESSING AND HANDLING EQUIPMENT

41_22_15	TOP RUNNING DOUBLE GIRDER BRIDGE CRANES
41_22_17	PORTABLE DAVIT CRANES

**DIVISION 43 - PROCESS GAS AND
LIQUID HANDLING, PURIFICATION, AND STORAGE EQUIPMENT**

43_24_50.10	VERTICAL TURBINE SHORT SETTING CENTRIFUGAL PUMPS
43_25_00.10	SUBMERSIBLE SUMP PUMPS
43_42_21.08	HYDROPNEUMATIC PRESSURE CONTROL SYSTEM INCLUDING TANK

DIVISION 46 - WATER AND WASTEWATER EQUIPMENT

46_05_10	COMMON WORK RESULTS FOR MECHANICAL EQUIPMENT
46_05_94	MECHANICAL EQUIPMENT TESTING

SECTION 01_11_00

SUMMARY OF WORK

PART 1 GENERAL

1.01 SUMMARY

- A. The Work is generally described as follows:
 - 1. Constructing a new Source Water Pump Station (SWPS), intake pipeline, intake structures, discharge pipeline, electrical service, and startup and commissioning of the SWPS.
 - 2. Startup and commissioning of the entire Thornton Water Project system, which includes pumping water from the SWPS to the Wes Brown Water Treatment Plant (WBWTP) through approximately 70 miles of pipeline. Additional components of the TWP system that will be incorporated into the startup and commissioning include the County Line pressure sensor, LCC PRV and Meter, Segment A PRV and Meter, Greeley No. 2 Return Flow Structure, Cache la Poudre River Return Flow Structure, Signal Hill pressure sensor, and Chemical Building.

1.02 DOCUMENT APPLICABILITY

- A. Requirements stated in the following documents apply to the Technical Sections except as amended in a Technical Section.
 - 1. Project Manual including City of Thornton General and Special Conditions.

1.03 CONTRACT DOCUMENTS

- A. The following documents represent the Contract Documents. Order of precedent shall be per City Contract:
 - 1. Contract and Project Manual.
 - 2. Volume 1: Drawings.
 - 3. Volume 2: Technical Specifications Divisions 1 through 46.
 - 4. Volume 3: Geotechnical Design Memorandum (GDM).
 - a. The GDM presents a summary of project design and construction recommendations for the project.
 - 5. Volume 4: Geotechnical Data Report (GDR).
 - a. The GIR presents a summary of project field investigations and laboratory testing for the project.
 - 6. Volume 5: City of Thornton Procured Equipment Contracts.
 - a. The contracts for the procured equipment that will be incorporated into the project.
 - 7. Volume 6: Materials Management Plan.
 - 8. Volume 7: Drawings for the Source Water Pump Station Access Road and design criteria for magnesium chloride road treatment.

1.04 OWNER AND ASSIGNED SUBCONTRACTORS

- A. Owner: The City of Thornton, 9500 Civic Center Drive, Thornton, CO 80229.
- B. The City of Thornton has retained the following Design Consultants under separate agreements to support design and construction:
 - 1. Engineer: Carollo Engineers, Inc., has been retained for preparation of Contract Documents. Address: 11030 Circle Point Road, Suite 400, Westminster, CO 80020.
 - 2. Owners Advisor: Jacobs Engineering has been retained to serve as the Owners Advisor and to assist the City of Thornton with management and administration of the Project.
 - 3. Environmental Consultant: ERO Resources has been retained to perform cultural resources survey, habitat and environmental surveys, and migratory bird and raptor surveys and to provide environmental considerations and work restrictions in the Contract Documents.
 - 4. Construction Manager: Construction Manager to support the City of Thornton during construction and to assist in administering agreements between the City of Thornton and Contractor.

1.05 THE WORK

- A. The Work consists of construction, permitting, coordination, quality control, and all items required to provide an operating system of:
 - 1. Source Water Pump Station improvements include construction of a new pump station building with a medium voltage electrical room, control room, main pump room, and wet well. The Work also includes, but is not limited to, new pumps, valves, flow meters, instrumentation, a new medium voltage power feed with transformers and switchgear, network racks, variable speed drives, PLC equipment, HVAC equipment, a bridge crane, intake piping, intake structures with gates, discharge piping, utilities, and other miscellaneous items.

1.06 COORDINATION WITH OTHER PROJECTS

- A. Contractor's use of premises:
 - 1. Contractor shall limit all work to the Limits of Construction as indicated on the Drawings.
 - 2. Storage of equipment and materials shall be limited to construction activities as indicated on the Drawings and shall be removed immediately upon completion of work.
 - 3. Contractor staging and laydown areas that have been approved by the City of Thornton are indicated on the Drawings. City of Thornton has made no provisions for additional Contractor staging and laydown areas. Contractor may make separate arrangements with adjacent or nearby property owners for acquisition of separate temporary easement for Contractors use at no additional cost to the City of Thornton. Provide written agreements to the Construction Manager for review and approval.
 - 4. Contractor shall maintain access to all roadways, trails, sidewalks, and all private residences for the duration of construction.

- B. Landowner's use of premises:
 - 1. Operating facilities, private landowners, utility owners, and ditch companies shall have access to properties and facilities the duration of construction. Contractor shall coordinate and cooperate with landowners to minimize construction impacts to existing operations to the extent possible.
- C. Activities by others which may affect performance of work:
 - 1. Construction and commissioning of Thornton Water Project Segment F Pipeline, which will connect to the SWPS discharge pipeline.
- D. Incorporation of Owner procured equipment into the project.
 - 1. The Owner has procured certain equipment that will be incorporated into the project. See the Contract Documents for details. The following are the delivery dates for the Owner procured equipment. Contractor shall incorporate the delivery dates into the project schedules.
 - a. 3,000 HP Pumps and Motors (Tag Numbers PMP-305, PMP-306), and 600 HP Pumps and Motors (Tag Numbers PMP-302, PMP-303):
 - 1) June 15, 2027.
 - b. VFDs for 3,000 HP Pumps and Motors (Tag Numbers VFD-305, VFD-306) and VFDs for 600 HP Pumps and Motors (Tag Numbers VFD-302, VFD-303):
 - 1) June 15, 2027.
 - c. Transformer (Tag Number XFMR-PP1), Switchgear (Tag Number SWGR-SW1), Switchboard (Tag Number SWBD-SW), Lighting Panel (Tag Number LP-101), and Power Panel (Tag Number PP-101):
 - 1) December 2, 2027.
- E. The City of Thornton is conducting the SCADA Upgrades Project during the timeframe of construction of this project. The Contractor will be required to coordinate SCADA requirements with the SCADA Upgrades Project.
- F. Programming and SCADA integration of the Source Water Pump Station and Thornton Water Project facilities will be performed by the Owner's programmer. Contractor shall coordinate startup and commissioning activities with the Owner's programmer.

1.07 SUBSURFACE UTILITY ENGINEERING

- A. A Subsurface Utility Engineering (SUE) investigation was performed as part of design. The SUE investigation utilized a number of location technologies to meet the performance standards of ASCE 38-02. Utilities shown within project limits have been located with electronic designation to meet ASCE Quality Level D.
- B. During construction, the Contractor will be responsible for providing utility locates for the project for the duration of construction.

1.08 PRESERVATION OF TREES

- A. Clearing, grubbing, and disposal of all trees, shrubs and other vegetation shall be performed within the limits of construction as required, and as identified in Section 32_92_19 - Seeding. Trees outside of limits of construction and those identified as being protected in place shall be preserved. Coordinate with the Construction Manager to identify trees that might be protected within temporary easements.

1.09 WORK RESTRICTIONS

- A. Construction staging and sequencing shall be determined by the Contractor subject to review by the Construction Manager, within the approved working hours in the contract. Review by the Construction Manager will be to ensure consistency with other project requirements and work restrictions and will not imply means and methods.
- B. Storage of fuel:
 - 1. Storage of fuel on site or surrounding areas is prohibited. Contractor must use a fueling truck to service and fuel equipment.
- C. Workdays and holidays:
 - 1. Construction shall be limited to Monday through Friday. Work may be scheduled for Saturdays with prior approval from the City of Thornton. No work will be allowed on Sunday except in the event of an emergency.
 - 2. The City of Thornton observes the following holidays, and the Contractor shall not schedule or execute work on these holidays:
 - a. New Year's Day, January 1.
 - b. Martin Luther King Day, 3rd Monday in January.
 - c. Presidents' Day, 3rd Monday in February.
 - d. Memorial Day, Last Monday in May.
 - e. Juneteenth, June 19.
 - f. Independence Day, July 4.
 - g. Labor Day, 1st Monday in September.
 - h. Veterans Day, November 11.
 - i. Thanksgiving Day, 4th Thursday in November.
 - j. Thanksgiving Friday, Friday following Thanksgiving.
 - k. Christmas Day, December 25.
- D. Work times:
 - 1. The Contractor shall limit their working hours to:
 - a. Daytime work between 7 a.m. to 7 p.m., Monday through Friday.
 - b. Nighttime work not allowed unless approved by the City of Thornton and Larimer County. See exterior lighting management plan requirements below.

- E. Noise Levels:
1. Contractor shall comply with the Larimer County noise ordinance (Ordinance No. 97-03) Noise levels for the project shall not exceed the following values:
 - a. Construction projects:
 - 1) 80 dB(A) During the Day, 7:00 a.m. to 7:00 p.m.
 - 2) 75 dB(A) During the Night, 7:00 p.m. to 7:00 a.m.
 2. See Section 01_50_00 - Temporary Facilities and Controls for noise control plan requirements.
- F. Public Outreach Program:
1. The City of Thornton has established a public outreach program for the project. The Contractor shall coordinate with the City of Thornton to implement this plan, including the following:
 - a. Display City of Thornton provided project signage identified in Section 01_50_00 - Temporary Facilities and Controls. The signage shall identify a 24-hour telephone, email, and website contact for questions and concerns about the project. City of Thornton shall provide the email and contact phone number and shall be responsible for a responding to questions and concerns.
 - 1) The Contractor shall display the sign and direct questions to the contact information shown on the sign.
 - b. Flyers to be issued to adjacent residents, as identified by the City of Thornton, informing them of planned construction activities in advance.
 - 1) The Contractor shall coordinate with the City on planned construction activities. The City will provide and distribute the flyers.
- G. Access and Inspection by Larimer County Staff:
1. Contractor shall invite appropriate Larimer County staff to regularly scheduled construction meetings.
 2. Contractor shall allow access to Larimer County staff and consultants for inspections and construction observation throughout the Project and for the term of the construction and any required ongoing monitoring during site reclamation and/or operations.
 3. Larimer County staff may provide quality assurance and quality control inspections and testing, and/or independent, supplemental geotechnical materials testing deemed appropriate by the County Engineer. The cost of this inspection and testing will be paid for by the City of Thornton. This testing is in addition to the testing required to be performed by the Contractor.
- H. Larimer County Approval of Haul Routes:
1. Site access is from Colorado Highway 1 using the Source Water Pump Station Access Road. Access from Eagle Lake Drive and Travis Road is not allowed.
 2. Contractor shall provide designated haul routes for any Larimer County roads to Larimer County for approval and submit documentation of approval by the County.

3. Contractor to provide video and summary table of existing pre-construction conditions of haul route roads to Larimer County before Larimer County issuance of Development Construction permit to establish existing surface condition. If it is determined by the County Engineer that there has been an acceleration in deterioration of the roadway surface during or after construction as a result of construction traffic, equipment, or hauling, the Contractor will be required to restore the roadways to their prior condition. This may include the need for regrading and or resurfacing.
 4. Heavy equipment traffic will be subject to all weight limit restrictions along adjacent roadways and will obtain oversize/overweight permits.
- I. Wildlife monitoring and mitigation measures will be employed for the Project, and include, but are not limited to the following:
1. Migratory birds and raptor surveys:
 - a. A wildlife biologist hired by the Owner performed migratory bird and raptor surveys to identify potential nesting habitat as described below:
 - 1) To the extent possible, clearing of vegetation within the pump station limits of construction should occur outside of the breeding season (during winter months). If vegetation is removed between March 15 and August 31 (within the primary nesting season), a nest survey will be completed within one week prior to construction to confirm no active nests are within the construction limits. If active nests are found, any work that would destroy the nests would not be conducted until the birds have vacated the nests to comply with the Migratory Bird Treaty Act. Notify the wildlife biologist hired by the Owner 2 weeks prior to vegetation removal to schedule the nest survey during those dates.
 2. Pre- and post-construction surveys for restoration of the various vegetation classes in the work limits to ensure successful restoration. All temporarily disturbed areas will be planted with native seed mixes, or as reasonably specified by the property owner, and mulched, to increase diversity and decrease nonnative and noxious weed cover. State stormwater discharge permits require 70 percent restoration is achieved.
 3. A wildlife biologist hired by the Owner conducted nesting raptor and eagle surveys during Spring and Summer 2025 to identify any active raptor nests within or near the project vicinity that may affect project construction. The project Drawings indicate the location of a Bald Eagle nest buffer within the project work. All located nests are being closely observed to determine the status (active/inactive); species of bird; and nesting stage (egg laying, incubating, brood rearing, or fledging).
 - a. When feasible, avoid the use of, including running, heavy machinery within a 0.5-mile buffer of the eagle nest during the bald eagle nesting season: December 1 through July 31, or until the last fledgling has fledged.
 - b. If work cannot be avoided within a 0.5-mile buffer of the eagle nest during the bald eagle nesting season, the following monitoring protocol must be conducted by the project biologist:
 - 1) Weekly monitoring 3 weeks in advance of construction activities associated with SWPS within a 0.5-mile buffer of the nest to establish a baseline.

- 2) Daily monitoring during the first two weeks of construction of construction activities associated with SWPS within a 0.5-mile buffer of the nest.
 - 3) Additional monitoring anytime heavy machinery is used within a 0.5-mile buffer of the eagle nest during the bald eagle nesting season.
 - 4) Monitoring would continue until either construction has been completed, young have fledged and are no longer dependent on the nest, or the nest fails.
- c. During monitoring, the project biologist will:
- 1) Identify adverse behavioral reactions to new disturbances (including visual or auditory) related to the project and other human activities that may disturb the eagles to the extent that breeding eagles may be adversely affected.
 - 2) Implement work stoppages, delays, or modifications to minimize any construction-related adverse disturbances.
 - a) If construction-related adverse disturbances are observed, the biologist has stop work authority. Work may continue after two hours, and if the eagles show signs of disturbance again, work will cease for the day and start again the next day.
 - b) If on-going construction-related adverse disturbances are observed, the City will work with CPW to implement a more rigorous nest monitoring approach using a disturbance indicator approach.
 - 3) If adverse behavioral reactions are not observed, the City will coordinate with CPW to determine if less frequent monitoring may be considered.
 - 4) The Larimer County Environmental Planner must be included in communications related to nest monitoring to verify adherence to mitigation requirements.
4. Surveys done by the wildlife biologist during 2025 did not find any results of prairie dog burrows. Coordination with the wildlife biologist hired by the Owner prior to construction to identify any work that may occur within 1/8-mile (660-foot) buffer of any prairie dog burrows between March 15 and October 31. If the work may impact this buffer, a burrowing owl survey will be completed. Contact the wildlife biologist hired by the Owner 1 month prior to construction to complete the survey. If owls are present in the project area, the wildlife biologist will contact Colorado Parks and Wildlife (CPW) to confirm restriction of construction activities within 660 feet of nest burrows until the owls have migrated from the site, which can be determined through monitoring.
5. Contractor is responsible for prairie dog management. Passive relocation of prairie dogs is required prior to construction and is not recommended during the birthing season, March 1 through May 31. If there are no viable passive relocation alternatives, lethal control of prairie dogs may be allowed based on consultation with ERO. Contact ERO one month prior to construction to determine the best management approach for each colony in accordance with City of Thornton prairie dog ordinance guidelines.

J. Aquatic Hitchhiker Prevention Requirements:

1. If heavy equipment is used for the project that was previously working in another stream, river, lake, pond, or wetland within 10 days of working on this project, one of the following disinfection practices is required prior to construction to prevent the spread of invasive aquatic species (including but not limited to Eurasian water milfoil, zebra mussel, quagga mussel, and New Zealand mud snails) into the drainages. These practices are also necessary after project completion, prior to this equipment being used in another stream, river, lake, pond, or wetland, for the same purpose.
2. Remove all mud and debris from equipment (tracks, turrets, buckets, drags, teeth, etc.) and spray/soak equipment with a solution of commercial grade quaternary ammonium disinfectant compound containing at least 8.0 percent active ingredient diluted in solution to achieve at least 0.8 percent concentration. Specifically, a 1:15 solution of Quat 4 or super HDQ Neutral Institutional cleaner and water, can be used for effective treatment. Treated equipment should be kept moist for at least 10 minutes, managing rinsate as a solid waste in accordance with local, county, state, or federal regulations.
3. Remove all mud and debris from equipment (tracks, turrets, buckets, drags, teeth, etc.) and spray/soak equipment with water hotter than 140 degrees Fahrenheit for at least 10 minutes.
4. Clean hand tools, boots, and any other equipment that will be used in the water using one of the above options as well.

K. Cultural Resources:

1. If the Contractor identifies evidence of historical or archeological significance during construction, the Contractor shall cease all excavation and notify the Construction Manager.
 - a. Work shall be discontinued until notified by the Construction Manager that work may proceed.
 - b. Owner will employ the services of an environmental consultant to survey the area and make recommendations on how to proceed.
 - c. Compensation to the Contractor, if any, for lost time, demobilization, remobilization, or changes to construction shall be determined in accordance with changed or extra work provisions of the Contract Documents.

L. Air Quality Management Plan:

1. Contractor shall provide an Air Quality Management Plan to Owner within 15 days of notice to proceed. Owner will submit to plan Larimer County for their approval. Approval of this plan is required before Larimer County issuance of the Development Construction Permit.
2. The plan shall outline best management practices to reduce air pollutant emissions during construction. These shall include the following, at a minimum:
 - a. Verification that the Contractor's vehicles and equipment meets state, federal, and county air quality standards.
 - b. Verification that the Contractor has applied for all CDPHE required air quality permits.

- c. Best management practices that will be used to reduce air emissions from project vehicles and equipment. Include measures to reduce air emissions beyond dust/particulate matter such as odor-producing equipment and activities, reducing potential exposure from generators if used, and other equipment when used near residences.
 - d. Verification that local, state, and federal requirements for volatile organic compound (VOC) emissions are met for any onsite painting.
 - 3. See Section 01_50_00 - Temporary Facilities and Controls for separate dust control plan requirements.
- M. Exterior Lighting Management Plan:
 - 1. Lighting outside of the standard operating hours of 7:00 a.m. to 7:00 p.m. should be avoided and is subject to review and approval by Larimer County staff on a case-by-case basis. Lighting should be avoided during times of peak spring and fall migration of birds.
- N. Comprehensive Best Management Practices (BMP) Plan:
 - 1. The Contractor shall develop a comprehensive document describing BMPs to be employed for construction that potentially affects developed, rural, wetland and riparian land areas or may involve stream crossings. Such documentation is to include, but not be limited to, preconstruction and construction BMPs relating to surface water, erosion and sediment control and prevention; groundwater considerations and protection; topsoil conservation and restoration and vegetation/revegetation considerations. Lastly, the document shall address cover post-construction BMPs and monitoring requirements and plans for adaptive management if necessary.
 - 2. Contractor shall submit written plan before commencement of construction activities. The written plan will be in the form of a table.
- O. Contaminated Soils:
 - 1. The wildlife biologist hired by the Owner has conducted an environmental records review and supplemental field investigations, included in Volume 6. Contaminated Soils are not expected based on field investigations and historical records review. In the event contaminated soils are encountered, Contractor shall refer to the Materials Management Plan (MMP), included in Volume 6. All handling and disposal requirements of contaminated soils shall comply with federal and State of Colorado regulations.
 - 2. If contaminated soils are encountered, the Contractor shall designate an Environmental Materials Management Coordinator (EMMC) that has sufficient knowledge and experience to identify suspected contaminated soils, groundwater, or other media within the project area.
 - a. The EMMC shall have the knowledge and experience with similar conditions and:
 - 1) Be accessible during all construction activities should suspicious material be encountered.
 - 2) Have sufficient training, awareness, and knowledge to identify field indications of contamination such as visual staining, discoloration, or oil sheen and able to use and interpret field equipment reading such as a Photoionization Detector (PID) used during the course of excavation to monitoring for potential soil contamination.

- 3) Have sufficient knowledge, training, and authority to coordinate the identification, confirmation, management, and disposal of suspected or confirmed contaminated soils, groundwater, or other media. The presence of potentially contaminated soils shall be determined through:
 - a) Visual detection of staining, discoloration, or oil sheen.
 - b) Odor detection.
 - c) PID monitoring device.
 - 4) May hold other roles within the project staffing but meets the above qualifications.
3. If contaminated or potentially contaminated soils are identified, the Contractor shall take the necessary precautions to protect all Contractor personnel, Owner, Owners Advisor, Construction Manager, Engineer, project area and lands.
- a. Contractor shall immediately notify the Construction Manager of the potential for contaminated soil.
 - b. Contractor shall segregate and remove potentially contaminated soil from the site for further disposition, analysis, and removal. Contractor shall replace material removed from the site with acceptable fill.
 - c. All contaminated soils shall be transported and disposed off-site at a certified Subtitle D landfill under a manifest in accordance with state and federal regulations. Contractor shall retain all copies of all laboratory data, profile approvals, manifests, and bills of lading for any contaminated soils encountered and disposed. Owner shall approve waste disposal profile and disposal facility prior to any disposal. Potential Subtitle D landfills include:
 - 1) Republic.
 - 2) Waste Connections.
 - 3) Waste Management.
- P. Survey Requirements Prior to Foundation Construction:
1. Prior to foundation pour, the Larimer County Building Department must be provided with a written certification by a Colorado Licensed Land Surveyor that the proposed structure is located where shown on the Larimer County approved Plat Plan for this Development.
- Q. Water Supply and Storage (WSSC) Reservoir No. 3 water level during construction:
1. The water level within WSSC Reservoir No. 3 will be reduced to elevation 5104.5 from September 1, 2026, to March 31, 2027. After that time, the water level will fluctuate up to a maximum of elevation 5,125.0 feet.
- R. Air Leakage - Thermal Envelope Testing
1. The thermal envelope of the pump station shall comply with International Energy Conservation Code (IECC) Section C402.5.1 through C402.5.8, as amended by Larimer County, or the building thermal envelope shall be tested in accordance with ASTM E 779 at a pressure differential of 0.3 inch water gauge or an equivalent method approved by the code official and deemed to comply with the provisions of this Section when the tested air leakage rate of the building thermal envelope is not greater than 0.40 cfm/ft². Where

compliance is based on such testing, the building shall also comply with IECC Sections C402.5.5, C402.5.6, and C402.5.7, as amended by Larimer County.

- S. Erosion Control Materials
 - 1. No plastic-welded erosion control materials are permitted to be installed at the site.
- T. Magnesium chloride treatment of Source Water Pump Station Access Road:
 - 1. After pump station work is complete, Contractor shall scarify the aggregate base course of the existing Access Road to 4-inches deep, incorporating two applications of magnesium chloride at 0.25 gallons per square yard each treatment, mix, moisture condition, grade, and recompact the road to previous finished grade. See Volume 7: Drawings for the Source Water Pump Station Access Road and design criteria for magnesium chloride road treatment.

1.10 PERMITS

- A. The Engineer and City of Thornton have prepared a list of permits as follows. Some permits will be or have been obtained by the City of Thornton. Unless otherwise noted, the responsible party will obtain and pay the associated permit fees. Costs associated with obtaining required permits shall be included in the Contractors' bid price and shall be considered incidental to the relevant work items include in the bid schedule. All known permits are listed, but this does not relieve the Contractor from obtaining and paying fees associated with other unknown permits.
- B. City of Thornton obtained permits. The Contractor shall be required to abide by all applicable portions of these permits:
 - 1. Larimer County 1041 Permit.
 - 2. Larimer County Building Permit.
- C. Larimer County Permits to be obtained by the Contractor:
 - 1. Stormwater Management Plan (SWMP):
 - a. The project area is outside Larimer County MS4 permit jurisdiction, but the County will review and approve the contractors prepared SWMP.
 - 2. Larimer County Technical Review:
 - a. The City of Thornton will take the lead on packaging the documents and submitting to Larimer County.
 - b. Required plans that are to be provided and are part of these specifications are as follows:
 - 1) SWMP.
 - 2) Noise Mitigation Plan.
 - 3) Fugitive Dust and Emissions Control Plan.
 - 4) Exterior Lighting Management Plan.
 - 5) Air Quality Management Plan.
 - 6) Comprehensive Best Management Practices (BMP) Plan.
 - 7) Designated Haul Routes plan.

3. Development Construction Permit (DCP).
 - a. A preconstruction DCP meeting is required. The DCP will be issued at that meeting. The Contractor, Engineer and Owner all will attend. Larimer County has indicated that the DCP will not be issued until Contractor plans listed in Larimer County Technical review are approved. In addition, the Contractor must have the following permits:
 - 1) Poudre Fire Authority construction permit.
 - 2) CDPHE COR400000, COG080000, COG604000, APCD-200, and APCD-223 permits.
 - 3) Colorado Division of Water Resources GWS-2 permit.
- D. Poudre Fire Authority:
 1. Construction permit.
- E. Colorado Department of Health and Environment (CDPHE) permits to be obtained by the Contractor:
 1. COR400000: CDPHE Stormwater Discharge for General Construction Activities. The Drawings include SWMP sheets based on anticipated requirements of the CDPHE permit requirements. These SWMP drawings are furnished to the Contractor to edit, update, and use as needed for the CDPHE permit application and for regular maintenance and inspection of BMP devices during construction.
 - a. The Contractor's state stormwater discharge permit shall not be closed until 70 percent vegetation cover is achieved and County Community Development staff have deemed the landscape restoration complete.
 2. COG080000: Discharges from Short-term (less than 2 years) Construction Dewatering Activities. The Contractor shall obtain permits as required for construction.
 3. COG604000: Hydrostatic Testing of Pipelines, Tanks and Similar Vessels: The Contractor shall obtain permits as required for hydrostatic testing of pipelines.
 4. APCD-200: General Air Emission Notice (APEN) and application for construction permit. The Contractor shall obtain permits as required for construction.
 5. APCD-223: Land Development APEN is required based on this project being part of the larger Thornton Water Project, which exceeds 25 acres total.
- F. If dewatering wells are installed for construction dewatering, a permit from the Colorado Division of Water Resources is needed, GWS-62: Dewatering Wells. Contractor shall obtain required permits needed for installing, operating, and abandoning all dewatering wells required for construction in accordance with the requirements of the Colorado Office of the State Engineer Division of Water Resources, Section 37-91-102(6.3), C.R.S.
 1. A monitoring well was installed during design to record groundwater levels. The well is within the limits of excavation for the pump station. Contractor to plug, seal, and abandon or demolish the well and notify Engineer so that Engineer can prepare the appropriate paperwork within 60 days of abandonment to notify the State Engineer of the well removal.

1.11 STARTUP AND COMMISSIONING OF SOURCE WATER PUMP STATION AND ENTIRE THORNTON WATER PROJECT (TWP) PIPELINE AND FACILITIES

- A. See Specification 01_75_17 - Commissioning for details, timelines, and constraints of the framework of the startup and commissioning of the Source Water Pump Station and the TWP Pipeline and Facilities, include accommodating work to be performed by others during startup. The Contractor will be required to submit a more detailed, step by step, startup and commissioning plan as described in that specification.
- B. The Work includes the startup and commissioning of the Source Water Pump Station.
- C. The Work also includes the startup and commissioning of the TWP pipeline and facilities including, but not limited to, the following:
 - 1. Filling and flushing approximately 70 miles of 42-inch pipeline.
 - 2. Verifying functionality of 378 air valves along the 70-mile pipeline.
 - a. Valves are in pairs in 189 vaults. Contractor to verify isolation valves for each air valve are in the open position before pipeline filling commences. Contractor to also verify that air is evacuated during pipeline filling and flushing activities and that valves are seated properly. Contractor is required to verify this visually and in person at each location.
 - 3. Verifying functionality of the County Line Road Pressure Sensor.
 - 4. Verifying functionality of the Greely No. 2 Return Flow Structure.
 - 5. Verifying functionality of the Cache la Poudre River Return Flow Structure.
 - 6. Verifying functionality of the Signal Hill Pressure Sensor.
 - 7. Verifying functionality of the LCC PRV and Meter facility.
 - 8. Verifying functionality of the Segment A PRV and Meter and Chemical Building.
 - 9. Verifying functionality of 8 high capacity blowoffs. See Section 01_75_17 - Commissioning for additional requirements.
 - a. Pipeline Segment F.2 – Box Elder Creek location.
 - b. Pipeline Segment E – Timnath Reservoir Outlet.
 - c. Pipeline Segment C North – Big Thompson River.
 - d. Pipeline Segment D Johnstown – Little Thompson River.
 - e. Pipeline Segment C South – Diamond Reservoir Inlet.
 - f. Pipeline Segment B – St. Vrain Creek.
 - g. Pipeline Segment B – Little Dry Creek.
 - h. Pipeline Segment B – Big Dry Creek.
- D. Functional testing of the pipeline and facilities listed above will be completed by others, but the Contractor is required to provide combined commissioning of the entire TWP pipeline and facilities resulting in a functioning system to deliver water from the Source Water Pump Station Intake Structure to the Wes Brown Water Treatment Plant, utilizing all of the facilities listed above. The Signal Hill Pressure Sensor, LCC PRV, Segment A PRV and Meter, and Chemical Building improvements will be constructed by the same contractor that is constructing the Source Water Pump Station improvements. See the Contract Documents for the Chemical Building and PRV Vaults Project for functional testing requirements for these facilities.

- E. The Contractor will coordinate the startup and commissioning with the automated SCADA programming and loop testing, that will be performed by the Owner's programmer.
- F. The Contractor will be given coordinates for locations of each of the air valves, facilities, high capacity blowoffs, and access points to permanent easements for the TWP pipeline and facilities. Contractor shall provide a plan and schedule for functionality verification of each facility to allow coordination with the City of Thornton and Construction Manager. See Section 01_75_17 - Commissioning for additional requirements.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION (NOT USED)

END OF SECTION

SECTION 01_20_20

MEASUREMENT AND PAYMENT

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Procedures for measurement and payment of Work under this Contract for lump sum items and unit prices.

1.02 REFERENCES

- A. Occupational Safety and Health Administration (OSHA).

1.03 BID ITEMS

- A. Item 1: Mobilization:
 - 1. Measurement:
 - a. Includes work for, but is not limited to, the following:
 - 1) Mobilization to the sites and demobilization from the sites and includes obtaining and paying all costs for permits, temporary utilities, moving construction equipment, materials and labor to the site, establishing a contractor's field office and other necessary facilities, and all other costs incurred or labor and operations which must be performed prior to beginning the other bid items under the contract.
 - 2) Preparatory work and operations including but not limited to those necessary for the movement of personnel, equipment, supplies and incidentals to the Project site; for the establishment of all contractor required offices, buildings, and other facilities necessary for the work on the Project and for all other work and operations which must be performed, or costs incurred prior to beginning work on the Project.
 - 3) Establishment of all Contractor required offices, buildings, and other facilities necessary for the work on the Project and for all other work and operations which must be performed, or costs incurred prior to beginning work on the Project.
 - 4) Furnishing the bonds and meeting the insurance requirements that are required by the General Conditions. Bond cost shall be verified by the City of Thornton as based on the invoices from the insuring firm(s).
 - 5) Demobilization including removal, disposal, service disconnects, and other work to completely remove equipment, temporary facilities, and other work product from the construction work areas.
 - b. Measurement for payment will be according to the City of Thornton formula for mobilization as described in Paragraph 22 of the Special Conditions. The price shall not exceed 10 percent of the original Contract Price.

- 2. Payment:
 - a. Lump sum.
- B. Item 2: City of Thornton's Field Offices:
 - 1. Measurement:
 - a. Includes work for, but is not limited to, the following:
 - 1) Furnishing, installing, moving, maintaining, the established City of Thornton's field office including all furniture, utilities, weekly housekeeping, maintenance, parking maintenance, snow removal permitting, and all other related and necessary materials work and equipment required to complete this item in accordance with the Drawings and Specifications.
 - b. Measurement for payment will be based on the number of months provided in accordance with the approved baseline schedule. Partial payments shall be based on a 30-day month. For example, providing an office for 10 days = $10/30 = 0.333$ * monthly price provided.
 - 2. Payment:
 - a. Unit price per month.
- C. Item 3: Sediment/Erosion Control:
 - 1. Measurement:
 - a. Includes work for, but is not limited to, the following:
 - 1) Maintaining project conformance with the grading, erosion, and sediment control drawings, and permits and will be based on a lump sum.
 - 2) Planning, designing, developing, applying, and achieving a stormwater discharge permit from the Colorado Department Public Health and Environment (CDPHE) and developing a Storm Water Pollution Prevention Plan (SWPPP).
 - 3) Development, implementation, conformance, inspection, reporting, and compliance with CDPHE construction stormwater permit and associated storm water pollution prevention plan shall include all labor, materials, work, and all costs of whatsoever nature to implement and maintain the project site in compliance with the stormwater discharge permit and per the SWPPP.
 - 4) Preparing and revising SWMP/SWPPP drawings, preparing and revising SWMP/SWPPP report, furnishing, installing, maintaining and removing best management practices including but not limited to: silt fence, construction fence, erosion control blankets, seeding, mulching, vehicle tracking pads, inlet protection, concrete washout areas, erosion control bales, sediment control logs, reinforced rock berms, and all other necessary material, work, and equipment required to complete this item in accordance with the jurisdictional requirements relating to storm water and pollution controls.
 - b. Measurement for payment will be lump sum and shall be based on a percent complete of this item. Percentages shall be as determined by the Construction Manager.
 - 2. Payment:
 - a. Lump sum.

- D. Item 4: Sediment/Erosion Control during warranty:
1. Measurement:
 - a. Includes work for, but is not limited to, the following for the 12-month warranty period:
 - 1) Maintaining project conformance with the grading, erosion, and sediment control drawings, and permits during the warranty period and will be based on a lump sum.
 - 2) Conformance, inspection, reporting, and compliance with CDPHE construction stormwater permit and associated storm water pollution prevention plan shall include all labor, materials, work, and all costs of whatsoever nature to maintain the project site in compliance with the stormwater discharge permit and per the SWPPP during the warranty period.
 - 3) Maintaining and removing best management practices including but not limited to: silt fence, construction fence, erosion control blankets, seeding, mulching, vehicle tracking pads, inlet protection, concrete washout areas, erosion control bales, sediment control logs, reinforced rock berms, and all other necessary material, work, and equipment required to complete this item in accordance with the jurisdictional requirements relating to storm water and pollution controls.
 - b. Measurement for payment will be based on a price per month with a total of 12 months.
 2. Payment:
 - a. Unit price per month.
- E. Item 5: 42-inch discharge piping connection to Segment F pipeline
1. Measurement:
 - a. Includes work for, but is not limited to, the following:
 - 1) Removing the dished test head from the Segment F pipeline (installed by others), removing the test head from the 42-inch discharge pipeline, installing a section of owner furnished 42-inch pipeline between the two segments, welding, coating repair, lining repair, excavation, soil hauling, pipe bedding, pipe backfill, excavation support and protection as specified in Section 31_50_00 - Excavation Support and Protection, work for dewatering and other appurtenant work and materials as specified in Section 31_23_19 - Dewatering for excavation activities, and all other related and necessary materials, work and equipment necessary to satisfactorily perform this item, complete in accordance with the Contract Documents.
 - b. Measurement for payment will be lump sum and shall be based on a percent complete of this item. Percentages shall be as determined by the Construction Manager.
 2. Payment:
 - a. Lump sum.

- F. Item 6: Yard Piping:
1. Measurement:
 - a. Includes work for, but is not limited to, the following:
 - 1) Includes work for laydown areas, protection and support of utilities adjacent to the Work, exploratory excavation, excavation, soil stabilization, soil hauling, pipe bedding, pipe backfill, all buried and exterior yard piping outside of the pump station building foundation and footprint including buried surge tank pipes, all fittings, all couplings, all appurtenances, all excavation support and protection as specified in Section 31_50_00 - Excavation Support and Protection, work for dewatering and other appurtenant work and materials as specified in Section 31_23_19 - Dewatering for all excavation activities, and all other related and necessary materials, work and equipment necessary to satisfactorily perform this item, complete in accordance with the Contract Documents.
 - b. Measurement for payment will be lump sum and shall be based on a percent complete of this item. Percentages shall be as determined by the Construction Manager.
 2. Payment:
 - a. Lump sum.
- G. Item 7: Grading, curb, gutter, sidewalk, fencing, gates, aggregate base course road, aggregate base course path, and recycled asphalt road:
1. Measurement:
 - a. Includes work for, but is not limited to, the following:
 - 1) Includes work for laydown areas, aggregate base course road, aggregate base course path, recycled asphalt pavement, curb, gutter, sidewalk, fencing, gates, and all other related and necessary materials, work and equipment necessary to satisfactorily perform this item, complete in accordance with the Contract Documents.
 - b. Measurement for payment will be lump sum and shall be based on a percent complete of this item. Percentages shall be as determined by the Construction Manager.
 2. Payment:
 - a. Lump sum.
- H. Item 8: Intake Structures, Hydraulic system 54-inch Intake Pipeline:
1. Measurement:
 - a. Includes work for, but is not limited to, the following:
 - 1) Includes work for laydown areas, protection and support of utilities adjacent to the Work, exploratory excavation, excavation, soil stabilization, soil hauling, pipe bedding, CLSM, installation of reservoir intake structures, intake structure gates, intake structure hydraulic actuators, hydraulic lines, hydraulic power unit, miscellaneous hydraulic system components, 54-inch intake pipeline, connections to piping outside of structures, screens, all excavation support and protection as specified in Section 31_50_00 - Excavation Support and Protection, work for dewatering and other appurtenant work and materials as specified in Section 31_23_19 - Dewatering for all excavation activities, and all other related and necessary

- materials, work and equipment necessary to satisfactorily perform this item, complete in accordance with the Contract Documents.
 - b. Measurement for payment will be lump sum and shall be based on a percent complete of this item. Percentages shall be as determined by the Construction Manager.
 - 2. Payment:
 - a. Lump sum.
- I. Item 9: Exterior and Buried Electrical Improvements and Duct banks:
 - 1. Measurement:
 - a. Includes work for, but is not limited to, the following:
 - 1) Includes work for laydown areas, protection and support of utilities adjacent to the Work, exploratory excavation, excavation, soil stabilization, soil hauling, duct bank bedding and backfill, main electrical service, transformers, conduits, wire, cable, duct banks, hand holes, manholes, pull boxes, installation and testing of all exterior and buried electrical materials and equipment, all excavation support and protection as specified in Section 31_50_00 - Excavation Support and Protection, work for dewatering and other appurtenant work and materials as specified in Section 31_23_19 - Dewatering for all excavation activities, and all other related and necessary materials, work and equipment necessary to satisfactorily perform this item, complete in accordance with the Contract Documents.
 - 2) For Owner procured exterior switchgear and transformer (Transformer [Tag Number XFMR-SW1], Switchgear [Tag Number SWGR-UT1]), includes installation, post-installation functional testing, supports, anchoring, appurtenances, and all other related and necessary materials, work and equipment necessary to satisfactorily perform, install, and test this item resulting in working electrical systems, complete in accordance with the Contract Documents.
 - b. Measurement for payment will be lump sum and shall be based on a percent complete of this item. Percentages shall be as determined by the Construction Manager.
 - 2. Payment:
 - a. Lump sum.
- J. Item 10: Cathodic Protection Anodes, Isolation Kits, Test Stations, and appurtenances:
 - 1. Measurement:
 - a. Includes work for, but is not limited to, the following:
 - 1) Furnishing and installing galvanic anodes, anode wiring, welded wire connections, test stations, joint bonding, wire connection protection, isolation kits, isolation testing of metallic pipe from structures and rebar both before and after concrete is poured, test station boxes, terminal boards, shunts, wire labels, holiday testing, coating testing, record keeping, system testing, and all other necessary material, work and equipment required to complete this item in accordance with the Drawings and Specifications. This includes all cathodic protection for the site, interior and exterior, buried and above ground.

- b. Measurement for payment will be lump sum and shall be based on a percent complete of this item. Percentages shall be as determined by the Construction Manager.
 - 2. Payment:
 - a. Lump sum.
- K. Item 11: Concrete drilled piers - 24-inch diameter.
 - 1. Measurement:
 - a. Includes work for, but is not limited to, the following:
 - 1) Concrete drilled piers, rebar, work for laydown areas, exploratory excavation, excavation, soil stabilization, soil hauling, all excavation support and protection as specified in Section 31_50_00 - Excavation Support and Protection, work for dewatering and other appurtenant work and materials as specified in Section 31_23_19 - Dewatering for all excavation activities, and all other related and necessary materials, work and equipment necessary to satisfactorily perform this item, complete in accordance with the Contract Documents.
 - b. Measurement for payment will be by linear foot of 24-inch diameter drilled pier installed and in place.
 - 2. Payment:
 - a. Vertical foot.
- L. Item 12: Concrete drilled piers - 36-inch diameter.
 - 1. Measurement:
 - a. Includes work for, but is not limited to, the following:
 - 1) Concrete drilled piers, rebar, work for laydown areas, exploratory excavation, excavation, soil stabilization, soil hauling, all excavation support and protection as specified in Section 31_50_00 - Excavation Support and Protection, work for dewatering and other appurtenant work and materials as specified in Section 31_23_19 - Dewatering for all excavation activities, and all other related and necessary materials, work and equipment necessary to satisfactorily perform this item, complete in accordance with the Contract Documents.
 - b. Measurement for payment will be by linear foot of 36-inch-diameter drilled pier installed and in place.
 - 2. Payment:
 - a. Vertical foot.
- M. Item 13: Wet well excavation and earthwork.
 - 1. Measurement:
 - a. Includes work for, but is not limited to, the following:
 - 1) Work for laydown areas, exploratory excavation, excavation, soil stabilization, soil hauling, foundation subgrade preparation, and all other related and necessary materials, work and equipment necessary to satisfactorily perform this item, complete in accordance with the Contract Documents.
 - b. Measurement for payment will be lump sum and shall be based on a percent complete of this item. Percentages shall be as determined by the Construction Manager.
 - 2. Payment:
 - a. Lump sum.

- N. Item 14: Wet well and foundations dewatering and excavation support and protection.
1. Measurement:
 - a. Includes work for, but is not limited to, the following:
 - 1) All wet well and foundations excavation support and protection as specified in Section 31_50_00 - Excavation Support and Protection, work for dewatering and other appurtenant work and materials as specified in Section 31_23_19 - Dewatering for all excavation activities, and all other related and necessary materials, work and equipment necessary to satisfactorily perform this item, complete in accordance with the Contract Documents.
 - b. Measurement for payment will be lump sum and shall be based on a percent complete of this item. Percentages shall be as determined by the Construction Manager.
 2. Payment:
 - a. Lump sum.
- O. Item 15: Concrete wet well and foundations.
1. Measurement:
 - a. Includes work for, but is not limited to, the following:
 - 1) Concrete wet well, concrete floor slabs, concrete foundations, concrete equipment pads, concrete pipe encasement, rebar, void form, and all other related and necessary materials, work and equipment necessary to satisfactorily perform this item, complete in accordance with the Contract Documents.
 - b. Measurement for payment will be by neat line cubic yards installed in place.
 2. Payment:
 - a. Cubic Yard.
- P. Item 16: Walls and roof.
1. Measurement:
 - a. Includes work for, but is not limited to, the following:
 - 1) Concrete and masonry walls, pilasters, rebar, steel roof joists, metal roofing materials, roofing appurtenances, roof drainage appurtenances, and all other related and necessary materials, work and equipment necessary to satisfactorily perform this item, complete in accordance with the Contract Documents.
 - b. Measurement for payment will be lump sum and shall be based on a percent complete of this item. Percentages shall be as determined by the Construction Manager.
 2. Payment:
 - a. Lump sum.

- Q. Item 17: Doors, windows, hatches, and ladders.
1. Measurement:
 - a. Includes work for, but is not limited to, the following:
 - 1) Rollup door, doors, windows, roof hatch, skylights, floor access hatches, ladders, hardware, appurtenances, and all other related and necessary materials, work and equipment necessary to satisfactorily perform this item, complete in accordance with the Contract Documents.
 - b. Measurement for payment will be lump sum and shall be based on a percent complete of this item. Percentages shall be as determined by the Construction Manager.
 2. Payment:
 - a. Lump sum.
- R. Item 18: Security and life safety systems.
1. Measurement:
 - a. Includes work for, but is not limited to, the following:
 - 1) Security cameras, card readers, entry and exit sensors, appurtenances, electronic access control, intrusion detection, smoke detection, fire alarms, and all other related and necessary materials, work and equipment necessary to satisfactorily perform this item, complete in accordance with the Contract Documents.
 - b. Measurement for payment will be lump sum and shall be based on a percent complete of this item. Percentages shall be as determined by the Construction Manager.
 2. Payment:
 - a. Lump sum.
- S. Item 19: Bridge crane:
1. Measurement:
 - a. Includes work for, but is not limited to, the following:
 - 1) Bridge crane, operators, testing, anchoring, supports, appurtenances, and all other related and necessary materials, work and equipment necessary to satisfactorily perform, install, and test this item resulting in a bridge crane system, complete in accordance with the Contract Documents.
 - b. Measurement for payment will be lump sum and shall be based on a percent complete of this item. Percentages shall be as determined by the Construction Manager.
 2. Payment:
 - a. Lump sum.
- T. Item 20: Pumps and motors.
1. Measurement:
 - a. Includes work for, but is not limited to, the following:
 - 1) All pumps, motors, factory testing, post-installation functional testing, pump and motor mounted or integral sensors, supports, anchoring, appurtenances, and all other related and necessary materials, work and equipment necessary to satisfactorily perform, install, and test this item resulting in working pump systems, complete in accordance with the Contract Documents.

- 2) For Owner procured pumps and motors (3,000 HP Pumps and Motors [Tag Numbers PMP-305, PMP-306], 600 HP Pumps and Motors [Tag Numbers PMP-302, PMP-303]), includes installation, post-installation functional testing, pump and motor mounted or integral sensors, supports, anchoring, appurtenances, and all other related and necessary materials, work and equipment necessary to satisfactorily perform, install, and test this item resulting in working pump systems, complete in accordance with the Contract Documents.
 - b. Measurement for payment will be lump sum and shall be based on a percent complete of this item. Percentages shall be as determined by the Construction Manager.
2. Payment:
 - a. Lump sum.
- U. Item 21: Interior piping, interior valves, and under slab and concrete encased piping.
1. Measurement:
 - a. Includes work for, but is not limited to, the following:
 - 1) All interior discharge piping, drain piping, vent piping interior and exterior, all other piping, valve actuators, valves, couplings, fittings, supports, anchoring, interior surge tank vault piping and valves, appurtenances, and all other related and necessary materials, work and equipment necessary to satisfactorily perform this item, complete in accordance with the Contract Documents.
 - 2) All under slab and concrete encased piping inside of the pump station building foundation and footprint. Includes work for laydown areas, protection and support of utilities adjacent to the Work, exploratory excavation, excavation, soil stabilization, soil hauling, pipe bedding, pipe backfill, all buried fittings, couplings, appurtenances, all excavation support and protection as specified in Section 31_50_00 - Excavation Support and Protection, work for dewatering and other appurtenant work and materials as specified in Section 31_23_19 - Dewatering for all excavation activities, and all other related and necessary materials, work and equipment necessary to satisfactorily perform this item, complete in accordance with the Contract Documents.
 - b. Measurement for payment will be lump sum and shall be based on a percent complete of this item. Percentages shall be as determined by the Construction Manager.
 2. Payment:
 - a. Lump sum.

V. Item 22: HVAC improvements.

1. Measurement:

a. Includes work for, but is not limited to, the following:

- 1) All exhaust fans, electric unit heaters, heating and cooling units, ducts, louvers, testing, adjusting, balancing, thermostats and other temperature monitoring and control instruments, Building Management System integration, controllers, and all other related and necessary materials, work and equipment necessary to satisfactorily perform this item, complete in accordance with the Contract Documents.

b. Measurement for payment will be lump sum and shall be based on a percent complete of this item. Percentages shall be as determined by the Construction Manager.

2. Payment:

a. Lump sum.

W. Item 23: Interior and in-slab electrical improvements.

1. Measurement:

a. Includes work for, but is not limited to, the following:

- 1) All in-slab or interior electrical equipment and appurtenances including PLCs, VFD, switchgear, transformers, manual transfer switch cabinets, panels, grounding, lighting, receptacles, wires, cables, terminations, conduits, factory testing, field acceptance testing, power monitors, disconnect systems, battery systems, lightning protection, surge protection, factory testing, post-installation functional testing, integral sensors, supports, anchoring, appurtenances, and all other related and necessary materials, work and equipment necessary to satisfactorily perform, install, and test this item resulting in working pump systems, complete in accordance with the Contract Documents.

- 2) For Owner procured VFDs, switchgear, switchboard, automatic transfer switch, lighting panel, power panel, and transformers (Transformer [Tag Number XFMR-PP1], Switchgear [Tag Number SWGR-SW1], Switchboard [Tag Number SWBD-SW], Lighting Panel [Tag Number LP-101], Power Panel [Tag Number PP-101], VFDs for 3,000 HP Pumps and Motors [Tag Numbers VFD-305, VFD-306], VFDs for 600 HP Pumps and Motors [Tag Numbers VFD-302, VFD-303]), includes installation, post-installation functional testing, supports, anchoring, appurtenances, and all other related and necessary materials, work and equipment necessary to satisfactorily perform, install, and test this item resulting in working electrical systems, complete in accordance with the Contract Documents.

b. Measurement for payment will be lump sum and shall be based on a percent complete of this item. Percentages shall be as determined by the Construction Manager.

2. Payment:

a. Lump sum.

- X. Item 24: Instruments.
1. Measurement:
 - a. Includes work for, but is not limited to, the following:
 - 1) Intelligent actuators, pressure instruments, level instruments, flow meters, vibration sensors that are not integral with equipment, level switches, miscellaneous switches and sensors, network racks and cards, and all other related and necessary materials, work and equipment necessary to satisfactorily perform this item, complete in accordance with the Contract Documents.
 - b. Measurement for payment will be lump sum and shall be based on a percent complete of this item. Percentages shall be as determined by the Construction Manager.
 2. Payment:
 - a. Lump sum.
- Y. Item 25: Surge Tanks, Surge Tank Concrete Vault, and Surge Tank Concrete Foundations.
1. Measurement:
 - a. Includes work for, but is not limited to, the following:
 - 1) Steel surge tanks, surge tank instruments and controls, surge tank air compressor, anchorage to concrete foundations, concrete foundations excluding drilled piers, concrete walls, concrete top slab, rebar, void form, work for laydown areas, sump pumps, ladders, manhole lids, exploratory excavation, excavation, soil stabilization, soil hauling, foundation subgrade preparation, all excavation support and protection as specified in Section 31_50_00 - Excavation Support and Protection, work for dewatering and other appurtenant work and materials as specified in Section 31_23_19 - Dewatering for all excavation activities, and all other related and necessary materials, work and equipment necessary to satisfactorily perform this item, complete in accordance with the Contract Documents.
 - b. Measurement for payment will be lump sum and shall be based on a percent complete of this item. Percentages shall be as determined by the Construction Manager.
 2. Payment:
 - a. Lump sum.
- Z. Item 26: Concrete structure water leakage tests and pipeline testing:
1. Measurement:
 - a. Includes work for, but is not limited to, the following:
 - 1) Requirements as specified in Section 40_05_00.09 - Piping Systems Testing and Section 01_75_19 - Water Leakage Test for Concrete Structures, and all other related and necessary materials, work and equipment necessary to satisfactorily complete these items, complete in accordance with the Contract Documents.
 - b. Measurement for payment will be lump sum and shall be based on a percent complete of this item. Percentages shall be as determined by the Construction Manager.
 2. Payment:
 - a. Lump sum.

AA. Item 27: Source Water Pump Station startup and commissioning.

1. Measurement:
 - a. Includes work for, but is not limited to, the following:
 - 1) Startup and commissioning of the Source Water Pump Station and all of its components which are not covered in other bid items, and all other related and necessary materials, work and equipment necessary to satisfactorily startup, commission, and test this item resulting in a fully functioning pump station with all of its components and systems, complete in accordance with the Contract Documents.
 - b. Measurement for payment will be lump sum and shall be based on a percent complete of this item. Percentages shall be as determined by the Construction Manager.
2. Payment:
 - a. Lump sum.

BB. Item 28: Thornton Water Project (TWP) startup and commissioning.

1. Measurement:
 - a. Includes work for, but is not limited to, the following:
 - 1) Startup and commissioning of the Thornton Water Project system from the Source Water Pump Station to the West Brown Water Treatment Plant, including the LCC PRV and Meter, Segment A PRV and Meter, Greeley No. 2 Return Flow Structure, Cache la Poudre River Return Flow Structure, Signal Hill pressure sensor, Chemical Building, high capacity blowoffs, air valves, and all other related and necessary materials, work and equipment necessary to satisfactorily startup, commission, and test this item resulting in a fully functioning TWP system that delivers the specified amount of water from the Source Water Pump Station to the West Brown Water Treatment Plant, with all of its components and systems, complete in accordance with the Contract Documents.
 - 2) This item also includes paying for all power costs associated with operation of the Source Water Pump Station and all other TWP facilities during the startup and commissioning activities.
 - 3) This item also includes flushing approximately 70 miles of 42-inch pipeline and treating the flushing water in accordance with the Contract Documents.
 - 4) This item also includes checking functionality of 378 air valves along the 70-mile pipeline and monitoring the exhausting of air within the pipeline filling and flushing activities.
 - 5) This item also includes checking functionality of high capacity blowoffs.
 - b. Measurement for payment will be lump sum and shall be based on a percent complete of this item. Percentages shall be as determined by the Construction Manager.
2. Payment:
 - a. Lump sum.

CC. Item 29: Seeding and surface restoration:

1. Measurement:
 - a. Includes work for, but is not limited to, the following:
 - 1) Rut removal, fine grading, rock removal, soil preparation, furnishing and installing top soil, top soil amendment, seed, maintenance, weed spraying, seed reapplication, ecologist observation and reports, and all other necessary material, work, and equipment required to complete this item in accordance with the Drawings and Specifications.
 - 2) Maintenance of newly seeded areas until the time of final acceptance to ensure and maintain adequate growth coverage for duration as outlined in the Specifications.
 - b. Measurement for payment will be lump sum and shall be based on a percent complete of this item. Percentages shall be as determined by the Construction Manager.
2. Payment:
 - a. Lump sum.

DD. Item 30: Contractor quality control - independent testing:

1. Measurement:
 - a. Includes work for, but is not limited to, the following:
 - 1) Contractor is responsible to provide all Quality Control for the project.
 - 2) Contractor to retain the services of a Certified Independent testing agency to perform required testing of all soil, concrete, aggregate, pipe, paint, and all materials to be incorporated into the Work, except that covered by Special Inspections. In addition, the Contractor shall retain the services of an Independent and Certified Welding inspector to inspect and provide written acceptance of all welds. Welding inspector shall be approved and acceptable to City of Thornton.
 - b. Measurement for payment will be lump sum and shall be based on a percent complete of this item. Percentages shall be as determined by the Construction Manager.
2. Payment:
 - a. Lump sum.

EE. Item 31: Allowance for Haul Route Restoration:

1. Measurement:
 - a. Includes work for, but is not limited to, the following:
 - 1) Restoration of haul route roads that are damaged by construction traffic.
2. The Contractor shall include a \$50,000 allowance in their bid to repair and restore haul route roads. Actual costs of road restoration will be negotiated with the Owner and shall be taken out of the allowance upon approval by the Owner.
3. Payment:
 - a. Square foot.

FF. Item 32: Incorporating City of Thornton Procured Equipment:

1. Measurement:
 - a. Includes work for, but is not limited to, the following:
 - 1) Incorporating City procured equipment into the project for installation, testing, startup, commissioning, warranty, and all other requirements for a complete and working system that is not covered by other bid items. The purchase agreements for the City procured equipment is included as an attachment to the specifications.
 - b. Measurement for payment will be lump sum and shall be based on a percent complete of this item. Percentages shall be as determined by the Construction Manager.
2. Payment:
 - a. Lump sum.

GG. Item 33: Magnesium Chloride Treatment of Source Water Pump Station Access Road:

1. Measurement:
 - a. Includes work for, but is not limited to, the following:
 - 1) Scarifying aggregate base course of existing road to 4-inches deep, incorporating two applications of magnesium chloride at 0.25 gallons per square yard each treatment, mixing, moisture conditioning, grading, compaction to previous finished grade, and all other related and necessary materials, work and equipment necessary to satisfactorily complete this item, complete in accordance with the Contract Documents.
 - b. The Contractor shall provide a price per linear foot based on the road centerline and total price for the base quantity provided in the bid form. Measurement for payment will be unit price based on the actual number of linear feet of magnesium chloride treated road installed, not the base quantity on the bid form.
2. Payment:
 - a. Unit price per linear foot.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION (NOT USED)

END OF SECTION

SECTION 01_31_19
PROJECT MEETINGS

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Requirements for conducting conferences and meetings for the purposes of addressing issues related to the Work, reviewing and coordinating progress of the Work and other matters of common interest, and includes the following:
 - a. Qualifications of Meeting Participants.
 - b. Basic Meeting Requirements.
 - c. Pre-construction Conference.
 - d. Pre-construction Safety Conference.
 - e. Pre-submittal Conference.
 - f. Progress Meetings.
 - g. Schedule Update Meetings.
 - h. Quality Control Meetings.
 - i. Pre-Installation Meetings.
 - j. Commissioning Coordination Meetings.
 - k. Instrumentation and Control Coordination Meetings.
 - l. Close-out Meeting.
 - m. Post Construction Meeting.

1.02 QUALIFICATIONS OF MEETING PARTICIPANTS

- A. Representatives of entities participating in meetings shall be qualified and authorized to act on behalf of entity each represents.

1.03 BASIC MEETING REQUIREMENTS

- A. Attendees:
 - 1. Meeting leader shall require attendance of parties directly affecting, or affected by, Work being discussed at the meeting.
- B. Location:
 - 1. In location convenient for most invitees.
 - 2. Provide video and telephone call-in options for meetings.
- C. Notification:
 - 1. Meeting leader shall notify attendees of the meeting, including an agenda, a minimum of 7 days prior to the meeting.
- D. Agenda:
 - 1. Meeting leader shall prepare copies of the agenda for participants and distribute at the meeting.

2. Minimum requirements:
 - a. Meeting purpose.
 - b. Review minutes of previous meeting.
 - c. Safety and security.
 - d. Discuss issues.
 - e. Action items.
 - f. Next meeting.
- E. Meeting minutes:
 1. Meeting leader shall prepare draft minutes and send to attendees for comment within 7 days.
 2. Meeting leader shall incorporate comments from attendees and submit final meeting minutes to attendees within 7 days of receipt of comments.

1.04 PRE-CONSTRUCTION CONFERENCE

- A. Construction manager leads the meeting.
- B. Timing:
 1. Upon issuance of Notice to Proceed, or earlier when mutually agreeable.
- C. Required attendees:
 1. Contractor's project manager and superintendent, Owner, Engineer, representatives of utilities, major subcontractors and others involved in performance of the Work, and others necessary to the agenda.
- D. Agenda minimum requirements:
 1. Meeting purpose:
 - a. To establish working understanding between parties and to discuss Construction Schedule, Shop Drawings and other Submittals, cost breakdown of major lump sum items, processing of Submittals and applications for payment, and other subjects pertinent to execution of the Work.
 2. Adequacy of distribution of Contract Documents.
 3. Distribution and discussion of list of major subcontractors and suppliers.
 4. Proposed progress schedules and critical construction sequencing.
 5. Major equipment deliveries and priorities.
 6. Project coordination.
 7. Designation of responsible personnel.
 8. Procedures and processing of:
 - a. Field decisions.
 - b. Proposal requests.
 - c. Submittals - separate meeting.
 - d. Change Orders.
 - e. Request for Information/Interpretations.
 - f. Applications for Payment.
 - g. Record documents.
 9. Use of premises:
 - a. Office, construction, and storage areas.
 - b. Owner's requirements.
 10. Construction facilities, controls, and construction aids.

11. Temporary utilities.
12. Safety and first aid procedures.
13. Security procedures.
14. Housekeeping procedures.
15. Safety and security.
16. Review proposed photographer Submittal.
17. Action items.
18. Next meeting.

1.05 PRE-CONSTRUCTION SCHEDULING MEETING

- A. Construction manager leads the meeting.
- B. Timing:
 1. Within 7 days of Notice to Proceed, or earlier when mutually agreeable.
- C. Required attendees:
 1. Contractor's project manager, superintendent, scheduler, Owner, Engineer, and others necessary to the agenda.
- D. Agenda minimum requirements:
 1. Meeting purpose:
 - a. To establish the format and features of the Construction Schedule.
 2. Schedule preparation.
 3. Reporting requirements.
 4. Updates and revision procedures.
 5. Schedule delay analysis procedures.
 6. Schedule methodology.
 7. Planned sequence of operations.
 8. Cost and labor loading methodology.
 9. Proposed activity coding structure as specified in Section 01_32_21 - Schedules and Reports.
 10. Naming convention: Name schedule files with the year, month and day of the data date, revision identifier, and a description of the schedule.
 - a. Example 1: 2021_07_30 rev 1 draft baseline schedule.xer.
 - b. Example 2: 2021_09_30 rev 2 sep final update.xer.
 11. Action items.
 12. Next meeting.

1.06 PRE-CONSTRUCTION SAFETY CONFERENCE

- A. Construction manager leads the meeting.
- B. Timing:
 1. Upon issuance of Notice to Proceed, or earlier when mutually agreeable.
- C. Required attendees:
 1. Contractor's project manager, safety representative, and superintendent; Owner, Engineer, representatives of utilities, major subcontractors and others involved in performance of the Work, and others necessary to the agenda.

- D. Agenda minimum requirements:
 - 1. Meeting purpose:
 - a. To establish safety procedures and identify lead participants.
 - 2. Review minutes of previous meeting.
 - 3. Safety and first aid procedures.
 - 4. Review of Experience Modification Rating for Contractor and each Subcontractor.
 - 5. Security procedures.
 - 6. Housekeeping procedures.
 - 7. Safety and security.
 - 8. Action items.
 - 9. Next meeting.

1.07 PRE-SUBMITTAL CONFERENCE

- A. Construction manager leads the meeting.
- B. Timing:
 - 1. Prior to producing any Submittals.
- C. Required attendees:
 - 1. Contractor's project manager and superintendent, Owner, Engineer, representatives of utilities, major subcontractors, individual equipment manufacturers furnishing major pieces of equipment, and others involved in performance of the Work, and others necessary to the agenda.
- D. Agenda minimum requirements:
 - 1. Meeting purpose:
 - a. Review the entire Project, equipment, control philosophy, schedules, and Submittal requirements.
 - b. Awareness of requirements by major subcontractors, major suppliers, and major equipment manufacturers.
 - c. Format and procedures for Submittals.
 - d. Review of the master Submittal schedule.
 - 2. Review equipment list.
 - 3. Review Submittal schedule.
 - 4. Format of Submittals.
 - 5. Procedures and processing of Submittals.
 - a. Review turn-around time.
 - 6. Discuss specific electrical and instrumentation and controls Submittal requirements.
 - 7. Safety and security.
 - 8. Action items.
 - 9. Next meeting.

1.08 PROGRESS MEETINGS

- A. Construction manager will lead the meeting.
- B. Timing:
 - 1. Hold meetings throughout progress of the Work at maximum weekly intervals.

- C. Required attendees:
 - 1. Owner, Engineer, Contractor, Contractor's project manager, superintendent, quality control manager, project scheduler, major subcontractors and suppliers as appropriate to the agenda topics for each meeting.
 - 2. Additional invitees:
 - a. Owner utility companies when the Work affects their interests, and others necessary to the agenda.
- D. Agenda minimum requirements:
 - 1. Meeting purpose:
 - a. Provide the status of the Work.
 - 2. Review minutes of previous meeting.
 - 3. Safety and security.
 - 4. Construction schedule summary.
 - 5. Review of 6 weeks schedule.
 - a. Provide printed hard copies for each attendee.
 - 6. Review of off-site fabrication and delivery schedules.
 - 7. Review of Submittals schedule and status of Submittals.
 - 8. Request for information (RFI) status.
 - 9. MOPO/shutdown coordination.
 - 10. Change order management status.
 - 11. Maintenance of quality standards (QA/QC).
 - 12. Field observations, problems, and conflicts.
 - 13. Commissioning.
 - 14. Partnering recognition status (optional).
 - 15. General items.
 - 16. Action items.
 - 17. Next meeting.

1.09 SCHEDULE UPDATE MEETINGS

- A. Contractor leads the meeting.
- B. Timing:
 - 1. Hold meetings throughout progress of the Work at maximum monthly intervals.
- C. Required attendees:
 - 1. Owner, Engineer, Contractor, Contractor's project manager, general superintendent, project scheduler, major subcontractors and suppliers as appropriate to the agenda topics for each meeting.
 - 2. Additional invitees:
 - a. Owner utility companies when the Work affects their interests and others necessary to the agenda.
- D. Agenda minimum requirements:
 - 1. Meeting purpose:
 - a. Identify and troubleshoot scheduling issues in a collaborative environment.
 - b. Provide further detail on Work status.
 - 2. Review minutes of previous meeting.

3. Monthly Schedule Review (Actual Progress and Variance).
 - a. "Activities Started/Completed" this period.
 - b. "Activities Started/Completed" "Variance" baseline vs. current.
 - c. "Added/Deleted Activities".
 - d. "Revised Activity Descriptions".
 - e. Any significant Proposed Logic Changes.
4. Review milestone "Substantial Completion" Schedule:
 - a. "Critical" Activities - "Critical Area, Float and Vital Statistics".
5. Review "Cumulative and Monthly Costs" graph.
6. Review "Budgeted Cost" indicating the Current Project Budgeted Cost.
7. Safety and security.
8. Action items.
9. Next meeting.

1.10 PRE-INSTALLATION MEETINGS

- A. Contractor leads the meeting.
- B. Location:
 1. Pre-installation meetings shall be held on-site.
- C. Timing:
 1. When specified in the Technical Sections or requested by the Engineer, before commencing Work of specific Section.
- D. Required attendees:
 1. Owner, Engineer, Contractor, Contractor's project manager, general superintendent, project scheduler, major subcontractors, including electrical instrumentation, and suppliers as appropriate to the agenda topics for each meeting.
 2. Additional invitees:
 - a. Owner utility companies when the Work affects their interests and others necessary to the agenda.
- E. Agenda minimum requirements:
 1. Meeting purpose:
 - a. Review conditions of installation, preparation, and installation procedures.
 - b. Review coordination with related work.
 2. Review minutes of previous meeting.
 3. Safety and security.
 4. Site walk.
 5. Action items.
 6. Next meeting.

1.11 QUALITY CONTROL MEETINGS

- A. Contractor leads the meeting.
- B. Timing:
 1. Hold meetings throughout progress of the Work at maximum weekly intervals.

- C. Required attendees:
 - 1. Engineer, construction manager and staff, Contractor's quality control manager, and staff.
- D. Agenda minimum requirements:
 - 1. Meeting purpose:
 - a. Update the Contractor's efforts to comply with quality requirements in the Contract Documents.
 - 2. Review minutes of previous meeting.
 - 3. Review of Work progress and schedule.
 - 4. Review of out-of-compliance inspection or test results.
 - 5. Field observations, problems, and decisions.
 - 6. Review of off-site fabrication and delivery schedules.
 - 7. Planned progress during succeeding work period.
 - 8. Coordination of required inspections and tests.
 - 9. Review 6-week schedule report with upcoming inspections and special tests.
 - 10. Maintenance of quality and work standards.
 - 11. Other business relating to the Work.
 - 12. Safety and security.
 - 13. Action items.
 - 14. Next meeting.

1.12 COMMISSIONING COORDINATION MEETINGS

- A. Contractor's Commissioning Coordinator leads the meeting.
- B. Timing:
 - 1. As specified in Section 01_75_17 - Commissioning.
 - 2. Additional commissioning coordination meetings shall be scheduled as required by the Engineer.
- C. Required attendees:
 - 1. Require attendance of parties directly affecting, or affected by process start-up and testing, including the Engineer, commissioning coordinator, specific work crews, Owner's operations, and maintenance staff.
- D. Agenda minimum requirements:
 - 1. Meeting purpose:
 - a. Coordinate commissioning activities.
 - 2. Review minutes of previous meeting.
 - 3. Review commissioning schedule.
 - 4. Review Owner Training schedule.
 - 5. Review test plans.
 - 6. Owner makes final decision for Commissioning GO or NO GO.
 - 7. Safety and security.
 - 8. Action items.
 - 9. Next meeting.

1.13 INSTRUMENTATION AND CONTROL COORDINATION MEETINGS

- A. Meetings and conferences as specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.

1.14 INITIAL ACCEPTANCE MEETING

- A. Construction Manager will schedule close-out meeting and Final Walk.
- B. Construction Manager will make arrangements for meeting and develop punch list as part of the final walk with all attendees.
- C. Attendance required: City of Thornton, Construction Manager, Contractor, Contractor's Project Manager, and Superintendent.
- D. Coordinate with Construction Manager and City of Thornton contracts department for substantial completion and initial acceptance letters.
- E. Agenda:
 - 1. Review punch list completion.
 - 2. Transfer of record documents (as-built red lined drawings).
 - 3. Substantial completion requirements.
 - 4. Initial acceptance requirements.
 - 5. Finalize payment and retention release.
- F. Construction Manager will record minutes and within 5 calendar days after meeting distribute copies to participants.
- G. City will issue an Initial Acceptance Letter upon Contractor meeting contractual requirements of Initial Acceptance.

1.15 FINAL ACCEPTANCE MEETING

- A. Meet with and inspect the Work 11 months after date of Initial Acceptance with City of Thornton and Construction Manager.
- B. City of Thornton will arrange meeting at least 7 days before meeting.
- C. Meet at project site to perform Final Acceptance walk.
- D. Inspect the Work and draft list of items to be completed or corrected.
- E. Review service and maintenance contracts and take appropriate corrective action when necessary.
- F. Complete or correct defective work within 30 days of inspection.

- G. Require attendance of Contractor, Project Manager, or Superintendent, appropriate manufacturers and installers of major units of constructions, affected subcontractors, and City of Thornton's operations and maintenance staff.
- H. Upon completion of all pending items, City of Thornton shall issue the Final Acceptance letter.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION (NOT USED)

END OF SECTION

SECTION 01_32_21
SCHEDULES AND REPORTS

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Schedules and reports.

1.02 TERMINOLOGY

- A. The words and terms listed below are not defined terms that require initial capital letters, but, when used in this Section, have the indicated meaning.
 - 1. Baseline schedule: A planned and approved timetable projection that illustrates the project execution strategy, key deliverables, planned activity dates and milestones.
 - 2. Critical path: The longest sequence of dependent tasks in a project.
 - 3. Near critical path: The longest path after the critical path.
 - 4. Weather day: The Contractor being prevented or inhibited from performing at least 4 hours of work on the critical path due to weather conditions.

1.03 SCHEDULING FORMAT

- A. Utilize critical path method (CPM) format.
- B. Provide a cost and labor loaded Schedule.
- C. Construction Manager approval of the format is required.

1.04 SCHEDULING HARDWARE AND SOFTWARE

- A. Scheduling software and hardware shall be located on-site.
- B. Prepare computerized schedule utilizing the most current version of Oracle Primavera P6 or Asta Powerproject, or approved equal.
- C. Contractor and Construction Manager must agree on the format.

1.05 SCHEDULE PREPARATION

- A. Preparation and submittal of Progress Schedule represents Contractor's intention to execute the Work within specified time and constraints.
- B. All costs associated with Schedule requirements are included in the Contract Price.
- C. During preparation of the preliminary Progress Schedule, the Construction Manager will facilitate Contractor's efforts by answering questions regarding sequencing issues, scheduling constraints, interface points, and dependency relationships.

- D. Prepare Schedule utilizing precedence diagramming method (PADM).
- E. Prepare Schedule utilizing activity durations in terms of working days.
 - 1. Do not exceed a 15 working day duration on activities except concrete curing, submittal review, and equipment fabrication and deliveries.
 - 2. Where duration of continuous work exceeds 15 working days, subdivide activities by location, stationing, or other sub-element of the Work.
 - 3. Coordinate holidays to be observed with the Owner and incorporate them into the Schedule as non-working days.
- F. Failure to include an activity required for execution of the Work does not excuse Contractor from completing the Work and portions thereof within specified times and at price specified in Contract.
 - 1. Contract requirements are not waived by failure of Contractor to include required Schedule constraints, sequences, or milestones in Schedule.
 - 2. Contract requirements are not waived by Owner's acceptance of the Schedule. In the event of conflict between accepted Schedule and Contract requirements, terms of Contract govern at all times, unless requirements are waived in writing by the Owner.
- G. Reference Schedule to working days beginning with Notice to Proceed as Contract Time as Day "1".
- H. Baseline Schedule and project completion:
 - 1. Should Contractor submit a Baseline Schedule showing project completion more than 20 working days prior to Contract completion date, Owner may issue Change Order, at no cost to Owner, revising time of performance of Work and Contract completion date to match Contractor's Schedule completion date.
 - 2. Adjust accordingly any Contract milestone dates.
- I. Imposed dates and hidden logic are prohibited.
- J. Interim milestone dates, operational constraints:
 - 1. In event there are interim milestone dates and/or operational constraints set forth in Contract, show them on Schedule.
 - 2. Do not use zero total float constraint or mandatory finish date on such Contract requirements.
- K. Contract float is for the mutual benefit of both Owner and Contractor.
 - 1. Changes to the Project that can be accomplished within this available period of float may be made by Owner without extending the Contract Time by utilizing float.
 - 2. Time extensions will not be granted nor delay damages owed until Work extends beyond currently accepted Contract completion date.
 - 3. Likewise, Contractor may utilize float to offset delays other than delays caused by the Owner.
 - 4. Mutual use of float can continue until all available float shown by Schedule has been utilized by either Owner or Contractor, or both. At that time, extensions of the Contract Time will be granted by Owner for valid Owner-caused or third

- party-caused delays which affect the planned completion date and which have been properly documented and demonstrated by Contractor.
5. Non-sequestering of float: Pursuant to float sharing requirements of Contract, Schedule submittals can be rejected for use of float suppression techniques such as preferential sequencing or logic, special lead or lag logic restraints, extended activity durations, or imposed dates.
- L. Resource loading and leveling:
1. Input labor data on each schedule activity.
 2. Manpower data consists of the man-hours estimated to perform each task, categorized by trade.
 3. Provide leveled manpower requirements.
 - a. Availability of the resources drive activity duration.
- M. Cost loading: All schedules:
1. Only on-site construction activities.
 2. The sum total of all cost loaded activities equal to the current value of the Contract, including change orders, at all times.
 3. Payment for mobilization or payment for materials or equipment delivered to the site, not yet incorporated into the Work.
- N. Schedule logic:
1. Assembled to show order in which Contractor proposes to carry out Work, indicate restrictions of access, availability of Work areas, and availability and use of manpower, materials, and equipment.
 2. Form basis for assembly of schedule logic on the following criteria:
 - a. Which activities must be completed before subsequent activities can be started?
 - b. Which activities can be performed concurrently?
 - c. Which activities must be started immediately following completed activities?
 - d. What major facility, equipment, or manpower restrictions are required for sequencing these activities?
- O. Major subcontractor, parallel prime contractor sign off:
1. Provide written confirmation of concurrence from all major subcontractors and independent prime contractors on site with all Schedule submittals.
 2. Term "major subcontractor" as used in this Section means any subcontractor, at any tier, with a subcontract worth 5 percent or more of the total cost of the Work.
- P. Schedule windows for Owner-furnished, Contractor-installed equipment or materials:
1. Immediately after Award of Contract, obtain from Construction Manager anticipated delivery dates of Owner furnished equipment or materials.
 2. Show these dates in the Schedule in same manner indicated by the Construction Manager.

1.06 SCHEDULER

- A. Designate, in writing within 5 calendar days after Notice of Award, the person responsible for preparation, maintenance, updating, and revision of all schedules.
- B. Scheduler shall have the authority to update Schedule on behalf of the Contractor.
- C. Qualifications:
 - 1. A minimum of 8 years verifiable experience in preparation of construction schedules for projects of similar value, size, and complexity.
 - 2. Knowledge of critical path method (CPM) scheduling utilizing the specified software.
- D. References:
 - 1. Submit written reference of 3 project Owners who have personal experience with this scheduler on previous projects.
 - 2. Identify name, address, telephone number, project name, and cost.
- E. Scheduler:
 - 1. Dedicated time to this Project.
 - 2. Scheduler will attend all project meetings called for as specified in Section 01_31_19 - Project Meetings.

1.07 SUBMITTAL REQUIREMENTS

- A. Preliminary and Baseline Progress Schedule.
- B. Preliminary and Baseline Schedule of Values.
- C. Preliminary and Baseline Schedule of Submittals.
- D. On a monthly basis, updated Schedules as specified.
- E. Final Schedules update as specified.
- F. Revised Schedules and time impact analyses as specified.
- G. Submit Schedules in the media and number of copies as follows:
 - 1. PDF format and in other formats specified in this Section.
 - 2. 2 sets of CPM Schedule data electronic files in a native backed-up file format.

1.08 GANTT CHART

- A. Produce a clear, legible, and accurate calendar based, time scaled, and graphical network diagram.
 - 1. Group activities related to the same physical areas of the Work. Produce the network diagram based upon the early start of all activities.
- B. Include for each activity, the description, activity number, estimated duration in working days, total float, and all activity relationship lines.

- C. Illustrate order and interdependence of activities and sequence in which Work is planned to be accomplished.
 - 1. Incorporate the basic concept of the precedence diagram network method to show how the start of 1 activity is dependent upon the start or completion of preceding activities and its completion restricts the start of following activities.
- D. Provide Progress Schedule showing the critical path for the Project.
- E. Provide report of Near Critical Path activities for the Project, when required by the Construction Manager.
- F. Delineate the specified Contract Times and identify the planned completion of the Work as a milestone.
 - 1. Show the time period between the planned and Contract completion dates, if any, as an activity identified as Project float.
- G. Identify system shutdown dates, system tie-in dates, specified interim completion or milestone dates and contract completion dates as milestones.
- H. Include, in addition to construction activities:
 - 1. Submission dates and review periods for major equipment submittals, and shoring submittals:
 - a. Shoring reviews: Allow 4-week review period for each shoring submittal.
 - 2. Any activity by the Owner or the Construction Manager that may affect progress or required completion dates.
 - 3. Equipment and long-lead material deliveries over 8 weeks.
 - 4. Approvals required by regulatory agencies or other third parties.
- I. Produce electronic network diagram on 22-inch by 34-inch sheets with grid coordinate system on the border of all sheets utilizing alpha and numeric designations.
- J. At a minimum, identify the execution of the following:
 - 1. Mobilization.
 - 2. All required Submittals and Submittal review times showing 30 calendar day duration for such activities and equal amount of time for resubmittal reviews.
 - 3. Equipment and materials procurement/fabrication/delivery.
 - 4. Excavation.
 - 5. Shoring design and submission of detailed shoring submittals. Identify submission as a milestone.
 - 6. Shoring review, shoring materials procurement, shoring installation, and shoring removal.
 - 7. Piles.
 - 8. Backfill and compaction.
 - 9. Dewatering.
 - 10. Grading, subbase, base, paving, and curb and gutters.
 - 11. Fencing and landscaping.
 - 12. Concrete, including installation of forms and reinforcement, placement of concrete, curing, stripping, finishing, and patching.
 - 13. Tests for leakage of concrete structures intended to hold water.
 - 14. Masonry.
 - 15. Metal fastenings, framing, structures, and fabrications.

16. Wood structures, finish carpentry, architectural woodwork, and plastic fabrications.
17. Waterproofing and dampproofing, insulation, roofing and flashing, and sealants.
18. Doors and windows, including hardware and glazing.
19. Finishes including coating and painting, flooring, ceiling, and wall covering.
20. Pumps and drives, including identification of ordering lead time, factory testing, and installation.
21. Conveying equipment including hoists and cranes, conveyor systems, and materials handling equipment, including identification of ordering lead-time and installation.
22. Other mechanical equipment including fans and heating, ventilating, and air conditioning equipment.
23. Trenching, pipe laying, and trench backfill and compaction.
24. Piping, fittings, and appurtenances, including identification of ordering and fabrication lead time, layout, installation and testing.
25. Valves, gates, and operators, including identification of order lead-time, installation, and testing.
26. Electric transmission, service, and distribution equipment, including identification of ordering lead-time, and factory testing.
27. Other electrical work including lighting, heating and cooling, and special systems, including identification of ordering lead-time.
28. Instrumentation and controls, including identification of ordering lead-time.
29. Preliminary testing of equipment, instrumentation, and controls.
30. Commissioning phase:
 - a. Source Testing.
 - b. Owner Training.
 - c. Installation Verification.
 - d. Functional Testing.
 - e. Start-up Phase.
 - f. Start-up Period.
31. Instrumentation and Controls Performance Testing.
32. Substantial completion.
33. Punch list work.
34. Demobilization.

1.09 PRELIMINARY SCHEDULE

- A. Procedure:
 1. Submit proposed Preliminary Schedule within 14 calendar days after Notice to Proceed.
 2. Meet with Construction Manager within 7 calendar days after receipt of Preliminary Schedule to review and make necessary adjustments.
 3. Submit revised Preliminary Schedule within 5 calendar days after meeting.
 4. Update Preliminary Schedule monthly until the Baseline Schedule is accepted.
- B. Format:
 1. Simplified Gantt chart.

- C. Activities:
 - 1. Define activities to be completed in the first 90 calendar days of Work.
 - 2. Actualize activities performed during the first 90 days into the first monthly Schedule update.

1.10 WORK WITHIN THE FIRST 90 DAYS

- A. Proceed with Work after Preliminary Schedule and Preliminary Schedule of Values have been accepted by Owner.
- B. Submittal and acceptance of Preliminary Schedule and Preliminary Schedule of Values is condition precedent to making of progress payments and payments for mobilization costs otherwise provided for in the Contract.

1.11 SCHEDULE OF SUBMITTALS

- A. Schedule of Submittals shall include Submittals required in the Contract Documents but not limited to test plans, training plans, test procedures, operation and maintenance manuals, Shop Drawings, samples, record documents, and specifically required certificates, warranties, and service agreements.
- B. Preliminary Schedule of Submittals:
 - 1. Due date: After Preliminary Schedule has been submitted and accepted by the Owner.
 - 2. Format:
 - a. Include Submittals anticipated in the first 90 calendar days after award of Contract using early start dates.
 - b. Indicate week and month anticipated for submittal to Construction Manager.
 - c. Indicate "Priority" Submittals where review time can impact Contractor's schedule.
 - 1) "Priority" indication will not alter review times specified in Section 01_33_00 - Submittal Procedures.
 - 2) Construction Manager will endeavor to provide early review of "Priority" Submittals where possible.
 - 3. Submittal of Preliminary Schedule of Submittals shall be a condition precedent to Owner making progress payments during the first 90 calendar days after award of Contract.
- C. Final Schedule of Submittals:
 - 1. Due date: 30 days after Baseline Schedule has been submitted and accepted by Owner.
 - 2. Format:
 - a. Include Submittals using early start dates.
 - b. Include all Submittals, including those required in the Preliminary Schedule of Submittals.
 - c. Indicate week and month anticipated for submittal to Construction Manager.

- d. Indicate "Priority" submittals where review time can impact Contractor's schedule.
 - 1) "Priority" indication will not alter review times specified in Section 01_33_00 - Submittal Procedures.
 - 2) Construction Manager will endeavor to provide early review of "Priority" Submittals where possible.
 - 3. Submittal of final Schedule of Submittals shall be a condition precedent to Owner making progress payments after the first 90 calendar days after Notice to Proceed.
- D. Provide updated Schedule of Submittals with updated schedules if Schedule revisions change listing and timing of Submittals.

1.12 BASELINE PROGRESS SCHEDULE AND BASELINE SCHEDULE OF VALUES

- A. Due date: No more than 45 calendar days after Notice to Proceed.
- B. Format:
 - 1. Progress Schedule: Show sequence and interdependence of all activities required for complete performance of all Work, beginning with date of Notice to Proceed and concluding with date of final completion of Contract.
 - 2. Schedule of Values: Include as required by the contract documents.

1.13 SUMMARY SCHEDULE

- A. Due date: At weekly progress meetings and after each Schedule update or Schedule revision.
- B. Format:
 - 1. Consolidate groups of activities associated with Major Items of Work shown on Baseline Schedule.
 - 2. Intended to give an overall indication of the Project Schedule without a large amount of detail.

1.14 COST FLOW SUMMARY

- A. Due date: After Baseline Schedule has been submitted and accepted by the Owner, submit on a monthly basis.
- B. Format:
 - 1. Tabular and graphic report showing anticipated earnings each month of the Contract period.
 - 2. Base tabulation on the summation of the cost-loaded activities each month.
 - 3. Show planned amounts.
 - 4. Show actual earned amounts and anticipated remaining earnings.
 - 5. Spreadsheet format of all schedule activities showing cost and percentage completion during the current month for which payment is sought.

1.15 PROGRESS SCHEDULE AND UPDATED SCHEDULE OF VALUES

- A. Due date: Submit on a monthly basis.
- B. Format: Include as required by the contract documents.

1.16 WEEKLY SCHEDULE

- A. Due date: At every weekly progress meeting.
- B. Format:
 - 1. Contractor and Construction Manager must agree on the format.
 - 2. 6-week Schedule showing the activities completed during the previous week and the Contractor's schedule of activities for following 5 weeks.
 - 3. Use the logic and conform to the status of the current Progress Schedule when producing a weekly Schedule in CPM schedule or a bar chart format.
 - a. In the event that the weekly Schedule no longer conforms to the current Schedule, Contractor may be required to revise the Schedule as specified in this Section.
 - 4. Activity designations used in the weekly Schedule must be consistent with those used in the Baseline Schedule and the monthly Schedule updates.

1.17 LABOR HISTOGRAM

- A. Due date:
 - 1. With progress payments after Baseline Schedule has been submitted and accepted by Owner.
- B. Format:
 - 1. Labor histogram depicting total craft manpower and craft manpower for Contractor's own labor forces and those of each subcontractor.
 - 2. Submit in electronic format.

1.18 EQUIPMENT SCHEDULE

- A. Due date: With any progress payment after Baseline Schedule has been submitted and accepted by Owner if it includes payment for equipment.
- B. Format:
 - 1. Tabular report listing each major piece of construction equipment to be used in performing the Work.
 - 2. Include major equipment for Contractor and each subcontractor.
 - 3. Submit electronically in Excel format with 1 paper copy.
- C. Progress payments after the first 90 calendar days after Notice to Proceed will not be made until equipment schedule is provided.

1.19 COMMISSIONING SCHEDULE

- A. Commissioning activities and milestones, as specified in Section 01_75_17 - Commissioning, shall be an integral part of the overall Progress Schedule.
 - 1. Commissioning activities and milestones shall be extracted from the Progress Schedule to provide a separate Commissioning schedule that is submitted each time the Progress Schedule is submitted.
- B. Proposed Commissioning Schedule:
 - 1. Schedule requirements: As specified in Section 01_75_17 - Commissioning.
 - 2. Submittal due date: Within 120 days after Notice to Proceed.
 - 3. Construction Manager response due within 20 calendar days of receipt.
 - 4. Contractor responsible for updating schedule and resubmitting within 10 calendar days of receipt of Construction Manager and Owner comments.
- C. Construction Schedule can include the Commissioning Schedule after Construction Manager acceptance of the Proposed Commissioning Schedule.
 - 1. Capable of extracting a stand-alone Commissioning Schedule.
 - 2. Capable of extracting a stand-alone Owner Training Schedule.
- D. Monthly update requirements:
 - 1. Highlight percentages of completion, actual start and finish dates, and remaining durations, as applicable.
 - 2. Include activities not previously included in the previously accepted detail work plan Commissioning Schedule.
 - 3. Change Order required for any change to contractual dates.
 - 4. Reviews of these Submittals by Construction Manager will not be construed to constitute acceptance within the time frames, durations, or sequence of work for each added activity.

1.20 REVIEW AND ACCEPTANCE OF SCHEDULES

- A. Construction Manager will review preliminary Schedules, Schedule updates, Schedule revisions, and time impact analyses to ascertain compliance with specified project constraints, compliance with milestone dates, durations and sequence, accurate inter-relationships, and completeness.
- B. Construction Manager and Owner will issue written comments following completion of review of baseline Schedules within 21 calendar days after receipt.
- C. Written comments on review of Schedule updates and Schedule revisions and time impact analyses will be returned to Contractor within 14 calendar days after receipt by Construction Manager.
- D. Revise and resubmit Schedules in accordance with Construction Manager's comments within 7 calendar days after receipt of such comments or request joint meeting to resolve objections.
- E. If the Construction Manager requests a meeting, the Contractor and all major subcontractors shall participate.
 - 1. Revise and resubmit Schedule within 7 calendar days after meeting.

- F. Use accepted Schedules for planning, organizing, and directing the Work and for reporting progress.
- G. Construction Manager's Submittal review response:
 - 1. When Schedules reflects the Owner's and Contractor's agreement of project approach and sequence, Schedules will be accepted by the Owner.
 - 2. Construction Manager's Submittal review response for Schedule Submittals will be "Receipt Acknowledged - Filed for Record".
 - 3. Acceptance of the Schedules by the Owner is for general conformance with the Contract Documents and for the Owner's planning information and does not relieve the Contractor of sole responsibility for planning, coordinating, and executing the Work within the Contract completion dates.
 - a. Omissions and errors in the accepted Schedules shall not excuse performance less than that required by the Contract Documents.
 - b. Acceptance by the Owner in no way constitutes an evaluation or validation of the Contractor's plan, sequence or means, methods, and techniques of construction.

1.21 SCHEDULE UPDATES

- A. Any update:
 - 1. Prepare update using most recent accepted version of Schedule including:
 - a. Actual start dates of activities that have been started.
 - b. Actual finish dates of activities that have been completed.
 - c. Percentage of completion of activities that have been started but not finished.
 - d. Actual dates on which milestones were achieved.
 - e. Update activities by inputting percent complete figures with actual dates.
 - f. Use retained logic in preparing Schedule updates.
 - g. When necessary, input remaining durations for activities whose finish dates cannot be calculated accurately with a percent complete figure only.
 - h. Revisions to the Schedule may be included that have been previously approved as specified.
- B. Monthly updates:
 - 1. Submit written narrative report in conjunction with each Schedule update, including descriptions of the following:
 - a. Activities added to or deleted from the Schedule are to adhere to cost and other resource loading requirements:
 - 1) Identify added activities in manner distinctly different from original activity designations.
 - b. Changes in sequence or estimated duration of activities.
 - c. Current or anticipated problems and delays affecting progress, impact of these problems and delays and measures taken to mitigate impact.
 - d. Assumptions made and activities affected by incorporating change order work into the Schedule.
 - e. Include a response in writing to each of the Construction Manager's comments or questions from the previous month's schedule review and number responses consistent with the Construction Manager's numbering.

2. Submit updated Schedule and materials specified under Submittal of Progress Schedules 5 calendar days before the monthly schedule update meeting.
 3. Since monthly Schedule update is the application for progress payment, submittal and acceptance of the monthly Schedule update is a condition precedent to the making of any progress payments.
- C. Weekly progress meeting:
1. Update the Schedule prior to weekly progress meeting.
 - a. Identify overall progress of each major item of work in the summary schedule.
 - b. If there are significant changes to the Schedule, submit a written report at the weekly progress meeting.
 2. Should monthly Schedule update show project completion earlier than current Contract completion date, show early completion time as schedule activity, identified as "Project Float".
 3. Should monthly Schedule update show Project completion later than current Contract completion date, prepare and submit a Schedule revision.

1.22 REVISIONS TO SCHEDULES

- A. Submit revised Schedules within 5 days:
1. When delay in completion of any activity or group of activities indicates an overrun of the Contract Time or milestone dates by 20 working days or 5 percent of the remaining duration, whichever is less.
 2. When delays in Submittals, deliveries, or work stoppages are encountered making necessary the replanning or rescheduling of activities.
 3. When the Schedule does not represent the actual progress of activities.
 4. When any change to the sequence of activities, the completion date for major portions of the Work, or when changes occur which affect the critical path.
 5. When Contract modification necessitates Schedule revision, submit schedule analysis of Change Order work with cost proposal.
- B. Create a separate Submittal for Schedule revisions.
1. Comply with Schedule updates as specified in this Section.
 2. Do not submit with Schedule updates.
- C. Schedule revisions will not be reflected in the Schedule until after the revision is accepted by the Owner.
1. This includes Schedule revisions submitted for the purpose of mitigating a Contractor-caused project delay (Recovery Schedule).

1.23 ADJUSTMENT OF CONTRACT TIME OR PRICE

- A. Contract Time will be adjusted only for causes specified in Contract Documents.
- B. If the Contractor believes that the Owner has impacted its work such that the Project completion date will be delayed, the Contractor must submit proof, in the form of a time impact analysis demonstrating the delay to the critical path.

- C. Time impact analysis:
1. Use the accepted Schedule update that is current relative to the time frame of the delay event (change order, third party delay, or other Owner-caused delay). Represent the delay event in the Schedule by:
 - a. Inserting new activities associated with the delay event into the Schedule.
 - b. Revising activity logic.
 - c. Revising activity durations.
 2. If the Progress Schedule's critical path and completion date are impacted as a result of adding this delay event to the Progress Schedule, a time extension equal to the magnitude of the impact may be warranted.
 3. The time impact analysis Submittal must include the following information:
 - a. A fragment of the portion of the Schedule affected by the delay event.
 - b. A narrative explanation of the delay issue and how it impacted the Schedule.
 - c. A schedule file used to perform the time impact analysis.
- D. When a delay to the Project as a whole can be avoided by revising preferential sequencing or logic and the Contractor chooses not to implement the revisions, the Contractor will be entitled to a time extension and no compensation for extended overhead.
- E. Indicate clearly that the Contractor has used, in full, all project float available for the Work involved in the request, including any float that may exist between the Contractor's planned completion date and the Contract completion date.
1. Utilize the latest version of the Schedule update accepted at the time of the alleged delay, and all other relevant information, to determine the adjustment of the Contract Time.
- F. Adjustment of the Contract Times will be granted only when the Contract float has been fully utilized and only when the revised date of completion of the Work has been pushed beyond the Contract completion date.
1. Adjustment of the Contract Times will be made only for the number of days that the planned completion of the work has been extended.
- G. Actual delays in activities which do not affect the Critical Path Work or which do not move the Contractor's planned completion date beyond the Contract completion date will not be the basis for an adjustment to the Contract Time.
- H. If completion of the project occurs within the specified Contract Time, the Contractor is not entitled to job-site or home office overhead beyond the Contractor's originally planned occupancy of the site.
- I. Notify Construction Manager of a request for Contract Time adjustment.
1. Submit request as specified in the Contract Documents.
 2. In cases where the Contractor does not submit a request for Contract Time adjustment for a specific change order, delay, or Contractor request within the specified period of time, then it is mutually agreed that the particular change order, delay, or Contractor request has no time impact on the Contract completion date and no time extension is required.

- J. Construction Manager will, within 30 calendar days after receipt of a Contract Time adjustment, request any supporting evidence, review the facts, and advise the Contractor in writing.
 - 1. Include the new Progress Schedule data, if accepted by the Owner, in the next monthly Schedule update.
 - 2. When the Owner has not yet made a final determination as to the adjustment of the Contract Time, and the parties are unable to agree as to the amount of the adjustment to be reflected in the Progress Schedule, reflect that amount of time adjustment in the Progress Schedule as the Construction Manager may accept as appropriate for such interim purpose.
 - 3. It is understood and agreed that any such interim acceptance by the Construction Manager shall not be binding and shall be made only for the purpose of continuing to schedule the Work, until such time as a final determination as to any adjustment of the Contract Time acceptable to the Construction Manager has been made.
 - 4. Revise the Progress Schedule prepared thereafter in accordance with the final decision.

1.24 WEATHER DAY ALLOWANCE

- A. As identified in the project General Conditions.

1.25 FINAL SCHEDULE

- A. The final Schedule update becomes the As-Built Schedule.
 - 1. The As-Built Schedule reflects the exact manner in which the project was constructed by reflecting actual start and completion dates for all activities accomplished on the project.
 - 2. Contractor's Project Manager and scheduler sign and certify the As-Built Schedule as being an accurate record of the way the project was actually constructed.
- B. Retainage will not be released until final Schedule update is provided.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION (NOT USED)

END OF SECTION

SECTION 01_32_34

PHOTOGRAPHIC AND VIDEOGRAPHIC DOCUMENTATION

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Requirements for photographs and videos.
- B. The purpose of the photographs and videos is to document:
 - 1. The condition of the facilities prior to the Work beginning at the Project Site.
 - 2. The progress of the Work.
 - 3. The Project Site after Substantial Completion.
- C. The scope of the photographic and videographic documentation shall be the sole responsibility of the Contractor but shall be acceptable to the Engineer.

1.02 ADMINISTRATIVE REQUIREMENTS

- A. Pre-construction photographs and videos: Submit prior to beginning work at the Project Site or prior to the preconstruction conference specified in Section 01_31_19 - Project Meetings, whichever occurs earlier.
- B. Construction photographs and videos: Submit with each application for payment.
- C. Post-construction photographs and videos: Submit with project closeout documents as part of project closeout procedures identified in General Conditions.

1.03 SUBMITTALS

- A. Submit a key plan of the Project Site with notation of vantage points marked for location and direction of each photograph.
 - 1. Include the same label information as the corresponding set of photographs.

1.04 PHOTOGRAPHER

- A. Photographer qualified and equipped to photograph interior and exterior exposures, with lenses ranging from wide angle to telephoto.

1.05 PHOTOGRAPHS

- A. Provide a digital copy of each photograph for each area of Work.
 - 1. Monthly: Indexed digital flash drive.
 - 2. Project record documents:
 - a. Catalog and index prints in chronological sequence.
 - b. Include typed table of contents.
 - 3. Provide a minimum of 12 photographs per week.

1.06 PRE-CONSTRUCTION PHOTOGRAPHS AND VIDEOS

- A. Provide photographs and video of the condition entire site, including each area of Work prior to the start of Work.
 - 1. Areas to be photographed and videoed shall include the site of the Work and all existing facilities, either on or adjoining the Project Site, including the interior of existing structures that could be damaged as a result of the Contractor's work.
 - 2. Include general condition, structures, vegetation, staging, storing, working, parking areas and excavation areas.
 - 3. Provide a minimum of 20 photographs.
- B. In addition, the Contractor shall provide an evaluation of the existing surface conditions of all planned haul routes.
 - 1. Contractor to provide, at a minimum, a video along the haul routes and a summary table of surface conditions along the routes.

1.07 CONSTRUCTION PHOTOGRAPHS AND VIDEOS

- A. Provide photographs and videos of construction in each area of Work throughout the progress of Work, including a key plan designating where each photograph was taken.
- B. Take site and interior photographs and videos from differing directions of building demolition, pre-excavation, footing excavation, soil testing, utility crossings, installation of bypass piping, excavation of access pits, installation of lining system in pipes, rehabilitation of manholes, building modifications, utilities, electrical and instrumentation modifications, and other applicable activities indicating relative progress of the work.
- C. Take photos a maximum of 7 calendar days prior to Submittal.

1.08 POST-CONSTRUCTION PHOTOGRAPHS AND VIDEOS

- A. Provide photographs of the entire site, including each area of Work at the completion of Work.
 - 1. Include general condition, structures, vegetation, staging, storing, working, parking areas and excavation areas.
 - 2. Take photos and video from same points in same direction as pre-construction examination.
 - 3. Provide a minimum of 20 photographs.

PART 2 PRODUCTS

- A. Digital media:
 - 1. Flash drive compatible with current version of Microsoft Windows.
 - 2. Provide photos as individual, indexed JPG files with the following characteristics:
 - a. Compression shall be set to preserve quality over file size.
 - b. Highest resolution JPG images shall be submitted. Resizing to a smaller size when high resolution JPGs are available shall not be permitted.

- c. JPG image resolution shall be 10 megapixels or higher.
 - d. Images shall have rectangular, clean images. Artistic borders, beveling, drop shadows, etc., are not permitted.
 - 3. Identification: On photograph, provide the following information:
 - a. Name of project.
 - b. Date stamp: Unless otherwise indicated, date and time stamp each photograph as it is being taken so stamp is integral to photograph.
 - c. Description of vantage point, indicating location and direction by compass point.
 - d. Description of what is being photographed.
 - 4. Contractor shall deliver electronic media files to Construction Manager and upload to document control system.
- B. Videos:
- 1. Quality: 720p HD or greater in MPG, AVCHD, AVI, or MP4 format.
 - 2. Digital color video format.
 - 3. Provide audio portion of the composite video sufficiently free from electrical interference and background noise to provide complete intelligibility of oral report.
 - 4. Identification: On each copy provide a label with the following information:
 - a. Name of project.
 - b. Date video was recorded.
 - c. Description of what is being filmed.
 - 5. Submit 1 copy of each video within 7 days of recording.
 - 6. Display continuous running time.
 - 7. At start of each video recording, record weather conditions from local newspaper or television and the actual temperature reading at the Project Site.
 - 8. Contractor shall deliver electronic media files to Construction Manager and upload to Procore Document control system.

PART 3 EXECUTION (NOT USED)

END OF SECTION

SECTION 01_33_00
SUBMITTAL PROCEDURES

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Requirements and procedures for Submittals to confirm compliance with the Contract Documents.

1.02 WEB-BASED CONSTRUCTION MANAGEMENT SOFTWARE UTILIZATION

- A. Web-based construction management software shall be utilized in connection with all document and information management required by these Contract Documents.
 - 1. System shall be Procore or approved equal.
 - 2. Contractor shall pay for use of the system for the project for Owner, Construction Manager, Engineer, and Contractor.
 - 3. Joint use of this system is to facilitate electronic exchange of information, automation of key processes, and overall management of the Contract Documentation.
 - 4. Web based construction management software shall be the primary means of project information submission and management.
 - 5. Data entered in a collaborative mode (entered with the intent to share as determined by permissions and workflows within the web-based construction management software system) by the Engineer and the Contractor will be jointly owned.
- B. Automated system notification and audit log tracking
 - 1. Review comments made (or lack thereof) by the Owner on Contractor-submitted documentation shall not relieve the Contractor from compliance with requirements of the Contract Documents.
 - 2. Contractor is responsible for managing, tracking, and documenting the Work to comply with the requirements of the Contract Documents.
 - 3. Owner's acceptance via automated system notifications or audit logs extends only to the face value of the submitted documentation and does not constitute validation of the Contractor's submitted information.
- C. Use the web-based construction management software feature for Master Submittals List.
 - 1. Select from the predefined submittals list.
- D. Submit Portable Document Format (PDF) documents to the web-based construction management software submittal workflow process and forms.
 - 1. Consolidate electronic format submittals with multiple pages into a single file.

1.03 GENERAL INSTRUCTIONS

- A. Contractor is responsible to determine and verify field measurements, field construction criteria, materials, dimensions, catalog numbers and similar data, and check and coordinate each item with other applicable approved Shop Drawings and Contract Document requirements.
- B. Provide Submittals:
 - 1. That are specified or reasonably required for construction, operation, and maintenance of the Work.
 - 2. That demonstrate compliance with the Contract Documents.
- C. Where multiple Submittals are required, provide a separate Submittal for each Specification section.
 - 1. In order to expedite construction, the Contractor may make more than one Submittal per Specification section, but a single Submittal may not cover more than one Specification section:
 - a. The only exception to this requirement is when one Specification section covers the requirements for a component of equipment specified in another section.
 - b. For example, circuit breakers are a component of switchgear. The switchgear Submittal must also contain data for the associated circuit breakers, even though they are covered in a different Specification section.
- D. Prepare Submittals in the English language. Do not include information in other languages.
- E. Present measurements in customary American units (feet, inches, pounds, etc.).
- F. Must be clear and legible, and of sufficient size for presentation of information.
- G. Page size, other than drawings:
 - 1. Minimum: 8-1/2 inches by 11 inches.
 - 2. Maximum: 11 inches by 17 inches.
- H. Drawing sheet size:
 - 1. Maximum: 22 inches by 34 inches.
 - a. Minimum plan scale: 1/8 inch equals 1 foot-0 inches.
 - b. Minimum font size: 1/8-inch.
 - 2. 11-inch by 17-inch sheet:
 - a. Minimum plan scale: 1/8 inch equals 1 foot-0 inches.
 - b. Minimum font size: 1/8-inch.
- I. Show dimensions, construction details, wiring diagrams, controls, manufacturers, catalog numbers, and all other pertinent details.
- J. Provide Submittal information from only one manufacturer for a specified product. Submittals with multiple manufacturers for one product will be rejected without review.

1.04 SUBMITTAL ORGANIZATION

- A. Organize Submittals in exactly the same order as the items are referenced, listed, and/or organized in the Specification section.
- B. For Submittals that cover multiple devices used in different areas under the same Specification section, the Submittal for the individual devices must list the area where the device is used.
- C. Bookmarks:
 - 1. Bookmarks shall match the table of contents.
 - 2. Bookmark each section (tab) and heading.
 - 3. Drawings: Bookmark at a minimum, each discipline, area designation, or appropriate division.
 - 4. At file opening, display all levels of bookmarks as expanded.
- D. Where applicable (i.e., except for Drawings, figures, etc.), Submittal content shall be electronically searchable utilizing the PDF file as submitted.
- E. Thumbnails optimized for fast web viewing.
- F. Sequentially number pages within the tabbed sections:
 - 1. Submittals that are not fully indexed and tabbed with sequentially numbered pages, or are otherwise unacceptable, will be returned without review.
- G. Attachments:
 - 1. Include with each Submittal a copy of the relevant Specification section.
 - a. Indicate in the left margin, next to each pertinent paragraph, either compliance with a check (✓) or deviation with a consecutive number (1, 2, 3).
 - b. Provide a list of all numbered deviations with a clear explanation and reason for the deviation.
 - 2. Include with each Submittal a copy of the relevant Drawing, including relevant addendum updates.
 - a. Indicate either compliance with a check (✓) or deviation with a consecutive number (1, 2, 3).
 - b. Provide a list of all numbered deviations with a clear explanation and reason for the deviation.
 - c. Provide field dimensions and relationship to adjacent or critical features of the Work or materials.
- H. Contractor: Prepare Submittal information in sufficient detail to show compliance with specified requirements.
 - 1. Determine and verify quantities, field dimensions, product dimensions, specified design and performance criteria, materials, catalog numbers, and similar data.
 - 2. Coordinate Submittal with other Submittals and with the requirements of the Contract Documents.
 - 3. Check, verify, and revise Submittals as necessary to bring them into conformance with the Contract Documents and actual field conditions.

- I. Contractor: Prepare "Or Equal" Submittal information.
1. Provide standard Submittal requirements.
 - a. In addition, provide in sufficient detail to show reason for variance from specified product and impacts.
 2. Provide reason the specified product is not being provided.
 3. Explain the benefits to the Owner for accepting the "Or Equal".
 4. Itemized comparison of the proposed "Or Equal" with product specified, including a list of significant variations:
 - a. Design features.
 - b. Design dimensions.
 - c. Installation requirements.
 - d. Operations and maintenance requirements.
 - e. Availability of maintenance services and sources of replacement materials.
 5. Reference projects where the product has been successfully used:
 - a. Name and address of project.
 - b. Year of installation.
 - c. Year placed in operation.
 - d. Name of product installed.
 - e. Point of contact: Name and phone number.
 6. Define impacts:
 - a. Impacts to other contracts.
 - b. Impacts to other work or products.
 7. Contractor represents the following:
 - a. Contractor bears the burden of proof of the equivalency of the proposed "Or Equal".
 - b. Proposed "Or Equal" is equal or superior to the specified product.
 - c. Contractor will provide the warranties or bonds that would be provided on the specified product on the proposed "Or Equal", unless the Owner requires a Special Warranty.
 - d. Contractor will coordinate installation of accepted "Or Equal" into the Work and will be responsible for the costs to make changes as required to the Work.
 - e. Contractor waives rights to claim additional costs caused by proposed "Or Equal" which may subsequently become apparent.
- J. Contractor: Prepare substitution Submittal information.
1. Provide standard Submittal requirements.
 - a. In addition, provide in sufficient detail to show reason for variance from specified product and impacts.
 2. Provide reason the specified product is not being provided.
 3. Explain the benefits to the Owner for accepting the substitution.
 4. Itemized comparison of the proposed substitution with product specified, including a list of significant variations:
 - a. Design features.
 - b. Design dimensions.
 - c. Installation requirements.
 - d. Operations and maintenance requirements.
 - e. Availability of maintenance services and sources of replacement materials.
 5. Reference projects where the product has been successfully used:
 - a. Name and address of project.
 - b. Year of installation.

- c. Year placed in operation.
- d. Name of product installed.
- e. Point of contact: Name and phone number.
- 6. Define impacts:
 - a. Impacts to Contract Price.
 - 1) Required license fees or royalties.
 - 2) Do not include costs under separate contracts.
 - 3) Do not include Engineer's costs for redesign or revision of the Contract Documents.
 - b. Impacts to Contract Time.
 - c. Impacts to Contract Scope.
 - d. Impacts to other contracts.
 - e. Impacts to other work or products.
- 7. Contractor represents the following:
 - a. Contractor shall pay associated costs for the Engineer to evaluate the substitution.
 - b. Contractor bears the burden of proof of the equivalency of the proposed substitution.
 - c. Proposed substitution does not change the design intent and will have equal performance to the specified product.
 - d. Proposed substitution is equal or superior to the specified product.
 - e. Contractor will provide the warranties or bonds that would be provided on the specified product on the proposed substitution, unless the Owner requires a Special Warranty.
 - f. Contractor will coordinate installation of accepted substitution into the Work and will be responsible for the costs to make changes as required to the Work.
 - g. Contractor waives rights to claim additional costs caused by proposed substitution which may subsequently become apparent.

1.05 SUBMITTAL IDENTIFICATION NUMBERING

A. Number each Submittal using the format defined in the table below:

	Spec Section Number	Dash	Initial Submittal - Sequential Number	Decimal Point	Subsequent Submittal Revisions Sequential Number
<i>Example 1 Description</i>	<i>Cast-In-Place Concrete</i>		<i>8th initial Submittal</i>		
	03_30_00	-	0008		
<i>Example 2 Description</i>	<i>Cast-In-Place Concrete</i>		<i>8th initial Submittal</i>		<i>First revision to the 8th initial Submittal</i>
	03_30_00	-	0008	.	1

1.06 SUBMITTALS IN ELECTRONIC MEDIA FORMAT

- A. General: Provide all information in PC-compatible format using Windows® operating system as utilized by the Owner and Engineer.
- B. Text: Provide text documents and manufacturer's literature in Portable Document Format (PDF).
- C. Graphics: Provide graphic Submittals (Drawings, diagrams, figures, etc.) utilizing Portable Document Format (PDF).

1.07 SUBMITTAL PROCEDURE

- A. Engineer: Review Submittal and provide response:
 - 1. Review description:
 - a. Engineer will be entitled to rely upon the accuracy or completeness of designs, calculations, or certifications made by licensed professionals accompanying a particular Submittal, whether or not a stamp or seal is required by the Contract Documents or Laws and Regulations.
 - b. Engineer's review of Submittals shall not release the Contractor from the Contractor's responsibility for performance of requirements of the Contract Documents. Neither shall the Engineer's review release the Contractor from fulfilling purpose of installation nor from the Contractor's liability to replace defective Work.
 - c. Engineer's review of Shop Drawings, samples, or test procedures will be only for conformance with design concepts and for compliance with information given in the Contract Documents.
 - d. Engineer's review does not extend to:
 - 1) Accuracy of dimensions, quantities, or performance of equipment and systems designed by the Contractor.
 - 2) Contractor's means, methods, techniques, sequences, or procedures, except when specified, indicated on the Drawings, or required by the Contract Documents.
 - 3) Safety precautions or programs related to safety which shall remain the sole responsibility of the Contractor.
 - e. Engineer can Approve or Not Approve any exception at their sole discretion.
 - 2. Review timeframe:
 - a. Except as may be provided in technical Specifications, a Submittal will be returned within 30 days.
 - b. When a Submittal cannot be returned within the specified period, Engineer will, within a reasonable time after receipt of the Submittal, give notice of the date by which that Submittal will be returned.
 - c. Engineer's acceptance of progress schedule containing Submittal review times less than those specified or agreed to in writing by the Engineer will not constitute Engineer's acceptance of review times.
 - d. Critical Submittals:
 - 1) Contractor will notify Engineer in writing that timely review of a Submittal is critical to the progress of Work.

3. Schedule delays:
 - a. No adjustment of Contract Times or Contract Price will be allowed due to Engineer's review of Submittals unless all of the following criteria are met:
 - 1) Engineer has failed to review and return first submission within the agreed upon time frame.
 - 2) Contractor demonstrates that delay in progress of Work is directly attributable to the Engineer's failure to return Submittal within time indicated and accepted by the Engineer.
4. Review response will be returned to the Contractor with one of the following dispositions:
 - a. Approved:
 - 1) No Exceptions:
 - a) There are no notations or comments on the Submittal and the Contractor may release the equipment for production.
 - 2) Make Corrections Noted - See Comments:
 - a) Contractor may proceed with the Work, however, all notations and comments must be incorporated into the final product.
 - b) Resubmittal not required.
 - 3) Make Corrections Noted - Confirm:
 - a) Contractor may proceed with the Work, however, all notations and comments must be incorporated into the final product.
 - b) Submit confirmation specifically addressing each notation or comment to the Engineer within 15 calendar days of the date of the Engineer's transmittal requiring the confirmation.
 - b. Not Approved:
 - 1) Correct and Resubmit:
 - a) Contractor may not proceed with the Work described in the Submittal.
 - b) Contractor assumes responsibility for proceeding without approval.
 - c) Resubmittal of complete Submittal package is required within 30 calendar days of the date of the Engineer's Submittal review response.
 - 2) Rejected - See Remarks:
 - a) Contractor may not proceed with the Work described in the Submittal.
 - b) Submittal does not meet the intent of the Contract Documents. Resubmittal of complete Submittal package is required with materials, equipment, methods, etc., that meet the requirements of the Contract Documents.
 - c. Receipt Acknowledged:
 - 1) Filed for Record:
 - a) This is used in acknowledging receipt of informational Submittals that address means and methods of construction such as schedules and work plans, conformance test reports, health and safety plans, etc.
 - 2) With Comments - Resubmit:
 - a) This is used in acknowledging receipt of informational Submittals that address means and methods of construction such as schedules and work plans, conformance test reports, health and safety plans, etc. Feedback regarding missing information,

conflicting information, or other information that makes it incomplete can be made with comments.

- B. Contractor: Prepare resubmittal, if applicable:
1. Clearly identify each correction or change made. Provide page references to the changed information within the resubmittal.
 2. Include a response in writing to each of the Engineer's comments or questions for Submittal packages that are resubmitted in the order that the comments or questions were presented from the first and subsequent Submittals and numbered consistent with the Engineer's numbering.
 - a. Acceptable responses to the Engineer's comments are listed below:
 - 1) "Incorporated" - Engineer's comment or change is accepted and appropriate changes are made.
 - 2) "Response" - Engineer's comment not incorporated. Explain why comment is not accepted or requested change is not made. Explain how requirement will be satisfied in lieu of comment or change requested by the Engineer.
 - b. Reviews and resubmittals:
 - 1) Contractor shall provide resubmittals which include responses to all Submittal review comments separately and at a level of detail commensurate with each comment.
 - 2) Contractor responses shall indicate how the Contractor resolved the issue pertaining to each review comment
 - a) Responses such as "acknowledged" or "noted" are not acceptable.
 - 3) Resubmittals which do not comply with this requirement may be rejected and returned without review.
 - 4) Contractor shall be allowed no extensions of any kind to any part of their contract due to the rejection of non-compliant Submittals.
 - 5) Submittal review comments not addressed by the Contractor in resubmittals shall continue to apply whether restated or not in subsequent reviews until adequately addressed by the Contractor to the satisfaction of the reviewing and approving authority.
 - c. Any resubmittal that does not contain responses to the Engineer's previous comments shall be returned for revision and resubmittal. No further review by the Engineer will be performed until a response for previous comments has been received.
 3. Resubmittal timeframe:
 - a. Contractor shall provide resubmittal within 15 days.
 - b. When a resubmittal cannot be returned within the specified period, Contractor shall notify the Engineer in writing.
 4. Review costs:
 - a. Costs incurred by the Owner as a result of additional reviews of a particular Submittal after the second time it has been reviewed shall be borne by the Contractor.
 - b. Reimbursement to the Owner will be made by deducting such costs from the Contractor's subsequent progress payments.

1.08 PRODUCT DATA

- A. Edit Submittals so that the Submittal specifically applies to only the product furnished.
- B. Neatly cross out all extraneous text, options, models, etc., that do not apply to the product being furnished so that the information remaining is only applicable to the product being furnished.

1.09 SHOP DRAWINGS

- A. Contractor to field verify elevation, coordinates, and pipe material for pipe tie-in to pipeline or structure prior to the preparation of Shop Drawings.
- B. Indicate project-designated equipment tag numbers for Submittal of devices, equipment, and assemblies.

1.10 SAMPLES

- A. Details:
 - 1. Submit labeled samples.
 - 2. Samples will not be returned.
 - 3. Provide number of sample Submittals as below:
 - a. Total: 3 minimum.
 - 1) Owner: 1.
 - 2) Engineer: 2.
 - 3) Contractor: None.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION (NOT USED)

END OF SECTION

ATTACHMENT A - CONTRACTOR SUBMITTAL TRANSMITTAL FORM

CONTRACTOR SUBMITTAL TRANSMITTAL FORM

Owner:	Click here to enter text.	Date:	MM/DD/YYYY
Contractor:	Click here to enter text.	Project No.:	XXXXX.XX
Project Name:	Click here to enter text.	Submittal Number:	000
Submittal Title:	Click here to enter text.		
To:	Click here to enter text.		
From:	Click here to enter text.	Click here to enter text.	
	Click here to enter text.	Click here to enter text.	

Specification No. and Subject of Submittal/Equipment Supplier			
Spec ##:	Spec ##.	Subject:	Click here to enter text.
Authored By:	Click here to enter text.	Date Submitted:	XX/XX/XXXX

Submittal Certification	
Check Either (A) or (B):	
☐ (A)	We have verified that the equipment or material contained in this Submittal meets all the requirements specified in the project manual or shown on the Contract Drawings with no exceptions.
☐ (B)	We have verified that the equipment or material contained in this Submittal meets all the requirements specified in the project manual or shown on the Contract Drawings, except for the deviations listed.
Certification Statement: By this Submittal, I hereby represent that I have determined and verified all field measurements, field construction criteria, materials, dimensions, catalog numbers and similar data, and I have checked and coordinated each item with other applicable approved Shop Drawings and all Contract requirements.	
General Contractor's Reviewer's Signature:	
Printed Name:	

PM/CM Office Use	
Date Received GC to PM/CM:	Click here to enter text.
Date Received PM/CM to Reviewer:	Click here to enter text.
Date Received Reviewer to PM/CM:	Click here to enter text.
Date Sent PM/CM to GC:	Click here to enter text.

SECTION 01_35_73

DELEGATED DESIGN PROCEDURES

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Delegated Design procedures.

1.02 GENERAL

- A. Delegated Design - Professional design services assigned to the Contractor by express delegation in the Contract Documents. Work is "Delegated Design" where the Technical Sections require the Contractor to provide professional design services and to submit signed and sealed documents from a registered Professional Engineer.
- B. Contractor's Professional Engineer - The design professional retained by the Contractor to perform Delegated Design.
- C. Owner may require Contractor to provide professional design services for a portion of the Work by express delegation in the Contract Documents.
 - 1. Requirements of Delegated Design component as specified in the Technical Section and as indicated on the Drawings.
 - 2. Such delegation will specify the performance and design criteria that such services must satisfy, and the Submittals that the Contractor must furnish to the Engineer with respect to the Delegated Design.
- D. Contractor shall cause such Delegated Design services to be provided pursuant to the professional standard of care by a properly licensed design professional, whose signature and seal shall appear on Drawings, calculations, Specifications, certifications, and Submittals prepared by such design professional.
 - 1. Contractor shall not be responsible for the adequacy of performance or design criteria specified by the Owner or Engineer.
 - 2. Contractor is not required to provide professional services in violation of applicable Laws and Regulations.
 - 3. Such design professional shall issue certifications of design required by Laws and Regulations.
 - 4. If a Shop Drawing or other Submittal related to the Owner-delegated design is prepared by the Contractor, a Subcontractor, or others for submittal to the Engineer, then such Shop Drawing or other Submittal shall bear the written approval of Contractor's design professional when submitted by the Contractor to the Engineer.

- E. Owner and Engineer shall be entitled to rely upon the adequacy, accuracy, and completeness of the services, certifications, and approvals performed or provided by the design professionals retained or employed by Contractor under Delegated Design, subject to the professional standard of care and the performance and design criteria stated in the Contract Documents.
- F. Engineer's review, approval, and other determinations regarding design drawings, calculations, Specifications, certifications, and other Submittals furnished by Contractor pursuant to a Delegated Design will be only for the following limited purposes:
 - 1. Confirming that Submittal is in conformance with the performance and design criteria specified in the Contract Documents.

1.03 CONTRACTOR'S PROFESSIONAL ENGINEER

- A. Contractor or Subcontractor shall retain a licensed Professional Engineer to perform Delegated Design.
- B. Qualifications:
 - 1. Holding a current license to perform the specified design in the same jurisdiction as the Project Site.
 - 2. Experienced in designing similar systems of similar complexity.
- C. Insurance:
 - 1. Provide as required by the Contract Documents.
- D. Responsibilities:
 - 1. Review and design in accordance with system performance and design criteria stated in the Contract Documents.
 - a. Prepare written requests for clarifications or interpretations of performance or design criteria for submittal to the Engineer by the Contractor.
 - 2. Sign and seal design reports, calculations, design drawings and specifications, and other design Submittals for the Delegated Design Work.
 - 3. Review and submit written approval of Submittals related to the Delegated Design Work.
 - 4. Design modifications to the Delegated Design Work as required.
 - 5. Visit the Site, as required, to verify that installation of the Delegated Design Work is in conformance with the Delegated Design Drawings and Specifications.
 - 6. Submit through Contractor to Engineer written, signed, and sealed certification that the installed Delegated Design Work complies with Contractor's Professional Engineer's design.

1.04 SUBMITTALS

- A. Prior to the start of Delegated Design:
 - 1. Contractor's Professional Engineer's qualifications:
 - a. Experience for the Delegated Design.
 - b. Evidence of Professional Engineering license.
 - 2. Contractor's Professional Engineer Professional Liability Insurance certificate.

- B. Delegated Design:
 - 1. Product data:
 - a. Details related to the Delegated Design as specified in Technical Sections to completely describe the system.
 - 2. Design documents with signature and seal from the Contractor's Professional Engineer.
 - a. Design documents include, but are not limited to, Drawings, calculations, Specifications, inspection reports, and certifications.
 - 3. Lists and schedules:
 - a. Prepare and submit lists or schedules of items where Delegated Design is required by the Contract Documents.
 - b. Group items by location in the Work.
 - 1) When "Area Numbers" are indicated on the Contract Drawings, group lists in accordance with those "areas".
 - 2) For work without area numbers, group using logical divisions acceptable to the Engineer.
 - 3) Group items within each "area" as follows:
 - a) Systems.
 - b) Components.
 - c) Supports.
 - d) Anchorage.
 - e) Bracing.
- C. Construction services:
 - 1. Contractor's Professional Engineer's comments on Submittals.
 - 2. Other construction documents, as required.

1.05 ENGINEER RESPONSE TO DELEGATED DESIGN SUBMITTALS

- A. Engineer response will be either of the following:
 - 1. Approved. Make Corrections Noted - See Comments:
 - a. Contractor may proceed with the Work; however, all notations and comments must be incorporated into the final product.
 - b. Review was for the limited purpose of determining that the document was stamped by a Professional Engineer and that such design is generally consistent with and will not negatively affect the design concept presented in the Contract Documents.
 - 2. Rejected - See Remarks:
 - a. Contractor may not proceed with the Work described in the Submittal.
 - b. Submittal does not meet the intent of the Contract Documents.
 - c. Resubmittal of complete Submittal package is required with materials, equipment, methods, etc., that meet the requirements of the Contract Documents.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION (NOT USED)

END OF SECTION

SECTION 01_41_00

REGULATORY REQUIREMENTS

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Regulatory authorities and codes.

1.02 AUTHORITIES HAVING JURISDICTION (AHJ)

- A. Authorities Having Jurisdiction (AHJ) for work within Larimer County:
 - 1. Also referred to as the permitting agency.
 - 2. Building Department: Larimer County.
 - 3. Fire Department: Poudre Fire Authority.
- B. Applicable codes for work within Larimer County:
 - 1. International Code Council (ICC).
 - a. Building code:
 - 1) International Building Code (IBC), 2021.
 - a) Local amendments per Larimer County.
 - 2) International Existing Building Code (IEBC), 2021.
 - a) Local amendments per Larimer County.
 - b. Electrical code:
 - 1) National Fire Protection Association (NFPA), NFPA 70.
 - 2) National Electrical Code (NEC), 2023.
 - a) Local amendments per Larimer County.
 - c. Energy code:
 - 1) International Energy Conservation Code (IECC), 2021.
 - 2) Local amendments per Larimer County.
 - d. Fire code:
 - 1) International Fire Code (IFC), 2021.
 - 2) Local amendments per Larimer County.
 - e. Fuel gas code:
 - 1) International Fuel Gas Code (IFGC) - 2021.
 - 2) Local amendments per Larimer County.
 - f. Mechanical code:
 - 1) International Mechanical Code (IMC), 2021.
 - 2) Local amendments per Larimer County.
 - g. Plumbing code:
 - 1) International Plumbing Code (IPC), 2021.
 - 2) Local amendments per Larimer County.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION (NOT USED)

END OF SECTION

SECTION 01_43_39

MOCKUPS

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Mockups of specific assemblies to be installed on this Project.

1.02 VISUAL MOCKUPS

- A. Definition:
 - 1. Separate mockup construction incorporating elements specified in various sections, intended to illustrate materials and workmanship in an assembly, and used for technical and aesthetic evaluation.
 - a. Mockup shall not be a part of the finished construction.
 - b. Mockup shall be accepted by the Engineer prior to beginning this work on the building.
 - 1) Configuration and extent of mockup: As required to illustrate the design intent for Engineer's evaluation.
 - 2) Place mockup on-site in a location where it will not be disturbed or damaged during construction.
- B. Maintain and protect Visual Mockups from damage during construction, and dispose of mockups when no longer required, as determined by the Engineer.

1.03 BENCHMARK MOCKUPS

- A. Definition:
 - 1. In-place portions of assemblies to be repeated throughout the Work.
 - 2. Accepted benchmark mockups are intended to serve as a standard by which the work will be judged.
 - 3. Accepted benchmark mockups may be incorporated into the final construction.
- B. Construct benchmark mockups to verify selections made under sample submittals, to demonstrate aesthetic effects, to set quality standards for materials and execution, and to set quality standards for fabrication and installation.
- C. Acceptance of benchmark mockups incorporated in the Work does not constitute approval of deviations from the Contract Documents unless the Engineer specifically approves such deviations in writing.
- D. Protect benchmark mockup from damage and ensure it is not disturbed at time of Project Completion.

1.04 MOCKUP DESCRIPTION

- A. Provide mockups as specified below:
 - 1. Mockup construction schedule: Indicate time required for mockup construction, Engineer's and Owner's review and acceptance, and removal/demolition work associated with mockups, in Construction Progress Schedule.
- B. Structural concrete F4 finish and tie-hole repair (visual mockup):
 - 1. Provide concrete finish mock-up involving the following Sections:
 - a. Section 03_30_00 - Cast-In-Place Concrete.
 - b. Section 03_35_29 - Concrete Finishes.
 - 2. Mockup shall consist of a 4-inch-thick vertical concrete panel divided into two 36-inch by 36-inch sections.
 - a. One section shall demonstrate the F4 concrete. Section shall include 1 horizontal and 1 vertical form joint.
 - b. Other section shall demonstrate the tie-hole repair. A minimum of 4 tie-holes shall be included.

PART 2 PRODUCTS

2.01 MATERIALS

- A. Materials as specified in the following Section:
 - 1. Section 03_30_00 - Cast-In-Place Concrete.
- B. All other products and materials as required for a complete mockup.

PART 3 EXECUTION

3.01 MOCKUP MATERIALS

- A. Contractor is cautioned to not purchase all materials for the project that are involved in any one mockup until after the mockup has been reviewed and accepted by the Engineer.

END OF SECTION

SECTION 01_45_17

CONTRACTOR QUALITY CONTROL PLAN

PART 1 GENERAL

1.01 REFERENCES

- A. The following is a list of standards which may be referenced in this section:
 - 1. ASTM International (ASTM):
 - a. D3740 - Evaluation of Agencies Engaged in the Testing and/or Inspection of Soil and Rock as Used in Engineering Design and Construction.
 - b. E329 - Use in the Evaluation of Testing and Inspection Agencies as Used in Construction.

1.02 DEFINITIONS

- A. Contractor Quality Control (CQC): The means by which Contractor ensures that the construction, to include that performed by subcontractors and suppliers, complies with the requirements of the Contract.

1.03 SCOPE OF WORK:

- A. Contractor to perform all Quality control on the project. In addition, the Contractor shall retain the services of a Certified Independent testing agency to perform testing for all soil, concrete, aggregate, pipe, paint, and all materials to be incorporated into the Work. Also, the Contractor shall retain the services of an Independent and Certified Welding inspector to inspect and provide written acceptance of all welds. Welding inspector shall be approved and acceptable to Owner or Designated Representative.

1.04 SUBMITTALS

- A. Informational Submittals:
 - 1. CQC Plan: Submit, not later than 30 days after receipt of Notice to Proceed.
 - 2. CQC Report: Submit, weekly, an original and one copy in report form.

1.05 OWNER'S QUALITY ASSURANCE

- A. Owner may perform Quality Assurance as it deems necessary to verify compliance of project specifications. Quality Assurance is at Owner option and not a substitute for Contractor quality control requirements.
- B. All Work is subject to City of Thornton's quality assurance inspection and testing at all locations and at all reasonable times before acceptance to ensure strict compliance with the terms of the Contract Documents.

- C. City of Thornton's quality assurance inspections and tests are for the sole benefit of City of Thornton and do not:
 - 1. Relieve Contractor of responsibility for providing adequate quality control measures.
 - 2. Relieve Contractor of responsibility for damage to or loss of the material before acceptance.
 - 3. Constitute or imply acceptance.
 - 4. Affect the continuing rights of City of Thornton after acceptance of the completed Work.
- D. The presence or absence of a quality assurance inspector does not relieve Contractor from any Contract requirement.
- E. Promptly furnish all facilities, labor, and material reasonably needed for performing such safe and convenient inspections and tests as may be required by Construction Manager.
- F. City of Thornton may charge Contractor for any additional cost of inspection or test when Work is not ready at the time specified by Contractor for inspection or test, or when prior rejection makes re-inspection or retest necessary. Quality assurance inspections and tests will be performed in a manner that will not unnecessarily delay the Work.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 GENERAL

- A. Maintain an adequate inspection system and perform such inspections as will ensure that the Work conforms to the Contract Documents.
- B. Maintain complete inspection records and make them available at all times to City of Thornton and Construction Manager.
- C. The quality control system shall consist of plans, procedures, and organization necessary to produce an end product that complies with the Contract Documents. The system shall cover all construction and demolition operations, both onsite and offsite, including Work by subcontractors, fabricators, suppliers and purchasing agents, and shall be keyed to the proposed construction sequence.
- D. Contractor shall retain the services of independent testing agencies to perform soil and concrete testing, and any other test as required. Contractor shall also retain the services of an independent and certified welding inspector.

3.02 COORDINATION MEETING

- A. After the Preconstruction Conference, but before start of construction, and prior to acceptance of the CQC Plan, schedule a meeting with Construction Manager and City of Thornton to discuss the quality control system.
- B. Develop a mutual understanding of the system details, including the forms for recording the CQC operations, control activities, testing, administration of the system for both onsite and offsite Work, and the interrelationship of Contractor's management and control with the City of Thornton's Quality Assurance.
- C. There may be occasions when subsequent conferences may be called by either party to reconfirm mutual understandings and/or address deficiencies in the CQC system or procedures that may require corrective action by Contractor.

3.03 QUALITY CONTROL ORGANIZATION

- A. CQC System Manager:
 - 1. Designate an individual within Contractor's organization who will be responsible for overall management of CQC and have the authority to act in CQC matters for the Contractor.
 - 2. CQC System Manager may perform other duties on the Project.
 - 3. CQC System Manager shall be an experienced construction person, with a minimum of 3 years construction experience on similar type Work.
 - 4. CQC System Manager shall report to the Contractor's project manager or someone higher in the organization. Project manager in this context shall mean the individual with responsibility for the overall quality and production management of the Project.
 - 5. CQC System Manager shall be onsite during construction; periods of absence may not exceed 2 weeks at any one time.
 - 6. Identify an alternate for CQC System Manager to serve with full authority during the System Manager's absence. The requirements for the alternate will be the same as for designated CQC System Manager.
- B. CQC Staff:
 - 1. Designate a CQC staff, available at the Site at all times during progress, with complete authority to take any action necessary to ensure compliance with the Contract. CQC staff members shall be subject to acceptance by Construction Manager.
 - 2. CQC staff shall take direction from CQC System Manager in matters pertaining to QC.
 - 3. CQC staff must be of sufficient size to ensure adequate QC coverage of Work phases, work shifts, and work crews involved in the construction. These personnel may perform other duties, but must be fully qualified by experience and technical training to perform their assigned QC responsibilities and must be allowed sufficient time to carry out these responsibilities.
 - 4. The actual strength of the CQC staff may vary during any specific Work period to cover the needs of the Project. Add additional staff when necessary for a proper CQC organization.

- C. Organizational Changes: Obtain Construction Manager's acceptance before replacing any member of the CQC staff. Requests for changes shall include name, qualifications, duties, and responsibilities of the proposed replacement.

3.04 QUALITY CONTROL PHASING

- A. CQC shall include at least three phases of control to be conducted by CQC System Manager for all definable features of Work, as follows:
 - 1. Preparatory Phase:
 - a. Notify City of Thornton at least 48 hours in advance of beginning any of the required action of the preparatory phase.
 - b. This phase shall include a meeting conducted by the CQC System Manager and attended by the superintendent, other CQC personnel (as applicable), and the foreman responsible for the definable feature. The CQC System Manager shall instruct applicable CQC staff as to the acceptable level of workmanship required in order to meet Contract requirements.
 - c. Document the results of the preparatory phase meeting by separate minutes prepared by the CQC System Manager and attached to the QC report.
 - d. Perform prior to beginning Work on each definable feature of Work:
 - 1) Review applicable Contract Specifications.
 - 2) Review applicable Contract Drawings.
 - 3) Verify that all materials and/or equipment have been tested, submitted, and approved.
 - 4) Verify that provisions have been made to provide required control inspection and testing.
 - 5) Examine the Work area to verify that all required preliminary Work has been completed and is in compliance with the Contract.
 - 6) Perform a physical examination of required materials, equipment, and sample Work to verify that they are on hand, conform to approved Shop Drawing or submitted data, and are properly stored.
 - 7) Review the appropriate activity hazard analysis to verify safety requirements are met.
 - 8) Review procedures for constructing the Work, including repetitive deficiencies.
 - 9) Document construction tolerances and workmanship standards for that phase of the Work.
 - 10) Check to verify that the plan for the Work to be performed, if so required, has been accepted by Construction Manager.
 - 2. Initial Phase:
 - a. Accomplish at the beginning of a definable feature of Work:
 - 1) Notify City of Thornton at least 48 hours in advance of beginning the initial phase.
 - 2) Perform prior to beginning Work on each definable feature of Work:
 - a) Review minutes of the preparatory meeting.
 - b) Check preliminary Work to verify compliance with Contract requirements.
 - c) Verify required control inspection and testing.
 - d) Establish level of workmanship and verify that it meets minimum acceptable workmanship standards.

- e) Resolve all differences.
 - f) Check safety to include compliance with and upgrading of the safety plan and activity hazard analysis. Review the activity analysis with each worker.
- 3) Separate minutes of this phase shall be prepared by the CQC System Manager and attached to the QC report. Exact location of initial phase shall be indicated for future reference and comparison with follow-up phases.
- 4) The initial phase should be repeated for each new crew to work onsite, or any time acceptable specified quality standards are not being met.
- 3. Follow-up Phase:
 - a. Perform daily checks to verify continuing compliance with Contract requirements, including control testing, until completion of the particular feature of Work.
 - b. Daily checks shall be made a matter of record in the CQC documentation and shall document specific results of inspections for all features of Work for the day or shift.
 - c. Conduct final follow-up checks and correct all deficiencies prior to the start of additional features of Work that will be affected by the deficient Work. Constructing upon or concealing nonconforming Work will not be allowed.
- 4. Additional Preparatory and Initial Phases: Additional preparatory and initial phases may be conducted on the same definable features of Work as determined by City of Thornton if the quality of ongoing Work is unacceptable; or if there are changes in the applicable QC staff or in the onsite production supervision or work crew; or if work on a definable feature is resumed after a substantial period of inactivity, or if other problems develop.

3.05 CONTRACTOR QUALITY CONTROL PLAN

- A. General:
 - 1. Plan shall identify personnel, procedures, control, instructions, test, records, and forms to be used.
 - 2. An interim plan for the first 30 days of operation will be considered.
 - 3. Construction will be permitted to begin only after acceptance of the CQC Plan or acceptance of an interim plan applicable to the particular feature of Work to be started.
 - 4. Work outside of the features of Work included in an accepted interim plan will not be permitted to begin until acceptance of a CQC Plan or another interim plan containing the additional features of Work to be started.
- B. Content:
 - 1. Plan shall cover the intended CQC organization for the entire Contract and shall include the following, as a minimum:
 - a. Organization: Description of the quality control organization, including a chart showing lines of authority and acknowledgment that the CQC staff will implement the three-phase control system (see paragraph QC Phasing) for all aspects of the Work specified.
 - b. CQC Staff: The name, qualifications (in resume format), duties, responsibilities, and authorities of each person assigned a QC function.

- c. Letters of Authority: A copy of a letter to the CQC System Manager signed by an authorized official of the firm, describing the responsibilities and delegating sufficient authorities to adequately perform the functions of the CQC System Manager, including authority to stop Work which is not in compliance with the Contract. The CQC System Manager shall issue letters of direction to all other various quality control representatives outlining duties, authorities, and responsibilities. Copies of these letters will also be furnished to City of Thornton.
 - d. Submittals: Procedures for scheduling, reviewing, certifying, and managing submittals, including those of subcontractors, offsite fabricators, suppliers and purchasing agents.
 - e. Testing: Control, verification, and acceptance testing procedures for each specific test to include the test name, frequency, specification paragraph containing the test requirements, the personnel and laboratory responsible for each type of test, and an estimate of the number of tests required.
 - f. Procedures for tracking preparatory, initial, and follow-up control phases and control, verification, and acceptance tests, including documentation.
 - g. Procedures for tracking deficiencies from identification through acceptable corrective action. These procedures will establish verification that identified deficiencies have been corrected.
 - h. Reporting procedures, including proposed reporting formats; include a copy of the CQC report form.
- C. Acceptance of Plans: Acceptance of the Contractor's basic and addendum CQC plans is required prior to the start of construction. Acceptance is conditional and will be predicated on satisfactory performance during the construction. City of Thornton reserves the right to require Contractor to make changes in the CQC plan and operations including removal of personnel, as necessary, to obtain the quality specified.
- D. Notification of Changes: After acceptance of the CQC plan, Contractor shall notify Construction Manager, in writing, a minimum of 7 calendar days prior to any proposed change. Proposed changes are subject to acceptance by Construction Manager.

3.06 CONTRACTOR QUALITY CONTROL REPORT

- A. As a minimum, prepare a CQC report for every 7 calendar days. Account for all days throughout the life of the Contract. Reports shall be signed and dated by CQC System Manager. Include copies of test reports and copies of reports prepared by QC staff.
- B. Maintain current records of quality control operations, activities, and tests performed, including the Work of subcontractors and suppliers.
- C. Records shall be on an acceptable form and shall be a complete description of inspections, the results of inspections, daily activities, tests, and other items, including but not limited to the following:
 - 1. Contractor/subcontractor and their areas of responsibility.
 - 2. Operating plant/equipment with hours worked, idle, or down for repair.

3. Work performed today, giving location, description, and by whom. When a network schedule is used, identify each phase of Work performed each day by activity number.
4. Test and/or control activities performed with results and references to specifications/plan requirements. The control phase should be identified (Preparatory, Initial, Follow-up). List deficiencies noted along with corrective action.
5. Material received with statement as to its acceptability and storage.
6. Identify submittals reviewed, with Contract reference, by whom, and action taken.
7. Offsite surveillance activities, including actions taken.
8. Job safety evaluations stating what was checked, results, and instructions or corrective actions.
9. List instructions given/received and conflicts in Drawings and/or Specifications.
10. Contractor's verification statement.
11. Indicate a description of trades working on the Project; the number of personnel working; weather conditions encountered; and any delays encountered.
12. These records shall cover both conforming and deficient features and shall include a statement that equipment and materials incorporated in file work and workmanship comply with the Contract.

3.07 SUBMITTAL QUALITY CONTROL

- A. Submittals shall be as specified in Section 01_33_00 - Submittal Procedures. The CQC organization shall be responsible for certifying that all submittals are in compliance with the Contract requirements.

3.08 TESTING QUALITY CONTROL

- A. Testing Procedure:
 1. Perform tests specified or required to verify that control measures are adequate to provide a product which conforms to Contract requirements. Procure services of a licensed testing laboratory. Perform the following activities and record the following data:
 - a. Verify testing procedures comply with contract requirements.
 - b. Verify facilities and testing equipment are available and comply with testing standards.
 - c. Check test instrument calibration data against certified standards.
 - d. Verify recording forms and test identification control number system, including all of the test documentation requirements, have been prepared.
 - e. Documentation:
 - 1) Record results of all tests taken, both passing and failing, on the CQC report for the date taken.
 - 2) If failing test is detected, Contractor must notify City of Thornton or Construction Manager immediately and work affected by failing test shall be discussed with City of Thornton or Construction Manager prior to continuing Work.
 - 3) All test results, regardless of pass or fail designation, shall be forwarded to City of Thornton or Construction Manager within 24 hours of test performance.

- 4) The Quality Control laboratory shall provide access to City of Thornton and Construction Manager to view all QC tests results.
- 5) Include specification paragraph reference, location where tests were taken, and the sequential control number identifying the test.
- 6) Actual test reports may be submitted later, if approved by City of Thornton or Construction Manager, with a reference to the test number and date taken.
- 7) Provide directly to City of Thornton or Construction Manager an information copy of tests performed by an offsite or commercial test facility. Test results shall be signed by an engineer registered in the state where the tests are performed.
- 8) Failure to submit timely test reports, as stated, may result in nonpayment for related Work performed and disapproval of the test facility for this Contract.

B. Testing Laboratories: Laboratory facilities, including personnel and equipment, utilized for testing soils, concrete, asphalt and steel shall meet criteria detailed in ASTM D3740 and ASTM E329, and be accredited by the American Association of Laboratory Accreditation (AALA), National Institute of Standards and Technology (NIST), National Voluntary Laboratory Accreditation Program (NVLAP), the American Association of State Highway and Transportation Officials (AASHTO), or other approved national accreditation authority. Personnel performing concrete testing shall be certified by the American Concrete Institute (ACI).

3.09 COMPLETION INSPECTION

- A. CQC System Manager shall conduct an inspection of the Work at the completion of all Work or any milestone established by a completion time stated in the Contract.
- B. Punch list:
1. CQC System Manager shall develop a punch list of items which do not conform to the Contract requirements.
 2. Include punch list in the CQC report, indicating the estimated date by which the deficiencies will be corrected.
 3. CQC System Manager or staff shall make a second inspection to ascertain that all deficiencies have been corrected and so notify the City of Thornton.
 4. These inspections and any deficiency corrections required will be accomplished within the time stated for completion of the entire Work or any particular increment thereof if the Project is divided into increments by separate completion dates.

END OF SECTION

SECTION 01_45_24

REGULATORY QUALITY ASSURANCE

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Project regulatory requirements for quality assurance that includes Special Inspections, Special Certification, and Structural Observation.
- B. Special Certification and Special Inspections in this Section are in addition to the requirements specified in Section 01_45_17 - Contractor Quality Control Plan, and in the individual Sections.

1.02 REFERENCES

- A. American Concrete Institute (ACI):
 - 1. 318 - Building Code Requirements for Structural Concrete.
 - 2. 530 - Building Code Requirements for Masonry Structures.
 - 3. 530.1 - Specification for Masonry Structures.
- B. American Institute of Steel Construction (AISC):
 - 1. 360 - Specification for Structural Steel Buildings.
- C. American Society of Civil Engineers (ASCE):
 - 1. 7 - Minimum Design Loads for Buildings and Other Structures.
- D. American Welding Society (AWS):
 - 1. D1.3 - Structural Welding Code - Sheet Steel.
 - 2. D1.4 - Structural Welding Code - Reinforcing Steel.
- E. ASTM International (ASTM):
 - 1. A706 - Standard Specification for Deformed and Plain Low-Alloy Steel Bars for Concrete Reinforcement.
 - 2. C31 - Standard Practice for Making and Curing Concrete Test Specimens in the Field.
 - 3. C172 - Standard Practice for Sampling Freshly Mixed Concrete.
 - 4. C1611 - Standard Test Method for Slump Flow of Self-Consolidating Concrete.
- F. Building Code:
 - 1. As specified in Section 01_41_00 - Regulatory Requirements.
- G. The Masonry Society (TMS):
 - 1. 402 - Building Code for Masonry Structures.
 - 2. 602 - Specifications for Masonry Structures.

1.03 TERMINOLOGY

- A. The words and terms listed below are not defined terms that require initial capital letters, but, when used in this Section, have the indicated meaning.
 - 1. Special Certification: Certification for designated seismic systems that demonstrates compliance with performance requirements.
 - 2. Special Inspection: Inspection of the materials, installation, fabrication, erection, or placement of components and connections requiring special expertise to ensure compliance with approved construction documents and referenced standards.
 - 3. Special Inspection, Continuous: The full-time observation of work requiring Special Inspection by an approved special inspector who is present in the area where the work is being performed.
 - 4. Special Inspection, Periodic: The part-time, or intermittent observation of work requiring Special Inspection by an approved special inspector who is present in the area where the work is being performed and at the completion of the work.
 - 5. Structural Observation: The visual observation of the structural system by a registered design professional for general conformance to the approved construction documents at significant construction stages and at completion of the structural system.

1.04 SUBMITTALS

- A. Submit Special Certifications for designated seismic systems.
- B. Schedule and coordinate the submittal of Special Inspection reports and test results prepared by others.

1.05 SPECIAL INSPECTION

- A. Owner will employ one or more special inspectors who will provide Special Inspections during construction.
- B. Special inspector(s) shall be qualified for inspection of the particular type of materials or operations requiring Special Inspection.
- C. Duties of special inspector:
 - 1. General: Required duties of the special inspector(s) shall be as described in the Building Code.
 - 2. Reporting: Special inspector(s) shall provide reports of each inspection to the Owner and shall distribute copies of inspection reports to the Engineer and Contractor as required.
 - a. Reports shall, at a minimum, include the following items:
 - 1) Date and time of inspection, and name(s) of individual(s) performing the inspection.
 - 2) Structures and areas of the structure where work or testing was observed.
 - 3) Discrepancies between the requirements of the Contract Documents and the work or testing observed.
 - 4) Other areas of deficiency in the Work.

- D. Special Inspections shall not be construed as fulfilling the requirements for Structural Observation.
- E. Owner or special inspector will select materials for Special Inspection.
 - 1. Contractor shall not select materials for Special Inspection.

1.06 SPECIAL CERTIFICATION

- A. Provide equipment that meets the special certification requirements of the Building Code.
- B. Designated seismic systems shall be subject to the testing and qualification requirements of the regulatory Building Code, and shall require Special Certification as set forth in ASCE 7:
 - 1. Mechanical equipment that is assigned an importance factor of 1.50 as specified in Section 01_81_50 - Design Criteria.
 - 2. All electrical equipment.
- C. Special certification requirements for designated seismic systems:
 - 1. Submittals shall include certification that the equipment is seismically qualified. Certifications are subject to review and acceptance by Owner.
 - 2. Certifications may be at least one of the following in accordance with ASCE 7:
 - a. Analysis.
 - b. Testing.
 - c. Experience data.

1.07 STRUCTURAL OBSERVATION

- A. Owner will employ one or more registered design professionals to provide Structural Observation(s) during construction.
 - 1. Registered design professional will be a civil or structural engineer currently licensed as such in the state where the project is located and regularly engaged in structural design equivalent to or similar to that indicated on the Drawings.
- B. Structural Observations shall not be construed as fulfilling the requirements for Special Inspections.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 SPECIAL INSPECTIONS

- A. Owner will provide Special Inspection of the following types of work as described in the Building Code wherever such work occurs, unless otherwise specified.
 - 1. Attachment A - Concrete - Special Inspection Schedule.
 - 2. Attachment B - Architectural, Mechanical, and Electrical Components - Special Inspection Schedule.

3. Attachment C2 - Masonry Special Inspection Schedule - "Level 3".
4. Attachment D - Soils - Special Inspection Schedule.
5. Attachment E - Structural Steel Welding - Special Inspection Schedule.
6. Attachment F - Structural Steel Bolting - Special Inspection Schedule.
7. Attachment G - Steel Construction - Steel Deck, Open Web Steel Joists and Joist Girders, and Cold Formed Steel Trusses - Special Inspection Schedule.
8. Attachment H - Deep Foundations, Cast-in-Place - Special Inspection Schedule.

3.02 SPECIAL CERTIFICATION

- A. Special inspector shall examine the designated seismic system(s) and determine whether the designated system components, including anchorage, are consistent with the evidence of compliance submitted for Special Certification.

3.03 STRUCTURAL OBSERVATION

- A. The following work requires Structural Observation in accordance with the Building Code.
 1. All structures in all areas:
 - a. Foundations.
 - b. Elevated slabs.

3.04 SCHEDULE

- A. Allow time necessary for Special Inspections and Structural Observation specified in this Section.
- B. Sufficient notice shall be given so that the Special Inspections and Structural Observations can be performed. Allow time for individuals performing to travel to the Site.

3.05 PROCEDURE

- A. Special inspector will immediately notify the Engineer of any corrections required and follow notification with appropriate documentation.
- B. Contractor shall not proceed until the Work is satisfactory to the Engineer.

END OF SECTION

ATTACHMENT A - CONCRETE - SPECIAL INSPECTION SCHEDULE

CONCRETE - SPECIAL INSPECTION SCHEDULE
(Includes: Cast-in-place, precast, prestressed, precast-prestressed, and shotcrete.)

Verification and Inspection	Reference Standard	Frequency of Inspection ⁽¹⁾ (During Task Listed)	
		Continuous	Periodic
1. Inspect reinforcement, including prestressing tendons, and verify placement.	ACI 318 Building Code		●
2. Reinforcing bar welding:			
a. Verify weldability of reinforcing bars other than ASTM A706;	AWS D1.4 ACI 318		●
b. Inspect single-pass fillet welds, maximum 5/16 inch; and	AWS D1.4 ACI 318		●
c. Inspect all other welds.	AWS D1.4 ACI 318	●	
3. Inspect anchors cast in concrete.	ACI 318		●
4. Inspect anchors post-installed in hardened concrete members:			
a. Adhesive anchors installed in horizontally or upwardly inclined orientations to resist sustained tension loads.	ACI 318	●	
b. Mechanical anchors and adhesive anchors not defined in 4.a.	ACI 318		●
5. Verify use of required design mix.	ACI 318 Building Code		●
6. Prior to concrete placement, fabricate specimens for strength tests, perform slump and air content tests, and determine the temperature of the concrete.	ASTM C172 ASTM C31 ACI 318 Building Code	●	
7. Inspect concrete and shotcrete placement for proper application techniques.	ACI 318 Building Code	●	
8. Verify maintenance of specified curing temperature and techniques.	ACI 318 Building Code		●
9. Inspect prestressed concrete for:			
a. Application of prestressing forces; and	ACI 318	●	
b. Grouting of bonded prestressing tendons.	ACI 318	●	
10. Inspect erection of precast concrete members.	ACI 318		●
11. Verify in-situ concrete strength, prior to stressing of tendons in post-tensioned concrete and prior to removal of shores and forms from beams and structural slabs.	ACI 318		●

Verification and Inspection	Reference Standard	Frequency of Inspection ⁽¹⁾ (During Task Listed)	
		Continuous	Periodic
12. Inspect formwork for shape, location and dimensions of the concrete member being formed.	ACI 318		●
<u>Notes:</u> (1) “●” represents a required inspection activity for the project where it occurs.			

**ATTACHMENT B - ARCHITECTURAL, MECHANICAL, AND ELECTRICAL COMPONENTS -
SPECIAL INSPECTION SCHEDULE**

**ARCHITECTURAL, MECHANICAL, AND ELECTRICAL COMPONENTS -
SPECIAL INSPECTION SCHEDULE**

Verification and Inspection	Reference Standard	Frequency of Inspection ⁽¹⁾ (During Task Listed)	
		Continuous	Periodic
1. Architectural components:			
a. Cladding - exterior, weighing more than 5 psf: Erection and fastening.	Building Code		●
b. Exterior insulation and finish system (EIFS):	Building Code		
c. Non-bearing walls - exterior: Erection and fastening.	Building Code		●
d. Non-bearing walls - interior, weighing more than 15 psf.	Building Code		●
e. Veneer, exterior and interior, weighing more than 5 psf: Erection and fastening.	Building Code		●
f. Access floors: Erection and anchorage.	Building Code		●
g. Suspended ceiling system: Bracing.			●
h. Storage racks - 8 feet or greater in height: Anchorage.	Building Code		●
i. Skylight: Verification of safety compliance and labeling and installation.	Building Code		●
2. Plumbing, mechanical, and electrical components:			
a. Anchorage of electrical equipment for emergency and standby power systems.	Building Code		●
b. Anchorage of other electrical and mechanical equipment over 400 lb. on floors or roofs.	Building Code		●
c. Installation and anchorage of pipelines carrying hazardous chemicals and their associated mechanical units.	Building Code		●
d. Installation and anchorage of pipelines greater than 8 inches in diameter.			●
e. Installation and anchorage of ductwork designed to carry hazardous materials.	Building Code		●
f. Installation and anchorage of ductwork greater than 6 sf in cross section.			●
g. Installation and anchorage of vibration isolation systems where Contract Documents require nominal clearance of 1/4 inch or less between the equipment support frame and its support/restraint.	Building Code		●

Verification and Inspection	Reference Standard	Frequency of Inspection ⁽¹⁾ (During Task Listed)	
		Continuous	Periodic
h. Installation of mechanical and electrical equipment, including ductwork, piping systems and their structural supports, where automatic fire sprinkler systems are installed.	Building Code		●
3. Fire-resistance elements:			
a. Sprayed fire-resistant coatings:	Building Code		
b. Mastic and intumescent coatings:	Building Code		
c. Fire-resistant penetrations and joint systems:	Building Code		
4. Smoke control systems;	Building Code		
<u>Notes:</u> (1) “●” represents a required inspection activity for the project where it occurs.			

ATTACHMENT C - MASONRY SPECIAL INSPECTION SCHEDULE - “LEVEL 3”

MASONRY SPECIAL INSPECTION SCHEDULE - "LEVEL 3"

MINIMUM TESTS

Verification of Slump flow and Visual Stability Index (VSI) as delivered to the Project Site as determined by ASTM C1611 for self-consolidating grout.

Verification of proportions of materials in premixed or pre-blended mortar and grout as delivered to the Project Site.

Verification of f'_m in accordance with Specification Section 04_22_00 - Concrete Unit Masonry prior to construction.

MINIMUM SPECIAL INSPECTION - LEVEL 3			
Verification and Inspection	Reference Standard	Frequency of Inspection ⁽¹⁾ (During Task Listed)	
		Continuous	Periodic
1. Verify compliance with the approved submittals.	TMS 602/ACI 530.1		●
2. As masonry construction begins, verify that the following are in compliance:			
a. Proportions of site-prepared mortar.	TMS 602/ACI 530.1		●
b. Placement of masonry units and construction of mortar joints.	TMS 602/ACI 530.1		●
c. Grade, size, and placement of reinforcement, connectors, and anchors.	TMS 602/ACI 530.1 TMS 402/ACI 530	●	
d. Reinforcing bar couplers and terminators.	ICC-ES Evaluation Report	●	
3. Prior to grouting, verify that the following are in compliance:			
a. Placement of masonry units and construction of mortar joints.	TMS 602/ACI 530.1		●
b. Grout space.	TMS 602/ACI 530.1	●	
c. Grade, type, and size of reinforcement and anchor bolts.	TMS 602/ACI 530.1 TMS 402/ACI 530		●
d. Grade, size, and placement of reinforcement, connectors, and anchors.	TMS 602/ACI 530.1 TMS 402/ACI 530	●	
4. Verify during construction:			
a. Materials and procedures with the approved submittals.	TMS 602/ACI 530.1		●
b. Size and location of structural elements.	TMS 602/ACI 530.1		●
c. Type, size, and location of anchors, including details of anchorage of masonry to structural members, frames, or other construction.	TMS 402/ACI 530	●	

MINIMUM SPECIAL INSPECTION - LEVEL 3			
Verification and Inspection	Reference Standard	Frequency of Inspection ⁽¹⁾ (During Task Listed)	
		Continuous	Periodic
d. Welding of reinforcement.	TMS 402/ACI 530	●	
e. Preparation, construction, and protection of masonry during cold weather (temperature below 40 degrees F) or hot weather (temperature above 90 degrees F).	TMS 602/ACI 530.1		●
f. Placement of grout is in compliance.	TMS 602/ACI 530.1	●	
5. Observe preparation of grout specimens, mortar specimens, and/or prisms.	TMS 602/ACI 530.1	●	
<u>Notes:</u> (1) "●" represents a required inspection activity for the project where it occurs.			

ATTACHMENT D - SOILS - SPECIAL INSPECTION SCHEDULE

SOILS - SPECIAL INSPECTION SCHEDULE

Verification and Inspection	Reference Standard	Frequency of Inspection ⁽¹⁾ (During Task Listed)	
		Continuous	Periodic
1. Verify materials below shallow foundations are adequate to achieve the design bearing capacity.	Building Code		●
2. Verify excavations are extended to proper depth and have reached proper material.	Building Code		●
3. Perform classification and testing of fill and backfill materials.	Building Code		●
4. Verify use of proper materials, densities, and lift thicknesses during placement and compaction of fill and backfill.	Building Code	●	
5. Prior to placement of fill, observe subgrade and verify that Site has been prepared properly.	Building Code		●
Notes: (1) “●” represents a required inspection activity for the project where it occurs.			

ATTACHMENT E - STRUCTURAL STEEL WELDING - SPECIAL INSPECTION SCHEDULE

STRUCTURAL STEEL WELDING - SPECIAL INSPECTION SCHEDULE

Verification and Inspection	Reference Standard	Frequency of Inspection ⁽¹⁾ (During Task Listed)	
		Continuous	Periodic
Inspection Tasks Prior to Welding	AISC 360		
1. Welding procedure specifications (WPSs) available.		●	
2. Manufacturer certifications for welding consumables available.		●	
3. Material identification (type/grade).			●
4. Welder identification system.			●
5. Fit-up groove welds (including joint geometry): - Joint preparation. - Dimensions (alignment, root opening, root face, bevel). - Cleanliness (condition of steel surfaces). - Tacking (tack weld quality and location). - Backing type and fit (if applicable).			●
6. Configuration and finish of access holes.			●
7. Fit-up of fillet welds: - Dimensions (alignment, gaps at root). - Cleanliness (condition of steel surfaces). - Tacking (tack weld quality and location).			●
8. Check welding equipment.			●
Inspection Tasks During Welding	AISC 360		
9. Use of qualified welders.			●
10. Control and handling of welding consumables: - Packaging. - Exposure control.			●
11. No welding over cracked tack welds.			●
12. Environmental conditions: - Wind speed within limits. - Precipitation and temperature.			●
13. WPS followed: - Settings on welding equipment. - Travel speed. - Selected welding materials. - Shielding gas type/flow rate. - Preheat applied. - Interpass temperature maintained (min/max). - Proper position (F, V, H, OH).			●

Verification and Inspection	Reference Standard	Frequency of Inspection ⁽¹⁾ (During Task Listed)	
		Continuous	Periodic
14. Welding techniques: • Interpass and final cleaning. • Each pass within profile limitations. • Each pass meets quality requirements.			•
Inspection Tasks After Welding	AISC 360		
15. Welds cleaned.			•
16. Size, length, and location of welds.		•	
17. Welds meet visual acceptance criteria: • Crack prohibition. • Weld/base-metal fusion. • Crater cross section. • Weld profiles. • Weld size. • Undercut. • Porosity.		•	
18. Arc strikes.		•	
19. k-area.		•	
20. Backing removed and weld tabs removed (if required).		•	
21. Repair activities.		•	
22. Document acceptance or rejection of welded joint or member.		•	
<u>Notes:</u> (1) “•” represents a required inspection activity for the project where it occurs.			

ATTACHMENT F - STRUCTURAL STEEL BOLTING - SPECIAL INSPECTION SCHEDULE

STRUCTURAL STEEL BOLTING - SPECIAL INSPECTION SCHEDULE

Verification and Inspection	Reference Standard	Frequency of Inspection ⁽¹⁾ (During Task Listed)	
		Continuous	Periodic
Inspection Tasks Prior to Bolting	AISC 360		
1. Manufacturer's certifications available for fastener materials.		●	
2. Fasteners marked in accordance with ASTM requirements.			●
3. Proper fasteners selected for the joint detail (grade, type, bolt length if threads are to be excluded from shear plane).			●
4. Proper bolting procedure selected for joint detail.			●
5. Connecting elements, including the appropriate faying surface condition and hole preparation, if specified, meet applicable requirements.			●
6. Pre-installation verification testing by installation personnel observed and documented for fastener assemblies and methods used.			●
7. Proper storage provided for bolts, nuts, washers and other fastener components.			●
Inspection Tasks During Bolting	AISC 360		
8. Fastener assemblies, of suitable condition, placed in all holes and washers (if required) are positioned as required.			●
9. Joint brought to the snug-tight condition prior to the pretensioning operation.			●
10. Fastener component not turned by the wrench prevented from rotating.			●
11. Fasteners are pretensioned in accordance with the RCSC Specification, progressing systematically from the most rigid point toward the free edges.			●
Inspection Tasks After Bolting	AISC 360		
12. Document acceptance or rejection of bolted connections.		●	
Notes: (1) "●" represents a required inspection activity for the project where it occurs.			

**ATTACHMENT G - STEEL CONSTRUCTION - STEEL DECK; OPEN WEB STEEL JOISTS
AND JOIST GIRDERS; AND COLD-FORMED STEEL TRUSSES -
SPECIAL INSPECTION SCHEDULE**

STEEL CONSTRUCTION - STEEL DECK; OPEN WEB STEEL JOISTS AND JOIST GIRDERS; AND COLD-FORMED STEEL TRUSSES - SPECIAL INSPECTION SCHEDULE

Verification and Inspection	Reference Standard	Frequency of Inspection ⁽¹⁾ (During Task Listed)	
		Continuous	Periodic
1. Cold-formed steel deck:			
a. Materials: Identification markings in accordance with ASTM standards specified in the approved construction documents.	Applicable ASTM material standards		●
b. Materials: Manufacturer's certified test reports.			●
c. Welding: Floor and roof deck welds.	AWS D1.3		●
2. Open web steel joints and joist girders:			
a. End connections - welded or bolted	SJI specs		●
b. Bridging - horizontal or diagonal	SJI specs		●
3. Cold-formed steel:			
a. Trusses: Inspect temporary and permanent installation restraints/bracing conform to approved truss submittal.	Building Code		●
Notes: (1) "●" represents a required inspection activity for the project where it occurs.			

**ATTACHMENT H - DEEP FOUNDATIONS, CAST-IN-PLACE -
SPECIAL INSPECTION SCHEDULE**

DEEP FOUNDATIONS, CAST-IN-PLACE - SPECIAL INSPECTION SCHEDULE

Verification and Inspection	Reference Standard	Frequency of Inspection ⁽¹⁾ (During Task Listed)	
		Continuous	Periodic
1. Observe drilling operations and maintain complete and accurate records for each element.	Building Code	●	
2. Verify placement locations and plumbness, confirm element diameters, bell diameters (if applicable), lengths, embedment into bedrock or specified stratum (if applicable), and adequate end-bearing strata capacity. Record concrete or grout volumes.	Building Code	●	
3. For concrete or grout installations, perform additional Special Inspection in accordance with Attachment A - Concrete Special Inspection.	Building Code	-	-
<u>Notes:</u> (1) "●" represents a required inspection activity for the project where it occurs.			

SECTION 01_50_00

TEMPORARY FACILITIES AND CONTROLS

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Furnishing, maintaining, and removing construction facilities and temporary controls, including temporary utilities, construction aids, barriers and enclosures, security, access roads, temporary controls, project sign, field offices and sheds, and removal after construction.

1.02 REFERENCE

- A. American National Standards Institute (ANSI).
- B. Occupational Safety and Health Administration (OSHA).

1.03 SUBMITTALS

- A. Submit as specified in Section 01_33_00 - Submittal Procedures.
- B. Submit Noise Mitigation plan for Larimer County approval.
- C. Submit Fugitive Dust and Emissions Control Plan for Larimer County approval.

1.04 TEMPORARY UTILITIES

- A. Temporary electrical power:
 - 1. Arrange with local utility to provide adequate temporary electrical service.
 - a. Local power utility is Poudre Valley Rural Electric Association (PVREA).
 - 2. Provide and maintain adequate jobsite power distribution facilities conforming to applicable Laws and Regulations.
 - 3. Provide, maintain, and pay for electric power for performance of the Work .
 - 4. Initial discussions with PVREA indicate that either a 150 kVA or 300 kVA temporary service would be available. Contractor to confirm actual details with PVREA.
- B. Temporary electrical lighting:
 - 1. In work areas, provide temporary lighting sufficient to maintain lighting levels during working hours not less than lighting levels required by OSHA and state agency which administers OSHA regulations where Project is located.
 - 2. When available, permanent lighting facilities may be used in lieu of temporary facilities:
 - a. Prior to final completion of the Work, replace bulbs, lamps, or tubes used by Contractor for lighting.

- C. Temporary heating, cooling, and ventilating:
 - 1. Heat and ventilate work areas to protect the Work from damage by freezing, high temperatures, weather, and to provide safe environment for workers.
 - 2. Permanent heating system may be utilized when sufficiently completed to allow safe operation.
- D. Temporary potable water:
 - 1. Pay for and construct facilities necessary to furnish potable water for human consumption and non-potable water for use during construction.
 - 2. Remove temporary piping and connections and restore affected portions of the facility to original condition before Substantial Completion.
 - 3. If potable water is not available from local water providers, furnish potable water for human consumption through other water provider services for the duration of construction.
 - 4. Pay for water used for construction prior to Substantial Completion.
- E. Temporary sanitary facilities:
 - 1. Provide suitable and adequate sanitary facilities that are in compliance with applicable Laws and Regulations.
 - 2. At completion of the Work, remove sanitary facilities and leave site in neat and sanitary condition.
- F. Temporary fire protection:
 - 1. Provide fire protection required to protect the Work and ancillary facilities.
- G. First aid: Post first aid facilities and information posters conforming to requirements of OSHA and other applicable Laws and Regulations in readily accessible locations.
- H. Temporary construction water (non-potable): Water from WSSC Reservoir No. 3 may be used where non-potable construction water is acceptable. The contractor is responsible for temporary pumping or other means needed to withdraw the water from the reservoir. The Contractor shall provide accurate flow metering, by a method acceptable to the Owner, of all water withdrawn from the reservoir. The Contractor shall provide daily reports of metered water to the Owner.

1.05 CONSTRUCTION AIDS

- A. Provide railings, kick plates, enclosures, safety devices, and controls required by Laws and Regulations and as required for adequate protection of life and property.
- B. Use construction hoists, elevators, scaffolds, stages, shoring, and similar temporary facilities of ample size and capacity to adequately support and move loads.
- C. Design temporary supports with adequate safety factor to ensure adequate load bearing capability:
 - 1. When requested, submit design calculations by professional registered engineer prior to application of loads.
 - 2. Submitted design calculations are for information and record purposes only.

- D. Accident prevention:
1. Exercise precautions throughout construction for protection of persons and property.
 2. Observe safety provisions of applicable Laws and Regulations.
 3. Guard machinery and equipment, and eliminate other hazards.
 4. Make reports required by authorities having jurisdiction, and permit safety inspections of the Work.
 5. Before commencing construction work, take necessary action to comply with provisions for safety and accident prevention.
- E. Barricades:
1. Place barriers at ends of excavations and along excavations to warn pedestrian and vehicular traffic of excavations.
 2. Provide barriers with flashing lights after dark.
 3. Keep barriers in place until excavations are entirely backfilled and compacted.
 4. Barricade excavations to prevent persons from entering excavated areas in streets, roadways, parking lots, treatment plants, or other public or private areas.
- F. Warning devices and barricades: Adequately identify and guard hazardous areas and conditions by visual warning devices and, where necessary, physical barriers:
1. Provide devices in accordance with minimum requirements of OSHA and State agency which administers OSHA regulations where Project is located.
- G. Hazards in public right-of-way:
1. Comply with local jurisdiction standards and requirements for right-of-way barricades and other safety devices.
 2. Mark at reasonable intervals, trenches, and other continuous excavations in public right-of-way, running parallel to general flow of traffic, with traffic cones, barricades, or other suitable visual markers during daylight hours:
 - a. During hours of darkness, provide markers with torches, flashers, or other adequate lights.
 3. At intersections or for pits and similar excavations, where traffic may reasonably be expected to approach head on, protect excavations by continuous barricades:
 - a. During hours of darkness, provide warning lights at close intervals.
- H. Hazards in protected areas: Mark or guard excavations in areas from which public is excluded, in manner appropriate for hazard.
- I. Protect existing structures, trees, shrubs, and other items to be preserved on Project site from injury, damage, or destruction by vehicles, equipment, worker or other agents with substantial barricades or other devices commensurate with hazards.
- J. Fences:
1. Enclose site of the Work with fence adequate to protect the Work against acts of theft, violence, and vandalism.
 2. Enclose temporary offices and storage areas with fence adequate to protect temporary facilities against acts of theft, violence, and vandalism.

3. When entire or part of site is to be permanently fenced, permanent fence may be built to serve for both permanent and temporary protection of the work site, provided that damaged or defaced fencing is replaced prior to Substantial Completion.
4. Protect temporary and permanent openings and close openings in existing fences to prevent intrusion by unauthorized persons.
 - a. Bear responsibility for protection of plant and material on site of the Work when openings in existing fences are not closed.
5. During night hours, weekends, holidays, and other times when no work is performed at site, provide temporary closures or enlist services of security guards to protect temporary openings.
6. Fence temporary openings when openings are no longer necessary.

1.06 SECURITY

- A. Make adequate provision for protection of the work area against fire, theft, and vandalism, and for protection of public against exposure to injury.
- B. Provide 24-hour contact information in case a security concern needs to be reported.

1.07 ACCESS ROADS

- A. General:
 1. Site access is from Colorado Highway 1 using the Source Water Pump Station access road. Access from Eagle Lake Drive and Travis Road is not allowed. Contractor shall not block access to other property owners on the Source Water Pump Station access road off of Colorado Highway 1.
 2. Build and maintain access roads to and on site of the Work to provide for delivery of material and for access to existing and operating plant facilities on site.
 3. Build and maintain dust free roads which are suitable for travel at 15 miles per hour.
- B. Off-site access roads:
 1. Build and maintain graded earth roads.
 2. Build roads only in public right-of-way as approved by entity having jurisdiction, or easements obtained by City of Thornton.
 3. Obtain rights-of-way or easements when electing to build along other alignment.
- C. On-site access roads:
 1. Maintain access roads to storage areas and other areas to which frequent access is required.
 2. Maintain similar roads to existing facilities on site of the Work to provide access for maintenance and operation.
 3. Protect buried vulnerable utilities under temporary roads with steel plates, wood planking, or bridges.
 4. Maintain on-site access roads free of mud.
 5. Provide controls to prevent vehicles leaving the site from tracking mud off the site onto the public right-of-way.

1.08 TEMPORARY CONTROLS

A. Dust Control.

1. Provide a Fugitive Dust and Emissions Control Plan to Owner within 15 days of notice to proceed. Owner will submit plan to Larimer County for their approval. Approval of this plan is required before Larimer County issuance of the Development Construction Permit. At a minimum, this plan shall include:
 - a. Best management practices to prevent dust nuisance caused by operations, unpaved roads, excavation, backfilling, demolition, or other activities.
 - b. Measures to control dust by sprinkling with water, use of dust palliatives, modification of operations, or other means acceptable to agencies having jurisdiction.
2. No off-site transport of visible emissions from disturbed areas, dirt access roads, stockpiles, and haul trucks.
3. A water truck shall be on-site during operating hours and nonoperating hours including Sundays to regularly apply water to active construction areas, dirt access roads, stockpiles, and other areas of disturbed soil to prevent visible emissions.
4. No earthwork allowed during days of high wind of 30 miles per hour or greater.
5. Speed limit signs shall be posted in active construction areas restricting speeds to 15 miles per hour.
6. Loaded haul trucks shall be covered during transport and storage to prevent visible emissions.
7. Sediment deposition shall be removed promptly when it occurs on public roads or rights-of-way as a result of the owner's or operator's operations.
8. Minimize drop height: Drivers and operators shall unload truck beds and loader or excavator buckets slowly and minimize drop height of materials to the lowest height possible.
9. Stockpiles shall remain at a height that a water haul truck or manual water hose can apply water on all surfaces.
10. Cover loads of material hauling trucks: Loads shall be completely covered, or all material enclosed in a manner that prevents the material from blowing, dropping, sifting, leaking, or otherwise escaping from the truck.
11. Litter Control: Work sites, temporary staging areas, field trailer areas, finished construction areas and where workers gather for breaks shall be maintained litter-free and supplied with lidded trash enclosures/dumpsters that can withstand water and wind.

B. Noise control:

1. Provide a Noise Mitigation Plan to Owner within 15 days of notice to proceed. Owner will submit to plan Larimer County for their approval. Approval of this plan is required before Larimer County issuance of the Development Construction Permit. At a minimum, this plan shall include:
 - a. Compliance with Larimer County noise ordinance noise and work hours regulations.
 - b. Outline control methods that will be implemented during construction amongst residential properties to remain within the County Ordinance, but also minimize negative impacts on the residents in the area.
 - c. The plan shall include adequate recommendations on how low frequency sound/vibrations are managed.

- d. The plan shall also include the details of the outreach and communication plan/program. The City of Thornton will provide information to be include in the Contractor's Noise Mitigation Plan. As part of this plan/program, easily visible signage with contact information (phone number, email, and the Thornton Water Project website) for addressing questions and concerns, shall be posted in active construction areas. The City of Thornton will provide these signs to the Contractor.
- e. The plan shall include additional noise mitigation to be implemented when construction activities are approved to go beyond the 7 a.m. to 7 p.m. time period and all 24-hour operations near occupied residences.
- f. Construction equipment and fleet trucks shall utilize white noise backup beepers.
- g. This plan shall include best management practices which may include but not be limited to:
 - 1) Ensuring equipment is serviced and maintained to manufacturer's specifications.
 - 2) Using appropriate mufflers.
 - 3) Idle equipment motors down when the equipment is not in immediate use.
 - 4) Schedule trucks to minimize long queue lines of idling trucks.
 - 5) Plan site circulation to minimize backup distances for trucks and other equipment.
 - 6) Use sound attenuated pumps and "quiet" generators where practical.
 - 7) Install temporary sound barriers when feasible near loud operations.
 - 8) Use portable sound barriers when feasible near jackhammer and concrete saw work.

C. Mud control:

- 1. Prevent mud nuisance caused by construction operations, unpaved roads, excavation, backfilling, demolition, or other activities.

1.09 PROJECT SIGNS

- A. The City of Thornton will provide up to 2 project signs approximately 4-foot high by 10-foot wide for the Contactor's use. Contractor shall install and maintain Project identification signs as directed by the Construction Manager. The sign will be suitable for installation on 4-foot by 4-foot lumber posts.
- B. Erect project identification sign where directed by Construction Manager within 14 days after the issuance of the Notice to Proceed.
- C. Contractor shall replace or repair the project sign if it is damaged or covered with graffiti within 2 working days of observation or notification of damage or graffiti. City of Thornton will provide new signs if required.

1.10 CONTRACTOR FIELD OFFICES AND SHEDS

- A. Contractor shall not locate field offices and sheds within 100-year floodplain or within public R.O.W. areas.

- B. Maintain on Project Site weather tight space in which to keep copies of Contract Documents, progress schedule, shop drawings, and other relevant documents.
- C. Provide field office with adequate space to examine documents, and provide lighting in that space.

1.11 CITY OF THORNTON'S FIELD OFFICE

- A. Provide separate field office on project site for the exclusive use of the Construction Manager, as follows:
 - 1. Size: Approximately 14 feet by 60 feet with 8-foot minimum ceiling height.
 - 2. Construction: Weather tight building constructed at the site, pre-manufactured building, or trailer.
 - 3. Layout approved by Construction Manager.
 - a. Private offices: 2.
 - b. Conference area: 1.
 - c. Washroom: 1.
 - 1) Room partitioned off from the working area.
 - 5) Single water discharge to nearest approved sanitary facility.
 - 6) Flush toilet.
 - 7) Vented exhaust fan.
 - 8) Sink with hot and cold water.
 - 9) Mirror.
 - 10) Water heater: 10-gallon capacity.
 - 11) Toilet tissue holder.
 - 12) Paper towel holder.
 - d. Closet with shelving: 1.
 - 4. Exterior materials:
 - a. Weather-resistant and finished in one color acceptable to Construction Manager.
 - b. Skirting for under pinning of field office.
 - 5. Provide wood stairs with handrails for each entry.
 - a. Porch landing 5 feet by 5 feet for each entry.
 - 6. Interior materials in offices:
 - a. Sheet-type materials for walls and ceilings, prefinished or painted; resilient floors and bases.
 - b. Insulate interior walls for noise attenuation.
 - 7. Openings:
 - a. At least 8 windows (with security screens, operable sash, insect screens, and blinds).
 - b. Entrance doors: Provide 2, each with cylinder lock and 4 keys.
 - 8. Exterior lighting over entrance doors.
 - 9. Fire extinguishers:
 - a. Appropriate type fire extinguisher(s) for field office.
 - 10. Twenty 110 volts AC duplex receptacles with at least 4 in each office, 1 on each wall.
- B. Arrange and pay for:
 - 1. Twice a week janitorial service, including dusting, floor cleaning (sweeping, vacuuming or mopping), and trash removal, and monthly comprehensive cleaning, including windows.

2. Heating, ventilating, and air conditioning equipment in operating condition.
 - a. Furnish maintenance and consumables.
 3. Electric wiring, power, and lighting fixtures capable of providing at least 75 foot-candles of light on work surfaces.
 4. A continuous supply of toilet paper, paper hand towels and hand soap for each washroom.
 5. Bottled drinking water service with hot and cold dispenser including water cups.
 6. Provide and maintain First Aid Kit and Cabinet in accordance with ANSI Z 308.1, and OSHA requirements.
 7. Provide boot scraper and brush at each entrance.
 8. Maintain approach walks, decking, porches, and parking lot free of mud, water, and snow.
 9. Maintain access and keep parking free and clear. Remove snow within six hours of event.
- C. Provide following furnishings and equipment:
1. Office desks: 2, 36 inches by 72 inches, with 6 drawers (2 with locks).
 2. Plan/conference table: 6 foldable tables, not less than 48 inches by 120 inches each.
 3. Drafting table: 1, not less than 36 inches by 72 inches.
 4. Metal drafting stools with backs: 2.
 5. Straight chairs (fully padded): 2.
 6. Folding chairs: 20.
 7. Swivel chairs (adjustable and fully padded): 2.
 8. Metal filing cabinet: 4, 18 inches by 30 inches by 52 inches, 4 drawers with locks.
 9. Supply cabinet: 1, with not less than 15 square feet of shelves.
 10. Bookcases: 3, with not less than 12 linear feet of shelves for each bookcase.
 11. Plan hold rolling stand of 12 binders: 1, with binders.
 12. Wastebaskets: 4.
 13. Dry erase board 96 by 48 inches, magnetic: 3.
 14. Provide: 1 tackboard 36 by 48 inches.
 15. Refrigerator: 15.0 cubic feet capacity.
 16. Microwave oven: 1.0 cubic feet.
 17. K-cup coffee maker with direct water hookup and coffee cups.
 18. 1 multiline telephone system with 10 lines and voicemail capabilities, 3-speaker capable phones with handsets, 1 for each desk and table and 1 conference phone for meeting room.
- D. Locate field office within 10 miles of project site.
- E. Have field office ready for occupancy within 2 weeks after start of the Work.
- F. Parking: 10 hard-surfaced parking spaces for use by Construction Manager connected to office by a hard-surfaced walkway.

1.12 CITY OF THORNTON'S FIELD OFFICE DATA SERVICE AND EQUIPMENT

- A. Provide the following data services for the duration of the project.

- B. Contractor is responsible for maintenance of service and hardware.
- C. Data service will be dedicated to the Construction Manager and not shared with any other party.
- D. Contractor provide a durable and weather tight system for connecting the Construction Manager trailer to the service provider's facilities at the jobsite boundary.
- E. Data service:
 - 1. Broadband Internet:
 - a. High speed internet though Comcast or Century Link for the exclusive use of the City of Thornton, Owner's Advisor, and Construction Manager.
 - b. Minimum Internet bandwidth speed:
 - 1) Download: 100 million bits per second (Mbps).
 - 2) Upload: 10 million bits per second (Mbps).
- F. Printer/Scanner:
 - 1. Manufacturers: The following or equal:
 - a. Canon Color Digital Multifunction printer (ImageRUNNER Advance C3330i).
 - 2. Functions:
 - a. Print, scan, and sort 11-inch by 17-inch and smaller paper size.
 - b. Send and receive Fax.
 - 3. Maintenance contract: Onsite maintenance for duration of project.
 - 4. Supplies: Paper (8-1/2-inch by 11-inch, 8-1/2-inch by 14-inch, and 11-inch by 17-inch) trays, toner, and other supplies for duration of project.

1.13 REMOVAL

- A. Remove temporary facilities and controls before inspection for Initial Acceptance or when directed.
- B. Clean and repair damage caused by installation or use of temporary facilities.
- C. Remove underground installations to minimum depth of 24 inches and grade to match surrounding conditions.
- D. Restore existing facilities used during construction to specified or original condition.
- E. Section includes:
 - 1. Furnishing, maintaining, and removing construction facilities and temporary controls, including temporary utilities, construction aids, barriers and enclosures, security, access roads, temporary controls, project sign, field offices and sheds, and removal after construction.

1.14 REFERENCE

- A. American National Standards Institute (ANSI).
- B. Occupational Safety and Health Administration (OSHA).

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION (NOT USED)

END OF SECTION

SECTION 01_60_01
PRODUCT REQUIREMENTS

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Requirements for products.

1.02 SHIPMENT

- A. Prepare products for shipment by:
 - 1. Tagging or marking to match the Shop Drawings or Contract Documents.
 - 2. Including complete packing lists and bills of material with each shipment.
 - 3. Packaging products to facilitate handling and protection against damage during transit, handling, and storage.
 - 4. Securely attach special instructions for proper field handling, storage, and installation before packaging and shipment.
- B. Transport products by methods that avoid product damage.
- C. Deliver products in undamaged condition in the manufacturer's unopened packaging.

1.03 DELIVERY AND HANDLING

- A. Handle products in accordance with the manufacturer's instructions.
- B. Deliver products in undamaged condition in the manufacturer's unopened packaging.
- C. Provide construction equipment and personnel to handle products by methods in accordance with the manufacturer's instructions.
- D. Upon delivery, promptly inspect shipments:
 - 1. Verify compliance with the Contract Documents, correct quantities, and undamaged condition of products.
 - 2. Acceptance of shipment does not constitute final acceptance of products.

1.04 STORAGE

- A. Immediately store and protect products until installed in the Work.
- B. Store products with seals and legible labels intact.
- C. Protect painted or coated surfaces against impact, abrasion, discoloration, and damage.
- D. Storage of spare parts, maintenance products, special tools.
 - 1. Immediately store in accordance with the manufacturer's instructions.

2. Store spare parts, maintenance products, and special tools in an enclosed, weather-proof, and lighted facility during the construction period.
 3. Protect parts subject to deterioration, such as ferrous metal items and electrical components with appropriate lubricants, desiccants, or hermetic sealing.
 4. Store large items individually:
 - a. Weight: Greater than 50 pounds.
 - b. Size: Greater than 24-inches wide by 18-inches high by 36-inches long.
 - c. Clearly labeled:
 - 1) Equipment tag number.
 - 2) Equipment manufacturer.
 - 3) Subassembly component, if appropriate.
 5. Store smaller items in spare parts boxes:
 - a. Weight: Less than 50 pounds.
 - b. Size: Less than 24 inches wide by 18 inches high by 36 inches long.
 - c. Clearly labeled:
 - 1) Equipment tag number.
 - 2) Equipment manufacturer.
 - 3) Subassembly component, if appropriate.
 6. Spare parts and special tools box:
 - a. Box material: Waterproof, corrosion resistant.
 - b. Hinged cover with locking hasp:
 - 1) Inventory list taped to underside of cover.
 - 2) Clearly labeled:
 - a) "Spare Parts and/or Special Tools".
 - b) Equipment tag number.
 - c) Equipment manufacturer.
 - d) Subassembly component, if appropriate.
- E. Exterior storage of fabricated products:
1. Place on aboveground supports that allow for drainage.
 2. Cover products subject to deterioration with impervious sheet covering.
 3. Provide ventilation to prevent condensation under covering.
- F. Store moisture sensitive products in watertight enclosures.
- G. Store loose granular materials on solid surfaces in well-drained area.
1. Prevent materials mixing with foreign matter.
 2. Provide access for inspection.
- H. When needed and approved by the Engineer, offsite storage location shall be within 20 miles of the Project Site.
1. Provide proof of insurance coverage for products stored offsite.
- I. Payment will not be made for products improperly stored or stored without providing the Engineer with the manufacturer's instructions for storage.

PART 2 PRODUCTS

2.01 GENERAL REQUIREMENTS

- A. Provide products by the same manufacturer when units are of similar nature, unless otherwise specified.
- B. Provide like parts of duplicate units that are interchangeable.
- C. Provide equipment or products that have not been in service prior to delivery, except as required by tests.
- D. For products or workmanship specified by association, trade, or other consensus standards, comply with requirements of the standard, except when more rigid requirements are specified or are required by applicable codes.
 - 1. Conform to reference standard by date of issue current on date of Contract Documents, except where specific date is established by code.
- E. Provide products produced by manufacturers regularly engaged in the production of these products.
- F. Provide products that bear approvals and labels as specified such as Factory Mutual (FM), Underwriters Laboratory (UL), or National Sanitation Foundation (NSF International) that are acceptable to the Authority Having Jurisdiction.

2.02 MATERIAL

- A. Dissimilar metals:
 - 1. Separate contacting surfaces with dielectric material.
 - 2. Neoprene, bituminous impregnated felt, heavy bituminous coatings, nonmetallic separators, washers, petrolatum tape, or other materials as specified.
 - 3. Dielectric coatings can be used to separate dissimilar metal couples from surrounding environment if isolation of metals is not possible, with approval of the Engineer.
- B. Edge grinding:
 - 1. Sharp projections of cut or sheared edges of ferrous metals which are not to be welded shall be ground to a radius required to ensure satisfactory paint adherence and mitigate any safety hazard.
 - 2. A surface profile will need to be re-established for coating adherence based on coating manufacturer's profile requirements.
- C. Use anti-galling compound on threads of stainless steel fasteners during factory assembly.
- D. Provide anti-galling compound with stainless steel fasteners shipped for field assembly.
- E. Aluminum in contact with concrete or masonry: Apply epoxy mastic.

2.03 PRODUCT SELECTION

- A. When products are specified without named manufacturers, provide products that meet or exceed the Specifications.
- B. When products are specified with names of manufacturers but no model numbers or catalog designations, provide products by one of the named manufacturers that meet or exceed specifications.
- C. When products are specified with names of manufacturers and model numbers or catalog designations, provide products with model numbers or catalog designations by one of the named manufacturers.
- D. When products are specified with names of manufacturers, but with brand or trade names, model numbers, or catalog designations by one manufacturer only, provide:
 - 1. Products specified by brand or trade name, model number, or catalog designation.
 - 2. Products by another named manufacturer proven, in accordance with requirements for an “or equal”, including the Engineer’s approval, to meet or exceed quality, appearance and performance of specified brand or trade name, model number, or catalog designation.
- E. When products are specified with only one manufacturer followed by “or equal,” provide:
 - 1. Products meeting or exceeding specifications by specified manufacturer.
 - 2. Engineer deemed “or equal” evidenced by an approved Shop Drawing or other written communication.
- F. When products are specified by naming 2 or more manufacturers with 1 manufacturer as a “Basis of Design”:
 - 1. Any of the named manufacturers can be submitted.
 - 2. If the product submitted is not by the named “Basis of Design” product and requires a change in the scope (dimensions, configuration, physical properties, etc.), schedule (longer lead time), or budget, the Contractor must submit a substitution request.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Inspect equipment or products prior to installation.
- B. Repaint or recoat damaged painted or coated surfaces after installation.
- C. Use anti-galling compound on stainless steel threads used for field assembly.

3.02 PROTECTION AFTER INSTALLATION

- A. Provide coverings as necessary to protect installed products from damage due to traffic and subsequent construction operations.
 - 1. Remove covering when no longer needed.
 - 2. Replace corroded, damaged, or deteriorated products before acceptance of the Project.

END OF SECTION

SECTION 01_71_23
FIELD ENGINEERING

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Field survey to establish lines and grades for the Work.
 - a. Requirements: All field surveys shall be performed under the supervision of a Professional Licensed Surveyor registered in the State of Colorado.

1.02 SUBMITTALS

- A. Submit as specified in Section 01_33_00 - Submittal Procedures.
- B. Qualifications of the professional land surveyor in the state where project is located that will be performing the field engineering.
 - 1. All survey work including staking in the field, layout, and as-built surveys shall be performed by a professional land surveyor licensed in the State of Colorado.
 - 2. Submit name, telephone number, email address, and qualifications of the surveyor, crew chief, and other important persons who are proposed to perform surveys or survey related duties prior to start of any survey work.
- C. Submit information on equipment to be used for field survey.
- D. Complete as-built data with final horizontal northing and easting coordinates, elevations, pipeline stationing, and pipeline mark number in ASCII file in CSV format and copy of corresponding field survey book pages. Submit survey data weekly to the City of Thornton through the document management system. Prior to Initial Acceptance, the Contractor/Surveyor shall submit a complete set of as-built data and drawings to the City of Thornton.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 SURVEY REFERENCE POINTS

- A. Basic reference line, a beginning point on basic reference line, and a benchmark will be provided by the City of Thornton.
- B. From these reference points, establish other control and reference points as required to properly lay out the Work.

- C. Locate and protect control points prior to starting site work, and preserve permanent reference points during construction:
 - 1. Make no changes or relocations without prior written notice.
 - 2. Replace Project control point, when lost or destroyed, in accordance with original survey control.
- D. Set monuments for principal control points and protect them from being disturbed and displaced:
 - 1. Re-establish disturbed monuments.
 - 2. When disturbed, postpone parts of the Work that are governed by disturbed monuments until such monuments are re-established.

3.02 PROJECT SITE SURVEY REQUIREMENTS

- A. Establish minimum of 2 permanent benchmarks on site referenced to data established by survey control points.
- B. Record permanent benchmark locations with horizontal and vertical data on Project Record Documents.
- C. Perform verifications and checking in accordance with standard surveying practice.
- D. Maintain complete, accurate log of control points and survey.
- E. Affix professional land surveyor's signature and registration number to Record Drawings to certify accuracy of information shown.

3.03 CONSTRUCTION STAKES, LINES, AND GRADES

- A. Execute the Work in accordance with the lines and grades indicated.
- B. Make distances and measurements on horizontal planes, except elevations and structural dimensions.

3.04 QUALITY CONTROL

- A. Accuracy of stakes, alignments, and grades may be checked randomly by Construction Manager:
 - 1. Notice of when checking will be conducted will be given.
 - 2. When notice of checking is given, postpone parts of the Work affected by stakes, alignments, or grades to be checked until checked.
 - 3. Construction Manager's check does not substitute or complement required field quality control procedures.

3.05 RECORD DOCUMENTS

- A. Prepare and submit Record Documents as specified in Contract Documents.

- B. Record in field books, original field notes, computations, and other records for the purpose of layout and quantity surveys. Field notes must be neat and legible, complete, self-explanatory, and self-checking. Include, but not limited to, the following in the field notes:
 - 1. Date of field work.
 - 2. Names of crew members.
 - 3. Description of controlling survey stations.
 - 4. Sketches of work where applicable.
 - 5. As-built information as specified.
 - 6. Electronic data collected and reported in CSV format.
- C. At project completion and as a requirement for Initial Acceptance, provide certified site survey in 1:50 scale including buildings, benchmarks, and appurtenances sealed and signed by professional land surveyor.
 - 1. File with permitting agency, as required.
 - 2. Provide pipeline as-built horizontal coordinates and vertical invert elevations.

END OF SECTION

SECTION 01_75_17

COMMISSIONING

TABLE OF CONTENTS

PART 1	GENERAL.....	2
1.01	SUMMARY	2
1.02	DEFINITIONS.....	2
1.03	COMMISSIONING COORDINATOR (CC).....	5
1.04	MANUFACTURER'S REPRESENTATIVES	6
1.05	PLANNING PHASE	6
1.06	TESTING AND TRAINING PHASE	8
1.07	START-UP PHASE	16
PART 2	PRODUCTS (NOT USED)	21
PART 3	EXECUTION (NOT USED)	21
ATTACHMENT A - MANUFACTURER'S CERTIFICATE OF SOURCE TESTING		
ATTACHMENT B - MANUFACTURER'S CERTIFICATE OF INSTALLATION VERIFICATION		
ATTACHMENT C - MANUFACTURER'S CERTIFICATE OF FUNCTIONAL COMPLIANCE		
ATTACHMENT D - TRAINING EVALUATION FORM		
ATTACHMENT E - COMMISSIONING ROLES AND RESPONSIBILITIES MATRIX		
ATTACHMENT F - FUNCTIONAL TESTING REQUIREMENTS		

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
1. Commissioning of the Source Water Pump Station (SWPS) and the entire Thornton Water Project System.

1.02 DEFINITIONS

- A. Commissioning: The process of planning for, testing of, and start-up of systems, subsystems, equipment, components, and devices of the Work to demonstrate, through documented verification, that the Work has successfully met the Contract Documents. It includes training the Owner's staff on operation and maintenance of the installed Work.
- B. Commissioning Phases: The activities of commissioning are grouped into the phases defined in the following table.
1. Table 1 - Commissioning Phases.

TABLE 1 - COMMISSIONING PHASES		
Planning Phase	Testing and Training Phase	Start-Up Phase
Draft Test Plans	Source Testing: • Documentation	Start-Up: • Documentation • Owner Training
	Installation Verification: • Documentation • Owner Training	
	Functional Testing: • Documentation • Owner Training	

- C. Component: A part of a system that does not have an electrical connection or internal electronics. Examples: Piping and pressure gauges.
- D. Device: A part of a system that has electrical connections or internal electronics. Examples: Level transmitter or pressure transmitter.
- E. Electrical Energization Plan: A plan to manage how and when power is applied to electrical equipment.
- F. Equipment: A factory or field assembled apparatus that performs an identifiable function. Examples: Pumps, motors, VFDs, MCCs.
- G. Functional Testing: Testing performed on a completed subsystem or system to demonstrate that the system meets the specified requirements. Example systems: Backwash system, dewatering system.

- H. Installation Verification: Testing to demonstrate that equipment or system and associated components or devices have been properly installed. Example equipment: Pumps, meters, and blowers with associated piping.
- I. Manufacturer's Certificate of Functional Compliance: The form completed by the manufacturer to confirm that testing of the installed equipment or system has been performed and the results conform to the specified performance. The form is provided in Attachment C provided at the end of this Section.
- J. Manufacturer's Certificate of Installation Verification: The form completed by the manufacturer to confirm that the equipment or system is installed in conformance with the Contract. The form is provided in Attachment B at the end of this Section.
- K. Manufacturer's Certificate of Source Testing: The form completed by the manufacturer to confirm that the specified source tests have been performed and the results conform to the specified requirements. The form is provided in Attachment A at the end of this Section.
- L. Owner Training: The Owner's staff is trained by the Contractor, with assistance from manufacturer, to operate and maintain the completed Work. This is sometimes referred to as Vendor Specific Training.
- M. Source Testing: Test equipment or products for performance at point of manufacture or assembly for the requirements specified in the Contract Documents. Also referred to as factory testing and factory acceptance testing (FAT).
- N. Start-Up: Operating the Work with water to verify the Work meets the Contract Documents.
- O. Start-Up Phase: The phase when Start-Up occurs.
- P. Subsystem: A grouping of equipment, components, and devices that is a part of a larger system and that perform a single definable function. Examples: Surge tanks, intake structures.
- Q. System: A grouping of equipment, components, and devices that perform a single definable function. If a system is a part of a larger system, it is referred to as a subsystem.
 - 1. Examples: Pump Station.
- R. System Testing: Testing of a completed system for an extended time period. Examples: Pump station operation.
- S. Water Management Plan: A plan to manage the test water used for commissioning from source to disposal. The test water will be raw water that the Contractor pumps from the Water Supply and Storage Reservoir No.3, where the SWPS intake structures and pipelines are built. The plan demonstrates how water will be produced, conveyed, treated, and disposed of.

- T. Project Commissioning:
1. Commissioning Coordinator's qualifications.
 - a. Submit to Engineer no later than 30 days after Notice to Proceed.
 - b. Describe previous similar experience on similar projects with a list of references, including phone numbers.
 - c. Provide names and qualifications of commissioning assistants, if applicable.
 2. Schedules:
 - a. Schedule for verification of functionality of all Thornton Water Project facilities that are described in the Contract Documents.
 - b. Commissioning Schedule containing all commissioning activities.
 - c. Owner Training Schedule.
 3. Test Plans:
 - a. Submit draft Test Plan outlined in the Planning Phase, unless specified otherwise.
 - 1) Engineer approval of draft Test Plans required for successful completion of Planning Phase.
 - b. Submit final Test Plan a minimum of 120 calendar days prior to testing.
 - c. Engineer approval of final Test Plan required prior to start of testing.
 4. Test Reports:
 - a. Submit draft Test Reports outline in the Planning Phase, unless specified otherwise.
 - 1) Engineer approval of draft Test Reports outline required for successful completion of Planning Phase.
 - b. Submit final Test Report a maximum of 30 calendar days after testing.
- U. Technical Sections Commissioning:
1. Manufacturer's representative's qualifications.
 - a. Submit to Engineer no later than 30 days in advance of required services.
 - b. Representative's name, phone, and e-mail address:
 - 1) May use 2 representatives: 1 for field testing and 1 for Owner Training.
 - 2) Provide resume stating instructor's technical expertise and instructional technology skills and experience.
 2. Test Plans:
 - a. Submit draft Test Plan outlined in the Planning Phase, unless specified otherwise.
 - 1) Engineer approval of draft Test Plans required for successful completion of Planning Phase.
 - b. Submit final Test Plan a minimum of 90 calendar days prior to testing.
 - c. Engineer approval of final Test Plan required prior to start of testing.
 3. Test Reports:
 - a. Submit draft Test Reports outline in the Planning Phase, unless specified otherwise.
 - 1) Engineer approval of draft Test Reports outline required for successful completion of Planning Phase.
 - b. Submit final Test Report a maximum of 30 calendar days after testing.
 4. Manufacturer's representatives field notes and data.
 5. Owner Training:
 - a. Prior to the training session:
 - 1) Training instructor qualifications.

- 2) Training course materials: Due 30 calendar days prior to initial training session.
 - a) If Owner requires, Continuing Education Units (CEUs), submit training materials to state regulatory agency in sufficient time to obtain approval for training prior to the training.
 - b) Drafts of training agenda, lesson plan, presentation, handouts, and list of audio-visual aids.
 - c) Format: 1 electronic copy in the format specified by the Owner and 3 hard copies organized in notebooks.
- b. Post training session:
 - 1) Training course materials: Due 14 calendar days after class completion.
 - a) Recordings.
 - b) Class attendance sheet.
 - c) Final version of training agenda, final lesson plan, presentation, handouts, and audio-visual aids.
 - d) Format: 1 electronic copy in the format specified by the Owner and 3 hard copies organized in notebooks.
 - 2) Provide materials for all sessions of the class in a single transmittal.
 - 3) If the Owner requires training CEUs, issue training CEU certificates approved by the state regulatory agency to Owner's staff who successfully completed the training.

1.03 COMMISSIONING COORDINATOR (CC)

- A. Responsibilities include the following:
 1. Full-time dedicated person with no other project responsibilities.
 2. Become thoroughly familiar with Contract Commissioning requirements.
 3. Provide the primary interface with Engineer and Owner for Commissioning efforts.
 4. Lead Commissioning efforts - all phases and tasks.
 5. Coordinate training efforts.
 6. Meetings:
 - a. CC is responsible for setting Commissioning coordination meeting dates and times, as well as preparing the agendas and meeting minutes.
 - b. CC shall conduct Commissioning progress meetings throughout construction, to plan, scope, coordinate, and schedule future activities, resolve problems, etc.
 - c. Frequency: Monthly minimum. Increase frequency as needed based on complexity and quantity of Commissioning activities.
- B. CC on site:
 1. Notice to Proceed to 30 percent milestone: 2 hours per week.
 2. 30 percent milestone to 70 percent milestone: 1 day per week.
 3. Testing and Training Phase: Full-time.
 4. Start-Up Phase: Full-time.

1.04 MANUFACTURER'S REPRESENTATIVES

- A. Qualifications: As specified below and in the Technical Sections:
 - 1. For Installation and Functional Testing:
 - a. Factory trained and experienced in the technical applications, installation, operation, and maintenance of respective equipment/system with full authority by the equipment/system manufacturer to issue the certifications required of the manufacturer.
 - 2. Training instructor qualifications:
 - a. Provide resume stating instructor's technical preparation and instructional technology skills and experience.
 - b. If CEUs are required, the operator training instructors must comply with state regulatory.
 - c. Knowledgeable in the equipment/system for which they are training.
 - d. Experienced in conducting classes.
 - e. Sales representatives are not qualified instructors unless they possess the detailed operating and maintenance knowledge required for proper class instruction.
 - 3. Representatives to be approved by Owner and Engineer.
 - 4. No substitute representatives without written approval by Owner and Engineer.
- B. Duties:
 - 1. Determine if additional time and/or trips (beyond those specified in the Technical Sections) is required to perform the specified services.
 - 2. Coordinate services in accordance with the Contractor's Project schedule, up to and including making multiple trips to the Project Site when there are separate milestones associated with installation of each occurrence of manufacturer's equipment.
 - 3. Perform on-site services as specified in the Technical Sections.
 - 4. Provide daily copies of manufacturer's representatives field notes and data to Contractor.

1.05 PLANNING PHASE

- A. Overview of Planning Phase:
 - 1. Define approach and timing for Commissioning.
 - 2. Obtain Engineer approval of draft Test Plans.
- B. Test Plans.
 - 1. Define approach and timing for:
 - a. Testing and Training Phases.
 - 1) Major systems, with separate plans for each system.
 - b. Start-Up Phase.
 - 2. Source Test (Factory Acceptance Test) and Functional Test Plans:
 - a. As specified in this Section and other Technical Sections.
 - b. Based on approved Shop Drawings.
 - c. Prepared by the Contractor.
 - d. Include the following items for each test:
 - 1) Purpose of the test.

- 2) Identification of each item of equipment/system to be tested, including system designation, location, tag number, control loop identifier, etc.
 - 3) Description of the pass/fail criteria that will be used.
 - 4) Listing of pertinent reference documents (Contract and industry standards or sections applicable to the testing).
 - a) Credentials of test personnel.
 - 5) Test equipment:
 - a) Include Product Data for the test equipment.
 - b) Appropriate calibration records.
 - (1) Drawings or photographs of test stands and/or test apparatus.
 - 6) Duration: Determine test durations with Owner's input.
 - 7) Detailed step-by-step test procedures.
 - a) Level of detail shall be sufficient for the witness to follow the steps.
 - e. Define for Functional Testing:
 - 1) Required temporary systems (pumps, piping, etc.).
 - 2) Shutdown requirements for existing systems.
 - f. Furnish labor, power, tools, equipment, instruments, and services required for and incidental to testing activities.
3. Test forms minimum requirements:
 - a. Name of product to be tested.
 - b. Test date.
 - c. Names of persons conducting the test.
 - d. Names of persons witnessing the test, where applicable.
 - e. Test data.
 - f. Applicable project requirements as specified in the Technical Sections.
 - g. Check offs for each completed test or test step.
 - h. Place for signature of person conducting tests and for the witnessing person, as applicable.
 4. Owner responsibilities:
 - a. Owner will schedule staff within the constraints of their workloads.
 - 1) Those who will participate in this test have existing full-time work assignments, and testing is an additional assigned work task, therefore, scheduling is imperative.
 - 2) Treatment facilities are typically operated on an around-the-clock basis and are staffed in work shifts.
 - 1) Maximum hours per day available for commissioning activities: 4.
 - 2) Days available for commissioning activities: Monday to Friday.
 - 3) Scheduling coordination with the CC.
 5. CC is responsible for the following:
 - a. Coordinate schedule with the Owner's personnel and manufacturer's representatives (instructors).

C. Test Reports:

1. Minimum requirements:
 - a. Title.
 - b. Abstract.
 - c. Equipment.
 - d. Procedures.

- e. Results.
 - 1) Complete disclosure of the calculation methodologies.
- f. Conclusions.
- g. Signature by an authorized party.
- h. Appendices.
 - 1) Completed test forms signed by witnesses.
- 2. Water Management Plan:
 - a. Requirements:
 - 1) Demonstrate how water will be produced, conveyed, treated, recycled, and or disposed until testing verifies specified requirements.
- 3. Commissioning Schedule:
 - a. Content:
 - 1) Comply with Attachment F - Functional Testing Requirements and provide activities organized by system and subsystem.
 - 2) Include:
 - a) Source Testing when required.
 - b) Functional Testing.
 - c) Owner Training.
 - 3) Comply with Attachment E - Commissioning Roles and Responsibilities Matrix.
 - b. Procedures:
 - 1) Submit Commissioning Schedule as specified in Section 01_32_21 - Schedules and Reports.

1.06 TESTING AND TRAINING PHASE

- A. Overview of Testing and Training Phase:
 - 1. General:
 - a. Contractor tests the Work to verify it meets the Contract requirements.
 - b. Contractor trains the Owner to operate and maintain the Work.
 - 2. Contractor responsibilities:
 - a. Furnish labor, power, tools, equipment, instruments, and services required for and incidental to completing Commissioning activities in accordance with the approved Commissioning Plans.
 - 3. Owner responsibilities:
 - a. Witness and observation.
- B. Source Testing:
 - 1. As specified in the Technical Section.
 - 2. Source Test Plan:
 - a. Engineer approval of Source Test Plan required prior to testing.
 - 3. Witnessed in person:
 - a. As specified in the Technical Section.
 - b. Contractor is responsible for trip costs associated with Owner's and Engineer's representatives.
 - 1) Transportation:
 - a) Commercial airline costs to and from Denver International Airport, including related fees.
 - b) Rental car to and from arrival airport, hotel, and test site, including related fees.

- 2) Hotel/Meals:
 - a) Hotel with an American Automobile Association 3 Diamond rating or higher equivalent for single occupancy room per person per day.
 - b) Meal allowance based on state government per diem guidelines per test site location.
- c. When factory is located outside of the United States, Contractor is responsible for costs associated with additional security of Owner's and Engineer's representatives, including armed escorts, as determined appropriate by the Owner and/or Engineer.
- 4. Virtual witness testing:
 - a. As specified in the Technical Sections.
 - b. Contractor is responsible for costs associated with virtual witness.
 - c. Provide the following:
 - 1) An agenda detailing start time of each major phase in the procedure defined in the approved Test Plan.
 - 2) A dedicated operator (separate from the test technician) to operate the camera, provide commentary throughout test, and inspect devices at the request of the attendees.
 - d. Online meeting platform: Microsoft Teams.
 - e. Share video through a high-definition camera.
 - f. Establish methods to communicate, convey, and record information clearly even in environments with loud background noise.
 - 1) Electronic feed for screen sharing of the control panel, HMI, or other screens used throughout testing.
 - 2) Provide recording of virtual sharing within 1 day after testing.
 - g. Test run of virtual sharing a minimum of 1 week prior to the test:
 - 1) Use current record documents in PDF format.
 - 2) Provide recording of virtual sharing within 1 day after the test run.
 - 3) Engineer approval of test run virtual sharing is required before Source Testing.
- 5. If the Source Test is not ready on the scheduled date or if the Source Test fails:
 - a. Contractor is responsible for associated costs:
 - 1) First test costs that are non-refundable, if applicable.
 - 2) Repeat test costs:
 - a) Trip costs, if applicable.
 - 3) Virtual witness costs, if applicable.
- 6. Source Testing is complete after successful testing, submittal of test report, and Manufacturer's Certificate of Source Testing.
- 7. Engineer approval of Source Testing Report is required.
- C. Installation Verification:
 - 1. Overview:
 - a. Verifying the installation of equipment to be in accordance with Manufacturer's Instructions.
 - 2. Prerequisite:
 - a. Engineer approval of Source Testing Report.
 - 3. Perform checks:
 - a. Structural anchorage check.
 - b. Electrical energization check.
 - c. Health and safety check.

4. Submit Manufacturer's Certificate of Installation Verification.
 5. Engineer approval of Manufacturer's Certificate of Installation Verification is required.
- D. Functional Testing:
1. Overview:
 - a. Testing the function of a system or subsystem.
 - b. Contractor shall provide detailed checklists of all specification requirements of each piece of equipment, system, and subsystem for functional testing sign off. The Contractor shall submit these checklists for review by the Owner or Construction Manager.
 - c. Contractor shall abide by OSHA requirements for lockout and tagout of equipment during functional testing.
 2. Prerequisites:
 - a. Engineer approval of Manufacturer's Certificate of Installation Verification.
 - b. Engineer approval of Functional Test Plan required prior to testing.
 - c. Draft Operations and Maintenance Manual as specified in Section 01_78_24 - Operations and Maintenance Manual.
 - d. Completed pipe, valve, and gate labeling of system or subsystem.
 - 1) As specified in Section 40_05_00.03 - Pipe Identification prior to the start of Functional Testing.
 3. Witnessed.
 4. Discipline checks:
 - 1) Physical safety checks.
 - 2) Electrical safety checks.
 - 1) Drainage, including sump pumps.
 - 1) Successful pressure and leakage testing as specified in Section 40_05_00.09 - Piping Systems Testing and the individual Technical Sections.
 - 1) Verify equipment/system protective devices and safety devices have been installed, calibrated, and tested.
 - 2) Remove rust preventatives and oils applied to protect equipment during construction and/or storage.
 - 3) Flush lubrication systems and properly dispose of flushing oils.
 - 4) Recharge lubrication system with lubricant recommended by manufacturer.
 - 5) Install and adjust packing, mechanical seals, O-rings, and other seals.
 - 6) Replace defective seals.
 - 7) Remove temporary supports, bracing, or other foreign objects installed to prevent damage during shipment, storage, and erection.
 - 8) Demonstrate proper rotation, alignment, speed, flow, pressure, vibration, sound level, adjustments, and calibration.
 - 9) Perform cold alignment and hot alignment to manufacturer's tolerances.
 - 10) Inspect hand and motorized valves for proper adjustment.
 - 11) Tighten packing glands to ensure no leakage but permit valve stems to rotate without galling.
 - 12) Verify valve seats are positioned for proper flow direction.
 - 13) Tighten leaking flanges or replace flange gasket.
 - 14) Inspect screwed joints for leakage.

- 15) Perform start-up sequencing of rotating equipment:
- 16) Include testing of alarms, interlocks, permissives, control circuits, capacities, speeds, flows, pressures, vibrations, sound levels, and other parameters.
 - 1) Inspect pipe supports.
 - 1) As specified in Section 26_08_50 - Field Electrical Acceptance Tests.
 - 2) As specified in Section 26_05_74 - Electrical System Studies.
 - 3) Electrical system is energized according to the Electrical Energization Plan and tested.
 - 4) Engineer approved Field Electrical Acceptance Tests and electrical system study draft reports required before energizing the electrical equipment.
- g. As specified in the individual Technical Sections.
5. Consecutive Day Test:
 - a. Operate the Work as specified in Attachment F - Functional Testing Requirements and as specified in the individual Technical Sections.
 - 1) Successful completion of subsystem testing required prior to system testing.
 - b. Failure response time:
 - 1) Be equipped and ready to provide emergency repairs, adjustments, and corrections to comply with the "Significant Interruption Duration" requirements as specified in Attachment F - Functional Testing Requirements.
 - c. Duration:
 - 1) As specified in Attachment F - Functional Testing Requirements.
 - 2) Restart the consecutive day test when the system performance failures exceed the "Significant Interruption Duration" time period specified in Attachment F - Functional Testing Requirements:
 - a) Individual equipment/system failures that are corrected within the "Significant Interruption Duration" time specified in Attachment F - Functional Testing Requirements shall not require the consecutive day test to be restarted unless the failure recurs.
 - b) Engineer has the authority to reject the consecutive day test if individual equipment/system failures are repetitive.
6. Instrumentation and controls tests.
 - a. Loop Validation Tests.
 - b. Complete End-to-End Testing (CEET):
 - 1) Signal are tested from the field device through the PLC program, the network, and all the way to the operator's HMI graphic screens.
7. Restore to condition prior to testing:
8. Submit Manufacturer's Certificate of Functional Compliance.
9. Engineer approval of Manufacturer's Certificate of Functional Compliance is required.
- E. Documentation:
 1. Provide records generated during Commissioning Phase of Project, including, but not limited to:
 - a. Training documentation.
 - b. Manufacturer's Certificate of Source Testing.
 - c. Manufacturer's Certificate of Installation Verification.

- d. Manufacturer's Certificate of Functionality Compliance.
 - e. Daily logs of equipment/system testing identifying tests conducted and outcome.
 - f. Test forms and documentation.
 - g. Functional Testing results.
 - h. Logs of time spent by manufacturer's representatives performing services on the job site.
 - i. Equipment lubrication records.
 - j. Electrical phase, voltage, and amperage measurements.
 - k. Insulation resistance measurements.
 - l. Bearing temperature measurements.
 - m. Data sheets of control loop testing, including testing and calibration of instrumentation devices and setpoints.
 - n. Provide: 1 electronic copy in format specified by Owner and 3 hard copies organized in notebooks.
 - o. Store the data within 24 hours of the test or document creation in the project system.
 - p. Due date: Within 14 calendar days of Substantial Completion.
2. Engineer approval of documentation is required.
- F. Owner Training:
- 1. Train Owner's staff on the operation and maintenance of the equipment/system.
 - 2. Train on each topic of the approved Operation and Maintenance Manual.
 - a. Include classroom instruction and field demonstration with all necessary tools and test equipment.
 - 3. Training tailored to the skills and job classifications of the staff attending the classes (e.g., maintenance technician, electrician, etc.).
 - 4. Training outcomes:
 - a. Owner's staff can safely operate, maintain, and repair the equipment/systems provided as recommended by the manufacturer.
 - 5. Training plan:
 - a. CC shall meet with Engineer and Owner's designated training coordinator to develop list of personnel to be trained and to establish expected training outcomes and objectives at least 30 calendar days prior to commissioning of equipment/system.
 - b. Coordinate and arrange for manufacturer's representatives to provide both classroom-based learning and field (hands-on) training, based on training module content and stated learning objectives.
 - c. Conduct classroom training at location designated by Owner.
 - d. Scope and sequence:
 - 1) Plan and schedule training in the correct sequence to provide prerequisite knowledge and skills to trainees.
 - a) Describe recommended procedures to check/test equipment/system following a corrective maintenance repair.
 - 2) If multiple classes are needed to meet the training objectives, they shall be included in the training plan.
 - 6. Owner Training Schedule:
 - a. Schedule Owner's staff training within the constraints of their workloads.
 - 1) Those who will participate in this training have existing full-time work assignments, and training is an additional assigned work task, therefore, scheduling is imperative.

- 2) Owner staff work schedules regularly shift, as treatment facilities are typically operated on an around-the-clock basis.
 - 3) Maximum training hours per week: 2.
 - 4) Days available for training:
 - a) Monday to Friday.
 - b. Training scheduling coordination:
 - 1) CC is responsible for the following:
 - a) Coordinate schedule for training periods with the Owner's personnel and manufacturer's representatives (instructors).
 - 2) Complete Owner Training no sooner than 15 calendar days prior to Functional Testing of each system.
 - c. Class logistics:
 - 1) Schedule specific sessions:
 - a) Minimum of 30 days in advance to allow Owner staffing arrangements to take place.
 - b) At the times requested by the Owner, within the period 7 a.m. to 7 p.m. Monday through Friday.
 - (1) Times scheduled will be at Owner's discretion.
 - c) Owner approval and confirmation required for session schedules.
7. Submittals:
- a. Submit Training Plan Schedule 30 calendar days before the first scheduled training session, including, but not limited to, lesson plans, participant materials, instructor's resumes, and training delivery schedules.
 - b. Submit training documentation, including the following:
 - 1) Training plan:
 - a) Training modules.
 - b) Scope and sequence statement.
 - c) Contact information for manufacturer's instructors. including name, phone, and e-mail address.
 - d) Instructor qualifications.
8. Lesson plans:
- a. Divide training into discrete modules appropriate for the equipment and trades.
 - b. State performance-based learning objectives in terms of what the trainees will be able to do at the end of the lesson.
 - c. Define student conditions of performance and criteria for evaluating instructional success.
 - d. Minimum requirements:
 - 1) Hands-on demonstrations planned for the instructions.
 - 2) Cross-reference training aids.
 - 3) Planned training strategies such as whiteboard work, instructor questions, and discussion points or other planned classroom or field strategies.
 - 4) Attach handouts cross-referenced by section or topic in the lesson plan.
 - 5) Indicate duration of outlined training segments.
 - e. Provide the following:
 - 1) Detailed component description:
 - a) Identify each component function and describe in detail.

- b) Identify equipment's mechanical, electrical, and electronic components and features.
 - c) Where applicable, group relative components into subsystems.
 - d) Identify and describe in detail equipment safety features, permissive and controls interlocks.
- 2) Equipment operation:
 - a) Describe equipment's operating (process) function and system theory.
 - b) Describe equipment's fundamental operating principles and dynamics.
 - c) Identify support equipment associated with the operation of subject equipment.
 - d) Detail the relationship of each piece of equipment or component to the subsystems, systems, and process.
 - e) Cite hazards associated with the operations, exposure to chemicals associated with the component, or the waste stream handled by the component.
 - f) Specify appropriate safety precautions, equipment, and procedures to eliminate, reduce, or overcome hazards.
- 3) Define Preventative Maintenance (PM) inspection procedures required on equipment in operation, spot potential trouble symptoms (anticipate breakdowns), and forecast maintenance requirements (predictive maintenance).
 - a) Review preventive maintenance frequency and task analysis table.
- 4) Define equipment Corrective Maintenance (CM) troubleshooting:
 - a) Describe recommended equipment preparation requirements as they relate to specific craft problems.
 - b) Identify and describe the use of any special tools required for maintenance of the equipment as they relate to specific craft problems.
 - c) Provide component specific troubleshooting checklists as they relate to specific craft problems.
 - d) Describe component removal/installation and disassembly/assembly procedures for specific craft repairs.
 - e) Perform at least 2 hands-on demonstrations of common corrective maintenance repairs.
- 5) Describe recommended measuring instruments and procedures, and provide instruction on interpreting alignment measurements, as appropriate.
- 9. Training instruction format:
 - a. Training for operations and maintenance personnel shall be provided as one entity.
 - b. Instructors shall apply adult education best practices, emphasizing learner participation and activity.
 - c. Lecturing should be less than 30 percent of class time.

- d. Training delivery may include problem solving, question/answer, hands-on instruction, practice, evaluation/feedback tools, and lecture to support training objectives.
 - 1) Contractor remains responsible for equipment disassembly or assembly during hands-on training situations involving equipment disassembly or assembly by Owner's personnel.
- 10. Training sessions:
 - a. Provide training sessions for equipment/system as specified in the individual equipment/system section.
 - b. Include the following information in the agenda:
 - 1) Instructor name.
 - 2) Listing of subjects to be discussed.
 - 3) Time estimated for each subject.
 - 4) Allocation of time for Owner staff to ask questions and discuss the subject matter.
 - 5) List of documentation to be used or provided to support training.
 - c. Owner may request that particular subjects be emphasized, and the agenda be adjusted to accommodate these requests.
 - d. Digitally record audio and video of each training session.
 - 1) Include classroom and field instruction with question and answering periods.
 - 2) Engineer approval required for producer of video materials from one of the following options:
 - a) Qualified, professional video production company or individual.
 - 3) Record in digital format and recording shall become property of the Owner with exclusive rights.
 - a) No video recording agreements will be entered into by the Owner.
 - 4) Media:
 - a) Video quality shall be 720p HD or greater in MPG, AVCHD, AVI, or MP4 format.
 - b) Identification: On each copy provide a label with the following information:
 - (1) Name of training.
 - (2) Date video was recorded.
 - c) Provide audio quality that is not degraded during the recording of the field sessions due to background noise, space, distance or other factors.
 - 5) Contractor shall provide a written release from all claims to the recorded training material produced, if required.
 - e. Distribute copies of the agenda to each student at the beginning of each training class.
 - f. Trainees will keep training materials and documentation after the session.
 - g. Distribute Training Evaluation Form following each training session.
 - 1) Training Evaluation Form is included in this Section.
 - 2) Return completed Training Evaluation Forms to Owner's designated training coordinator immediately after session is completed.
 - 3) Revise training sessions judged "Unsatisfactory" by a majority of attendees.
 - a) Conduct training sessions again until a satisfactory rating is achieved.
- 11. Engineer approval of Owner Training is required.

1.07 START-UP PHASE

- A. The start-up requirements below are intended to be a framework for the Contractor to create a more detailed, step by step, startup plan. The timeline and duration constraints shall be included in the Contractor's project schedule based on the Contractor's detailed start-up plan. Contractor shall provide a detailed startup schedule for approval by the Owner and Construction Manager as part of the startup plan.
- B. Overview of Start-Up Phase:
 - 1. General:
 - a. As part of startup of the SWPS and TWP Pipeline and Facilities, the Contractor must verify that Functional Testing of the following facilities has been performed. If Functional Testing is performed by Others, the Contractor shall verify basic functionality of each of these facilities and report any discrepancies to the Owner or Construction Manager.
 - 1) SWPS and associated components.
 - 2) County Line Road Pressure Sensor (by Others).
 - 3) Greeley No. 2 Return Flow Structure (by Others).
 - a) Contractor shall include 14 days total in the startup schedule for functional testing, by Others, of the Greeley No. 2 Return Flow Structure and Cache la Poudre River Return Flow Structure. The functional testing must occur after the pipeline is filled and flushed.
 - 4) Cache la Poudre River Return Flow Structure (by Others).
 - a) Contractor shall include 14 days total in the startup schedule for functional testing, by Others, of the Greeley No. 2 Return Flow Structure and Cache la Poudre River Return Flow Structure. The functional testing must occur after the pipeline is filled and flushed.
 - 5) Signal Hill Pressure Sensor.
 - a) Constructed by the same contractor that is constructing the Source Water Pump Station improvements. See the Contract Documents for the Chemical Building and PRV Vaults Project for functional testing requirements for these facilities.
 - 6) LCC PRV facility.
 - a) Constructed by the same contractor that is constructing the Source Water Pump Station improvements. See the Contract Documents for the Chemical Building and PRV Vaults Project for functional testing requirements for these facilities.
 - b) The LCC meter facility is currently in service and does not need functional testing verification.
 - 7) Segment A PRV and Meter and Chemical Building.
 - a) Constructed by the same contractor that is constructing the Source Water Pump Station improvements. See the Contract Documents for the Chemical Building and PRV Vaults Project for functional testing requirements for these facilities.
 - 8) Fiber optic communication and cellular backup communication is in place and functional between the SWPS, WBWTP, two Return Flow Structures, Signal Hill Pressure Sensor, County Line Road Pressure

- Sensor, LCC PRV and Meter facility, Segment A PRV and Meter, and Chemical Building (by Others).
- 9) Verifying functionality of 8 high capacity blowoffs. Operate isolation valves to fully open, run blowoff for 10 minutes, and fully close the valve at each location.
 - a) Pipeline Segment F.2 – Box Elder Creek location.
 - b) Pipeline Segment E – Timnath Reservoir Outlet.
 - c) Pipeline Segment C North – Big Thompson River.
 - d) Pipeline Segment D Johnstown – Little Thompson River.
 - e) Pipeline Segment C South – Diamond Reservoir Inlet.
 - f) Pipeline Segment B – St. Vrain Creek.
 - g) Pipeline Segment B – Little Dry Creek.
 - h) Pipeline Segment B – Big Dry Creek.
 - 10) Verifying functionality of 378 air valves along the 70-mile pipeline.
 - a) Valves are in pairs in 189 vaults. Contractor to verify isolation valves for each air valve are in the open position before pipeline filling commences. Contractor to also verify that air is evacuated during pipeline filling and flushing activities and that valves are seated properly. Contractor is required to verify this visually and in person at each location.
 - b. Contractor shall comply with all OSHA lockout and tagout procedures of electrical and other equipment as part of commissioning activities.

C. Start-Up Period:

1. Contractor responsibilities:
 - a. Contractor shall provide start-up of the SWPS, the TWP pipeline, and the TWP facilities described above.
 - b. Contractor shall pay for power used for all startup and commissioning activities. Contractor shall pay for all power costs until Initial Acceptance.
 - 1) PVREA will be the electrical power utility for the SWPS. PVREA rates for Large Power Primary Meter for 2026 are as follows:
 - a) Facility Charge - \$250.
 - b) Demand Charge/kW - \$21.19.
 - c) Power Cost Adjustment – Demand Charge/kW - \$1.00.
 - d) Energy Charge/kWh - \$0.04995.
 - 2) It is anticipated that the Contractor will work weekends during startup to maximize number of testing days within the time window.
 - c. Contractor shall notify Owner a minimum of 60 days before commencing start-up activities.
 - d. Contractor shall notify Owner a minimum of 60 days before accessing each of the TWP facilities and air valve vaults.
2. Owner responsibilities:
 - a. Witness the operation of the Work.
 - b. Operate the East Gravel Lakes Pump Station as part of filling and flushing the pipeline from the WBWTP to the LCC PRV and Meter.
 - c. Operate the SCADA system.
3. Prerequisites:
 - a. Engineer, Owner, and Construction Manager approval of Testing and Training Phase.

4. Duration and critical dates:
 - a. See table below.
 - b. The Contractor must complete the startup activities described below within the time periods and dates listed.
 5. Engineer approval of Start-Up Period is required to achieve substantial completion.
- D. Sequence of start-up activities and start-up constraints.
1. Verify functional testing of SWPS equipment and TWP facilities listed previously is complete, with the exception of items that require the TWP pipeline to be full. Provide functional testing as expeditiously as possible for those items once the pipeline is full.
 2. Fill the pipeline from the Wes Brown Water Treatment Plant (WBWTP), using East Gravel Lakes as the water source, to the LCC PRV and Meter.
 - a. Owner staff shall operate East Gravel Lakes Pump Station to fill the pipeline from the WBWTP to the LCC PRV and Meter.
 3. Flush the pipeline from WBWTP to the LCC PRV and Meter and treat the flushing water.
 - a. Owner staff shall operate East Gravel Lakes Pump Station to flush the pipeline from the WBWTP to the LCC PRV and Meter.
 - 1) Flushing of this section of pipe is preferred to occur between December and March.
 - 2) The East Gravel Lakes Pump Station can only be used to pump flushing water for 2 days if flushing occurs outside of the December to March timeframe.
 - b. The Contractor shall treat the water to be within the 6.5 to 9.0 s.u. limits of the CDPHE discharge permit.
 - 1) Contractor shall assume that water in the pipeline has an initial pH of 12.
 - 2) East Gravel Lakes water pH ranges from 7.86-9.31 s.u.
 - 3) Flushing is considered complete when no treatment is needed to keep the water within the permit limits, including any pH requirements.
 4. Fill the pipeline from the SWPS, using WSSC Reservoir No.3 as the water source, to the LCC PRV and Meter.
 - a. Filling the pipeline shall be accomplished using one of the 600-hp SWPS pumps, and shall be performed at a maximum flow rate of 2.6 mgd.
 5. Flush the pipeline from the SWPS to the LCC PRV and Meter and treat the flushing water.
 - a. The Contractor shall treat the water to be within the 6.5 to 9.0 s.u. limits of the CDPHE discharge permit.
 - 1) Contractor shall assume that water in the pipeline has an initial pH of 12.
 - 2) WSSC No. 3 water pH ranges from 8.19-9.06 s.u.
 - 3) WSSC No. 3 water alkalinity ranges from 58.5-98.6 mg/l.
 - 4) Flushing is considered complete when no treatment is needed to keep the water within the permit limits, including any pH requirements.
 6. After flushing is complete, Contractor is still responsible to maintain pH within the 6.5 to 9.0 s.u. limits for the duration of startup up until water is flowing to the WBWTP.

7. Accommodate 14-day functional test of the Return Flow Structures by Others after filling and flushing activities are completed.
 - a. Greeley No. 2 Return Flow Structure can only discharge flows during the April to October ditch season.
8. Test 8 high volume blowoff valves
 - a. Operate isolation valves to fully open, run for 10 minutes, and fully close the valve at each location. This testing may occur at any time after filling and flushing of the pipeline is completed.
9. Provide testing as described in the table below from the SWPS to the LCC PRV and Meter structure, which discharges to the Owner's Cooley Reservoir.
 - a. Utilize automated programming mode Lower Clear Creek to Cooley Diversion Auto Mode (see Section 40_61_16.10 - Specific Control Strategies for details).
 - 1) Loop testing and tuning of this mode to be performed by Owner's Programmer.
 - b. Test automated programming mode Return Flows Only Auto Mode (see Section 40_61_16.10 - Specific Control Strategies for details).
 - 1) Loop testing and tuning of this mode to be performed by Owner's Programmer.
 - c. PVREA requires that the 3,000 hp pumps be started no more than 3 times per day.
10. Contractor shall transition directly from testing flows from SWPS to the LCC PRV and Meter structure to testing flows from SWPS to the WBWTP, with no days in between unless approved by the Construction Manager and Owner.
11. Provide testing as described in the table below from the SWPS to the WBWTP.
 - a. Utilize automated programming mode WBWTP Flow Control Auto Mode (see Section 40_61_16.10 - Specific Control Strategies for details).
 - 1) Loop testing and tuning of this mode to be performed by Owner's Programmer.
 - 2) Include testing of full range of flows to each of the Return Flow Structures that is part of this operational mode.
 - b. PVREA requires that the 3,000 hp pumps be started no more than 3 times per day.
 - c. Flow parameters may be changed at Owner's discretion based on actual WBWTP flows needed to provide potable water to City of Thornton customers.
 - d. During this testing phase, the SWPS will be operating outside of normal start-up hours to maintain consistent water quality to the City of Thornton potable water distribution system. In the event of an unplanned shutdown of the SWPS during this time, Contractor shall provide a minimum response time of 30 minutes to be onsite at the SWPS by qualified Contractor personnel, with the intention to restore the SWPS to service.
 - 1) Contractor to provide resumes to the Owner for approval of Contractor staff who will be considered "qualified personnel", that would be able to troubleshoot and get SWPS restarted.
 - 2) City of Thornton staff will provide notification to the contractor to initiate unplanned shutdown response.
 - 3) Contractor shall provide verification to City of Thornton staff that SWPS is operational before restarting or after an alarm or failure.

1.08 START-UP TESTING CRITERIA TABLE

Testing Criteria	Requirements
Earliest start date	May 8, 2028
Latest completion date	September 15, 2028
	Testing from the SWPS to WBWTP can only occur between June 1, 2028 and September 15, 2028.
Latest completion date of 7-day test following startup	September 22, 2028
Maximum flow step increase during testing	0.5 mgd per hour
Criteria before moving on to next flow rate	Demonstrate stability at flow rate (within 1% of selected flow rate) for 45 minutes before moving to next flow rate
Testing from SWPS to LCC	Test at a minimum from 3.5 mgd up to 14.8 mgd and from 14.8 mgd down to 3.5 mgd
	Test pump transitions from small to large pump 3 times going up in flow rate, and from large to small pump 3 times going down in flow rate
Testing from SWPS to LCC - Failure modes	Test failure of pump station due to alarms of power loss, loss of communication, and loss of Signal Hill pressure sensor communication
	Test at low flow and high flow for each pump envelope (3.5 mgd and approximately 9 mgd for each small pump, and approximately 7 mgd to 14.8 mgd for each large pump)
	Test each pump for each failure mode separately (total of 6 failure mode tests per pump, test all 4 pumps).
	Only test one failure per day.
Failure mode restart flow step during testing	Restart at minimum pump flow of 3.5 mgd, can increase flow at 2.5 mgd increment every 15 minutes before returning to previous flow rate.
Testing from SWPS to WBWTP	Test at a minimum from 3.5 mgd up to 14.8 mgd and from 14.8 mgd down to 3.5 mgd
	Test pump transitions from small to large pump 3 times going up in flow rate, and from large to small pump 3 times going down in flow rate
	For flows from the SWPS to WBWTP, startup testing hours are between 7 a.m. to 4 p.m. The last startup flow rate change can happen no later than 3 p.m.
Testing from SWPS to WBWTP - Failure modes	Test failure of pump station due to alarms of power loss, loss of communication, and loss of Signal Hill pressure sensor communication
	Test at low flow and high flow for each pump envelope (3.5 mgd and approximately 9 mgd for each small pump, and approximately 7 mgd to 14.8 mgd for each large pump)
	Test each pump for each failure mode separately (total of 6 failure mode tests per pump, test all 4 pumps).
	Only test one failure per day.

Failure mode restart flow step during testing	Restart at minimum pump flow of 3.5 mgd, can increase flow at 2.5 mgd increment every 15 minutes before returning to previous flow rate.
Testing Return Flow Structures	Test each structure from 3.5 mgd to 7.0 mgd flow rate, and combined flow rates of 4.0 mgd to 7.0 mgd with each structure being tested in 0.5 mgd increments.
	Flow step of 0.5 mgd per hour.
	Test each structure individually and both structures combined in Return Flows Only Auto Mode and WBWTP Flow Control Auto Mode.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION (NOT USED)

END OF SECTION

ATTACHMENT A- MANUFACTURER’S CERTIFICATE OF SOURCE TESTING

MANUFACTURER'S CERTIFICATE OF SOURCE TESTING

OWNER _____ EQPT/SYSTEM _____
PROJECT NAME _____ EQPT TAG NO. _____
PROJECT NO. _____ EQPT SERIAL NO. _____
SPECIFICATION NO. _____
SPECIFICATION TITLE _____

Comments: _____

I hereby certify Source Testing has been performed on the above-referenced equipment/system as defined in the Contract, and results conform to the Contract Document requirements. Testing data is attached.

Date of Execution: _____, 20 _____

Manufacturer: _____

Manufacturer's Authorized Representative Name (*print*): _____

(Authorized Signature)

If applicable, Witness Name (*print*): _____

(Witness Signature)

ATTACHMENT B - MANUFACTURER’S CERTIFICATE OF INSTALLATION VERIFICATION

MANUFACTURER'S CERTIFICATE OF INSTALLATION VERIFICATION

OWNER _____ EQPT/SYSTEM _____
PROJECT NAME _____ EQPT TAG NO. _____
PROJECT NO. _____ EQPT SERIAL NO. _____
SPECIFICATION NO. _____
SPECIFICATION TITLE _____

I hereby certify the installation of the above-referenced equipment/system as defined in the Contract Documents.

NOTES:

1. Attach written certification report prepared by and signed by the electrical and/or instrumentation subcontractor.

Comments: _____

I, the undersigned manufacturer's representative, hereby certify that I am (i) a duly authorized representative of the manufacturer, (ii) empowered by the manufacturer to inspect, approve, and operate this equipment/system, and (iii) authorized to make recommendations required to ensure that the equipment/system furnished by the manufacturer is complete and operational, except as may be otherwise indicated herein. I further certify that all information contained herein is true and accurate.

Date: _____

Manufacturer: _____

Manufacturer's Authorized Representative Name (*print*): _____

By Manufacturer's Authorized Representative: _____
(Authorized Signature)

ATTACHMENT C - MANUFACTURER’S CERTIFICATE OF FUNCTIONAL COMPLIANCE

MANUFACTURER'S CERTIFICATE OF FUNCTIONAL COMPLIANCE

OWNER _____ EQPT/SYSTEM _____
PROJECT NAME _____ EQPT TAG NO. _____
PROJECT NO. _____ EQPT SERIAL NO. _____
SPECIFICATION NO. _____
SPECIFICATION TITLE _____

I hereby certify the Functional Testing of the above-referenced equipment/system as defined in the Contract Documents.

NOTES:

1. Attach test results with collected data and test report.
2. Attach written certification report prepared by and signed by the electrical and/or instrumentation subcontractor.

Comments: _____

I, the undersigned manufacturer's representative, hereby certify that I am (i) a duly authorized representative of the manufacturer, (ii) empowered by the manufacturer to inspect, approve, and operate this equipment/system, and (iii) authorized to make recommendations required to ensure that the equipment/system furnished by the manufacturer is complete and operational, except as may be otherwise indicated herein. I further certify that all information contained herein is true and accurate.

Date: _____

Manufacturer: _____

Manufacturer's Authorized Representative Name (*print*): _____

By Manufacturer's Authorized Representative: _____
(Authorized Signature)

WITNESSES:

By Owner's Authorized Representative: _____
(Authorized Signature)

By Engineer's Authorized Representative: _____
(Authorized Signature)

ATTACHMENT D - TRAINING EVALUATION FORM

TRAINING EVALUATION FORM

EQUIPMENT/SYSTEM ITEM: _____

VENDOR/MANUFACTURER: _____

DATE: _____ NAME OF REPRESENTATIVE: _____

1. Was representative prepared?	Acceptable	Unacceptable	or	N/A
2. Was an overview description presented?	Acceptable	Unacceptable	or	N/A
3. Were specific details presented for system components?	Acceptable	Unacceptable	or	N/A
4. Were alarm and shutdown conditions clearly presented?	Acceptable	Unacceptable	or	N/A
5. Were step-by-step procedures for starting, stopping, and troubleshooting presented?	Acceptable	Unacceptable	or	N/A
6. Were routine/preventative maintenance items clearly identified?	Acceptable	Unacceptable	or	N/A
7. Was the lubrication schedule (if any) discussed?	Acceptable	Unacceptable	or	N/A
8. Was the representative able to answer all questions?	Acceptable	Unacceptable	or	N/A
9. Did the representative agree to research and answer unanswered questions?	Acceptable	Unacceptable	or	N/A

10. Comments: _____

11. Overall Rating	Satisfactory	Unsatisfactory

Note:

Sessions judged "Unsatisfactory" by a majority of attendees shall be revised and conducted again until a satisfactory rating is achieved.

ATTACHMENT E- COMMISSIONING ROLES AND RESPONSIBILITIES MATRIX

COMMISSIONING ROLES AND RESPONSIBILITIES MATRIX

NO.	TASK	OWNER	CONTRACTOR	ENGINEER
Testing and Training Phase				
Source Testing				
	Source Testing	Witnessed as specified in the Technical Sections.	Lead	Witnessed as specified in the Technical Sections. Review
	Manufacturer's Certificate of Source Testing	No Action	Lead	Review
Installation Verification				
	Structural Anchorage Check	Witness	Lead	Review
	Health and Safety Check	Witness	Lead	Review
	Manufacturer Requirements Verification	No Action	Lead	Review
	Contract Documents Verification	No Action	Lead	Review
	Manufacturer's Certificate of Installation Verification	No Action	Lead	Review
Functional Testing				
	Checks	Witness	Lead	Witness, Review
	Tests	Witness	Lead	Witness, Review
	Manufacturer's Certificate of Functional Compliance	No Action	Lead	Witness, Review
System Testing				
	System Testing	Witness	Lead	Witness, Review
Start-Up Phase				
	Start-Up	Witness	Lead	Witness, Review
Legend: Lead: Primarily responsible for organization, coordination, and execution of task work product or result. Support: Assist the lead with organization, coordination, and execution of task work product or result. Witness: Observe and document completion of task work product or result. No Action: Limited or no involvement. Review: Approve for compliance with Contract Documents or reject.				

ATTACHMENT F - FUNCTIONAL TESTING REQUIREMENTS

FUNCTIONAL TESTING REQUIREMENTS

System	Subsystem	Consecutive Day Test Duration (Days)	Significant Interruption Duration (Hours)	Test Liquid	System Operated By
Source Water Pump Station (Flows from SWPS to BWTP only)		7	2	Raw Water	Contractor
	Pumps	N/A	N/A	Raw Water	Contractor
	Variable Frequency Drives	N/A	N/A	Raw Water	Contractor
	Intake Structures and Gates	N/A	N/A	Raw Water	Contractor
	Surge Tanks	N/A	N/A	Raw Water	Contractor
	Instruments	N/A	N/A	Raw Water	Contractor
	Motorized Actuated Valves	N/A	N/A	Raw Water	Contractor

A. Schedule delays:

1. Changes in the dates for Source Testing less than 30 days of the date provided in the latest approved Commissioning Schedule are considered delays.
2. Contractor is responsible for associated costs resulting from delays:
 - a. In person and/or virtual witnessing.
 - b. Travel costs and witness labor costs.
 - 1) Witness labor costs at \$300 per hour.

B. Repeat test costs:

1. Contractor is responsible for associated costs for repeat testing:
 - a. In person and/or virtual witnessing.
 - b. Travel costs and witness labor costs.
 - 1) Witness labor costs at \$300 per hour.

SECTION 01_75_19

WATER LEAKAGE TEST FOR CONCRETE STRUCTURES

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Hydrostatic leakage test for concrete water-holding structures.

1.02 TERMINOLOGY

- A. The words and terms listed below are not defined terms that require initial capital letters, but, when used in this Section, have the indicated meaning.
 - 1. Containment structure, lined: Liquid-containing structure with barrier coating or membrane applied to the inside surfaces to prevent leaking of contents to the outside.
 - 2. Containment structure, unlined: Liquid containing structure where only the concrete structure itself is used to prevent leaking of contents to the outside.
 - 3. Damp spots: Surfaces where visible moisture can be picked up by a dry hand.

1.03 ADMINISTRATIVE REQUIREMENTS

- A. Coordination.
- B. Pre-installation meetings.
- C. Sequencing.
- D. Scheduling.

1.04 SUBMITTALS

- A. Product data.
- B. Shop Drawings:
 - 1. Description and details of each evaporation/precipitation-measuring device anticipated for use during the test.
- C. Samples.
- D. Certificates.
- E. Delegated Design Submittals.
- F. Tests and evaluation reports:
 - 1. Results of water leakage test for each structure and for each portion of a structure designated for testing.

- G. Manufacturer instructions.
- H. Source quality control Submittals.
- I. Field/site quality control Submittals.
- J. Manufacturer reports.
- K. Sustainable design Submittals.
- L. Special procedure Submittals:
 - 1. Testing plan for each structure, or portion thereof, required to be tested.
 - a. Describe methods of obtaining water for testing and of releasing water for disposal, including provisions for dechlorination if required.
 - b. Include plans showing locations where measurements will be made and locations of evaporation/precipitation-measuring device.
 - c. Indicate plans for filling and draining structure(s).
 - d. Include schedule showing duration of test for each structure or cell to be tested, date and time for start of each test, dates and times of observations and measurements during the test, dates and times for closeout of testing procedures, and date for submittal of final results.
 - 2. Proposed procedures and products for repair of leaks.
- M. Qualifications statements.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 GENERAL

- A. Test structures and portions of structures listed in the following paragraphs for water leakage.
 - 1. Unless otherwise specified:
 - a. Obtain required permits for discharging testing water.
 - b. Provide dechlorination of such water if required by the permits.
 - c. Prepare and fill the structures.
 - d. Provide access and equipment required for testing and for recording test results.
 - e. Take measurements and make observations required for testing.
 - 2. At all times during testing, the Engineer shall have access to observe measurements by others or to make independent measurements.
- B. Test the following concrete structures for water leakage:
 - 1. Pump Station Wet Well.

- C. Required preparation for testing is designated in this Section. Waiver of, or failure to complete preparations shall not change the testing criteria or approval criteria for the areas tested.
- D. Retest structures and portions of structures until the evaluation criteria are satisfied.

3.02 TEST WATER SOURCE AND DISPOSAL

- A. Water used for filling of the structures to be tested:
 - 1. Obtain water for leakage testing from nearby WSSC Reservoir No. 3.
- B. After leakage testing is complete, Contractor shall dispose of water by returning it to the reservoir.

3.03 PREPARATION

- A. For each structure to be tested, prepare and submit a plan showing schedule and sequence of activities, method of filling, and methods of disposing of test water.
- B. Sequencing requirements:
 - 1. Complete construction of concrete structure and cure concrete to obtain minimum specified 28-day compressive strength as specified in Section 03_30_00 - Cast-in-Place Concrete.
 - a. Do not begin tests until all portions of the wet well structure are complete and have reached their minimum specified 28-day compressive strength.
 - 1) The wet well top slab must be in place before performing the test.
 - b. Do not begin tests until at least 14 days have passed since completion of the last concrete placement.
 - 2. Complete tests before:
 - a. Covering any surface of the structure with materials that might mask the location of leaks or obscure damp concrete surfaces. Such coverings include, but are not limited to, basin bottom grout, masonry veneer, stucco, plaster, and other coatings.
 - b. Installation of equipment, unless otherwise approved by the Engineer.
 - c. Backfilling structures.
 - 3. Liners and coatings:
 - a. Unless otherwise specified, do not install surface-applied protective or decorative coatings and linings until leakage tests have been completed.
- C. Weather requirements:
 - 1. Tests on structures with tops open to the atmosphere shall not be scheduled for periods when the 10-day weather forecast indicates a substantial change in weather patterns.
 - 2. Measurements of water surface levels in the structure shall not be scheduled for periods when the weather forecast indicates a difference of more than 35 degrees Fahrenheit between the ambient temperature readings at the times of initial and final measurements.
 - 3. Tests shall not be scheduled for periods when the 10-day weather forecast indicates that the water surface may freeze before the test is complete.

- D. Clean interior of structure:
 - 1. Remove dirt, contaminants, and construction debris.
 - 2. Flush floors and sumps to provide clean surfaces.
 - 3. Remove standing water that would interfere with examination of surfaces, cracks, or joints.
- E. Observe the structure, or portions of the structure being tested, for potential leak locations:
 - 1. Give particular attention to cracks, open joints, voids, and honeycombed and repaired surfaces.
 - 2. Visually observe openings, fitting, and pipe penetrations in the structure at both faces, if possible.
 - 3. Repair potential leak locations in accordance with these Specifications and as approved by the Engineer.
 - 4. Backfill excavations to the top of the structure foundation. Do not place backfill against water-bearing walls or over footings unless approved in advance by the Engineer.
 - a. If requesting backfilling of walls before testing, include a description of methods that will be used to detect leakage in the backfilled areas.
 - b. Engineer's approval of backfilling before testing shall not relieve the Contractor of the responsibility to conduct leakage tests, to satisfy the leakage acceptance criteria for the structure, or to repair leaking portions of the structure, including those portions below or behind the backfill.
 - 5. See Drawings and Section 31_00_00 - Earthwork for requirements to provide wall stability before backfilling.
- F. Inlets to/outlets from the structure:
 - 1. Make inlets to and outlets from the structure watertight.
 - a. Include valves; stop, sluice, and slide gates; and temporary bulkheads as required.
 - b. Inlets and outlets not required to be operable may be temporarily sealed before testing of the compartments to which they open.
 - c. Secure inlets used to fill the structure for testing to ensure that no water is entering or leaving the structure once it has been filled to the test level.
 - 2. Adjustments to measured leakage at inlets and outlets based on the manufacturer's or Contractor's estimates will not be allowed.
 - a. May be permitted by the Engineer, and, at his/her discretion, only when the Contractor makes specific measurements of leakage at each individual inlet and outlet using methods approved by the Engineer.

3.04 HYDROSTATIC LEAKAGE TEST FOR OPEN OR COVERED CONTAINMENT STRUCTURES ("HST-100")

- A. Isolate sections of water-holding structures that can be isolated in actual operation. Fill and test sections for leakage separately.
 - 1. Fill structures and sections of structures scheduled for testing to the normal operating water level indicated on the Hydraulic Profile indicated on the Drawings.
- B. Initial rate for filling of structures shall not exceed 4 feet per hour.

- C. HST-100 testing includes 2 parts, "Qualitative Testing," and "Quantitative Testing," as described in the following paragraphs:
1. HST-100, Part 1 - Qualitative Testing:
 - a. During the first 24 hours after structures are filled, examine exposed concrete surfaces for damp spots or flowing water.
 - 1) Make observations in early morning, at midday, and in late afternoon.
 - 2) Continue observations through the duration of the Quantitative Testing period.
 - 3) Pay particular attention to conditions at joints, honeycombed areas, cracks, and repaired portions of the structure.
 - b. Evaluation criteria:
 - 1) Structure shall be considered to have failed these Qualitative Testing requirements if any of the following conditions are observed.
 - a) Water droplets or moist areas on an outside surface that could only have originated inside the structure.
 - b) Water is flowing or seeping from joints, cracks, or surfaces.
 - (1) Exception: Dampness or wetness on top of a footing, in the absence of flowing water, shall not be considered as failure to meet this criterion.
 - c) Moisture can be transferred to a dry hand from the outside surfaces of the filled area.
 - c. Repairs and retesting:
 - 1) Where damp spots or flowing water as described in the preceding paragraphs are observed, mark locations, provide repairs, and retest the structure as specified in subsequent paragraphs.
 2. HST-100 - Part 2: Quantitative Testing:
 - a. If approved by the Engineer, Quantitative Testing may begin before repairs are made to areas failing Part 1 of this test; however:
 - 1) Adjustments to volume loss calculations of Quantitative Testing based on observed leakage will not be permitted.
 - 2) Defects identified for repair during Qualitative Testing shall be repaired to the satisfaction of the Engineer before approval of the structure.
 - b. Report the results of quantitative testing.
 - 1) Submit completed Attachment A - Leakage Test Report or at a minimum, include the information specified in Attachment A - Leakage Test Report.
 - c. Unlined concrete structures:
 - 1) Fill to the designated water surface elevation. Maintain that level for at least 72 hours before recording initial water levels for leakage test.
 - 2) Duration of test:
 - a) Theoretical time required to lower the water surface in the structure by 3/8 inch when leakage is occurring at the maximum allowable rate specified in subsequent paragraphs of this Section.

- b) Duration ("D") of the test in days is determined by the following equation:

$$D = \frac{0.375 \text{ inches}}{(0.0005 \text{ in/in/day} \times H \text{ ft} \times 12 \text{ in/ft})}$$

Where: H = maximum liquid depth

- (1) Round results upward to the next full 24-hour period (day).
 - (2) Minimum duration of test: 24 hours (1 day).
 - (3) Maximum duration of test: 120 hours (5 days).
- d. Measurements: Water level:
- 1) Record water levels at 24-hour intervals for the full duration of the test period.
 - 2) Measure water levels at not less than 2 locations on opposite ends of the structure and preferably at 4 locations spaced equally around the structure. Mark locations on the structure and take measurements at the same locations throughout the duration of the test.
 - 3) Measure, to an accuracy of 1/16 inch, the vertical distance to the water surface from a fixed point on the structure above.
- e. Measurements: Temperatures:
- 1) As part of the first and last sets of level measurements, record water temperature at a depth of 18 inches below the water surface. Measure temperature at the same locations where level measurements are taken.
 - 2) Record ambient temperature at the time of each water level measurement.
- f. Measurements: Evaporation and precipitation:
- 1) Measure evaporation and precipitation by floating pans inside the structures during testing.
 - a) For uncovered structures, measure both evaporation and precipitation.
 - b) For covered structures that are well ventilated, measure evaporation.
 - 2) Measure using specially constructed clear containers:
 - a) Provide clear plastic, calibrated, open-top containers not less than 18 inches in diameter and 18-inches deep.
 - b) Partially fill containers with water and float inside the structure. Make provisions to hold containers in place at each measurement location, but away from structure walls and items passing overhead, such as beams or pipes.
 - c) Measure initial depth of water in each device. Measure changes in water level in each device at the same time measurements of the water level inside the structure are taken.

- g. Restart of test:
 - 1) Engineer may order a restart of the test when, in the Engineer's opinion, measurements have become unreliable due to unusual precipitation or other factors.
 - 2) If measurements or observed leakage during the testing period indicate that the allowable leakage requirements will be exceeded, the test may be terminated before completion of the full test period. Take appropriate actions to correct problems before restarting the test.
- h. Calculations of leakage test results:
 - 1) For each section of the structure tested, use water surface level records to calculate average loss of volume per 24-hour interval.
 - a) For each 24-hour interval during the test, calculate the average of all measured drops in water level around the structure.
 - b) Use the average drop thus determined to calculate an average loss of volume for each 24-hour interval.
 - 2) Adjustments to leakage calculations:
 - a) For uncovered basins, calculations shall be corrected for precipitation added to the structure.
 - b) Calculations may be corrected for evaporation and water temperature.
- i. Evaluation criteria:
 - 1) Unless otherwise specified, the average loss of volume during any 24-hour interval shall not exceed the limits shown in Table A.

Table A - Loss of Volume Criteria for Leakage Tests	
Structure Type	Maximum Loss of Water Volume
Wet Well	0.050 percent of volume per 24-hour period.

- j. Repairs and retesting:
 - 1) Structures and portions of structures that have satisfied the qualitative requirements of HST-100 but have failed to satisfy the quantitative requirements of HST-100 may be immediately retested for volume loss.
 - a) If the structure fails the second test for volume loss, the structure shall be drained and the Contractor shall observe the interior for probable areas of leakage.
 - b) Structure shall not be retested until repairs to the probable areas of leakage are complete.

3.05 REPAIRS FOR RETESTING

- A. Locations showing damp spots or flowing water:
 - 1. Mark locations of visible leaks and damp spots.
 - 2. Drain structures for repair.
 - 3. Repair defects causing damp spots and flowing water using methods specified in Section 03_30_00 - Cast-in-Place Concrete and approved by the Engineer.
 - a. Repair both interior and exterior surfaces and make structures watertight.
 - b. Submit proposed repair products and procedures for Engineer's review.
 - c. Refill structures for retesting.
 - 4. Repeat filling, observations, and repairs until no leaks or damp spots appear.

- B. Structures for which water volume loss exceeds the limits specified after adjustments for evaporation, and precipitation:
1. Determine cause of volume loss.
 2. Drain structures of water.
 3. Repair defects causing loss of water volume using methods specified in Section 03_30_00 - Cast-in-Place Concrete and approved by the Engineer.
 - a. Submit proposed repair products and procedures for Engineer's review.
 4. Refill water-holding structures.
 5. Repeat testing and repairs until volume loss does not exceed specified limits.

END OF SECTION

ATTACHMENT A - LEAKAGE TEST REPORT

LEAKAGE TEST REPORT

PROJECT: _____			SUBMITTED BY: _____				
STRUCTURE: _____			WITNESSED BY: _____				
AREA: _____			TEST DATES: _____				
TEST DURATION: _____			TEST DURATION: _____				

Surface area of structure tested: _____	(square feet)
Volume of structure tested: _____	(cubic feet)
Volume of structure tested: _____	(gallons)
Measured loss through gates, etc.: _____	(gallons / day)
Allowable loss of water volume: _____	(per day)
Allowable loss of water volume: _____	(% in 24 hours)
Allowable measured loss over test duration (inches): _____	
Measured loss of water: _____	(gallons / day - From E below)
Measured loss of water volume (%): _____	(in 24 hours - From E below)

Water Temperature:		Start of test: _____ °F		End of test: _____ °F	

			Water Surface Elevation (top of structure to top of water)				
			Location #1	Location #2	Location #3	Location #4	Initials**
Day	Date	Time	(inches)	(inches)	(inches)	(inches)	
1							
2							
3							
4							
5							
Changes in Level:							

A. Average change in level (feet): _____	(Average of total charges for all locations)
B. Correction for precipitation: _____	(Measured from pan)
C. Correction for evaporation: _____	(Measured from pan)
D. Corrected change in level (CL): _____	
E. Total days tested: _____	
F. Average measured % water loss in 24 hours: _____	$= \frac{(\text{CL}) \times (\text{surface area}) \times 100}{(\text{initial water volume}) \times (\text{number of test days})}$

Notes and field observations**

**Place date and initials at the beginning of each entry.

Water Leakage Test for Concrete Structures

01_75_19-10

203505

CO/Thornton/203505-100000/04 Design/04 Specs/Carollo/SWPS/01_75_19 (IFB2)

Thornton Water Project (12-777XP)

Source Water Pump Station

May 2026

SECTION 01_78_24

OPERATION AND MAINTENANCE MANUALS

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Preparation and submittal of manual with requirements to operate and maintain the equipment.

1.02 ADMINISTRATIVE REQUIREMENTS

- A. Sequencing:
 - 1. Submit draft operation and maintenance manuals prior to shipment of the equipment to the Site.
 - 2. Submit approved operation and maintenance manuals at least 30 days prior to Functional Testing and at least 60 days prior to Owner Training.
 - 3. Make final operation and maintenance manuals available at the Site for use by construction personnel.

1.03 SUBMITTALS

- A. Furnish Submittals as specified in Section 01_33_00 - Submittal Procedures and the Technical Sections.
- B. Draft operation and maintenance manuals:
 - 1. Quantity:
 - a. Electronic copy in portable document format (PDF) format.
- C. Final operation and maintenance manuals:
 - 1. Revised in accordance with the Owner's and Engineer's comments on the draft operation and maintenance manuals, and to include Functional Testing results and certificates.
 - 2. Quantity:
 - a. Electronic copy in PDF format.
- D. Spare parts list:
 - 1. Provide a consolidated spare part list required in accordance with the Technical Specifications.
 - 2. Engineer and Owner to review list prior to the Contractor's procurement of spare parts.
- E. Project operation and maintenance manual list: An Excel file log of manuals to be provided on the Project for tracking and review by the Owner and Engineer.

1.04 PREPARATION

- A. General requirements:
 - 1. Provide dimensions in English units.
 - 2. Assemble material, where possible, in the same order within each volume.
 - 3. Complete forms on computer; handwriting is not acceptable.
 - 4. Delete items or clearly mark out options not provided in the supplied equipment.
 - 5. Cover page shall include the following information:
 - a. Operation and maintenance manual.
 - b. Equipment name.
 - c. Specification Section number.
 - d. Equipment tag number s.
 - e. Owner's name.
 - f. Project number and name.
 - g. Date.
- B. Electronic requirements:
 - 1. File format:
 - a. Entire manual in PDF.
 - 1) Include text and drawing information.
 - 2) Provide a single PDF file.
 - 3) Create PDF from the native format of the document (Microsoft Word, graphics programs, drawing programs, etc.).
 - a) Scanned images are not acceptable.
 - b) At file opening, display the entire cover page.
 - 4) Pagination and appearance to match hard copy.
 - 5) Ensure that page numbers are included on every page of the document.
 - 6) Text searchable throughout the entire document, including drawings.
 - 7) Bookmarks: As specified in Section 01_33_00 - Submittal Procedures.
 - 8) Thumbnails optimized for fast web viewing.
 - b. Drawing requirements:
 - 1) Provide electronic file with drawings in most current version of AutoCAD format.
 - 2) White background.
 - 3) Shapes shall not degrade when closely zoomed.
 - 4) Screening effects intended to de-emphasize detail in a drawing must be preserved.
 - 2. Label media with the following information:
 - a. Operation and maintenance manual.
 - b. Equipment name.
 - c. Specification Section number.
 - d. Equipment tag number.
 - e. Owner's name.
 - f. Project number and name.
 - g. Date.
 - 3. If multiple Submittals are made together, each Submittal must have its own subdirectory that is named and numbered based on the Submittal number.

1.05 CONTENTS

- A. Cover page.
- B. Table of Contents: General description of information provided within each tab section.
- C. Complete Attachment A - Equipment Summary Form.
- D. Completed motor data sheet as specified in Section 26_05_10 - Medium Voltage Motors.
- E. Programming:
 - 1. Provide package control system annotated PLC code, if applicable.
 - 2. Contractor furnished programming.
- F. Description of system and components.
- G. Complete parts list for equipment, including, but not limited to, the following information:
 - 1. Catalog data: Generic title and identification number of each component part of equipment.
 - 2. Include bearing manufacturer, model, and ball or roller pass frequencies for every bearing.
 - 3. Availability.
 - 4. Service locations.
- H. Spare parts list:
 - 1. Recommended number of parts to be stored at the Site and special storage instructions.
- I. Engineering data:
 - 1. Complete set of 11-inch by 17-inch equipment drawings.
 - 2. Exploded view or plan and section views with detailed callouts.
 - 3. Outline, cross-section, and assembly drawings.
 - 4. System drawings: Provide interconnection and wiring diagrams, plan views, panel layouts, bill of materials, etc.
 - 5. Packaged equipment system drawings: Provide instrumentation loop drawings, control schematic diagrams, interconnection and wiring diagrams, plan views, panel layouts, bill of materials, etc.
 - 6. System drawings and data sheets: Include drawings and data furnished by the Engineer and the Supplier; provide "as installed" version.
 - 7. Provide electrical and instrumentation schematic record drawings.
 - 8. Information required by the Technical Specifications.
- J. Description of equipment function, normal operating characteristics, and limiting conditions.
- K. Online resources.
- L. Telephone resources.

- M. Approved Submittals.
 - 1. Markup with any field changes.
 - 2. Quality Control Submittals:
 - a. Source Testing and Functional Testing test reports and test data.
 - b. Manufacturer's certificates.
 - c. Performance curves.
- N. Start-up procedures: Recommendations for installation, adjustment, calibration, and troubleshooting.
- O. Operating procedures:
 - 1. Step-by-step instructions, including, but not limited to, the following:
 - a. Safety precautions and applicable safety data sheets.
 - b. Guidelines.
 - c. Other information as needed for safe system operation and maintenance.
- P. Preventative maintenance procedures:
 - 1. Recommended steps and schedules for maintaining equipment.
 - 2. Troubleshooting.
- Q. Storage instructions.
- R. Lubrication information: Required lubricants and lubrication schedules.
- S. Overhaul instructions: Directions for disassembly, inspection, repair and reassembly of the equipment; safety precautions; and recommended tolerances, critical bolt torques, and special tools that are required.
- T. Manufacturer's technical reference manuals.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION (NOT USED)

END OF SECTION

ATTACHMENT A - EQUIPMENT SUMMARY FORM

EQUIPMENT SUMMARY FORM

1. EQUIPMENT ITEM: _____
2. MANUFACTURER: _____
3. EQUIPMENT TAG NUMBER(S): _____
4. LOCATION OF EQUIPMENT: _____
5. WEIGHT OF INDIVIDUAL COMPONENTS (OVER 100 POUNDS): _____

6. NAMEPLATE DATA:

Horsepower: _____

Amperage: _____

Voltage: _____

Service Factor (S.F.): _____

Speed: _____

ENC Type: _____

Capacity: _____

Other: _____

7. MANUFACTURER'S LOCAL REPRESENTATIVE:

Name: _____

Address: _____

Telephone Number: _____

8. MAINTENANCE REQUIREMENTS:

Maintenance Operation	Frequency	Lubricant (if applicable)	Comments
(List each operation required. Refer to specific information in manufacturer's manual, if applicable)	(List required frequency of each maintenance operation)	(Refer by symbol to lubricant list as required)	

9. LUBRICANT LIST:

Reference Symbol	Conoco Phillips	Exxon/Mobil	BP/Amoco	Other (List)
(Symbols used in Item 8 above)	(List equivalent lubricants, as distributed by each manufacturer for the specific use recommended)			

10. SPARE PARTS (recommendations): _____

11. COMMENTS: _____

12. GENERAL INFORMATION:

Date Accepted:* _____

Expected Life:* _____

Project Name and Number: _____

Design Engineer: _____

13. WARRANTY:

Start Date: _____

Expiration Date: _____

Prorated: _____

SECTION 01_78_36
WARRANTIES AND BONDS

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Warranty and bonds requirements.

1.02 WARRANTY REQUIREMENTS

- A. See General Conditions 61 and 62 for project warranty requirements.

1.03 MANUFACTURER'S SPECIAL WARRANTY

- A. Manufacturer's special warranty is a written warranty published by the manufacturer which includes the requirements as specified in the Technical Section.
 - 1. Project-specific information and requirements.
 - 2. Properly executed by product manufacturer.
 - 3. Expressly states that its provisions are for the benefit of the Contractor or Owner.
 - 4. Manufacturer's special warranties commence on the date that the associated item is certified by Engineer as substantially complete.

1.04 BOND REQUIREMENTS

- A. See General Conditions 50 for project bond requirements.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION (NOT USED)

END OF SECTION

SECTION 01_81_50

DESIGN CRITERIA

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Design criteria for use in the selection of equipment and appurtenances specified in Technical Sections of these Specifications and indicated on the Drawings.
 - 2. Criteria for design of systems, components and equipment fabricated off site and shipped to the Work for installation.
 - 3. Criteria for design of anchors to connect equipment and appurtenances to supports and structures.
- B. The criteria in this Section apply throughout the Work, unless additional criteria, or more restrictive criteria, are indicated.
 - 1. Additional criteria and requirements relevant to specific locations, specific materials, and specific equipment are indicated on the Drawings and in the Technical Sections.

1.02 REFERENCES

- A. American Society of Civil Engineers (ASCE):
 - 1. 7-16 - Minimum Design Loads and Associated Criteria for Buildings and Other Structures. (ASCE 7)
 - 2. Local amendments: Larimer County, Colorado.
- B. American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE):
 - 1. ASHRAE Fundamentals Handbook.
- C. International Code Council (ICC):
 - 1. International Energy Conservation Code (IECC).
 - 2. International Plumbing Code (IPC).
- D. Sheet Metal and Air Conditioning Contractor's National Association (SMACNA):
 - 1. Seismic Restraint Manual: Guidelines for Mechanical Systems, 3rd edition 2008.

PART 2 PRODUCTS

2.01 DESIGN CRITERIA - SITE INFORMATION

- A. Site name: Source Water Pump Station.
 - 1. Street address: As specified in Section 01_11_00 - Summary of Work.
 - a. Coordinates (approximate): Latitude 40.669527; Longitude -105.088229.

2. Site elevation (approximate):
 - a. 5141.57 feet (NAVD 88).
3. Groundwater elevation:
 - a. See Project geotechnical reports, listed in Document 01_11_00 - Summary of Work, for information.

2.02 DESIGN CRITERIA - REGULATORY REQUIREMENTS

- A. Requirements of authorities having jurisdiction over the Project are included in Section 01_41_00 - Regulatory Requirements.

2.03 DESIGN CRITERIA - OPERATING ENVIRONMENT

- A. Drawings and Technical Sections include additional criteria and requirements relevant to specific locations, materials, and equipment.
- B. Outdoor conditions:
 1. International Energy Conservation Code (IECC): Climate Zone 5B.
 2. Site climatic data location: 724697 Fort Collins.
 3. Temperature criteria: As specified in the following Table: Design Temperatures - Outdoor Criteria in Accordance with ASHRAE Fundamentals Handbook.

Table: Design Temperatures - Outdoor Criteria in Accordance with ASHRAE Fundamentals Handbook	
Reference Location:	Fort Collins, Colorado, USA
Condition	Criteria
Daily mean range:	25.5 degrees Fahrenheit.
Winter:	At or above this temperature 99.6 percent of the time: -4 degrees Fahrenheit dry bulb.
Summer:	At or above this temperature 0.4 percent of the time: 94 degrees Fahrenheit dry bulb.

4. Rainfall intensity:
 - a. Reference: International Plumbing Code (IPC):
 - 1) 2.3 inches per hour (100-year, 1-hour rainfall).
- C. Indoor conditions:
 1. HVAC schedules as indicated on the Drawings.
 2. Humidity:
 - a. Moisture/humidity conditions: As specified, and as defined in individual equipment sections.

2.04 DESIGN CRITERIA - STRUCTURAL

- A. General:
 1. Criteria for structural design of:
 - a. Equipment at locations subject to seismic events.

- b. Equipment exposed to outdoor environments.
 - c. Equipment supports and bracing, and anchorage of such items to building and non-building structures.
 - d. Structures provided for the Work through Delegated Design.
 - e. Manufactured and prefabricated structures, and anchorage of such structures to foundations or other supporting elements.
 - 2. Structural design criteria used by the Engineer of record and required by the building code to be indicated on the Drawings are included on the Contract Drawing titled "General Structural Notes".
- B. Delegated Design:
- 1. As specified in Section 01_35_73 - Delegated Design Procedures.
 - 2. Structural engineering design shall be performed by a Professional Engineer licensed in the State of Colorado.
- C. Structure risk category:
- 1. Develop design loads and provide detailing in accordance with the provisions of ASCE 7 and the building code specified in Section 01_41_00 - Regulatory Requirements, based on the Structure Risk Category indicated in Table: Project Structures - Risk Category and Seismic Design Information.
- D. Seismic loads:
- 1. Seismic design parameters: Basic parameters - ASCE 7:
 - a. Ground motion MCE_R , 5 percent damped:
 - 1) Short periods, $S_s = 0.198 g$.
 - 2) 1 second period, $S_1 = 0.056 g$.
 - b. Peak ground acceleration, MCE_G :
 - 1) Peak ground acceleration, $PGA = 0.105 g$.
 - c. Mapped long-period transition period:
 - 1) $TL = 4$ seconds.
 - 2. Structures - General:
 - a. Seismic Design Category (SDC): As indicated in the following Table: Project Structures - Risk Category and Seismic Design Information.

Table: Project Structures - Risk Category and Seismic Design Information						
Description: Water Treatment Facility						
Area	Description	Risk Category	Site Class	S_{DS}	S_{D1}	Seismic Design Category ⁽¹⁾
All	All Structure	IV	C	0.172	0.056	C
Notes: (1) Seismic Design Category for Delegated Design, and for seismic certification of electrical and mechanical equipment as required by ASCE 7.						

- b. Structure response modification coefficient, R :
 - 1) In accordance with ASCE 7 and the requirements of the Technical Sections.
 - 3. Structures - Tanks and vessels.
 - a. Includes: Tank structures, tank supports, and anchorage to structures or foundations.

- b. Liquid storage structures (e.g., basins and tanks).
 - 1) Include impulsive and convective (“sloshing”) effects.
 - 2) Component response modification factor - impulsive effects, R_i : In accordance with ASCE 7, Table 15.4-2.
 - 3) Component response modification factor - convective effects, $R_c = 1.0$.
- c. Dry material storage structures (e.g., silos, hoppers):
 - 1) Include effects of stored materials.
 - 2) Component response modification factor - impulsive effects, R_i : In accordance with ASCE 7, Table 15.4-2.
- 4. Non-structural components - General:
 - a. Includes:
 - 1) Mechanical and electrical equipment; anchorage of equipment to structures or supports; design of supports; and anchorage of supports to structures or foundations.
 - 2) Distribution systems associated with mechanical and electrical equipment such as piping, ductwork, conduits, cable trays, raceways, bus ducts, and similar items; anchorage of such systems to supports and structures; and bracing of such systems.
 - b. Seismic design requirements for non-structural components are based on the Seismic Design Category (SDC) of the structure or facility where the equipment is installed.
 - c. Design components, component anchorage, and component connections to piping and utilities in accordance with the requirements of ASCE 7, Table 13.2-1.
 - d. Component amplification factor (a_p), response factor (R_p), and overstrength factor for anchorage to concrete (Ω_o):
 - 1) Mechanical and electrical components and systems: In accordance with ASCE 7, Table 13.6-1, unless otherwise indicated in the Technical Sections for these items.
 - 2) Architectural components and systems: In accordance with ASCE 7, Table 13.6-1, unless otherwise indicated in the Technical Sections for these items.
 - e. Component importance factor, I_p :
 - 1) In accordance with the following Table: Component Importance Factor for Seismic Design, I_p .
 - 2) For items not listed in Table: Component Importance Factor for Seismic Design, I_p , designate importance factor in accordance with the provisions of ASCE 7, Chapter 13, and submit to the Engineer for review prior to developing calculations and details related to that component.

Table: Component Importance Factor for Seismic Design, I_p		
Structure Seismic Design Category	Components	I_p
All	Electrical: Items and distribution system components specified in Division 26 - Electrical.	1.5
All	Process Control and Instrumentation Systems: Components and distribution systems specified in Division 40 - Process Integration.	1.5

Table: Component Importance Factor for Seismic Design, I_p		
Structure Seismic Design Category	Components	I_p
All	Equipment and components specified in Divisions 11 through 49, except HVAC and plumbing components listed below.	1.5
All	HVAC equipment specified in the following Sections: 23_81_14 - Air Conditioning Units 23_83_01 - Heating Units	1.0
All	Other equipment not listed above.	1.0

5. Non-structural components: HVAC ductwork.
 - a. Component importance factor, I_p : Determine in accordance with ASCE 7, Section 15.4.1.1.
 - b. Seismic design category:
 - 1) See Table: Component Importance Factor for Seismic Design, I_p (preceding).
 - c. SMACNA seismic hazard level.
 - 1) Seismic hazard level for design of heating, ventilating, and air conditioning ductwork in accordance with SMACNA Seismic Restraint Manual:
 - a) SMACNA Seismic hazard level = D.
- E. Wind loads:
1. Design structures and non-structural components that are exposed to wind to withstand design wind loads.
 - a. Reduction of wind loads based on shielding effects of surrounding structures or components is not allowed.
 - b. Design for wind loading is not required for non-structural components and for non-building structures located inside enclosed buildings.
 2. Design parameters:
 - a. Basic wind speed:
 - 1) 130 miles per hour (33 feet, 3 second gust).
 - b. Exposure category: C.
 - c. Topographic factor, K_{zt} : 1.0.
 - d. Wind pressure for design of "components and cladding".
 - 1) "Components and cladding" includes doors, windows, siding panels, skylights, parapets and similar architectural elements.
 - 2) Minimum wind pressure for components and cladding, strength level:
 - a) Wall elements: Minimum 80 pounds per square foot, pressure or vacuum.
 - b) Roof elements: Minimum 167 pounds per square foot, pressure or vacuum.
 - c) For "allowable stress level" pressures, multiply strength level pressures by 0.625.
- F. Snow loads:
1. Design for snow loading is not required for non-structural components and for non-building structures located inside enclosed buildings.

2. Design parameters:
 - a. Ground snow load: $p_g = 45$ pounds per square foot.
 - b. Flat roof snow load: $p_f = 30$ pounds per square foot.
 - c. Rain-on-snow load surcharge: 5 pounds per square foot applied to balanced load case only.
 - d. Exposure factor, minimum: $I = 1.1$.
 - e. Importance factor, minimum: $I_s = 1.2$.
 - f. Drifting:
 - 1) Consider effects of adjacent and nearby structures and equipment on drift loads.
- G. Rainfall loads:
 1. Determine rainfall loads using rainfall intensity specified in this Section and including effects of exposed surface slope, height above surface to discharge elevation, and deflection of ponded surfaces.
- H. Operational loads:
 1. Loads may include equipment vibration, torque, thermal effects, effects of internal contents (weight and sloshing), surge or "water hammer," and other load conditions.
 2. Design for loads indicated by the equipment manufacturer.
 3. Design for loads indicated in the Technical Sections for equipment and appurtenances.
- I. Serviceability considerations:
 1. Deflection, unless otherwise indicated on the Drawings, or specified:
 - a. Beam deflection as fraction of span:
 - 1) Walkways and platforms: Total load = $L/240$; live load = $L/360$.
 - 2) Equipment supports: $L/450$.

PART 3 EXECUTION

3.01 GENERAL

- A. Design approach and criteria in accordance with:
 1. Regulatory requirements, including, but not limited to, the building code specified in Section 01_41_00 - Regulatory Requirements.
 2. Reference standards and project-specific design criteria listed in this Section.
 3. Specific requirements for individual elements and components of the Work as specified in subsequent Technical Sections.
- B. In the event of conflicts between design criteria, contact Engineer for interpretation.
- C. Where Owner-Delegated Design is required by the Specifications, prepare and submit designs as specified in Section 01_35_73 - Delegated Design Procedures.

3.02 DELEGATED DESIGN

- A. Where Delegated Design is required by the Technical Sections, prepare and submit designs as specified in Section 01_35_73 - Delegated Design Procedures.

- B. Calculations:
1. Where submittal of calculations is required:
 - a. Provide complete calculations, including sketches to illustrate the design concepts being evaluated, and details to fully describe proposed construction.
 2. Requirements for seismic design calculations will be waived for the following:
 - a. Furniture and storage racks 6 feet in height or less.
 - b. Moveable equipment.
 - c. Mechanical and electrical equipment and components located in structures designated as Seismic Design Category A or B.
 - d. Mechanical and electrical equipment and components located in structures designated as Seismic Design Category C and where the component importance factor, I_p , is equal to 1.0.
 3. Requirements for wind design calculations will be waived for the following:
 - a. Equipment and components located inside structures, and away from the effects of wind loads.
- C. Shop Drawings:
1. Describing components and manufacturer's requirements for connections.
 - a. Include details for connections of components to structures and supports.
 - b. Include details for anchoring bracing to structures where required.

3.03 DESIGN - ANCHORS FOR EQUIPMENT, COMPONENTS, AND BRACING

- A. General:
1. Engineer's approval of anchor designs is required before placement of construction that supports or provides bracing for anchored equipment and components.
 - a. Prepare anchor designs after the Engineer's approval of the products and layout, and before placement of concrete or masonry that supports them.
 2. Adjust equipment pad sizes and add additional anchor confinement reinforcing to provide required strength at anchorage points between equipment and pad, and between pad and structure.
 3. Supports and bracing:
 - a. Design and install braces and anchors to transfer forces from equipment and components to the lateral force resisting system of the surrounding structure.
 - b. Anchor and brace piping, ductwork, and electrical distribution components so that lateral or vertical displacement does not result in damage to or failure of essential architectural, mechanical, or electrical equipment.
 - 1) Provide supplementary framing where required to transfer forces.
 - 2) Detail and locate braces and anchors to minimize differential movements between components and structure.
- B. Preparation:
1. Obtain manufacturer's information:
 - a. Weight and dimensions of components.
 - b. Layout and location of anchors that connect to equipment base plates, sole plates, skids, or pads.
 - c. Sizes of holes for anchors that will be provided in equipment bases or support frames.

- C. Analysis and design:
1. Perform and submit calculations to determine anchor designs at locations where equipment and equipment supports are connected to the supporting structure.
 - a. Indicate number, size, type, and material for anchors.
 2. In determining forces at locations where equipment is anchored to structures, include effects of:
 - a. Equipment self-weight and operating weight.
 - b. Location of equipment center of mass.
 - c. Forces from equipment operation, including, but not limited to:
 - 1) Effects of internal contents, including weight and sloshing.
 - 2) Effects of thrust, surge, and water hammer where specified.
 - 3) Equipment reactions and operating torque.
 - 4) Equipment vibration.
 - 5) Thermal effects from equipment and from distribution systems connected to the equipment (piping, ducts, and electrical).
 - 6) Other load or displacement inducing conditions.
 - d. Forces on equipment from loads specified in this Section.
 - 1) Include effects of wind, snow, and icing loads where applicable.
 - 2) Design for load combinations indicated in ASCE 7, unless otherwise specified or indicated on the Drawings.
 - 3) Seismic and wind loads: For equipment and tanks with weight that varies based on the volume of contained material, determine anchor forces to accommodate the full range of filled, partially filled, and empty conditions.
 3. Determine forces and overturning moments at equipment supports and at locations where supports are anchored to structures.
 - a. Indicate shear force and associated axial force at each anchor.
 4. Do not use friction to resist sliding resulting from seismic or wind forces.
 - a. Resist sliding only by direct application of sliding loads to fasteners as bearing, shear, tension, or compression forces.
 5. Using combined shears and axial forces at each anchor, design anchors and anchor groups for ductile failure.
 - a. Ductile failure: Anchor yield before failure of base material, typically concrete or masonry, at the anchor.
 6. Anchor selection:
 - a. Provide anchors type indicated on the Drawings.
 - b. Where anchors are not specifically indicated on the Drawings, select in accordance with the following:
 - 1) Anchors that resist seismic and wind forces:
 - a) Cast-in-place forged hex-head anchor bolt.
 - 2) Anchors loaded in sustained tension:
 - a) Cast-in-place forged hex-head anchor bolt.
 - 3) Anchors for reciprocating, vibrating, and rotating equipment:
 - a) Cast-in-place forged hex-head anchor bolt.
 - c. Do not use post-installed anchors, mechanical or adhesive, unless:
 - 1) Post-installed anchors are indicated on the Drawings, or
 - 2) Post-installed are approved by the Engineer prior to placement of the surrounding concrete or masonry.

- d. Anchor diameter:
 - 1) Select diameter so that hole in base plate is not greater than 125 percent of the nominal diameter of the anchor, nor greater than the diameter of the anchor plus 1/4 inch.
- 7. Determine number, size, layout, and minimum effective embedment for anchors.
 - a. Layout includes anchor spacing and required distance(s) from anchor to edge(s) of supporting concrete or masonry.
 - b. Anchors in concrete: Design based on minimum specified 28-day compressive strength, f'_c , as follows, unless otherwise indicated on the Drawings for the Work area:
 - 1) Concrete placed for this Work: $f'_c = 4500$ pounds per square inch.
 - c. Anchors in masonry: Design based on minimum specified compressive strength, f'_m , as follows, unless otherwise indicated on the Drawings for the Work area:
 - 1) Concrete masonry placed for this Work: $f'_m = 2,000$ pounds per square inch.
- 8. Prepare Drawings showing construction details of anchor designs.
- 9. Submit design calculations and Drawings prior to placement of anchors, and of the structural elements to which they will connect.

END OF SECTION

SECTION 03_11_07
CONCRETE FORMWORK

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Concrete formwork.

1.02 REFERENCES

- A. American Concrete Institute (ACI):
 - 1. 117 - Specifications for Tolerances for Concrete Construction and Materials and Commentary.
- B. NSF International (NSF):
 - 1. 61 - Drinking Water System Components - Health Effects.
- C. Underwriters Laboratories (UL).

1.03 TERMINOLOGY

- A. Green concrete: Concrete with less than 100 percent of the minimum specified compressive strength (f'_c).
- B. Void form: Pre-manufactured forming system composed of corrugated paper cellular structures installed to provide temporary support for concrete; to maintain a void space between the concrete surface and surrounding soil until the concrete achieves sufficient strength to span between permanent supports; and to lose its strength after the concrete has cured so that a hollow space between the concrete and the soil is maintained over the life of the structure.
- C. Void filler: Rigid foam board installed to permanently fill spaces between concrete placements.

1.04 SUBMITTALS

- A. Furnish Submittals as specified in Section 01_33_00 - Submittal Procedures.
- B. Information on proposed forming system:
 - 1. Submit in such detail as the Engineer may require to assure themselves that intent of the Specifications can be complied with by use of proposed system.
 - 2. Alternate combinations of plywood thickness and stud spacing may be submitted.
- C. Product data:
 - 1. Void form.
 - a. Manufacturer's product data for forms and accessories.

- 2. Void filler:
 - a. Manufacturer's product data for filler boards and adhesive.
 - b. Manufacturer's installation instructions.
- D. Form release agent: NSF 61 certification prepared by NSF, UL, or other similar nationally recognized testing laboratory acceptable to the Engineer.

1.05 QUALITY ASSURANCE

- A. Qualifications of formwork manufacturers: Use only forming systems by manufacturers having a minimum of 5 years of experience, except as otherwise specified, or accepted in writing by the Engineer.
- B. Regulatory requirements: Install Work of this Section in accordance with local, state, and federal regulations.

1.06 DELIVERY, STORAGE AND HANDLING

- A. General:
 - 1. Deliver, store and handle products in accordance with manufacturer's recommendations.
- B. Void forms:
 - 1. Store materials in a dry area protected from sunlight and weather until installation.
 - 2. Stack on pallets or other supports raised off the ground. Provide adequate number of support points to prevent bending, deformation, or other damage before installation.
- C. Void filler:
 - 1. Store materials in a dry area protected from sunlight and weather until installation.
 - 2. Do not expose products to open flame or other ignition sources.

PART 2 PRODUCTS

2.01 DESIGN AND PERFORMANCE CRITERIA

- A. Design requirements:
 - 1. Concrete forms, falsework, and shoring in accordance with local, state, and federal regulations.
 - 2. Forms and ties to withstand concrete pressures without bulging, spreading, or lifting of forms.
- B. Performance requirements:
 - 1. Construct forms so that finished concrete conforms to shapes, lines, grades, and dimensions indicated on the Drawings.
 - 2. It is intended that surface of concrete after stripping presents smooth, hard, and dense finish that requires minimum amount of finishing.

3. Provide sufficient number of forms so that the Work may be performed rapidly and present uniform appearance in form patterns and finish.
4. Use forms that are clean and free from dirt, concrete, and other debris.
 - a. Coat with form release agent if required, prior to use or reuse.

2.02 MANUFACTURED UNITS

A. Forms:

1. Built-up plywood:
 - a. May be substituted for prefabricated forming system, subject to the following minimum requirements:
 - 1) Size and material:
 - a) Use full size 4-foot by 8-foot plywood sheets, except where smaller pieces are able to cover entire area.
 - b) Sheet construction: 5-ply plywood sheets, 3/4-inch nominal, made with 100 percent waterproof adhesive, and having finish surface that is coated or overlaid with surface which is impervious to water and alkaline calcium and sodium hydroxide of cement.
 - 2) Wales: Minimum 2-inch by 4-inch lumber.
 - 3) Studding and wales: No loose knots and free of warps, cups, and bows.
2. Steel:
 - a. Rigidly constructed and capable of being braced for minimum deflection of finish surface.
 - b. Capable of providing finish surfaces that are flat without bows, cups, or dents.
3. Steel-framed plywood:
 - a. Provide forms that are rigidly constructed and capable of being braced.
 - b. Plywood paneling: 5-ply, 5/8-inch nominal or 3/4-inch nominal, made with 100 percent waterproof adhesive, and having finish surface that is coated or overlaid with surface which is impervious to water and alkaline calcium and sodium hydroxide of cement.

B. Form release agent.

1. Effective, non-staining, bond-breaking coating compatible with form surfaces and concrete mixes used.

C. Form ties:

1. General:
 - a. Provide form ties for forming system selected that are manufactured by a recognized manufacturer of concrete forming equipment.
 - b. Do not use wire ties or wood spreaders.
 - c. Provide ties of type that accurately tie, lock, and spread forms.
 - d. Provide form ties of such design that when forms are removed, they locate no metal or other material within 1-1/2 inches of the surface of the concrete.
 - e. Do not allow holes in forms for ties to allow leakage during placement of concrete.

2. Cone-snap ties:
 - a. Shall form a cone shaped depression in the concrete with minimum diameter of 1 inch at the surface of the concrete and minimum depth of 1-1/2 inches.
 - b. Provide neoprene waterseal washer that is located near the center of the concrete.
 3. Taper ties:
 - a. Neoprene plugs for taper tie holes: Size so that after they are driven, plugs are located in center third of wall thickness.
- D. Void form:
1. Void forms shall support all vertical and lateral loads from preparation, reinforcement, and placement of plastic concrete over and around them, while simultaneously maintaining the full void dimension indicated on the Drawings until concrete reaches its specified 28-day compressive strength (f'_c).
 2. Void forms shall have a minimum initial strength to support at least 5 times the weight of the concrete slab above.
 3. Provide special prefabricated void forms (custom blackout) to fit properly around the helical pier shaft.
 4. Cellular form system:
 - a. Fabricated of corrugated paper in rectangular box shapes suitable to form the void dimensions indicated on the Drawings.
 - b. Including a moisture resistant exterior surface and a cellular interior structure designed to lose strength and stiffness after the concrete placed upon it has cured.
 5. Accessories:
 - a. Backfill void form retainers for edges of slabs, grade beams, concrete encasements, and other concrete construction that projects vertically below the bottom of the slab.
 - 1) Fabricated from high-impact resistant polyethylene (HDPE) plastic.
 - 2) The top of the void form retainer shall extend 4 inches above the top of the void form.
 - 3) Embedment into the sub-base shall be sufficient to prevent backfill from entering into the void form gap.
 - b. Protective cover board:
 - 1) Fabricated of 1/4-inch Masonite hardboard.
 - c. Seam pads to cover joints in the void forms below grade beams.
 6. Manufacturers: The following, or equal:
 - a. SureVoid Products, Inc. Englewood, Colorado.
- E. Void filler:
1. Filler material:
 - a. Expanded polystyrene rigid board conforming to ASTM C 578.
 - b. Thickness as indicated on the Drawings.
 - c. Material properties as follows:
 - 1) Density: 2.4 pounds per cubic foot. minimum.
 - 2) Compressive strength: At 10 percent deflection, not less than 40 pounds per square foot.
 - 3) Flexural strength: 60 pounds per square inch, minimum.
 - 4) Flame spread: Less than 25 when tested in accordance with ASTM E 84.

2. Adhesive:
 - a. As recommended by the manufacturer for attaching void fillers to adjacent concrete surfaces and holding the fillers securely in place during concrete casting.
 3. Manufacturer: The following, or equal:
 - a. ACH Foam Technologies, LLC, Tijuana, Mexico.
- F. Incidentals:
1. External angles:
 - a. Where not otherwise indicated on the Drawings, provide with 3/4-inch bevel, formed by utilizing true dimensioned wood or solid plastic chamfer strip on walkways, slabs, walls, beams, columns, and openings.
 - b. Provide 1/4-inch bevel formed by utilizing true dimensioned wood or solid plastic chamfer strip on walkways, walls, and slabs at expansion, and construction joints.
 2. Keyways: Steel, plastic, or lumber treated with form release agent.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Site verification of conditions:
1. Do not place concrete until forms have been checked for alignment, level, and strength, and mechanical and electrical inserts or other embedded items for correct location.

3.02 INSTALLATION

- A. Forms:
1. Built-up plywood:
 - a. Studding:
 - 1) Spaced at 16 inches or 24 inches on center.
 - 2) Closer spacing may be required depending upon strength requirements of the forms, in order to prevent any bulging surfaces on faces of finished concrete work.
 - 3) Install studs perpendicular to grain of exterior plys of plywood sheets.
 - b. Wales: Double lumber material with minimum size as specified in this Section.
 - c. Number of form reuses: Depends upon durability of surface coating or overlay used and ability to maintain forms in condition such that they are capable of producing flat, smooth, hard, dense finish on concrete when stripped.
 2. Steel:
 - a. Adequately brace forms for minimum deflection of finish surface.
 3. Steel-framed plywood:
 - a. Rigidly construct and brace with joints fitting closely and smoothly.
 - b. Number of form reuses: Depends upon durability of surface coating or overlay used.

4. Built-up plywood forms may be used in conjunction with steel forms or steel-framed plywood forms for special forming conditions such as corbels and forming around items which will project through forms.
- B. Form bracing and alignment:
1. Line and grade: Limit deviations to tolerances which will permit proper installation of structural embedded items or mechanical and electrical equipment and piping.
 2. Formwork:
 - a. Securely brace, support, tie down, or otherwise hold in place to prevent movement.
 - b. Make adequate provisions for uplift pressure, lateral pressure, and deflection of forms.
 3. When second lift is placed on hardened concrete, take special precautions in formwork at top of old lift and bottom of new lift to prevent:
 - a. Spreading and vertical or horizontal displacement of forms.
 - b. Grout "bleeding" onto finish concrete surfaces.
 4. Pipe stubs, anchor bolts, conduits, and other embedded items:
 - a. Set in forms, position, and secure prior to placement of concrete to maintain a minimum 1-1/2-inch clearance between the item and any concrete reinforcement.
 - b. Securing embedded items in position by wiring or welding to the reinforcement is not permitted.
 5. Cracks, openings, or offsets at joints in formwork: Close those that are 1/16 inch or larger by tightening forms or by filling with acceptable crack filler acceptable to the Engineer.
- C. Forming incidentals:
1. Keyways: Construct as indicated on the Drawings.
 2. Reentrant angles: May be left square.
 3. Level strips: Install at top of wall concrete placements to maintain true line at horizontal construction joints.
 4. Inserts:
 - a. Encase pipes, anchor bolts, steps, reglets, castings, and other inserts, as indicated on the Drawings or as required, in concrete.
- D. Form release agent:
1. Apply in accordance with the manufacturer's instructions.
- E. Form ties:
1. Cone-snap ties: Tie forms together at not more than 2-foot centers vertically and horizontally.
- F. Void form:
1. Place over ground surfaces that are firm and level or sloped to an even plane. Remove rocks or materials that would puncture or damage void form.
 2. Assemble materials and install as recommended by the manufacturer.
 3. Coordinate placement of void forms around the tops of the helical pier shafts. Void forms shall fit properly around the helical pier shaft within the specified voided area.

4. There shall be no gaps in the void form system. Properly seal any gaps to prevent infiltration of concrete during casting.
 5. Protection:
 - a. Protect void form materials from premature degradation by ground moisture or precipitation until concrete placement and curing is complete. Protection provided shall not inhibit the deterioration of the void forms after concrete has cured.
 - b. Protect void form from puncture or damage during placement of reinforcing and concrete using a protective cover board system.
 - c. Immediately protect slab perimeter after forms have been stripped with a backfill void form retainer. Install backfill void form retainer in accordance with the manufacturer's instructions.
 6. Maintain moisture and humidity levels beneath the slab after the concrete sets.
- G. Void filler:
1. Clean surfaces where filler will be attached of loose material, dust, and debris that would inhibit bonding of the void filler material to concrete surfaces.
 2. Install filler in accordance with manufacturer's recommendations.
 3. Begin installation of board at one corner of surface to be covered. Tightly butt joints to form uninterrupted surface. Cut boards and fit as necessary to accommodate dimensions and conditions.

3.03 FORM REMOVAL

- A. Do not remove forms from concrete which has been placed when outside ambient air temperature is below 50 degrees Fahrenheit until the following conditions are satisfied:
1. Concrete has sufficient strength to allow form removal without damage to surfaces.
 2. At least 48 hours have elapsed since the end of concrete placement.
 3. Provisions are in place to maintain moisture for curing concrete, and temperature at or above the required minimum curing temperature specified.
- B. Vertical forms:
1. Retain in place for a minimum of 24 hours after concrete is placed.
 2. If concrete has sufficient strength and hardness to resist surface or other damage after 24 hours, forms may be removed.
- C. Other forms supporting concrete and shoring: Retain in place as follows:
1. Formed sides of footings: 24 hours minimum.
 2. Formed vertical sides of beams, girders, and similar members: 48 hours minimum.
 3. Forms below slabs, beams, and girders: Until concrete strength reaches specified strength $f'c$ or until shoring is installed.
 - a. Shoring for slabs, beams, and girders: Shore until concrete strength reaches minimum specified 28-day compressive strength.

3.04 SURFACE REPAIRS AND FINISHING

- A. Immediately after forms are removed, carefully examine concrete surfaces, and repair any irregularities in surfaces and finishes as specified in Section 03_30_00 - Cast-in-Place Concrete.
- B. Finish concrete as indicated on the Drawings and as specified in Section 03_35_29 - Concrete Finishes.
- C. Form ties: Fill tie holes as specified in Section 03_35_29 - Concrete Finishes.

3.05 CONCRETE TOLERANCES

- A. Finish concrete shall conform to shapes, lines, grades, and dimensions indicated on the Drawings.
- B. Construct Work within the tolerances in accordance with ACI 117, except as modified in the following paragraphs or as indicated on the Drawings.
 - 1. General:
 - a. At certain locations, tolerances required for equipment placement and operation may be more restrictive than the general tolerance requirements in this Section.
 - b. Confirm equipment manufacturers' required tolerances for location and operation of equipment that will be installed, and construct concrete to satisfy those requirements.
 - 2. Slabs:
 - a. Slope: Uniformly sloped to drain when slope is indicated on the Drawings.
 - b. Slabs indicated to be level: Maximum vertical deviation of 1/8 inch in 10-foot horizontal length without any apparent changes in grade.
 - 3. Circular tank walls:
 - a. May deviate from finish line indicated on the Drawings by use of forms with chord lengths not to exceed 2 feet.
 - 4. Inserts and embedments:
 - a. Set to tolerances required for proper installation and operation of equipment or systems to which insert pertains.
 - b. Maximum tolerances as follows:

Item	Tolerance
Sleeves and inserts	Plus 1/8 inch; minus 1/8 inch.
Anchor bolts:	
Projected ends	Plus 1/4 inch; minus 0.0 inch.
Axial alignment	Not more than 2 degrees off the axis indicated on the Drawings.
Setting location	Plus 1/16 inch; minus 1/16 inch.
All embedments	Minimum 1 inch clearance from reinforcing steel.

- c. Securing embedded items in formwork by wiring or welding to reinforcement is not permitted.

- C. Remove and replace Work that does not conform to the required tolerances.

END OF SECTION

SECTION 03_15_00
CONCRETE ACCESSORIES

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Waterstops.
 - 2. Joint fillers.

1.02 REFERENCES

- A. ASTM International (ASTM):
 - 1. D570 - Standard Test Method for Water Absorption of Plastics.
 - 2. D624 - Standard Test Method for Tear Strength of Conventional Vulcanized Rubber and Thermoplastic Elastomers.
 - 3. D638 - Standard Test Method for Tensile Properties of Plastics.
 - 4. D746 - Standard Test Method for Brittleness Temperature of Plastics and Elastomers by Impact.
 - 5. D747 - Standard Test Method for Apparent Bending Modulus of Plastics by Means of a Cantilever Beam.
 - 6. D792 - Standard Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement.
 - 7. D1751 - Standard Specification for Preformed Expansion Joint Filler for Concrete Paving and Structural Construction (Nonextruding and Resilient Bituminous Types).
 - 8. D1752 - Standard Specification for Preformed Sponge Rubber Cork and Recycled PVC Expansion Joint Fillers for Concrete Paving and Structural Construction.
 - 9. D2240 - Standard Test Method for Rubber Property - Durometer Hardness.
- B. American National Standards Institute (ANSI):
 - 1. A135.4 - Basic Hardboard.
- C. U. S. Army Corps of Engineers (USACE):
 - 1. CRD-C-572, Specification for Polyvinyl Chloride Waterstop.

1.03 SUBMITTALS

- A. Product data:
 - 1. Polyvinyl chloride waterstops: Complete physical characteristics.
 - 2. Preformed expansion joint material: Sufficient information on each type of material for review to determine conformance of material to requirements specified.
- B. Samples:
 - 1. Polyvinyl chloride waterstop.

- C. Laboratory test reports: Indicating that average properties of polyvinyl chloride waterstops material and finish conform to requirements specified in this Section.
- D. Quality control submittals:
 - 1. Certificates of Compliance:
 - a. Written certificates that polyvinyl chloride waterstops supplied on this Project meet or exceed physical property in accordance with USACE CRD-C-572 and the requirements of this Section.
 - 2. Manufacturer's instructions: For materials specified in this Section that are specified to be installed with such instructions.

1.04 QUALITY ASSURANCE

- A. Mock-ups:
 - 1. Welding demonstration:
 - a. Demonstrate ability to weld acceptable joints in polyvinyl chloride waterstops before installing waterstop in forms.
- B. Field joints:
 - 1. Polyvinyl chloride waterstops field joints: Free of misalignment, bubbles, inadequate bond, porosity, cracks, offsets, and other defects which would reduce the potential resistance of material to water pressure at any point. Replace defective joints. Remove faulty material from site and disposed of by Contractor at its own expense.
- C. Inspections:
 - 1. Quality of welded joints will be subject to acceptance of Engineer.
 - 2. Polyvinyl chloride waterstop: Following defects represent partial list that will be grounds for rejection:
 - a. Offsets at joints greater than 1/16 inch or 15 percent of the material thickness, at any point, whichever is less.
 - b. Exterior crack at joint due to incomplete bond, which is deeper than 1/16 inch or 15 percent of material thickness, at any point, whichever is less.
 - c. Any combination of offset or crack that will result in net reduction in cross section of waterstop in excess of 1/16 inch or 15 percent of material thickness, at any point, whichever is less.
 - d. Misalignment of joint that will result in misalignment of waterstop in excess of 1/2 inch in 10 feet.
 - e. Porosity in welded joint as evidenced by visual inspection.
 - f. Bubbles or inadequate bonding.

PART 2 PRODUCTS

2.01 JOINT FILLERS

- A. General:
 - 1. Use specific type in applications as indicated on the Drawings.
 - 2. Do not use scrap or recycled materials to manufacture joint fillers.

- B. Preformed expansion joint materials:
1. Bituminous fiber expansion joint material:
 - a. Properties:
 - 1) Thickness: To match joint width indicated on the Drawings.
 - 2) Asphalt-impregnated fiber in accordance with ASTM D1751.
 - b. Manufacturers: One of the following or equal:
 - 1) Durajoint.
 - 2) W.R. Meadows, SealTight Fibre Expansion Joint.
 2. Synthetic sponge rubber expansion joint material:
 - a. Properties:
 - 1) Thickness: As recommended for width indicated on the Drawings.
 - 2) Material in accordance with ASTM D1752, Type I.
 - b. Manufacturers: One of the following or equal:
 - 1) Williams Products Inc., Everlastic 1300.
 - 2) W.R. Meadows, SealTight Sponge Rubber.

2.02 WATERSTOPS

- A. Waterstops - polyvinyl chloride (PVC):
1. Manufactured from prime virgin polyvinyl chloride plastic compound containing the plasticizers, resins, stabilizers, and other materials necessary to meet the requirements as specified in this Section.
 2. Manufacturers: One of the following or equal:
 - a. Vinylex Corp.
 - b. Sika Corp., Greenstreak PVC Waterstop.
 3. Type: Ribbed waterstop:
 - a. Construction joints: 6-inch-wide ribbed type.
 - b. Expansion joint for wall penetrations for concrete encased electrical duct banks: 6-inch ribbed type with hollow center bulb.
 - c. Expansion joints: 9-inch-wide ribbed type with hollow center bulb.
 - d. Dumbbell-type waterstop will not be allowed unless otherwise specified or indicated on the Drawings.
 - e. No scrap or reclaimed material shall be used.
 4. Properties as indicated in the following table:

Physical Characteristics	Test Method	Required Results
Specific Gravity	ASTM D792	Not less than 1.3.
Hardness	ASTM D2240	70 to 90 Type A15 Shore durometer.
Tensile Strength	ASTM D638	Not less than 2,000 pounds per square inch.
Ultimate Elongation	ASTM D638	Not less than 300 percent.
Alkali Extraction	CRD-C-572	Change in weight after 7 days: Between minus 0.1 percent and plus 0.25 percent. Change in hardness after 7 days: Not more than plus 5 points.
Low Temperature Brittle Point	ASTM D746	No sign of cracking or chipping at -35 degrees Fahrenheit.

Physical Characteristics	Test Method	Required Results
Water Absorption	ASTM D570	Not more than 0.15 percent after 24 hours.
Accelerated Extraction Test	CRD-C-572	Tensile strength: Not less than 1,600 pounds per square inch. Elongation: Not less than 280 percent.
Stiffness in Flexure	ASTM D747	Not less than 600 pounds per square inch.
Tear Resistance	ASTM D624	Not less than 225 pounds per inch.
Thickness	-	3/8 inch.
Center Bulb		
6-inch Waterstops	-	7/8 inch or 1-inch nominal outside diameter.
9-inch Waterstops	-	For expansion joints 1 inch and narrower: 1-inch nominal outside diameter. For expansion joints wider than 1 inch: 2-inch nominal outside diameter.
Allowable Tolerances		
Width	-	Plus or minus 3/16 inch.
Thickness	-	Plus or minus 1/32 inch.

PART 3 EXECUTION

3.01 INSTALLATION

A. Waterstops:

1. General:

- a. Store waterstops so as to permit free circulation of air around waterstop material and prevent direct exposure to sunlight.
- b. Install waterstops in concrete joints where indicated on the Drawings.
- c. Carry waterstops in walls into lower slabs and join to waterstops in slabs with appropriate types of fittings.
- d. In waterbearing structures: Provide all joints with waterstops, whether indicated on the Drawings or not.
- e. Provide waterstops that are continuous.
- f. Set waterstops accurately to position and line as indicated on the Drawings.
- g. Hold and securely fix edges in position at intervals of not more than 24 inches so that they do not move during placing of concrete.
- h. Position the waterstop so that symmetrical halves of waterstop are equally divided between concrete pours. Center axis of waterstop shall be coincident with centerline of the joint.
- i. Do not drive nails, screws, or other fasteners through waterstops in vicinity of construction joints.
- j. Use wires at not more than 24 inches on centers near outer edge of waterstop to tie waterstops into position.

- k. Special clips may be used in lieu of wires, at Contractor's option.
 - l. Terminate waterstops 3 inches from top of finish surfaces of walls and slabs unless otherwise specified or indicated on the Drawings.
 - m. When any waterstop is installed in concrete on one side of joint, while the other half or portion of the waterstop remains exposed to the atmosphere for more than 2 days, take suitable precautions to shade and protect exposed waterstop from direct rays of sunlight during entire exposure and until exposed portion is embedded in concrete.
 - n. When placing concrete at waterstops in slabs, lift edge of waterstop while placing concrete below the waterstop. Manually force waterstop against and into concrete, and then cover waterstop with fresh concrete.
2. Polyvinyl chloride waterstop:
- a. Install waterstops so that joints are watertight.
 - b. Weld joints such as unions, crosses, ells, and tees, with thermostatically controlled equipment recommended by waterstop manufacturer:
 - 1) Do not damage material by heat sealing.
 - 2) Make joints by overlapping, then simultaneously cut ends of sections to be spliced so they will form smooth even joint. Heat cut ends with splicing tool until the plastic melts. Press 2 ends together until plastic cools.
 - 3) Maintain continuity of waterstop ribs and tubular center axis.
 - 4) The splices shall have tensile strength of not less than 60 percent of unspliced materials tensile strength.
 - c. Butt joints of ends of 2 identical waterstop sections may be made while material is in forms.
 - d. Manufacturer shall factory prefabricate joints for crosses and tees.
 - e. Split-type waterstops will not be permitted except where specifically indicated on the Drawings.
- B. Joints:
- 1. Construct construction and expansion joints as indicated on the Drawings.
 - 2. Preformed expansion joint material: Fasten expansion joint strips to concrete, masonry, or forms with adhesive. No nailing will be permitted, nor shall expansion joint strips be placed without fastening.

END OF SECTION

SECTION 03_20_00
CONCRETE REINFORCING

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Reinforcing bars.
 - a. Carbon steel.
 - 2. Thread bars.
 - 3. Bar supports.
 - 4. Tie wires.

1.02 REFERENCES

- A. American Concrete Institute (ACI):
 - 1. 318 - Building Code Requirements for Structural Concrete and Commentary.
 - 2. SP-66 - ACI Detailing Manual.
- B. American Iron and Steel Institute (AISI).
- C. American Welding Society (AWS):
 - 1. D1.4 - Structural Welding Code - Reinforcing Steel.
- D. ASTM International (ASTM):
 - 1. A493 - Standard Specification for Stainless Steel Wire and Wire Rods for Cold Heading and Cold Forging.
 - 2. A615 - Standard Specification for Deformed and Plain Carbon Steel Bars for Concrete Reinforcement.
 - 3. A706 - Standard Specification for Low-Alloy Steel Deformed and Plain Bars for Concrete Reinforcement.
 - 4. A1064 - Standard Specification of Carbon-Steel wire and Welded Wire Reinforcement, Plain and Deformed, for Concrete.
- E. Concrete Reinforcing Steel Institute (CRSI):
 - 1. Manual of Standard Practice.

1.03 TERMINOLOGY

- A. The words and terms listed below are not defined terms that require initial capital letters, but, when used in this Section, have the indicated meaning.
 - 1. Architectural concrete: Concrete surfaces that will be exposed to view in the finished work.
 - a. Additionally, for purposes of this Section, includes:
 - 1) Concrete surfaces that are designated to receive paints or coatings.
 - 2) Exposed concrete in open basins, channels, and similar liquid containing structures: Surfaces shall be considered exposed to view

if located above a line 2 feet below the normal operating water surface elevation in that structure.

2. Bars: Reinforcement or reinforcing bars as specified in this Section.
3. Evaluation Report: Report prepared by ICC-ES, or by other testing agency acceptable to the Engineer and to the Building Official, that documents testing and review of a product to confirm that it complies with the requirements of designated ICC-ES Acceptance Criteria, and its acceptance for use under the Building Code specified in Section 01_41_00 - Regulatory Requirements.
4. Give away bars: Reinforcing bars that are not required by the Contract Documents but are installed by the Contractor to provide support for the required reinforcing bars.
5. Wire supports: Metal reinforcing supports constructed of steel wire as specified. Includes individual high chairs, continuous high chairs, bolsters and other similar configurations and shapes.

1.04 SUBMITTALS

A. General:

1. Submit in accordance with Section 01_33_00 - Submittal Procedures.
2. Changes to reinforcement in Contract Documents:
 - a. Indicate in a separate letter submitted with Shop Drawings any changes to reinforcement indicated on the Drawings or specified.
 - b. Such changes will not be acceptable unless the Engineer has accepted them in writing.

B. Product data:

1. Bar supports:
 - a. Wire bar supports:
 - 1) Schedule of support materials to be provided and locations of use.
 - b. Precast concrete bar supports ("dobies"):
 - 1) Manufacturer's data indicating compression strength of concrete and confirming dimensions and thickness(es), height(s) to be provided for each location where used.

C. Shop Drawings:

1. Reinforcement Shop Drawings:
 - a. Submit Drawings showing bending and placement of reinforcement required by the Contract Documents.
 - b. Provide CAD generated Shop Drawings.
 - c. Clearly indicate structures or portions of structures covered by each Submittal.
 - d. Shop Drawings shall conform to the recommendations of the CRSI Manual of Standard Practice and be in accordance with ACI SP-66.
 - e. Use the same bar identification marks on bending detail Drawings, placement Drawings, and shipping tags.
 - f. Submittals consisting solely of reinforcing bar schedules, without accompanying placement Drawings, will not be accepted unless accepted under prior written agreement with the Engineer.

2. Reinforcement placement Drawings:
 - a. Clearly show placement of each bar listed in the bill of materials, including additional reinforcement at corners and openings, and other reinforcement required by details in the Contract Documents.
 - b. Clearly identify locations of reinforcement with coatings (e.g., galvanized or epoxy) and with yield strength other than ASTM A615, Grade 60.
 - c. Show anchor bolt locations based on anchor bolt templates for approved equipment.
 - d. Show splice locations.
 3. Reinforcement fabrication Drawings:
 - a. If bend types or nomenclature differs from that recommended in the CRSI Manual of Standard Practice, provide details showing bend types and dimensional designations.
 - b. Clearly identify reinforcement with coatings and with yield strength other than ASTM A615, Grade 60.
- D. Samples (when requested by the Engineer):
1. Bar supports/wire reinforcement supports: Samples of each type of chair and bolster proposed for use. Submit with letter stating where each type will be used.
 2. Precast concrete bar supports: Samples of each type of precast support proposed for use. Submit with letter stating where each will be used.
- E. Test reports:
1. Certified copy of mill test for each steel used. Show physical properties and chemical analysis.
 - a. Mill test reports may be submitted as record documents at the time the reinforcement from that heat of steel is shipped to the site.
 - b. In such cases, submit certificates under the Shop Drawing Submittal number with the letter "R" (for record date) appended to the end (e.g., if the reinforcement was submitted as 03_20_00-002-1, deliver the associated mill certificate as Submittal 03_20_00-002-1R).
- F. Manufacturer's instructions.
- G. Special procedures:
1. Welding procedures in accordance with AWS D1.4 for reinforcement to be field welded.
 - a. Procedures qualification record.
- H. Qualifications statements:
1. Welder qualifications.
- I. Closeout documents:
1. Field quality control and inspection reports.
 2. Field quality assurance special inspection and testing reports.

1.05 DELIVERY, STORAGE, AND HANDLING

- A. Packing and shipping:
1. Deliver bars bundled and tagged with identifying tags.

- B. Acceptance at site:
 - 1. Reinforcing bars: Deliver reinforcing bars lacking grade identification marks with letter containing manufacturer's guarantee of grade.

1.06 SEQUENCING AND SCHEDULING

- A. Bar supports:
 - 1. Do not place concrete until samples and product data for bar supports have been accepted by the Engineer.

PART 2 PRODUCTS

2.01 DESIGN AND PERFORMANCE CRITERIA

- A. Drawings contain notes describing the size and spacing of reinforcement and its placement, details of reinforcement at wall corners and intersections, and details of extra reinforcement around openings in concrete, and other related information.

2.02 MATERIALS

- A. Reinforcing bars:
 - 1. Provide reinforcement of the grades and quality specified, fabricated from new stock, free from excessive rust or scale, and free from unintended bends or other defects affecting its usefulness.
 - 2. ASTM A615 Grade 60 deformed bars, including the following requirements
 - a. Actual yield strength based on mil tests of reinforcement provided shall not exceed the minimum yield strength specified in this Section by more than 18,000 pounds per square inch.
 - b. Ratio of actual ultimate tensile strength to actual tensile yield strength shall not be less than 1.25.
 - 3. Reinforcing bars designated or required to be welded:
 - a. Low-alloy, ASTM A706 Grade 60, deformed bars.
- B. Bar supports:
 - 1. Wire supports:
 - a. All stainless steel bar supports:
 - 1) Conforming to CRSI Manual of Standard Practice recommendations for types and details, but custom fabricated entirely from stainless steel wire in accordance with ASTM A493, AISI Type 316.
 - b. Stainless steel protected bar supports:
 - 1) Conforming to CRSI Manual of Standard Practice Class 2, Type B, and consisting of bright basic wire support fabricated from cold-drawn carbon steel wire with stainless steel ends attached at the bottom of each leg.
 - 2) Stainless steel wire ends shall be in accordance with ASTM A493, AISI Type 316 and shall extend at least 3/4 inch inward from the formed surface of the concrete.
 - c. Bright basic wire bar supports.
 - 1) Conforming to CRSI Manual if Standard Practice, Class 3.

2. Plastic supports:
 - a. Manufacturers: The following or equal:
 - 1) Aztec Concrete Accessories.
 3. Deformed steel reinforcing bar supports:
 - a. Fabricated of materials and to CRSI details recommended for typical reinforcement embedded in concrete and bent to dimensions required to provide specified clearances and concrete cover.
 4. Precast concrete bar supports ("dobies"):
 - a. Pre-manufactured, precast concrete blocks with cast-in annealed steel wires, 16-gauge or heavier.
 - b. Compression strength of concrete: Equal to or exceeding the compression strength of the surrounding concrete.
 - c. Block dimensions:
 - 1) Height to provide specified concrete cover.
 - 2) Footprint not less than 3 inches by 3 inches, and adequate to support the weight of the reinforcement and maintain specified concrete cover without settling into the underlying surface.
- C. Tie wires:
1. General use: Black annealed steel wire, 16-gauge or heavier.
- D. Welded wire fabric reinforcement:
1. Material:
 - a. Carbon steel in accordance with ASTM A1064.
 2. Provide welded wire reinforcement in flat sheet form. Rolled wire fabric is not permitted.
 3. Fabric may be used in place of reinforcing bars if accepted by the Engineer:
 - a. Provide welded wire fabric having cross-sectional area per linear foot not less than the cross-sectional area per linear foot of reinforcing bars indicated on the Drawings.

2.03 FABRICATION

- A. Shop fabrication and assembly:
1. Cut and bend bars in accordance with provisions of ACI 318 and the CRSI Manual of Standard Practice.
 2. Bend bars cold. Use bending collars to develop the recommended bend radius.
 3. Provide bars free from defects and kinks and from bends not indicated on the Drawings.
 4. Circumferential and radiused reinforcement: Roll to the radius required for its location in the structure before installation.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Verification of conditions:
 - 1. Reinforcing bars and welded wire reinforcement:
 - a. Verify that reinforcement is new stock, free from rust scale, loose mill scale, excessive rust, dirt, oil, and other coatings that will adversely affect bonding capacity when placed in the Work.
 - 2. Welded wire fabric:
 - a. Verify that sheets are not curled or kinked before or after installation.

3.02 PREPARATION

- A. Surface preparation:
 - 1. Reinforcing bars - uncoated:
 - a. Clean reinforcement of concrete, dirt, oil and other coatings that will adversely affect bond before embedding bars in subsequent concrete placements.
 - b. Thin coating of red rust resulting from short exposure will not be considered objectionable. Thoroughly clean bars having rust scale, loose mill scale, or thick rust coat.
 - c. Partially embedded reinforcement: Remove concrete or other deleterious coatings from dowels and other projecting bars by wire brushing or sandblasting before bars are embedded in subsequent concrete placements.

3.03 INSTALLATION

- A. Reinforcing bars: General:
 - 1. Field-cutting of reinforcing bars is not permitted.

Table 1. Reinforcement Placing Tolerances		
Member	Tolerance on Reinforcement Location ⁽¹⁾	Tolerance on Minimum Concrete Cover ^(1,2)
Slabs, beams, walls and columns except as noted below:		
10 inches thick and less	± 3/8 inch	- 3/8 inch
More than 10 inches thick	± 1/2 inch	- 1/2 inch
Formed soffits	As noted above	- 1/4 inch
Longitudinal location of bends and ends of reinforcement:		
Conditions not listed below	± 2 inches	- 1/2 inch
At discontinuous ends of brackets and corbels	± 1/2 inch	- 1/4 inch
At discontinuous ends of other members	± 1 inch	- 1/2 inch

Table 1. Reinforcement Placing Tolerances		
Member	Tolerance on Reinforcement Location ⁽¹⁾	Tolerance on Minimum Concrete Cover ^(1,2)
Notes: (1) $\pm$ indicates “plus or minus;” - indicates “minus;” + indicates “plus”. (2) Tolerance on cover is limited as noted but decrease in cover shall not exceed one third of the minimum cover indicated on the Drawings.		

2. Field-bending of reinforcing bars, including straightening and rebending, is not permitted.
- B. Placing reinforcing bars:
1. Accurately place bars to meet position and cover requirements indicated on the Drawings and specified. Secure bars in position.
 2. Tolerances for placement and minimum concrete cover: As listed in Table 1.
 3. Spacing between bars:
 - a. Minimum clear spacing between bars in a layer:
 - 1) As indicated on the Drawings, but not less than the larger of 1.5 times the bar diameter or 1-1/2 inches.
 - b. Minimum clear spacing between bars in 2 or more parallel layers:
 - 1) Place bars in upper layers directly above bars in lower layers.
 - 2) Minimum spacing between layers: As indicated on the Drawings, but not less than the larger of 1.5 times the bar diameter or 1-1/2 inches.
 - c. Limits on minimum clear spacing between bars also applies to the clear spacing between a lap splice and the adjacent bars and/or lap splices.
 4. Lap splices for bars:
 - a. Lap splice locations and lap splice lengths: As indicated on the Drawings. Where lap lengths are not indicated, provide in accordance with ACI 318.
 - b. Unless otherwise specifically indicated on the Drawings (and noted as “non-contact lap splice”), install bars at lap splices in contact with each other and fasten together with tie wire.
 - c. Where bars are to be lap spliced at concrete joints, ensure that bars project from the first concrete placement a length equal to or greater than minimum lap splice length indicated on the Drawings.
 - d. Stagger lap splices where indicated on the Drawings.
 - e. Where lap splice lengths are not indicated on the Drawings, provide lap splice lengths in accordance with ACI 318.
- C. Reinforcing supports:
1. Provide supports of sufficient numbers, sizes, and locations to maintain concrete cover, to prevent sagging and shifting, and to support loads during construction without displacement and without gouging or indentation into forming surfaces.
 - a. Quantities and locations of supports shall not be less than those indicated in ACI SP-66 and the CRSI Manual of Standard Practice.
 2. Do not use brick, concrete masonry units, concrete spalls, rocks, wood, or similar materials for supporting reinforcement.
 3. Do not use “give away bars” that have less cover than that required by the Contract Documents. Do not adjust the location of reinforcement required by the Contract Documents to provide cover for give away bars.

4. Provide bar supports of height required to maintain the clear concrete cover indicated on the Drawings.
5. Provide bar supports at formed vertical faces to maintain the clear concrete cover indicated on the Drawings.
6. Schedule of reinforcement support materials: Provide bar supports as indicated in Table 2.

Table 2. Reinforcement Support Materials		
Case	Location	Material
a.	Concrete placed over earth and concrete seal slabs ("mud mats")	Precast concrete bar supports.
b.	Concrete placed against forms and exposed to water or wastewater process liquids (whether or not such concrete received additional linings or coatings)	All stainless steel bar supports.
c.	Concrete placed against forms and exposed to earth, weather, frequent washdown, or groundwater in the finished work	All stainless steel bar supports.
d.	Concrete placed against forms and exposed to interior equipment/piping areas in the finished work	All stainless steel bar supports.
e.	Between mats of reinforcement, and fully embedded within a concrete member	Bright basic wire bars supports, or deformed steel reinforcing bars.

- D. Tying of reinforcing:
1. Fasten reinforcement securely in place with wire ties.
 2. Tie reinforcement at spacings sufficient to prevent shifting.
 - a. Provide at least 3 ties in each bar length. (Does not apply to dowel lap splices or to bars shorter than 4 feet, unless necessary for rigidity).
 3. Tie slab bars at every intersection around perimeter of slab.
 4. Tie wall bars and slab bar intersections other than around perimeter at not less than every fourth intersection, but at not more than the spacing indicated in Table 3:

Table 3. Maximum Spacing of Tie Wires for Reinforcement		
Bar Size	Slab Bar Spacing (inches)	Wall Bar Spacing (inches)
Bars Number 5 and Smaller	60	48
Bars Number 6 through Number 9	96	60
Bars Number 10 and Number 11	120	96

5. After tying:
 - a. Bend ends of wires inward towards the center of the concrete section. Minimum concrete cover for tie wires shall be the same as cover requirements for reinforcement.
 - b. Remove tie wire clippings from inside forms before placing concrete.
- E. Welded wire fabric reinforcement:
1. Install only where indicated on the Drawings or accepted in advance by the Engineer.

2. Install necessary tie wires, spacing chairs, and supports to keep welded wire fabric at its designated position in the concrete section while concrete is being placed.
 3. Straighten welded wire fabric to make sheets flat in the Work.
 4. Do not allow wire fabric to drape between supports unless such a configuration is specifically indicated on the Drawings.
 - a. If fabric is displaced during placement of concrete, make provisions to restore it to the designated location using methods acceptable to the Engineer.
 5. Bend welded wire fabric as indicated on the Drawings or required to fit Work.
 6. Lap splice welded wire fabric as indicated on the Drawings.
 - a. If lap splice length is not indicated, splice in accordance with ACI 318, but not less than 1 1/2 courses of fabric or 8 inches minimum. Tie laps at ends and at not more than 12 inches on center.
- F. Welding reinforcing bars:
1. Weld only where indicated on the Drawings or where acceptance is received from the Engineer prior to welding.
 2. Perform welding in accordance with AWS D1.4 and welding procedures accepted by the Engineer.
 - a. Conform to requirements for minimum preheat and interpass temperatures.
 3. Submit:
 - a. Welding procedures specification.
 - b. Procedures qualification record.
 - c. Welder qualification test record.
 4. Do not tack weld reinforcing bars except where specifically indicated on the Drawings.

3.04 FIELD QUALITY CONTROL

- A. Provide quality control for the Work of this Section as specified in Section 01_45_17 Contractor Quality Control Plan.
- B. Field inspections and testing:
1. Submit records of inspections and testing to the Engineer in electronic format within 24 hours after completion.

3.05 FIELD QUALITY ASSURANCE

- A. Provide quality assurance as specified in Section 01_45_17 - Contractor Quality Control Plan.
- B. Special inspections and tests:
1. Provide as specified in Section 01_45_24 - Regulatory Quality Assurance.
 2. Frequency of inspections:
 - a. Unless otherwise indicated on the Drawings or in this Section, provide periodic special inspection as required by the Building Code specified in Section 01_41_00 - Regulatory Requirements.
 3. Preparation:
 - a. Review Drawings and Specification for the Work to be observed.
 - b. Review approved Submittals and Shop Drawings.

4. Inspections: Special inspection shall include, but is not limited to, the following items:
 - a. Reinforcement: General:
 - 1) Type (material) and location of reinforcement supports.
 - 2) Bar material/steel grade and bar size.
 - 3) Location, placement, and spacing of bars.
 - 4) Clear concrete cover over reinforcement.
 - 5) Lap splice: Location and lap length. Bars within tolerances for contact (unless non-contact splice is indicated on the Drawings).
 - 6) Bar hooks and development lengths embedded within concrete sections as indicated on the Drawings.
 - 7) Reinforcement tied in position and tie wire legs turned inward toward the center of the concrete section.
 - b. Reinforcement: Welding:
 - 1) Inspector qualification and inspections shall be in accordance with the requirements of AWS D1.4.
 - 2) Provide periodic inspection for:
 - a) Weldability of reinforcement other than ASTM A706.
 - b) Single pass fillet welds with thickness less than or equal to 5/16 inch.
 - 3) Provide continuous inspection for:
 - a) Other welds.
 - b) Welds at mechanical reinforcing bar couplers and end anchors.
 - 4) In addition to visual inspection, Owner may inspect reinforcing bar welds by other methods, including radiographic inspection.
5. Records of inspections:
 - a. Provide a written record of each inspection using forms acceptable to the Engineer and to the Building Official.
 - b. Submit electronic copies of inspection reports to the Engineer within 24 hours after completion of inspections.

3.06 NON-CONFORMING WORK

- A. Before placing concrete, adjust or remove and re-install reinforcement to conform to the requirements of the Contract Documents.

END OF SECTION

SECTION 03_21_17

ADHESIVE-BONDED REINFORCING BARS AND ALL THREAD RODS IN CONCRETE

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Bonding reinforcing bars and all thread rods in concrete using adhesives.

1.02 REFERENCES

- A. American Concrete Institute (ACI).
 - 1. 355.4 - Qualification of Post-Installed Adhesive Anchors in Concrete and Commentary.
- B. American National Standards Institute (ANSI):
 - 1. Standard B212.15 - Carbide Tipped Masonry Drills and Blanks for Carbide Tipped Masonry Drills.
- C. ASTM international (ASTM):
 - 1. C881 - Standard Specification for Epoxy-Resin-Base Bonding Systems for Concrete.
- D. Concrete Reinforcing Steel Institute (CRSI).
- E. ICC Evaluation Service, Inc. (ICC-ES):
 - 1. AC308 - Acceptance Criteria for Post-Installed Adhesive Anchors in Concrete Elements.
- F. Society for Protective Coatings (SSPC):
 - 1. SP 1 - Solvent Cleaning.

1.03 TERMINOLOGY

- A. The words and terms listed below are not defined terms that require initial capital letters, but, when used in this Section, have the indicated meaning.
 - 1. Evaluation Service Report (ESR): Report prepared by ICC-ES or other testing agency acceptable to the Engineer and to the building official that documents testing and review of a product to confirm that it complies with the requirements of designated ICC-ES acceptance criteria, and to document its acceptance for use under the building code specified in Section 01_41_00 - Regulatory Requirements.

1.04 SUBMITTALS

- A. Product data: Technical data for adhesives, including:
 - 1. Manufacturer's printed installation instructions (MPII).

2. Independent laboratory test results indicating allowable loads in tension and shear for concrete of the types included in this Work, with load modification factors for temperature, spacing, edge distance, and other installation variables.
 3. Handling and storage instructions.
- B. Quality Control Submittals:
1. Special inspection: Detailed step-by-step instructions for the special inspection procedures required by the building code specified in Section 01_41_00 - Regulatory Requirements.
 2. For each adhesive to be used, Evaluation Report confirming that the product complies with the requirements of ICC-ES AC308 for both un-cracked and cracked concrete and for use in Seismic Design Categories A through F.
 3. Installer qualifications:
 - a. Submit evidence of successful completion of the adhesive manufacturer's installation training program.
 - b. Submit evidence of current certification for installation of inclined and overhead anchors under sustained tension loading.
 4. Inspection and testing reports:
 - a. Field quality control: Reports of inspections and tests.
 - b. Field quality assurance: Reports of special inspections and tests.

1.05 QUALITY ASSURANCE

- A. Qualifications:
1. Installation requirements:
 - a. Have available at the Site and install anchors in accordance with the adhesive MPII.
 2. Installer qualifications:
 - a. Demonstrating successful completion of the adhesive manufacturer's on-site training program for installation of adhesive-bonded anchors.
 - b. Holding current certification for installation of adhesive-bonded anchors by a qualified organization acceptable to the Engineer and to the building official.
 - 1) Organizations/certification programs deemed to be qualified are:
 - a) ACI-CRSI Adhesive Anchor Installer Certification Program.
 - b) Adhesive anchor manufacturer's certification program, subject to acceptance by the Engineer and the building official.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. As specified in Section 01_60_01 - Product Requirements.
- B. Store and protect products as follows, unless more restrictive requirements are recommended by the manufacturer:
1. Store adhesives and adhesive components on pallets or shelving in a covered-storage area protected from weather.
 2. Control temperature to maintain storage within the manufacturer's recommended temperature range.
 - a. If products have been stored at temperatures outside the manufacturer's recommended range, test by methods acceptable to the Engineer to confirm acceptability before installing in the Work.

3. Dispose of products that have passed their expiration date.

1.07 PROJECT CONDITIONS

- A. As specified in Section 01_81_50 - Design Criteria.
- B. Seismic Design Category (SDC) for structures: As specified in Section 01_81_50 - Design Criteria.

PART 2 PRODUCTS

2.01 GENERAL

- A. Like items of materials: Use end products of one manufacturer in order to achieve structural compatibility and singular responsibility.
- B. Adhesives shall have a current Evaluation Report documenting testing and compliance in accordance with ACI 355.4 and ICC-ES AC308 for use with un-cracked concrete and with cracked concrete in the seismic design category specified.
- C. Bond reinforcing bars and all thread rods in concrete using epoxy adhesive unless other adhesives specified are specifically indicated on the Drawings or approved in writing by the Engineer.

2.02 EPOXY ADHESIVE

- A. Materials:
 1. In accordance with the physical requirements of ASTM C881, Type IV, Grade 3, Class B or C, depending on Site conditions.
 2. Two-component, 100 percent solids, insensitive to moisture.
 3. Cure temperature, pot life, and workability: Compatible with intended use and environmental conditions.
- B. Packaging:
 1. Disposable, self-contained cartridge system furnished in side-by-side cartridges designed to fit into a manually or pneumatically operated caulking gun, and with resin and hardener components isolated until mixing through the manufacturer's static mixing nozzle.
 - a. Nozzle designed to dispense components in the proper ratio and to thoroughly blend the components for injection from the nozzle directly into the prepared hole.
 - b. Provide nozzle extensions as required to allow full-depth insertion and filing from the bottom of the hole.
 2. Container markings: Include the manufacturer's name, product name, batch number, mix ratio by volume, product expiration date, ANSI hazard classification, and appropriate ANSI handling precautions.
- C. Manufacturers: One of the following or equal:
 1. Hilti, Inc., HIT-RE 500-V3.
 2. Simpson Strong-Tie Co., Inc., SET-3G.

2.03 ALL THREAD RODS

- A. Materials: As specified in Section 05_12_00 - Structural Steel Framing for rods, nuts, and washers.

2.04 REINFORCING BARS

- A. As specified in Section 03_20_00 - Concrete Reinforcing.

2.05 REPAIR MATERIALS

- A. Dry-pack mortar: As specified in Section 03_35_29 - Concrete Finishes.
- B. Epoxy grout: As specified in Section 03_60_00 - Grouting.

PART 3 EXECUTION

3.01 GENERAL

- A. Execution of this Work is restricted to installers who have personally completed the adhesive manufacturer's on-site training for the products to be installed, and who are personally certified through a qualified certification program described under the Quality Assurance article and accepted by the Engineer and the building official.
 - 1. Do not install holes or adhesive until training is complete.
- B. Perform Work in compliance with the accepted MPII and the following instructions. Where the accepted MPII and the instructions conflict, the MPII shall prevail.
- C. Install reinforcing bars and all thread rods to embedment depth and at spacing and locations indicated on the Drawings.
 - 1. If embedment depth is not indicated, contact the Engineer for requirements.
 - 2. Do not install adhesive-bonded all thread rods or reinforcing bars in upwardly inclined or overhead applications unless accepted in advance by the Engineer.

3.02 PREPARATION

- A. Do not begin installation of adhesive bonded anchors until:
 - 1. Concrete has achieved an age of at least 21 days after placement.
 - 2. On-site training in installation of adhesive bonded anchors by the manufacturer's technical representative is complete. Do not drill holes in concrete or install adhesive and embeds in holes.
- B. Review the MPII and "Conditions of Use" stipulated in the Evaluation Report before beginning work.
 - 1. Bring to the attention of the adhesive manufacturer's technical representative any discrepancies between these documents and resolve before proceeding with installation.

- C. Install adhesive bonded anchors in full compliance with the MPII using personnel who have successfully completed the manufacturer's on-site training for products to be used and who hold certifications specified in this Section.
- D. Confirm that adhesive and substrate receiving adhesive are within the manufacturer's recommended range for temperature and moisture conditions and will remain so during the curing time for the product.

3.03 HOLE SIZING AND INSTALLATION

- A. Drilling holes:
 - 1. Determine location of reinforcing bars or other obstructions with a nondestructive indicator device and mark locations with construction crayon on the surface of the concrete.
 - 2. Do not damage or cut existing reinforcing bars, electrical conduits, or other items embedded in the existing concrete without prior acceptance by the Engineer.
- B. Hole-drilling equipment:
 - 1. Electric or pneumatic rotary impact type with medium or light impact.
 - a. Installation of anchors in cored holes is not permitted.
 - b. Set drill to "rotation only" mode, or to "rotation plus hammer" mode in accordance with the manufacturer's installation instructions and the requirements of the Evaluation Report.
 - c. Where edge distances are less than 2 inches and "rotation plus hammer" mode is permitted, use lighter impact equipment to prevent micro-cracking and concrete spalling during the drilling process.
 - 2. Drill bits: Carbide-tipped in accordance with ANSI B212-15, unless otherwise recommended by the manufacturer or required as a condition of use in the Evaluation Report.
 - a. Hollow drill bits with flushing air systems are preferred. Air supplied to drill bits shall be free of oil, water, or other contaminants that will reduce bond.
- C. Hole diameter: As recommended in the manufacturer's installation instructions and the Evaluation Report.
- D. Hole depth: As recommended in the manufacturer's installation instructions to provide minimum effective embedment indicated on the Drawings.
- E. Obstructions in drill path:
 - 1. If an existing reinforcing bar or other obstruction is hit while drilling a hole, unless otherwise accepted by the Engineer, stop drilling. Prepare and fill the hole with dry-pack mortar. Relocate the hole to miss the obstruction and drill another hole to the required depth.
 - a. Obtain the Engineer's acceptance of distance between abandoned and relocated holes before proceeding with the relocation.
 - b. Allow dry-pack mortar to cure to a strength equal to that of the surrounding concrete before resuming drilling in the area.
 - c. Epoxy grout may be substituted for dry-pack mortar when accepted by the Engineer.

2. Avoid drilling an excessive number of holes in an area of a structural member, which would excessively weaken the member and endanger the stability of the structure.
 3. When existing reinforcing steel is encountered during drilling and when specifically accepted by the Engineer, enlarge the hole by 1/8 inch, core through the existing reinforcing steel at the larger diameter, and resume drilling at original hole diameter using pneumatic rotary impact drill.
 4. Bent bar reinforcing bars: Where edge distances are critical and interference with existing reinforcing steel is likely, if acceptable to the Engineer, drill hole at 10-degree (or less) angle from axis of reinforcing bar or all thread rod being installed.
- F. Cleaning holes:
1. Insert air nozzle to bottom of hole and blow out loose dust.
 - a. Use compressed air that is free of oil, water, or other contaminants that will reduce bond.
 - b. Provide minimum air pressure of 90 pounds per square inch for not less than 4 seconds.
 2. Using a stiff bristle brush with diameter that provides contact around the full perimeter of the hole, vigorously brush hole to dislodge compacted drilling dust.
 - a. Insert brush to the bottom of the hole and withdraw using a simultaneous twisting motion.
 - b. Repeat at least 4 times.
 3. Repeat the preceding steps as required to remove drilling dust or other material that will reduce bond, and in the number of cycles required by the MPII and the Evaluation Report.
 4. Leave prepared holes clean and dry.
 5. Protect prepared and cleaned holes from contamination and moisture until adhesive is installed.
 6. Re-clean and dry previously prepared holes if, in the opinion of the Engineer, the hole has become contaminated after initial cleaning.

3.04 INSTALLATION OF ADHESIVE AND INSERTS

- A. Clean and prepare inserts reinforcing bars and all thread rods:
1. Prepare embedded length of reinforcing bars and all thread rods by cleaning to bare metal. Inserts shall be free of oil, grease, paint, dirt, mill scale, rust, or other coatings that will reduce bond.
 2. Solvent clean prepared reinforcing bars and all thread rods over the embedment length in accordance with SSPC-SP 1. Provide an oil and grease free surface for bonding of adhesive to steel.
- B. Fill holes with adhesive:
1. Fill hole with adhesive only when dry. Do not fill when the hole is filled with water or damp, except with written authorization by the Engineer.
 2. Starting at the bottom of the hole, fill hole with adhesive inserting the reinforcing bar or all thread rod.
 3. Fill hole as nozzle is withdrawn without creating air voids.

4. Unless otherwise indicated on the Drawings, fill hole with sufficient adhesive so that excess adhesive is extruded out of the hole when the reinforcing bar or all thread rod is inserted.
 5. Where necessary, seal hole at surface of concrete to prevent loss of adhesive during curing.
- C. Installing reinforcing bars and all thread rods.
1. Unless otherwise indicated on the Drawings, install bars and rods perpendicular to the concrete surface.
 2. Insert reinforcing bars and all thread rods into adhesive in accordance with the manufacturer's recommended procedures.
 3. Confirm that insert has reached the designated embedment in the concrete and that adhesive completely surrounds the embedded portion.
 4. Securely brace bars and all thread rods in place to prevent displacement while the adhesive cures. Bars and rods displaced during curing will be considered damaged and replacement will be required.
 5. Clean excess adhesive from the mouth of the hole.
- D. Curing and loading.
1. Provide and maintain curing conditions recommended by the adhesive manufacturer for the period required to fully cure the adhesive at the temperature of the concrete.
 2. Do not disturb or load bonded embeds until the manufacturer's recommended cure time, based on temperature of the concrete, has elapsed.

3.05 POST-INSTALLATION ACTIVITIES

- A. Do not bend bars or all thread rods after bonding to the concrete, unless accepted in advance by the Engineer.
- B. Attachments to all thread rods:
1. After assemblies to be connected are placed, install nuts and washers for threaded rods as indicated on the Drawings.

3.06 FIELD QUALITY CONTROL

- A. Provide field quality control over the Work of this Section as specified in Section 01_45_17 - Contractor Quality Control Plan.
- B. Do not allow Work described in this Section to be performed by individuals who do not hold the specified certifications and who have not completed the specified jobsite training.
- C. Manufacturer's services:
1. Before beginning installation, adhesive manufacturer's technical representative to conduct on-site training in proper storage and handling of adhesive, drilling and cleaning of holes, and preparation and installation of reinforcing bars and all thread rods.
 - a. Provide notice of scheduled training to the Engineer and to special inspector(s) not less than 10 working days before training occurs. Engineer and special inspector may attend training sessions.

2. Submit record, signed by the manufacturer's technical representative, listing the Contractor's personnel who completed the training. Only qualified personnel who have completed the manufacturer's on-site training shall perform installations.
- D. Field inspections and testing:
1. Hole drilling and preparation.
 2. Results: Submit records of inspections and testing to the Engineer by electronic copies within 24 hours after completion.

3.07 FIELD QUALITY ASSURANCE

- A. Provide field quality assurance over the Work of this Section as specified in Section 01_45_17 - Contractor Quality Control Plan.
- B. Special inspections, special tests, and structural observation:
1. Provide as specified in Section 01_45_24 - Regulatory Quality Assurance.
 2. Frequency of inspections:
 - a. Unless otherwise indicated on the Drawings or in this Section, provide periodic special inspection as required by the Evaluation Report for the product installed.
 - b. Provide continuous inspection for the initial installation of each type and size of adhesive bonded reinforcing bar and all thread rod. Subsequent installations of the same anchor may be installed with periodic inspection as defined in subsequent paragraphs.
 3. Preparation:
 - a. Review Drawings and Specifications for the Work to be observed.
 - b. Review the adhesive manufacturer's MPII and recommended installation procedures.
 - c. Review Evaluation Report "Conditions of Use" and "Special Inspection" requirements.
 4. Inspection: Periodic:
 - a. Initial inspection. Provide an initial inspection for each combination of concrete and reinforcing bar strength or concrete strength and all thread rod material being installed. During initial inspection, observe the following for compliance with the installation requirements.
 - 1) Concrete: Class (minimum specified compressive strength) and thickness.
 - 2) Environment: Temperature conditions at the work area and moisture conditions of concrete and drilled hole.
 - 3) Holes: Locations, spacing, and edge distances; verification of drill bit compliance with requirements; cleaning equipment and procedures; cleanliness of hole. Before adhesive is placed, confirm that depth and preparation of holes conforms to the requirements of the Contract Documents, the MPII, and the "Conditions of Use" listed in the Evaluation Report.
 - 4) Adhesive: Product manufacturer and name, lot number and expiration date, temperature of product at installation, installation procedure. Note initial set times observed during installation.

- 5) Reinforcing bars and all thread rods: Material diameter and length; steel grade and/or strength; cleaning and preparation; cleanliness at insertion; minimum effective embedment provided.
- b. Subsequent inspections: Subsequent installations of the same reinforcing bars or all thread rods may be performed without the presence of the special inspector, provided that:
 - 1) There is no change in personnel performing the installation, the general strength and characteristics of the concrete receiving the inserts, or the reinforcing bars and all thread rods being used.
 - 2) For ongoing installations, the special inspector visits the Site at least once per day during each day of installation to observe the Work for compliance with material requirements and installation procedures.
- 5. Inspection: Continuous.
 - a. Make observations as described under “Inspection - Periodic, Initial Inspection” during drilling, cleaning, and bonding activities for all bars and rods installed.
- 6. Records of inspections:
 - a. Provide a written record of each inspection using forms acceptable to the Engineer and to the building official.
 - b. Submit electronic copies of inspection reports to the Engineer within 24 hours after completion of inspection.

END OF SECTION

SECTION 03_30_00

CAST-IN-PLACE CONCRETE

TABLE OF CONTENTS

PART 1	GENERAL	2
1.01	SUMMARY	2
1.02	REFERENCES	2
1.03	TERMINOLOGY	4
1.04	DELEGATED DESIGN	5
1.05	SUBMITTALS	5
1.06	QUALITY ASSURANCE	9
1.07	DELIVERY, STORAGE, AND HANDLING	10
1.08	PROJECT CONDITIONS	10
1.09	SEQUENCING AND SCHEDULING	10
PART 2	PRODUCTS	11
2.01	DESIGN AND PERFORMANCE CRITERIA	11
2.02	MATERIALS - GENERAL	11
2.03	MATERIALS - CONCRETE MIX CONSTITUENTS	12
2.04	MATERIALS FOR PLACING AND CURING	16
2.05	EQUIPMENT	17
2.06	CONCRETE MIXES	19
2.07	SOURCE QUALITY CONTROL	29
PART 3	EXECUTION	30
3.01	PREPARATION	30
3.02	CONCRETE JOINTS	31
3.03	MEASURING AND BATCHING MATERIALS	32
3.04	MIXING AND TRANSPORTING	32
3.05	PLACING AND CONSOLIDATING	34
3.06	FINISHING CONCRETE	36
3.07	CURING	37
3.08	PROTECTION	39
3.09	COLD WEATHER CONCRETING	40
3.10	HOT WEATHER CONCRETING	43
3.11	FIELD QUALITY CONTROL BY CONTRACTOR	44
3.12	FIELD QUALITY CONTROL BY OWNER	46
3.13	NON-CONFORMING WORK	46

ATTACHMENT A - MENZEL FORMULA AND NOMOGRAPH

ATTACHMENT B - COARSENESS FACTOR CHART

ATTACHMENT C - COMBINED AGGREGATE GRADATION CHART

ATTACHMENT D - CONCRETE PLACEMENT CHECKLIST

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Cast-in-place concrete.
- B. The requirements of this Section require advance planning for preparation and testing of trial batches. Review the mix design and testing requirements carefully and schedule preparations and testing with sufficient time to complete tests, to obtain the Engineer's review of mixes and testing results, and to complete revisions and re-testing if required.

1.02 REFERENCES

- A. American Concrete Institute (ACI):
 - 1. CODE-318 - Building Code Requirements for Structural Concrete and Commentary.
 - 2. CODE-350 - Code Requirements for Environmental Engineering Concrete Structures and Commentary.
 - 3. PRC-212.3 - Report on Chemical Admixtures for Concrete.
 - 4. PRC-302.1 - Guide to Concrete Floor and Slab Construction.
 - 5. PRC-305 - Guide to Hot Weather Concreting.
 - 6. PRC-306 - Guide to Cold Weather Concreting.
- B. ASTM International (ASTM):
 - 1. C29 - Standard Test Method for Bulk Density ("Unit Weight") and Voids in Aggregate.
 - 2. C31 - Standard Practice for Making and Curing Concrete Test Specimens in the Field.
 - 3. C33 - Standard Specification for Concrete Aggregates.
 - 4. C39 - Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens.
 - 5. C40 - Standard Test Method for Organic Impurities in Fine Aggregates for Concrete.
 - 6. C42 - Standard Test Method of Obtaining and Testing Drilled Cores and Sawed Beams of Concrete.
 - 7. C88 - Standard Test Method of Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate.
 - 8. C94 - Standard Specification for Ready-Mixed Concrete.
 - 9. C114 - Standard Test Methods for Chemical Analysis of Hydraulic Cement.
 - 10. C117 - Standard Test Method for Materials Finer than 75-µm (No. 200) Sieve in Mineral Aggregates by Washing.
 - 11. C123 - Standard Test Method for Lightweight Particles in Aggregate.
 - 12. C131 - Standard Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine.
 - 13. C136 - Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates.
 - 14. C138 - Standard Test Method for Density (Unit Weight), Yield, and Air Content (Gravimetric) of Concrete.

15. C142 - Standard Test Method for Clay Lumps and Friable Particles in Aggregate.
16. C143 - Standard Test Method for Slump of Hydraulic-Cement Concrete.
17. C150 - Standard Specification for Portland Cement.
18. C156 - Standard Test Method for Water Loss from a Mortar Specimen Through Liquid Membrane-Forming Curing Compounds for Concrete.
19. C157 - Standard Test Method for Length Change of Hardened Hydraulic-Cement Mortar and Concrete.
20. C171 - Standard Specifications for Sheet Materials for Curing Concrete.
21. C172 - Standard Practice for Sampling Freshly Mixed Concrete.
22. C173 - Standard Test Method for Air Content of Freshly Mixed Concrete by the Volumetric Method.
23. C260 - Standard Specification for Air-Entraining Admixtures for Concrete.
24. C293 - Standard Test Method for Flexural Strength of Concrete (Using Simple Beam With Center-Point Loading).
25. C295 - Standard Guide to Petrographic Examination of Aggregates for Concrete.
26. C309 - Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete.
27. C311 - Standard Test Methods for Sampling and Testing Coal Ash or Natural Pozzolans for Use in Portland-Cement Concrete.
28. C494 - Standard Specification for Chemical Admixtures for Concrete.
29. C595 - Standard Specification for Blended Hydraulic Cements.
30. C618 - Standard Specification for Coal Ash and Raw or Calcined Natural Pozzolan for Use in Concrete.
31. C702 - Standard Practice for Reducing Samples of Aggregate to Testing Size.
32. C856 - Standard Practice for Petrographic Examination of Hardened Concrete.
33. C1064 - Standard Test Method for Temperature of Freshly Mixed Hydraulic-Cement Concrete.
34. C1218 - Standard Test Method for Water-Soluble Chloride in Mortar and Concrete.
35. C1260 - Standard Test Method of Potential Alkali Reactivity of Aggregates (Mortar Bar Method).
36. C1293 - Standard Test Method for Determination of Length Change of Concrete due to Alkali-Silica Reaction.
37. C1567 - Standard Test Method for Determining the Potential Alkali-Silica Reactivity of Combinations of Cementitious Materials and Aggregate (Accelerated Mortar-Bar Method).
38. C1602 - Standard Specification for Mixing Water Used in the Production of Hydraulic Cement Concrete.
39. D75 - Standard Practice for Sampling Aggregates.
40. D2103 - Standard Specification for Polyethylene Film and Sheeting.
41. D3665 - Standard Practice for Random Sampling of Construction Materials.
42. D4791 - Standard Test Method for Flat Particles, Elongated Particles, or Flat and Elongated Particles in Coarse Aggregate.

C. National Ready-Mixed Concrete Association (NRMCA).

1.03 TERMINOLOGY

- A. The words and terms listed below are not defined terms that require initial capital letters, but, when used in this Section, have the indicated meaning.
1. Alkali: The sum of sodium oxide and potassium oxide calculated as sodium oxide.
 2. Alkali load: Amount of alkalies contributed by the portland cement in a concrete mixture, expressed in pounds per cubic yard (lb/yd³) and calculated by multiplying the portland cement content of the concrete in lb/yd³ by the alkali content of the portland cement, or the portland cement portion of a blended cement, divided by 100.
 3. Architectural concrete: Concrete surfaces that will be exposed to view in the finished Work.
 - a. For purposes of this Section, include only those surfaces that receive paint or coatings.
 - b. Exposed concrete surfaces in open basins, channels, and similar liquid containing structures: Surfaces will be considered exposed to view if located above the water line as defined in Section 03_35_29 - Concrete Finishes.
 - c. Exterior concrete surfaces with portions above and below grade: Surface will be considered exposed to view if located above the grade line as defined in Section 03_35_29 - Concrete Finishes.
 4. Average daily temperature: Calculated by summing hourly measurements of air temperature in the shade at the face of the concrete and dividing that sum by 24. In calculating the sum of the temperatures recorded, any measurement less than 50 degrees Fahrenheit shall be recorded as 0 degrees Fahrenheit and included in the sum.
 5. Cementitious materials: Portland cement or blended cement and supplementary cementitious materials.
 6. Class of concrete: Refers to a mix with characteristics, proportions, and constituents (including a specific combination of admixtures) as specified in this Section.
 - a. Any change in the source or characteristics of constituent materials, in the proportions of materials, or in the admixtures included in a mix shall be considered as creating a new and separate class of concrete.
 - b. Any mix to be placed by pumping shall be considered as creating a new and separate class of concrete.
 7. Cold weather: Includes one or more of the following conditions:
 - a. Current air temperature is 45 degrees Fahrenheit and falling.
 - b. Air temperature during the first 24 hours after placement is expected to fall into the range of 45 degrees Fahrenheit to 40 degrees Fahrenheit.
 - c. A period when, for more than 3 consecutive days, the following conditions exist:
 - 1) The average daily air temperature drops below 40 degrees Fahrenheit.
 - 2) The air temperature is not greater than 50 degrees Fahrenheit for more than one-half of any consecutive 24-hour period.
 8. Cold weather concreting: Operations for placing, finishing, curing, and protecting concrete during cold weather.
 9. Green concrete: Concrete that has not yet achieved 100 percent of the minimum specified compressive strength, f'c, for that mix.

10. Hairline crack: Crack with a crack width of less than 4 thousandths of an inch (0.004 inches).
11. Hot weather: Any combination of ambient temperature, concrete temperature, relative humidity, wind speed, and solar radiation intensity that creates conditions that will evaporate water from a free concrete surface at a rate equal to or greater than 0.2 pounds per square foot per hour as determined by the Menzel Formula and nomograph published in ACI PRC-305 and in this Section, Attachment A - Menzel Formula and Nomograph.
12. Hot weather concreting: Operations for placing, finishing, curing, and protecting concrete during hot weather.
13. Paste content: The total concrete volume minus the volume of aggregate, expressed as a percentage of total volume. Paste volume includes volume of cementitious materials, water, air, admixtures materials, and any fibers.
14. Supplemental cementitious material: Inorganic material such as coal ash or natural pozzolans that reacts pozzolanically.

1.04 DELEGATED DESIGN

- A. As specified in Section 01_35_73 - Delegated Design Procedures.
- B. Concrete mix designs.

1.05 SUBMITTALS

- A. Furnish Submittals as specified in Section 01_33_00 - Submittal Procedures.
- B. General:
 1. Data for concrete mixes and mix constituents supplied to the Work shall be coordinated through a single supplier.
 2. A maximum of 2 mix designs will be reviewed by the Engineer for each class of concrete required.
 - a. Review of additional mix designs shall be at the expense of the Contractor.
- C. Product data:
 1. Data for all products in the mix for each class of concrete shall be submitted concurrently with that mix design.
 2. Where products conforming to NSF 61 are required, submit evidence of testing and listing under NSF 61 for use in direct contact with potable water. Testing and listing shall be by a nationally recognized agency acceptable to the Engineer.
 3. Admixtures:
 - a. For each admixture included in concrete mixes, submit manufacturer's product data demonstrating compliance with standards specified.
 - b. If air entraining admixture requires test method other than ASTM C173 to accurately determine air content, make special note of requirements in Submittal.
 4. Curing compound: Submit complete data on proposed compound.

D. Delegated Design Submittals:

1. Concrete mix designs:
 - a. Submit full details, including mix design calculations and plots, for proposed concrete mixes.
 - b. Include mix design calculations of proportions by both weight and volume.
 - c. Determine and include the alkali load of the proposed mix.
 - d. Include information on correction of batching for varying moisture contents of fine aggregate.
 - e. Submit source quality test records with mix design Submittal.
 - f. Provide calculations demonstrating that the proposed mixes provide the required average compression strength of concrete (f'_{cr}) based on source quality test records.
 - g. For each Class A or Class M mix design submitted, plot the mix design Attachment B - Coarseness Factor Chart and submit.
 - h. For each Class A or Class M mix design submitted, plot the combined aggregate gradation on the chart Attachment C - Combined Aggregate Gradation Chart and submit.

E. Concrete mixes - Trial batches:

1. Drying shrinkage test results.
 - a. Submit results of testing.
 - b. Submit test specimens from drying shrinkage tests for trial batches.
 - 1) Submit specimens from each mix accepted by the Engineer.
 - 2) Using indelible marker, clearly label each specimen with concrete class, trial batch mix designator, and specimen number.
2. Compression strength test results.
 - a. Submit results of testing. Provide data for each cylinder tested.
 - b. Submit data indicating trial batch mix designator, slump, and specimen number for each test cylinder.
 - c. Submit test specimens from compression strength tests for trial batches.
 - 1) Using indelible marker, clearly label each cylinder with concrete class, trial batch number, and specimen number.
3. If there is any change in suppliers or in quality of concrete mix constituents, submit new test data.

F. Test reports:

1. Dated not more than 24 months prior to the date of Submittal.
2. Aggregate:
 - a. Submit certified copies of commercial laboratory tests proposed for use in concrete.
 - b. Sieve analyses:
 - 1) During construction, submit sieve analyses of coarse, fine, and combined aggregates used any time there is a change in supplier or a significant change in the character and/or grading of materials, and when requested by the Engineer.
 - c. Aggregates - coarse:
 - 1) Physical properties:
 - a) Sieve analysis.
 - b) Percentage of particles having flat and/or elongated characteristics.

- c) Abrasion loss.
 - d) Soundness.
 - 2) Deleterious substances:
 - a) Clay lumps and friable particles content.
 - b) Materials finer than No. 200 sieve (percentage).
 - c) Shale and chert content.
 - d) Coal and lignite content.
 - 3) Alkali reactivity.
 - 4) Deleterious substances:
 - a) Clay lumps and friable particles content.
 - b) Chert and shale content.
 - c) Coal and lignite content.
 - d) Materials finer than No. 200 sieve.
 - 5) Alkali reactivity.
- d. Aggregates - Fine:
 - 1) Physical properties:
 - a) Sieve analysis and fineness modulus.
 - b) Soundness.
 - 2) Deleterious substances:
 - a) Clay lumps and friable particles (percentage).
 - b) Materials finer than No. 200 sieve (percentage).
 - c) Coal and lignite (percentage).
 - d) Shale and chert.
 - e) Organic impurities ("Color" as determined by ASTM C40).
 - 3) Alkali reactivity.
- e. Aggregates - Combined:
 - 1) Test combined gradation for the following sieve sizes: 1.5 inches, 1 inch, 3/4 inch, 1/2 inch, 3/8 inch, No. 4, No. 8, No. 16, No. 30, No. 100, No. 200.
 - 2) Bulk density in accordance with ASTM C29.
 - 3) Void content in accordance with ASTM C29.
 - 4) Submit at:
 - a) Initial mixture design Submittal.
 - b) Intervals of not more than 4 weeks.
 - c) Any time there is a change in character or grading of constituent materials.
 - d) When requested by the Engineer.
- 3. Cement:
 - a. Mill tests, including alkali content measured as equivalent alkalis, for each shipment of cement included in the Work.
 - 1) During construction, submit mill certificates for cement being used at intervals of not more than 90 days, any time there is a change in supplier or a significant change in the character of the materials, and when requested by the Engineer.
- 4. Supplemental cementitious material:
 - a. Coal ash: Identify source and provide testing results to demonstrate compliance with requirements of ASTM C618 and this Section.
 - 1) Include the Supplier's report certifying the total alkali content of the material, expressed as equivalent percentage of sodium oxide (Na_2Oe).

- G. Certificates:
1. Current NRMCA certification for all plants and trucks that will be used to supply concrete.
- H. Source Quality Control Submittals:
1. Truck batch tickets for each load of concrete delivered to the Site, whether accepted or rejected.
 2. Concrete supplier's quality control plan. Include the following elements, at a minimum:
 - a. Names and qualifications of key quality control personnel:
 - 1) Quality control manager.
 - 2) Testing and inspection personnel.
 - b. Names and qualifications of testing laboratories:
 - 1) Each laboratory shall hold current accreditation from the AASHTO Accreditation Program, or other accreditation program acceptable to the Engineer, for each test performed.
 - c. Example forms for: Inspection reports, certificates of compliance, and test results.
 - d. Quality control procedures: Method and frequency of performing each procedure, including inspections and materials testing. At a minimum, the plan shall include:
 - 1) Daily testing of aggregate gradation.
 - 2) Monthly testing of cement quality.
 - 3) Monthly testing of coal ash quality.
 - e. Procedures to control quality characteristics, including standard procedures to address properties outside the specified operating limits, and example reports to document non-conformances and corrective actions taken. Include procedure for notifying the Contractor and Engineer of non-conformances.
 - f. Procedures for verifying that:
 - 1) Materials are properly stored during concrete batching operations.
 - 2) Batch plants have the ability to maintain concrete consistency during periods of extreme heat and of low temperatures.
 - 3) Admixtures are dispensed in the correct dosages within the accuracy requirements specified.
 - 4) Delivery trucks have a valid NRMCA certification card.
 - g. Procedures for verifying that weighmaster certificate for each load of concrete shows:
 - 1) Cement and supplementary materials are from sources designated in the approved Submittals.
 - 2) Concrete as-batched complies with the constituent weights designated in the approved Submittals.
 - 3) Corrections for aggregate moisture are being correctly applied.
 - 4) Any mix water withheld from the batch.
 - h. Procedures for visually inspecting concrete during discharge.
- I. Field Quality Control Submittals:
1. Contractor's notifications of readiness for concrete placement.
 2. Contractor's reports of field quality control testing.
 - a. Include with each report the concrete batch ticket number and identification numbers for associated cylinders used for compressive strength testing.

- b. Testing results for slump, temperature, unit weight, and air entrainment.
 - c. Testing results for compressive strength at 7 and 28 days, and for any compressive strength tests after 28 days.
 - d. Note on batch ticket the amount of water that was withheld and the maximum amount that can be added onsite as "Max add water." Record on the batch ticket the volume of water actually added at the Site.
 - e. Note on the batch ticket the concrete mix classification as defined in Table 3 of this Section.
- J. Special procedure Submittals:
- 1. Sequence of concrete placing:
 - a. Submit proposed sequence of placing concrete showing proposed beginning and ending of individual placements. Submittal shall include plans sections and details to address all pours.
 - 2. Cold weather concreting plan.
 - 3. Hot weather concreting plan.
 - 4. Repair of defective concrete: Submit mix design for repair materials to be used.

1.06 QUALITY ASSURANCE

- A. Pre-installation meetings:
- 1. Schedule and conduct pre-installation meeting at least 10 days prior to batching and placing of concrete.
 - a. Provide additional meetings if necessary, to discuss specific concrete Submittals, mixes, or placing and curing conditions.
 - b. Notify the Engineer of location and time of each conference.
 - 2. Required attendees:
 - a. Contractor, including Contractor's superintendent and key personnel.
 - b. Concrete supplier.
 - c. Technical representative(s) of supplier(s) of concrete admixtures.
 - d. Subcontractor(s) providing pumping, placing, finishing, and curing.
 - e. Subcontractor(s) providing embedded items (structural embedded plates, electrical conduit).
 - f. Sampling and testing personnel.
 - g. Engineer.
 - h. On-site inspectors representing the Engineer.
 - i. Other persons deemed by the Engineer and the Contractor to be critical to the quality and efficiency of the Work.
 - 3. Agenda:
 - a. Review of requirements of Drawings and Specifications.
 - b. Project and product safety requirements.
 - c. Discussion of points of interface and coordination between various trades or products to be used in the Work.
 - d. Contractor's schedule for cast-in-place concrete work.
 - e. Mix designs, mix tests, and Submittals.
 - f. Admixture types, dosing, performance, requirements for monitoring, and limits on dosing or re-dosing at the Site.
 - g. Placement and consolidation methods, techniques, and equipment and the effects of those methods on form pressures.
 - h. Slump and limits on placing time or conditions to maintain placeability.
 - 1) Field adjustment of slump and air content.

- i. Procedures for finishing, curing, and retention of moisture during these operations.
 - j. Procedures and protection for hot and cold weather conditions.
 - k. Requirements and coordination for inspections.
 - 1) Responsibility for test specimen curing and storage.
 - 2) Distribution of test reports.
 - l. Other Specification requirements requiring coordination between parties to the Work.
- 4. Prepare and submit minutes of the pre-installation meeting as specified in Section 01_31_19 - Project Meetings.

1.07 DELIVERY, STORAGE, AND HANDLING

- A. Packing and shipping:
 - 1. Deliver, store, and handle concrete materials in a manner that prevents damage and inclusion of foreign substances.
 - 2. Deliver and store packaged materials in original containers until ready for use.
 - 3. Deliver aggregate to mixing site and handle in such manner that variations in moisture content will not interfere with steady production of concrete of specified degree of uniformity and slump.
 - 4. For Class M concrete:
 - a. Store coarse and fine aggregate in covered area. Shade aggregates to prevent heating by direct sunlight.
 - b. Store cementitious materials in covered, shaded silos to prevent heating by direct sunlight.
- B. Acceptance at Site:
 - 1. Reject material containers or materials showing evidence of water or other damage.
 - 2. Concrete mixes: Do not accept or incorporate into the Work concrete mixes that do not comply with the specified requirements for water content, slump, temperature, and air content.

1.08 PROJECT CONDITIONS

- A. Cold weather concreting: During periods of cold weather as defined in this Section, implement cold weather concreting procedures in this Section.
- B. Hot weather concreting: During periods of hot weather as defined in this Section, implement hot weather concreting procedures in this Section.

1.09 SEQUENCING AND SCHEDULING

- A. Schedule placing of concrete in a manner that completes all placing operations from one construction, contraction, or expansion joint to another construction, contraction, or expansion joint.
- B. Joints at each end of the placement shall be as indicated on the Drawings, or as identified and accepted in advance by the Engineer.

PART 2 PRODUCTS

2.01 DESIGN AND PERFORMANCE CRITERIA

- A. Provide concrete with a homogeneous mixture, that, when hardened, will have required strength, watertightness, and durability.
- B. Provide a workable, low-shrinkage concrete mix that maximizes aggregate content and minimizes paste content.
- C. Performance requirements:
 - 1. General:
 - a. Except as otherwise specified, provide concrete composed of portland cement or blended cement, supplemental cementitious materials, aggregate, admixtures and water, proportioned and mixed to produce a plastic, workable mixture in accordance with requirements of this Section, and suitable to specific conditions of placement.
 - b. Proportion aggregates to produce an gradation of aggregate that combines aggregate in well-graded proportions that maximizes the aggregate content and minimizes the paste content of the mix. Gradation should maximize long-term durability and strength of the concrete mixture.
 - c. Durability requirements will be deemed to be satisfied when:
 - 1) Mixture is proportioned with a well-graded combined aggregate.
 - 2) Specified water-cement ratio is satisfied.
 - 3) Concrete contains the specified range of air content.
 - 4) Maximum specified paste content is satisfied.
 - d. Proportion materials in a manner that will secure the lowest cement content, water-cementitious materials ratio, and paste volume that is consistent with good workability that provides a plastic and cohesive mixture, and that provides a slump that is within the specified range.
 - e. Construction and expansion joints have been positioned in structures as indicated on the Drawings, and curing methods have been specified, for purpose of reducing the number and size of cracks, resulting from normal expansion and contraction expected from the concrete mixes specified.
 - f. Remove and replace, or repair as specified in this Section, non-conforming work and surfaces with cracks, voids and honeycombs, or surface wetness.
 - 2. Workmanship and methods: Provide concrete work, including detailing of reinforcing, in accordance with best standard practices and as set forth in ACI CODE-318 and ACI CODE-350.

2.02 MATERIALS - GENERAL

- A. Water and ice:
 - 1. Water for concrete mixes, for washing aggregate, and for curing concrete: Clean and free from oil and deleterious amounts of alkali, acid, organic matter, or other substances from a municipal potable water source.
 - 2. Do not use water from concrete production operations, or combined water from concrete production operations as defined in ASTM C1602.
 - 3. Do not use water recycled from previously returned fresh concrete.

2.03 MATERIALS - CONCRETE MIX CONSTITUENTS

- A. Water and ice:
 - 1. As specified in the preceding paragraphs.
- B. Cementitious materials:
 - 1. Portland cement:
 - a. In accordance with ASTM C150.
 - 1) Type II, or Type II (MH) as scheduled for each mix.
 - b. Single source: To provide uniformity of appearance, for each structure use only one source, type, and brand of portland cement for walls and slabs that will be exposed in the finished Work.
 - 1) Confirm adequate supply of cement over duration of the Project before making trial batches or beginning concrete placements.
 - c. Cement for finishing: Provide cement from the same source and of the same type as concrete to be finished or repaired.
 - 2. Blended hydraulic cement:
 - a. In accordance with ASTM C595-25:
 - 1) Type IP (MS).
 - 2) Type IL (MS).
 - 3) Type IS (<70)(MS).
 - b. Single source: To provide uniformity of appearance and quality, for each structure use only one source, type, and brand of cement.
 - c. Confirm adequate supply of cement over duration of the Project before making trial batches or beginning concrete placements.
 - d. Cement for finishing: Provide cement from same source and of same type as concrete to be finished or repaired.
- C. Supplementary cementitious materials:
 - 1. Coal ash:
 - a. Class C or Class F coal ash in accordance with the requirements of ASTM C618, except as modified in this Section.
 - 1) Class C may be used in concrete made with Type II portland cement.
 - 2) Class F required if used in concrete mixes containing aggregates classified as potentially reactive based on ASTM C1293 or ASTM C1260.
 - a) CaO content: Less than 18 percent.
 - b. Loss on ignition: Not exceeding 3 percent.
 - c. Replace portland cement at ratio of 1.0-pound coal ash for each pound of cement, up to minimum and maximum replacement as specified in Requirements for mix proportioning.
- D. Admixtures:
 - 1. General:
 - a. Do not include admixtures, other than those specified, unless written acceptance has been obtained from the Engineer during Submittal of mix designs.
 - b. Compatible with concrete constituents and with other admixtures.
 - 1) All admixtures in a given mix shall be products of the same manufacturer to ensure compatibility.

- 2) Manufacturers: One of the following or equal:
 - a) Euclid Chemical.
 - b) GCP Applied Technologies (formerly W.R. Grace).
 - c) Master Builders Solutions/Sika.
 - d) Sika Corp.
 - c. Do not use admixtures containing chlorides, calculated as chloride ion, in excess of 0.5 percent by weight of cement.
 - d. Use in accordance with manufacturer's recommendations. Add each admixture to concrete mix separately.
 - e. Admixtures used shall be the same products used in concrete trial batches, or the same products used in concrete represented by submitted field test records.
- 2. Air entraining admixture (AEA):
 - a. In accordance with ASTM C260 and dosed to provide entrained air percentages specified in this Section.
 - b. Provides entrained air as bubbles, evenly dispersed at the time of placement and during curing.
- 3. Water reducing admixture (WRA):
 - a. May be used at the Contractor's option.
 - b. In accordance with ASTM C494, Type A (water-reducing).
 - 1) ASTM C494, Type D (water-reducing and retarding) may be used during periods of hot weather with prior acceptance by the Engineer.
 - c. Not containing air-entraining agents.
 - d. Liquid form before adding to the concrete mix.
- 4. High-range water-reducing admixture (superplasticizer) (HRWR):
 - a. In accordance with ASTM C494, Type F (high-range, water-reducing).
 - 1) ASTM C494, Type G (high-range, water-reducing and retarding) may be used during periods of hot weather with prior acceptance by the Engineer.
 - 2) ASTM C494, Type G (high-range, water-reducing and retarding) is required for Class M concrete in the wet well.
 - b. Producing non-segregating, plasticized concrete with little bleeding and the physical characteristics of low water/cement ratio concrete.
 - c. Admixture shall maintain treated concrete in a plasticized state for not less than 1 hour.
- 5. Shrinkage reducing admixture (SRA):
 - a. May be used at the Contractor's option.
 - 1) Provide shrinkage reducing admixture in sufficient dosage so as to produce shrinkage within the limits specified.
 - b. Not containing expansive agents.
 - c. In accordance with ASTM C494, Type S (specific performance).
 - d. One of the following or equal:
 - 1) Euclid Chemical: Eucon SRA Series.
 - 2) GCP Applied Technologies: Eclipse Series.
 - 3) Master Builders Solutions/Sika: SRA Series.
- 6. Set-controlling admixtures:
 - a. Shall not be used without prior acceptance from the Engineer.
 - b. Accelerating admixtures: Not permitted.

- E. Coloring admixtures:
1. Conduit encasement coloring agent:
 - a. Red color concrete used for encasement of electrical ducts, conduits, and similar type items.
 - b. Manufacturers: One of the following or equal:
 - 1) Davis Co., #100 Utility Red.
 - 2) Euclid Chemical Co., Increte Division, Colorcrete Brick Red.
 - 3) I. Reiss Co., Inc., equivalent product.
 - c. Conduit encasement concrete: Mix into each cubic yard of concrete 10 pounds of coloring agent.
- F. Aggregate:
1. General:
 - a. Provide concrete aggregates that are sound, graded as specified, and free of deleterious material in excess of allowable amounts specified.
 - b. Provide aggregates to produce in place concrete with unit weight as follows:
 - 1) Normal weight concrete: Not less than 140 pounds per cubic foot.
 - c. Do not use aggregate made from recycled materials such as crushed and screened hydraulic-cement concrete, brick, and other construction materials.
 - d. Do not use aggregate recycled from fresh concrete returned to the batching facility.
 2. Alkali-silica reactivity:
 - a. Provide aggregate having expansion not greater than 0.10 percent at 14 days when tested in accordance with ASTM C1260.
 - b. Aggregates having expansion in excess of 0.10 percent at 14 days when tested in accordance with ASTM C1260 may be accepted by the Engineer if additional reactivity and mitigation testing is available. Test methods and thresholds to define acceptable aggregate performance may be longer in duration and more restrictive than defined in currently published standards.
 3. Fine aggregate:
 - a. Material graded such that 95 to 100 percent of material passes the No. 4 (4.75 mm) sieve, when sampled in accordance with ASTM D75 and ASTM D3665, and tested in accordance with ASTM C136.
 - b. Provide fine aggregate consisting of clean, natural sand, or sand prepared from crushed stone or crushed gravel.
 - c. In accordance with ASTM C33 requirements for grading, deleterious substances, soundness, and alkali reactivity, except as modified in the following paragraphs:
 - 1) Grading: For sieve sizes listed in ASTM C33 for fine aggregate, not more than 45 percent passing any sieve and retained on the next consecutive sieve.
 - 2) Deleterious substances: Not in excess of the percentages by weight specified in Table 1 of this Section.

Table 1. Fine Aggregate, Limits on Deleterious Substances		
Item	Test Method	Percent (maximum)
Materials finer than No. 200 sieve ⁽²⁾	ASTM C117	3.00 ⁽²⁾
Clay lumps and friable particles	ASTM C142	1.00
Lightweight particles (SG < 2.40) Chert or shale ⁽¹⁾	ASTM C123	1.00
	ASTM C295	1.00 ⁽¹⁾
Coal and lignite	ASTM C123	0.50
Notes: (1) ASTM C123 tests for particles in the sample having a specific gravity less than 2.40. ASTM C295 is used to identify which of those lightweight particles are chert, shale, or coal and lignite. If testing under ASTM C123 indicates a combined percentage of lightweight particles (sum of shale, chert, coal and lignite) not greater than 1.00, testing under ASTM C295 will not be required. (2) For manufactured sand, if material finer than the No. 200 sieve consists of crusher dust and the aggregate is essentially free of clay or shale, maximum percentage may be increased to 5.0 percent.		

- 3) Organic impurities: Free of injurious amounts of organic matter and producing a supernatant liquid with color not darker than "standard color" when tested in accordance with ASTM C40.
- 4) Soundness: In accordance with requirements of ASTM C33 when tested in accordance with ASTM C88 using sodium sulfite solution.
4. Coarse aggregate:
 - a. Materials graded such that not more than 10 percent of material passes the 3/8-inch sieve, when sampled in accordance with ASTM D75 and ASTM D3665 and tested in accordance with ASTM C136.
 - b. Consisting of gravel, crushed gravel, crushed stone, or a combination of these materials having clean, hard, durable particles free from calcareous coatings, organic matter, or other deleterious substances.
 - c. Conforming to the requirements of ASTM C33, Class 4S for physical properties, deleterious substances, and alkali reactivity, except as modified in the following paragraphs:
 - 1) Grading:
 - a) Size number as specified in ASTM C33 and as indicated in Table 3 of this Section, except as otherwise specified or accepted by the Engineer.
 - b) Weights of flat or elongated particles (particles having a length greater than 3 times average width or thickness) not exceeding 15 percent when tested in accordance with ASTM D4791.
 - 2) Deleterious substances: Not in excess of the percentages by weight specified in Table 2 of this Section and having total of all deleterious substances exceeding 2 percent.

Table 2. Coarse Aggregate, Limits on Impurities		
Item	Test Method	Percent (maximum)
Clay lumps and friable particles	ASTM C142	0.50
Lightweight particles (SG < 2.40) Chert or shale ⁽¹⁾	ASTM C123	1.25
	ASTM C295	1.00 ⁽¹⁾

Table 2. Coarse Aggregate, Limits on Impurities		
Item	Test Method	Percent (maximum)
Materials finer than No. 200 sieve	ASTM C117	0.50 ⁽²⁾
Coal and lignite	ASTM C123	0.25
Notes: (1) ASTM C123 tests for particles in the sample having a specific gravity less than 2.40. ASTM C295 is used to identify which of those lightweight particles are chert, shale, or coal and lignite. If testing under ASTM C123 indicates a combined percentage (sum of shale, chert, coal and lignite) not greater than 1.25, testing under ASTM C295 will not be required. (2) When material finer than No. 200 sieve consists of crusher dust, maximum percentage may be increased to 1.00 percent. When mix design complies with provisions of ASTM C33, Table 4, footnote C, the maximum percentage may be increased in accordance with the equation in footnote C, up to a maximum of 1.5 percent.		

- 3) Abrasion loss: Loss not greater than 45 percent after 500 revolutions when tested in accordance with ASTM C131.
- 4) Soundness: Loss not greater than 10 percent when tested in accordance with ASTM C88 using sodium sulfate solution.

2.04 MATERIALS FOR PLACING AND CURING

- A. General:
 1. Materials shall be compatible with concrete and with other materials.
- B. Neat cement grout:
 1. Use: For spreading over surface of construction and cold joints in concrete before placing additional concrete above those joints.
 2. As specified in Section 03_60_00 - Grouting.
- C. Concrete sealer:
 1. As specified in Section 03_35_29 - Concrete Finishes.
 2. Not for use in water-containment structures.
- D. Evaporation retardant:
 1. Use: For mitigating surface moisture evaporation from freshly placed concrete during rapid drying conditions. Placed after screeding.
 2. Waterborne, monomolecular, spray-applied compound, with fugitive dye to indicate coverage.
 3. Manufacturers: One of the following or equal:
 - a. Euclid Chemical Co., Eucobar.
 - b. Master Builders Solutions/Sika, MasterKure ER 50.
- E. Nonslip abrasive:
 1. Aluminum oxide abrasive size 8/16, having structure of hard aggregate that is, homogenous, nonglazing, rustproof, and unaffected by freezing, moisture, or cleaning compounds.
 2. Manufacturers: One of the following or equal:
 - a. Abrasive Materials, Inc.
 - b. Exolon Co.

- F. Plastic membrane for curing:
 - 1. Polyethylene film: In accordance with ASTM C171.
 - 2. Properties:
 - a. Color: White.
 - b. Thickness: Nominal thickness of polyethylene film shall not be less than 0.0040 inches when measured in accordance with ASTM D2103. Thickness of polyethylene film at any point shall not be less than 0.0030 inches.
 - c. Loss of moisture: Not exceeding 0.055 grams per square centimeter of surface when tested in accordance with ASTM C156.
- G. Sprayed membrane curing compound:
 - 1. Combination curing and sealing products (cure and seal) will not be permitted.
 - 2. Properties:
 - a. Clear type with fugitive dye conforming with ASTM C309, Type 1D and containing no wax, paraffin, or oils.
 - b. For concrete placed or cured during hot weather, curing compound shall be as specified, except that:
 - 1) It shall include a white, reflective fugitive dye.
 - 2) Moisture loss during a 72-hour period shall not exceed 0.55 kg/square meter when tested in accordance with ASTM C156.
- H. Surface-applied crystalline coating:
 - 1. Manufacturers: One of the following or equal:
 - a. Euclid Chemical Co., Vandex Super.
 - b. Kryton International, Inc., Krystol T1.
 - c. Xypex Chemical Corp., Xypex Concentrate.
 - 2. Where surface-applied crystalline coating is placed over concrete containing permeability reducing admixture for concrete exposed to hydrostatic conditions (PRAH), provide products of same manufacturer providing the admixture.

2.05 EQUIPMENT

- A. General:
 - 1. Provide adequate equipment and facilities for accurate measurement and control of materials and for readily changing proportions of material into mixers.
- B. Batching equipment, or batch plant.
 - 1. Capable of controlling delivery of all material to mixer within 1 percent by weight of individual material.
- C. Mixing equipment:
 - 1. Mixers may be of stationary plant, paver, or truck mixer type, as appropriate to the Work.
 - 2. Capable of combining aggregates, water, and cementitious materials, and admixtures within specified time into a thoroughly mixed and uniform mass, and of discharging the mixture without segregation.
 - a. Maintain concrete mixing equipment in good working order and operate at loads, speeds, and timing recommended by the manufacturer or as specified.
 - b. Proportion cementitious materials and aggregate by weight.

3. If bulk cementitious materials are used, weigh them on separate visible scale which will accurately register scale load at any stage of weighing operation from zero to full capacity.
 4. Prevent cementitious materials from coming into contact with aggregate or with water until materials are in mixer ready for complete mixing with all mixing water.
 5. Procedure of mixing cementitious materials with sand or with sand and coarse aggregate for delivery to the Project Site, for final mixing and addition of mixing water will not be permitted.
 6. Retempering of concrete will not be permitted.
 7. Discharge entire batch before recharging.
 8. Volume of mixed material per batch: Not to exceed manufacturer's rated capacity of mixer.
 9. Equip each mixer with device for accurately measuring and indicating quantity of water entering concrete, and operating mechanism such that leakage will not occur when valves are closed.
 10. Equip each mixer with device for automatically measuring, indicating, and controlling time required for mixing:
 - a. Interlock device to prevent discharge of concrete from mixer before expiration of mixing period.
 11. Transit-mixed concrete:
 - a. Mix and deliver in accordance with ASTM C94.
 - b. Total elapsed time between addition of water at batch plant and discharging completed mix:
 - 1) Not to exceed 90 minutes.
 - 2) Elapsed time at the Project Site shall not exceed 30 minutes.
 - 3) Under conditions contributing to quick setting, total elapsed time permitted may be reduced by the Engineer.
 - c. Equip each truck mixer with device interlocked to prevent discharge of concrete from drum before required number of turns and furnish device that is capable of counting number of revolutions of drum.
 12. Continuously revolve drum after it is once started until it has completely discharged its batch:
 - a. Do not add water until drum has started revolving.
 - b. Right is reserved to increase required minimum number of revolutions or to decrease designated maximum number of revolutions allowed, if necessary, to obtain satisfactory mixing. Contractor will not be entitled to additional compensation because of such increase or decrease.
- D. Other types of mixers: For other types of mixers, mixing shall be as follows:
1. Mix concrete until there is uniform distribution of materials and discharge mixer completely before recharging.
 2. Neither speed nor volume loading of mixer shall exceed manufacturer's recommendations.
 3. Continue mixing for minimum of 1-1/2 minutes after all materials are in drum, and for batches larger than 1 cubic yard increase minimum mixing time 15 seconds for each additional cubic yard or fraction thereof.

2.06 CONCRETE MIXES

A. General:

1. Develop and provide mix designs for each concrete class listed in Table 3 of this Section.
2. Select and proportion mixes and document properties using one of the 2 methods that follow. Procedures and requirements for use of each alternative are specified in subsequent paragraphs of this Section.
 - a. Field experience method.
 - b. Trial batch method.
3. Organize and submit mix designs with data on all constituent materials and products for that mix for the Engineer's review.
4. Do not place concrete until the mix design for that concrete class has been accepted by the Engineer.
5. After acceptance, do not modify accepted mixes or provide new mixes without the Engineer's prior review and acceptance of the proposed alternative.
 - a. Exception: At all times, adjust batching of water to compensate for free moisture content of the fine aggregate used.
 - b. For any change to approved mixes, the Engineer may require new trial batching and testing program as specified in this Section before acceptance and use.
 - c. For any change to approved mixes, make modifications within limits set forth in this Section.
 - d. If there is change in source or quality of any constituent of the concrete class or mix, the revised mix will be considered a new class of concrete and shall require full re-submittal of all data describing mix constituents, design, and testing.
6. Material sampling, mix designs, trial batch preparation and testing, modifications to mix designs, and any re-testing required to satisfy the requirements of this Section or to obtain satisfactory performance shall be at the Contractor's expense and shall not be considered cause for delay.

B. Measurements of materials:

1. Measure materials by weighing, except as otherwise specified or where other methods are specifically authorized in writing by the Engineer.
2. Furnish apparatus for weighing aggregates and cementitious materials that is suitably designed and constructed for this purpose.
3. Accuracy of weighing devices: Furnish devices that have capability of providing successive quantities of individual material that can be measured to within 1 percent of desired amount of that material.
4. Measuring or weighing devices: Subject to review by the Engineer. Shall bear valid seal of the Sealer of Weights and Measures having jurisdiction.
5. Weighing cementitious materials:
 - a. Weigh cementitious materials separately.
 - b. Cement in unbroken standard packages (sacks): Need not be weighed.
 - c. Weigh bulk cementitious materials and fractional packages.
6. Measure mixing water by volume or by weight.

- C. Requirements for mix proportioning:
1. Develop and provide mixes that:
 - a. Can be readily worked into corners and angles of forms and around reinforcement, without excessive vibration, and without permitting materials to segregate or free water to collect on surface.
 - b. Prevent unnecessary or haphazard changes in the consistency of the concrete supplied.
 2. Constituent materials:
 - a. Provide concrete mixes composed of portland cement or blended cement, blended aggregates, admixtures and water.
 - 1) Admixtures required for each concrete class are indicated in Table 3 of this Section. Admixtures not specifically required by that table for a specific concrete class are optional and may be included at the discretion of the Contractor based on the Contractor's planned means and methods of construction.
 - b. In no case shall returned fresh concrete or its constituents be incorporated into concrete batched for the Work.
 3. Minimum specified compressive strength:
 - a. Minimum specified compressive strength is designated at 28 days, unless otherwise indicated in Table 3 of this Section.
 - b. For locations where the placed concrete is adequately protected and is not subjected to loads for an extended period during construction, the Contractor may request that the period for achieving the minimum specified compressive strength be extended to 56 days.
 - 1) If accepted by the Engineer, provide mixes that achieve at least 75 percent of their minimum specified compressive strength after 28 days.
 4. Proportions and consistency:
 - a. Ratio of water to cementitious materials, and cementitious materials content:
 - 1) Conform to maximum and minimum cementitious material content requirements specified in Table 3 of this Section.
 - 2) Cementitious materials content: Consisting of portland cement or blended cement as indicated in Table 3 of this Section, plus supplemental cementitious materials if aggregate testing indicates potentially reactive aggregates:
 - a) Coal ash content:
 - (1) Minimum: 15 percent of the total weight of cementitious materials.
 - (2) Maximum: 25 percent of the total weight of cementitious materials.
 - (3) Class M: Provide 20 to 25 percent by weight of the total cementitious content as Class F Coal ash.

- b. Aggregate size and content:
 - 1) Blend aggregates to produce an optimized gradation that combines well-graded coarse, intermediate, and fine aggregates in proportions that maximize the aggregate content of the mix, and that minimize the cement paste content of the mix.
 - a) Percentage of individual fractions of the combined aggregate gradation retained on individual sieve sizes: Within the range shown in Attachment C - Combined Aggregate Gradation Chart (Tarantula Curve).
 - b) Sum of the percentages of individual fractions retained on the No. 8, No. 16, and No. 30 sieves: Greater than 20 percent.
 - c) Sum of the percentages of individual fractions retained on the No. 30, No. 50, No. 100, and No. 200 sieves: Within the range of 25 percent to 40 percent.
- c. Determine bulk density and void content of the combined gradation of aggregates in accordance with ASTM C29. Results for combined aggregates shall not be the summation of results of testing of the individual gradations.
 - 1) Sample the combined aggregate from a flowing aggregate stream or conveyor in accordance with ASTM D75. Take care to ensure that the sample is representative of the proportions of the combined aggregate of the proposed mix.
 - 2) Reduce sample of combined aggregate to test sample size in accordance with ASTM C702, Method A - mechanical splitter or Method B - quartering.
 - 3) Perform bulk density test of combined aggregate in accordance with ASTM C29, Procedure A - rodding.
 - 4) Determine void content of the combined aggregate in accordance with ASTM C29, Procedure A - rodding. Specific gravity of the combined aggregate shall be determined in accordance with ASTM C136.
- d. Paste content: Limited to the following:
 - 1) Class A mixes without air entrainment: Maximum 28 percent measured by volume.
 - 2) Class A mixes with air entrainment: Maximum 28 percent measured by volume plus the target air content.
 - 3) Paste content shall be limited 200 percent of the void content of the combined aggregate gradation determined by ASTM C29.
- e. Total water content:
 - 1) Not exceeding the water to cementitious material ratio specified in Table 3 of this Section.
- f. Coarseness/workability (Shilstone Method):
 - 1) Proportion mixes to fall into the "Optimal" zone (Zone II) when plotted on the Coarseness Factor Chart ("Coarseness Factor" versus "Workability Factor") included as Attachment B - Coarseness Factor Chart to this Section. Provide plot for each Class A mix to be used in the Work.

- 2) Coarseness factor (CF) for each mix shall be calculated as the percent of the combined aggregate gradation retained on the 3/8-inch sieve, divided by the percent of the combined aggregate gradation retained on the No. 8 sieve, multiplied by 100, or:

$$CF = \frac{(\% \text{ retained on } 3/8\text{-in sieve})}{(\% \text{ retained on No. 8 sieve})} \times 100$$

- 3) Workability factor (WF) for each mix shall be the percent of the combined aggregate gradation retained on the No. 8 sieve, adjusted for cement content in the mix.
- Determine volume of total cementitious material in the mix.
 - For each 94 pounds of cement content above 564 pounds per cubic yard, increase workability factor by 2.5 units.
 - For each 94 pounds of cement below 564 pounds per cubic yard, decrease workability factor by 2.5 units.
 - Proportion adjustment factor by linear interpolation for each fraction of 94 pounds above or below the 564-pound basis.
 - Example:
650 pounds per cubic yard = 564 pounds + 86 pounds.
Adjustment = (86 lb / 94 lb) x 2.5 = + 2.28.

D. Concrete classes for use in the Work:

- Provide concrete classes listed in Table 3 of this Section.
- Provide normal weight concrete, having minimum weight of 140 pounds per cubic foot, unless otherwise noted.
- Pumped concrete:
 - Provide pumped concrete that complies with all requirements of this Section.
 - Mixes placed by pumping shall be considered a sub class of each concrete class listed in Table 3 of this Section. Prepare and submit a separate mix design for each mix to be placed by pumping.
- Class PM concrete: In addition to the requirements of Table 3 of this Section, conform to the following:
 - Minimum 28 day flexural strength: 650 psi when tested in accordance with ASTM C293.
 - Cementitious materials content: 75 percent portland cement plus 25 percent Class F coal ash (by weight), blended cement conforming to Type IP(25), or 75 percent Type IL blended cement plus 25 percent Class F coal ash (by weight).
 - Aggregate:
 - Minimum 55 percent coarse aggregate conforming to ASTM C33 size number 357 or size number 467.
 - Substitute ASTM C33 size number 57, or size number 67 if mechanical paving equipment is not used.

5. Class M concrete: In addition to the requirements of Table 3 of this Section, conform to the requirements for Class A concrete.

Table 3. Concrete Classes									
Concrete Class⁽¹⁾	Minimum Specified Compressive Strength at 28 Days, f_c (UNO)⁽²⁾ (pounds per square inch)	Ratio of Water to Cementitious Materials⁽³⁾ (minimum - maximum)	Cementitious Materials Content (pounds per cubic yard of concrete by weight)⁽⁴⁾	Cement Type	Maximum Chloride Content (percent by weight of cement)	Maximum Size of Coarse Aggregate (ASTM C33)	Air Entrainment (percent), (n/a: not applicable)	Admixtures Required^(4,5,6)	Slump Range (inches)
A	4,500	0.40 to 0.42	535 to 575	ASTM C150, Type II(MH) or ASTM C595, Type IL(<15)(MS) or IP(20)(MS)	0.10	#57	6±1.5	AEA WRA	2 to 4
A-NA	4,500	0.40 to 0.45	535 to 575	ASTM C150, Type II(MH) or ASTM C595, Type IL(<15)(MS) or IP(20)(MS)	0.10	#57	n/a	WRA	2 to 4
C	2,500	0.62 maximum	423 minimum	ASTM C150, Type II(MH) or ASTM C595, Type IL(<15)(MS) or IP(20)(MS)	No limit	#57	6±1.5	AEA WRA	3 to 6
CE	3,000	0.62 max.	423 minimum	ASTM C150, Type II(MH) or ASTM C595, Type IL(<15)(MS) or IP(20)(MS)	No limit	#8	5±1.5	AEA WRA	SCC ⁽⁶⁾
P	4,500	0.45	535 to 575	ASTM C150, Type II(MH) or ASTM C595, Type IL(<15)(MS) or IP(20)(MS)	0.10	#57	n/a	WRA	SCC ⁽⁶⁾
PM	4500	0.40	535 to 575	ASTM C150, Type II(MH) or ASTM C595, Type IL(<15)(MS) or IP(20)(MS)	0.15	#57	5±1.5	AEA WRA	3 to 6

Table 3. Concrete Classes

Concrete Class ⁽¹⁾	Minimum Specified Compressive Strength at 28 Days, f'c (UNO) ⁽²⁾ (pounds per square inch)	Ratio of Water to Cementitious Materials ⁽³⁾ (minimum - maximum)	Cementitious Materials Content (pounds per cubic yard of concrete by weight) ⁽⁴⁾	Cement Type	Maximum Chloride Content (percent by weight of cement)	Maximum Size of Coarse Aggregate (ASTM C33)	Air Entrainment (percent), (n/a: not applicable)	Admixtures Required ^(4,5,6)	Slump Range (inches)
M	4,500 at 56 days	0.45	535 to 575	ASTM C150, Type II(MH) or ASTM C595, Type IL(<15)(MS) or IP(25)(MS)	0.10	#4	n/a	WRA HRWA (Type G)	2 to 4

Notes:

(1) Sub classes within major concrete classes are designated as follows:
NA: Without air entrainment.

(2) At locations where concrete will not be subjected to load from other elements of the structure or from the Contractor's placing and/or backfilling operations, maximum time period for achievement of specified compressive strength may be extended to 56 days when accepted by the Engineer.

(3) W/C Ratio = Ratio of water to cementitious materials by weight. Include weight of admixtures in the water content of the mix when the quantity of the admixtures exceeds 10 ounces per 100 pounds of cement.

(4) Cementitious material includes portland cement plus supplemental cementitious materials. If trial batch testing demonstrates that the required strength cannot be met at 28 or 56 days with the specified combined aggregate gradation and the paste content limits, cementitious material content may be increased with the Engineer's approval if a Thermal Control Plan and Temperature Monitoring Program specified in Section 03_70_30 - Thermal Control of Concrete is provided for cast-in-place concrete elements. Cement content and/or threshold for the thermal control requirement may be adjusted by the Engineer based on the Equivalent Cement Content (ECC) of the approved concrete mix.

Admixtures are designated as follows:

AEA: Air entraining admixture.

HRWR: High-range water-reducing admixture.

PRAH: Permeability-reducing admixture for concrete exposed to hydrostatic conditions.

SFR: Synthetic fiber reinforcement.

SRA: Shrinkage-reducing admixture.

WRA: Water-reducing admixture.

(5) At the Contractor's option, each concrete class may include a high-range water reducing admixture (HRWR). Designate such mixes as the "class" specified followed by "SP" (e.g., A-SP, A-NA-SP, P-SP, etc.). Submit as separate mixes for review. Slump range after addition of HRWR: 4 to 6 inches.

(6) If the slump of a mix is designated as self-consolidating concrete (SCC) in lieu of a numerical range, the class of concrete is designated as a SCC mix and the additional requirements of Section 03_31_26 - Self-Consolidating Concrete Requirements apply.

- E. Install concrete classes in accordance with the following requirements, unless otherwise indicated on the Drawings.
1. Class A concrete: Structural concrete.
 - a. Use at all locations unless other Classes are specified or indicated on the Drawings.
 2. Class A-NA concrete: Structural concrete without air entrainment.
 - a. May be used in lieu of Class A at indoor slabs (not subject to freezing and thawing) where inclusion of an air-entraining admixture makes it difficult to achieve the specified concrete finish.
 3. Class C concrete: Miscellaneous concrete fill and encasement.
 - a. May be used for fill for unauthorized excavation, for thrust blocks and ground anchors for piping, for bedding of pipe, and where indicated on the Drawings.
 4. Class CE concrete: Use for electrical conduit encasements.
 5. Class P concrete: Use for drilled piers.
 6. Class PM concrete: Use for concrete pavement, cart paths, curbs, gutters, and sidewalks.
 7. Class M concrete: Use at placements of the wet well below elevation 5131.50.
- F. Concrete mix design documented by field experience:
1. Mix design:
 - a. Prepare preliminary mix design for each concrete class. Submit mix design with product and testing data for materials to be used in the mix for the Engineer's review.
 2. Historical records for similar mix.
 - a. Determinations of similarity of materials and proportions between historical and proposed mixes shall be by the Engineer, and that shall be final.
 - b. Historical record - Materials:
 - 1) Submit with each mix design the following data for a previously-supplied concrete mix similar to that proposed for this Work.
 - 2) Records demonstrating that the previously supplied mix included similar materials and proportions as those of the proposed mix.
 - a) Documentation that the same concrete supplier will provide both mixes.
 - b) Documentation that the materials used was from the same suppliers and had essentially the same properties, demonstrated by test data, as those proposed.
 - c) Documentation that proportions of materials in the record mix are essentially the same as those proposed and that the specified compressive strength of the record mix is within 1,000 pounds per square inch of that required by this Section.
 - d) Concrete supplier's statement describing any changes made to production of the record mix during the time period reported.
 - e) Concrete supplier's statement that preparation and quality control procedures for the record mix were essentially the same as those to be employed for this Work.
 - c. Historical record - Testing:
 - 1) Submit with each record mix, corresponding test data for slump, compressive strength (with relationships for rate of strength gain between testing ages), and drying shrinkage.

- 2) Only records satisfying the following requirements will be accepted.
 - a) All tests were conducted within a period of 1 year preceding the date of the Submittal.
 - b) All tests were conducted over a period including not less than 45 days.
 - c) Record of compressive strength testing includes at least 30 tests for slump and 28-day compressive strength.
 - d) Record of compressive strength tests is consecutive. In other words, it includes all tests conducted on the subject mix within the 1-year time period described above (not just selected tests during that period).
 - e) Submit concrete supplier's sworn statement confirming that all tests for the record mix have been reported.
 - f) Tests for drying shrinkage are described in subsequent paragraphs of this Section for "concrete mix design documented by trial batch preparation and testing".
 - g) Provide supplementary testing if requested by the Engineer.
- d. For mixes determined to be similar and to have an acceptable test history, acceptance criteria shall be as follows:
 - 1) Acceptance criteria:
 - a) Slump: All tests within limits specified for record mix.
 - b) Compressive strength: Average compression strength for tests, as determined by ACI CODE-350 not less than minimum required average strength.
 - c) Drying shrinkage: Within limits stated in subsequent paragraphs of this Section for "concrete mix design documented by trial batch preparation and testing".

G. Concrete mix design documented by trial batch preparation and testing:

1. Mix design and trial batches:
 - a. Prepare preliminary mix design for each concrete class. Submit mix design with product and testing data for each combination of materials and proportions to be used for the Engineer's review.
 - 1) Determine water content of the mix based on curves showing the relation between water-cementitious materials ratio and the 7- and 28-day compressive strength of the concrete.
 - 2) Determine each curve using 4 or more points, each representing the average compressive strength value of at least 3 specimens tested at each age.
 - b. After materials and proposed mix designs have been accepted by the Engineer, have trial batches for each concrete mix design prepared by the Contractor's testing laboratory.
 - 1) Prepare trial batches using the cementitious materials, aggregates, and admixtures proposed to be used for the Work.
 - 2) Provide batches of sufficient quantity to determine slump, workability, consistency, setting time, and finishing characteristics, and to provide sufficient specimens for testing.

- c. For each trial batch, make and test specimens to determine and report slump, compressive strength (with relationships for rate of strength gain between testing ages), and drying shrinkage.
 - 1) If trial batches do not produce concrete conforming to the specified requirements for slump, strength, workability, consistency, drying shrinkage, restrained shrinkage, and finishing, change mix proportions and, if necessary, sources of materials.
 - 2) Make additional trial batches and perform additional tests until a batch that conforms to requirements of this Section is produced.
- 2. Testing - Slump:
 - a. Determine slump in accordance with ASTM C143.
 - b. Acceptance criterion: Slump within range specified.
- 3. Testing - Compressive strength:
 - a. Prepare 4-inch diameter by 8-inch long cylinders in accordance with ASTM C31 for tests specified in this Section.
 - b. Determine average compressive strength:
 - 1) Test at least 12 cylinders from each trial batch for compressive strength in accordance with ASTM C39.
 - 2) Test 4 cylinders at 7 days, another 4 at 28 days, and another 4 at 56 days.
 - 3) Calculate average compression strength for 7-day tests, for 28-day tests, and for 56-day tests.
 - 4) Calculate ratios for:
 - a) Average 7 day strength to average 28 day strength.
 - b) Average 28 day strength to average 56 day strength.
 - c. Determine the required average compressive strength for each mix, f'_{cr} , as described in the following paragraphs:
 - 1) Calculate required average compressive strength (f'_{cr}) based on the minimum specified 28-day compressive strength, f'_c , plus a standard deviation determined from the test history available for that mix.
 - 2) Determine f'_{cr} as specified in ACI CODE-350, except as modified in the following paragraphs:
 - a) Where 15 or more 28-day compressive strength tests are available, calculate standard deviation as described in the preceding paragraphs for "concrete mix design documented by field experience". Add this standard deviation to the specified minimum compressive strength to determine the required average compressive strength (f'_{cr}) for the mix.
 - b) Where fewer than 15 compressive strength tests at 28 days are available, determine minimum required compressive strength, (f'_{cr}) from Table 4 of this Section.

Table 4. Required Average Compressive Strength, Fewer than 15 Tests Available	
Minimum Specified Compressive Strength, f'_c (pounds per square inch)	Required Average Compressive Strength, f'_{cr} (pounds per square inch)
Less than 3,000	$f'_c + 1,000$
3,000 to 5,000	$f'_c + 1,200$
Over 5,000	$f'_c + 1,400$

- d. Acceptance criterion: Average compressive strength of the 4 cylinders tested at 28 days, or of the 4 cylinders tested at 56 days when permitted by the Engineer, shall equal or exceed the required average compression strength, f'_{cr} for that concrete mix design.
- 4. Testing - Chloride content:
 - a. Submit test results showing that the concrete mix contains water-soluble chloride ion content contributed from the constituents, including water, aggregates, cementitious materials, and admixtures is less than the limit specified in Table 3 of this Section. Test shall be performed in accordance with ASTM C1218 at age between 28 and 42 days.
- 5. Testing - Drying shrinkage - Prism specimens:
 - a. Class A (including A, A-NA, A-SP, and A-NA-SP), Class M, and Class PM: From trial batch for each mix, prepare 10 drying shrinkage specimens in accordance with ASTM C157.
 - 1) Divide specimens into 2 groups of 5 specimens each: 1 group including shrinkage-reducing admixture and 1 group without shrinkage-reducing admixture.
 - b. Prepare, cure, and test both groups in accordance with ASTM C157, except as modified in the following paragraphs.
 - 1) Remove drying shrinkage specimens from molds at age of 23 hours, plus or minus 1 hour, after trial batching.
 - a) Immediately place them in lime-saturated water maintained at 73 degrees Fahrenheit, plus or minus 3 degrees, for at least 30 minutes.
 - b) Remove specimens from the water and wipe with a damp cloth.
 - c) Measure to nearest 0.0001 inch to determine original length.
 - d) Record measurements and re-submerge specimens in lime-saturated water at 73 degrees Fahrenheit, plus or minus 3 degrees, for moist curing.
 - 2) Maintain submerged curing conditions at 73 degrees Fahrenheit, plus or minus 3 degrees, for 7 days. 7 days after batching, remove specimens from water and repeat measuring procedures.
 - 3) Immediately store specimens in a humidity controlled room maintained at 73 degrees Fahrenheit, plus or minus 3 degrees, and at 50 percent relative humidity plus or minus 4 percent for remainder of the test.
 - 4) At periods of 14, 21, 28, and 56 days after batching, remove specimens from curing room and repeat measurements.
 - c. Drying shrinkage test report:
 - 1) Report measurements of all specimens at 1, 7, 14, 21, 28, and 56 days after batching.
 - 2) Using measured length at 7 days as base length for drying shrinkage, calculate the following for each measuring period:
 - a) Drying shrinkage of each specimen. Determine as difference between the 7-day base length and measured length for each period.

- b) Average of these differences. If drying shrinkage of any specimen departs from the average of the measurements for each period by more than 0.0004 inch, disregard results obtained from that specimen.
 - c) Percentage of drying shrinkage from batching to date of measurement.
 - d. Drying shrinkage acceptance criteria:
 - 1) Average shrinkage of trial batch concrete specimen group at 28 days after batching, when measured and cured as indicated, shall not exceed 0.035 percent.
 - e. Mixes accepted by the Engineer:
 - 1) Retain drying shrinkage test specimens. Bag in re-sealable plastic bags and submit to the Engineer.
 - 2) Indicate trial batch identifier, specimen number, and date of final measurements on each specimen bag.
- 6. Modulus of elasticity: Tests: Test 2 cylinders at 28 days for static modulus of elasticity in compression in accordance with ASTM C469.
 - a. Required results: Modulus of elasticity shall not be less than 54,000 times square root of the 28-day strength of the cylinders.

2.07 SOURCE QUALITY CONTROL

- A. Sample and test materials in accordance with the following requirements:
 - 1. Sampling, testing, and reporting frequency:
 - a. In preparation for mix design submittals and trial batch tests.
 - b. Whenever there is a change in source of the material, or a significant change in the characteristics or quality of materials from the same source.
 - c. For each 10,000 cubic yards of concrete mix produced.
 - d. At intervals not exceeding 90 calendar days, unless otherwise specified in the following paragraphs.
 - 2. Supplemental cementitious materials.
 - a. Sample and test coal ash in accordance with ASTM C311.
 - 3. Aggregate:
 - a. Sample combined aggregate in accordance with ASTM D75 and ASTM D3665, and test for gradation in accordance with ASTM C136.
 - b. At least once every 30 days, and when requested by the Engineer.
 - c. Submit test results.
 - 4. Cementitious materials:
 - a. Sample and test cementitious materials and provide mill certificates demonstrating compliance with ASTM C150 or ASTM C595, and additional requirements of this Section.
 - 1) Determine alkali content by method set forth in ASTM C114.
 - b. At least once every 90 days, and when requested by the Engineer.
 - c. Submit test results.
- B. Batch materials in accordance with the following requirements:
 - 1. Concrete batch weights: Control and adjust so as to secure maximum yield, and at all times maintain proportions of concrete mix within specified limits.

2. Aggregates:
 - a. Obtain aggregate from a source capable of providing uniform quality, moisture content, and grading during any single day's operation.
 - b. Furnish satisfactory means at batching plant for checking moisture content of fine aggregate for each batch.
3. Admixtures:
 - a. Batch solutions using mechanical batcher capable of accurate measurement.
 - b. Air entraining admixture: Add to batch in portion of the mixing water, unless otherwise recommended by the admixture manufacturer.

PART 3 EXECUTION

3.01 PREPARATION

- A. Prepare and submit mix designs for each concrete class indicated in Table 3 of this Section.
- B. Submit proposed sequence of concrete placements. After acceptance, adhere to proposed sequence of placing concrete, except when specific changes are requested by the Contractor and accepted by the Engineer.
 1. Use construction methods and sequence work to allow concrete placement to reach adequate strength and to be constructed with required support to prevent overstress of the concrete structure during construction.
- C. Make provisions for monitoring weather conditions:
 1. Install an outdoor weather station capable of measuring and recording ambient temperature, wind speed, and humidity. Furnish instruments accurate to within 2 degrees Fahrenheit, 5 percent relative humidity, and 1 mile per hour wind speed.
 2. Monitor the weather forecast beginning at least 48 hours prior to any concrete placement and make provisions for cold weather concreting or hot weather concreting if those conditions exist or are forecast to exist during the period of placement, finishing, and curing.
 - a. Record temperature, relative humidity, and wind speeds for each placement beginning at least 24 hours before scheduled delivery of concrete.
- D. Place no concrete without the Engineer's prior acceptance of conditions.
- E. Notify the Engineer in writing that preparations are complete and ready for placement of concrete. Such notification shall indicate readiness - not just intention - to place concrete for the designated portion of the Work.
 1. Submit notification to the Engineer on forms provided by or acceptable to the Engineer and bearing the signature of the Contractor's superintendent.
 - a. Sample form is included at the end of this Section, see Attachment B - Coarseness Factor Chart.

2. Submittal of notification will be the Contractor's certification that preparations are complete and in accordance with the Contract Drawings and Specifications.
3. Provide notification for the Engineer to make final observations at the locations of concrete placements not less than 24 hours before commencing placement of concrete.

3.02 CONCRETE JOINTS

- A. Locations of joints are indicated on the Drawings.
 1. In order to preserve strength and watertightness of structures, make no other joints, except as authorized by the Engineer.
 2. Construct joints where indicated and as indicated on the Drawings.
 3. Where joint locations are not indicated on the Drawings, submit the Contractor's proposed locations for the Engineer's review and acceptance. Provide construction joints in slabs and walls at intervals not greater than 35 feet.
- B. Time between placements of adjacent concrete separated by joints.
 1. Provide not less than 3 days (72 hours) between placement of adjacent sections for the following:
 - a. Slabs.
 - b. Walls.
 2. Provide not less than 7 days (168 hours) between placement of the lower and upper pours for the following:
 - a. Walls over slabs.
 - b. Slabs over walls.
 - c. Slabs keyed into the sides of walls.
- C. Edges of joints:
 1. Provide joints have edges detailed as indicated on the Drawings.
 2. Protect wall and slab surfaces at edges from concrete splatter. Thoroughly clean adjacent surfaces after completion of each placement.
- D. Joint construction:
 1. Preparation of forms:
 - a. Provide cleanout holes at base of each wall and column for inspection and cleaning.
 - b. Wash forms and adjacent joint surfaces of sawdust, chips, and other debris after forms are built, and immediately before concrete or grout placement.
 - c. Should formwork confine sawdust, chips, or other loose matter in such manner that it is impossible to remove them by flushing with water, use a vacuum cleaner for their removal and then flush cleaned surfaces with water.
 2. Before placing concrete against previously placed concrete, thoroughly clean the prior placement of laitance, grease, oil, mud, dirt, curing compounds, mortar droppings, or other objectionable matter by means of pressure washing.
 3. Provide and install waterstops, expansion joint material, and other similar materials as indicated on the Drawings and as specified.
 - a. Take special care to ensure that waterstops are secured in proper position.
 - b. Take special care to ensure that concrete is well consolidated around and against waterstops during placement.

4. Horizontal joints:
 - a. As initial placement over cold joints, thoroughly spread bed of neat cement grout.
 - 1) Thickness: Not less than 1/2 inch or more than 1 inch.
 - b. For wall placements above planned cold joints, placement of neat cement grout will not be required for locations where the wall mix includes high-range water-reducing admixture (superplasticizers), and the Contractor can demonstrate dense concrete joints without voids or honeycomb after the forms are removed.

3.03 MEASURING AND BATCHING MATERIALS

- A. Measurements of materials:
 1. Proportion and measure cementitious materials and aggregates by weight.
 - a. Weigh cementitious materials separately.
 - b. If bulk cementitious materials are used, weigh them on separate visible scale that will accurately register scale load at any stage of weighing operation from zero to full capacity.
 - c. Cement in unbroken standard packages (sacks) need not be weighed.
 2. Mixing water: Measure by volume or by weight.
 3. Other mix constituents: Measure by weight, except as otherwise specified or accepted by the Engineer.
 4. Weighing and measuring devices:
 - a. Use equipment designed and constructed specifically for that purpose.
 - b. Furnish devices capable of weighing successive quantities of individual material measured to within 1 percent of desired weight of that material.
 - c. Bearing valid seal of the department of weights and measures for the authority having jurisdiction over the Work.
 5. Measurements and measuring devices:
 - a. Subject to review by the Engineer.
- B. Batching:
 1. Admixtures shall be added at the concrete batch plant.
 2. Addition of admixtures in the field is permitted only with prior acceptance by the Engineer, and only when the following conditions are satisfied:
 - a. Dosage and mixing is personally overseen by the concrete supplier's trained technologist.
 - b. Adequate mixing is provided after addition.
 - c. Maximum time to placement of concrete remains 90 minutes after water added to mix - not 90 minutes after any field additions/adjustments.
 - d. Slump at discharge after additions/modifications conforms to the requirements of Table 3 of this Section.

3.04 MIXING AND TRANSPORTING

- A. Machine mixing:
 1. Prevent cementitious materials from coming into contact with aggregate or with water until materials are in mixer and ready for complete mixing with all mixing water.

2. Procedure of mixing cementitious materials with sand, or with sand and coarse aggregate, for delivery to the Project Site for final mixing and addition of mixing water is not permitted.
 3. Remixing of concrete that has started to take its initial set (retempering) is not permitted.
 4. Discharge entire batch before recharging.
 5. Volume of mixed material per batch: Not exceeding manufacturer's rated capacity of mixer.
- B. Transit-mixed concrete:
1. Mix and deliver in accordance with ASTM C94, except as modified in this Section.
 2. Total elapsed time between addition of water at batch plant and discharging completed mix:
 - a. Not to exceed 90 minutes or 300 revolutions of the mixing drum.
 - b. Under conditions contributing to rapid setting, total elapsed time permitted may be reduced by the Engineer.
 3. Temperature - minimum and maximum allowable during mixing and transporting:
 - a. Minimum: 50 degrees Fahrenheit.
 - b. Maximum: 90 degrees Fahrenheit.
 4. Continuously revolve drum after it is started until it has completely discharged its batch.
 - a. Do not add water until drum has started revolving.
 - b. Engineer reserves the right to increase required minimum number of revolutions or to decrease designated maximum number of revolutions allowed, if necessary, to obtain satisfactory mixing. Contractor will not be entitled to additional compensation because of such increase or decrease.
- C. Concrete delivery:
1. Furnish to the Engineer a delivery ticket for each batch of ready mixed concrete within 24 hours after delivery. Include the following information on each ticket:
 - a. Time of day concrete was batched and time of day that discharge from the truck is complete.
 - b. Printed record of the individual weight of each of the following constituents in the batch: Fine aggregate, coarse aggregate, cement, pozzolan, and water.
 - c. Concrete class as defined in Table 3 of this Section.
 - d. Type, brand, and quantity of each admixture in the batch.
 - e. Total volume of water allowed in the mix, volume of mixing water added at the batch plant, volume of mixing water withheld from the mix during batching, and total volume of any water added to the mix after leaving the batch plant.
 - 1) In no case shall volume of mixing water withheld result in a water/cementitious materials ratio less than the minimum values specified in Table 3 of this Section.
 - f. Number of revolutions of transit truck at arrival onsite and total number of revolutions when discharge is complete.
 - g. Volume of concrete delivered in the batch.
 - h. Numerical sequence of the batch delivered for that placement.

2. Additional water may only be added to the mix when the following conditions are fully satisfied:
 - a. Batch ticket showing total volume of water already added and maximum volume of water that may be added is available for the Engineer's observation before any additional water is added.
 - b. Total volume of water in the mix after the addition will be less than the maximum allowable volume of water indicated on the ticket.
 - c. Full concrete load is still within the truck's mixing drum and truck has not begun to discharge the load. Under no conditions shall water be added in the field to a partial truckload of concrete.
 - d. Volume of water added and time of addition are clearly marked for record on the batch ticket delivered to the Engineer.
 3. Addition of admixtures in the field is permitted only with prior approval by the Engineer, and when the following conditions are satisfied:
 - a. Dosage and mixing is personally overseen by the concrete supplier's trained technologist and the admixtures supplier's representative.
 - b. Adequate mixing time is provided after addition of admixtures.
 - c. Maximum time to placement of concrete remains 90 minutes after water is added to the mix - not 90 minutes after any field additions/adjustments.
 - d. Slump at discharge after additions/modifications conforms to the requirements of Table 3 of this Section.
- D. Conveying concrete:
1. Convey concrete from mixer to location of final deposit by methods that prevent separation or loss of materials.
 2. Use equipment for chutes, pumps, and conveying of concrete of such size and design as to ensure practically continuous flow of concrete, from delivery to the point of placement, without separation of materials.
 3. Design and use chutes and devices for conveying and depositing concrete that direct concrete vertically downward when discharged from chute or conveying device.
 4. Keep equipment for conveying concrete thoroughly clean by washing and scraping upon completion of any day's placement.

3.05 PLACING AND CONSOLIDATING

- A. Preparation:
1. Obtain the Engineer's acceptance of completed preparations before placing concrete.
 - a. Notify the Engineer in writing that all preparations are complete and ready for placement of concrete. Such indication shall indicate readiness, not just intention, to place concrete for the designated portion of the Work.
 - b. Submit completed Attachment D - Contractor's Concrete Placement Checklist Form.
 2. Confirm completeness of the following before notification of readiness is given to the Engineer:
 - a. Place forms, reinforcement, screeds, anchors, ties, and inserts in final position.
 - b. Reinforcement is secure and properly fastened in its correct position.
 - c. Loose form ties at construction joints have been retightened.

- d. Dowels, bucks, sleeves, hangers, pipes, conduits, anchor bolts, and any other fixtures required to be embedded in concrete have been placed and adequately anchored to maintain a minimum 2-inch clearance between the item and any concrete reinforcement.
 - 1) Securing embedded items in position by wiring or welding to the reinforcement is not permitted.
 - e. Forms have been cleaned of debris and form release agents are applied as specified.
 - 3. Preparation for placement of footings and slabs on grade:
 - a. Do not place concrete on ground or compacted fill until subgrade is in moist condition acceptable to the Engineer.
 - b. If necessary, sprinkle subgrade with water not less than 6 or more than 20 hours in advance of placing concrete.
 - c. If subgrade surface becomes dry prior to actual placing of concrete, sprinkle again, without forming pools of water.
 - d. Do not place concrete if subgrade is muddy or soft.
 - 4. Keep sufficient protective coverings on hand at all times for protection of concrete during and after placement.
 - a. Protect concrete placed before rain to prevent water from coming in contact with such concrete.
 - b. Protect concrete placed before winds to prevent excessive drying or embedment of debris in the finished surfaces.
- B. Concrete placement:
 - 1. Do not place concrete:
 - a. With slump outside the limits specified in Table 3 of this Section.
 - b. In which initial set has occurred, or that has been retempered.
 - c. During rainstorms or high velocity winds.
 - 2. Deposit concrete at or near its final position to avoid segregation caused by rehandling or flowing.
 - a. Do not deposit concrete in large quantities in one place, and then work material along forms with vibrator or by other methods.
 - 3. Do not drop concrete freely into place from height greater than 5 feet. Use tremies for placing concrete where drop is over 5 feet.
 - 4. Place concrete on slopes starting from bottom of slope and working upward.
 - 5. Place concrete in horizontal lifts not exceeding 24 inches in depth and bring up evenly in all parts of forms.
 - 6. After concrete placement begins, continue in a continuous operation without significant interruption until the end of the placement. Plan and implement precautions to prevent any delay, between layers or adjacent volumes, from exceeding 20 minutes.
 - 7. If concrete is to be placed over previously placed concrete and more than 20 minutes has elapsed, spread layer of neat cement grout over surface before placing additional concrete. Provide grout layer thickness of not less than 1/2 inch or more than 1 inch.
 - 8. Placement of concrete for slabs, beams, or walkways:
 - a. If cast monolithically over walls or columns, do not commence until concrete in walls or columns has been allowed to set and shrink.
 - b. Allow set time of not less than 1 hour for shrinkage.
 - 1) During waiting time, keep top surface of concrete moist, but not wet.

- 2) Do not permit water to pond or stand on the surface.
 - 3) Do not coat surface with evaporation retarders or curing agents.
 - c. Start placement above wall or column with layer of neat cement grout as described in the preceding paragraph.
- C. Consolidating concrete:
- 1. Consolidate concrete with aid of acceptable mechanical vibrators.
 - 2. Thoroughly consolidate concrete around reinforcement, pipes, or other shapes built into the Work.
 - 3. Provide sufficiently intense vibration to cause concrete to flow and settle readily into place and to visibly affect concrete over radius of at least 18 inches.
 - 4. Vibrators:
 - a. Keep sufficient vibrators on hand at all times to vibrate concrete as placed.
 - b. In addition to vibrators in actual use while concrete is being placed, have on hand a minimum of 1 spare vibrator in operable condition.
 - c. Do not place concrete until it has been confirmed that all vibrating equipment, including spares, are in operable condition.
 - 5. Place concrete solidly against forms and concrete surfaces, leaving no voids or honeycomb.
 - 6. Make concrete solid, compact, and smooth. If for any reason surfaces or interiors have voids or are in any way defective, repair such concrete in manner acceptable to the Engineer.
 - 7. Do not over-vibrate so as to produce segregation.

3.06 FINISHING CONCRETE

- A. Provide concrete finishes as specified in Section 03_35_29 - Concrete Finishes, unless otherwise indicated on the Drawings.
- B. Liquid evaporation retardant:
 - 1. Under conditions that result in rapid evaporation of moisture from the surface of the concrete, coat the surface of the concrete with a liquid evaporation retardant immediately after screeding.
 - 2. Conditions that result in rapid evaporation of moisture are defined as any combination of ambient temperature, concrete temperature, relative humidity, wind speed, and solar radiation intensity that creates conditions that will evaporate water from a free concrete surface at a rate equal to or greater than 0.1 pounds per square foot per hour as determined by the Menzel Formula and nomograph published in ACI PRC-305 and included as Attachment A - Menzel Formula and Nomograph to this Section.
 - a. If concrete is batched with ASTM C595, Type IL cement, apply evaporation retardant when evaporation rate reaches 0.05 pounds per square foot per hour.
 - 3. Apply evaporation retardant again after each finishing operation as necessary to prevent drying shrinkage cracks.
 - 4. Do not work evaporation retardant into the surface of the concrete.
 - 5. Do not use evaporation retardant as finishing aid (to rehydrate surface a creamy state for finishing).

- C. Concrete sealer:
 - 1. Floors and slabs to receive concrete sealer: See Room Finish Schedule on the Drawings and Section 03_35_29 - Concrete Finishes.
- D. Surface-applied crystalline coating:
 - 1. Apply surface-applied crystalline coating in accordance with the manufacturer's directions.
 - 2. Spray, squeegee or roll on liquid to clean, dry concrete surface at 225 square feet per gallon.
 - a. Scrub liquid into the surface with a mechanical scrubber.
 - b. Keep surface wet for a minimum of 30 minutes with the surface-applied crystalline coating during application.
 - c. When the product thickens, but not more than 60 minutes after initial application, squeegee or vacuum the surface to remove all excess liquid.
 - d. Do not leave any residue on surface.
 - e. Do not track material on to untreated surfaces.
 - 3. Where concrete continues to sweat or leak, apply additional coats of surface-applied crystalline coating until the sweating or leaks stop.

3.07 CURING

- A. Cure concrete by methods specified in this Section.
- B. For placements of Class M concrete, as specified in Section 03_70_30 - Thermal Control of Concrete for additional requirements.
- C. Cure period: Keep concrete continuously moist and at an average daily temperature of at least 50 degrees Fahrenheit for a minimum of 14 days after placement (28 days for mixes with 56-day specified strength).
 - 1. If hourly temperatures at any surface of a concrete placement drop below 50 degrees Fahrenheit during the curing period, count the period below 50 degrees Fahrenheit as zero degrees, and extend the curing time to compensate.
- D. Schedule of curing methods:
 - 1. Cure the following concrete surfaces using water curing or plastic membrane curing:
 - a. Floor surfaces of water containment structures.
 - b. Surfaces where additional concrete will be placed over or against the surface, including concrete joints.
 - c. Surfaces where grout or other toppings will be placed over the surface.
 - d. Slabs scheduled to receive concrete sealer, or other bonded or adhered architectural finishes.
 - e. Formed surfaces scheduled to receive coatings, paint, adhered masonry, cementitious materials, or other similar finishes, and where formwork is removed before the end of the curing period.
 - f. Horizontal concrete surfaces at tops of walls.
 - 2. Cure the following concrete surfaces by water curing, plastic membrane curing, or sprayed curing membrane. Selection of methods shall be at the Contractor's option:
 - a. Surfaces not listed in the preceding paragraph.

E. Water curing:

1. Keep surfaces of concrete constantly and visibly wet, day and night, for not less than the specified cure period.
 - a. Each day forms remain in place will be counted as 1 day of water curing.
 - b. Do not loosen form ties during period when concrete is cured by leaving forms in place. No further curing credit will be allowed for forms remaining in place after contact has been broken between concrete surface and forms.
2. Begin water curing as soon as concrete attains initial set.
3. Maintain a wet surface by ponding, continuous sprinkling, covering with saturated burlap, or otherwise saturating the surface by means acceptable to the Engineer.
 - a. Flood top of walls with water at least 3 times per day and keep surfaces moist at all times during the curing period.
 - b. Provide plastic sheet material over surfaces if required to maintain a wet surface during arid or windy conditions. See plastic membrane curing requirements for additional details.
4. Use water having a temperature within 20 degrees Fahrenheit of the temperature of concrete, and not lower than the minimum temperature allowed for the concrete surface during curing.

F. Plastic membrane curing:

1. Install plastic membrane as soon as concrete is finished and can support limited pedestrian traffic without damage.
2. Cover entire surface of finished concrete with membrane.
3. Anchor membrane to prevent uplift from wind or air trapped below the sheet.
4. Fully seal joints and edges to provide full seal around perimeter.
5. Keep concrete under plastic membrane moist, regularly monitoring surfaces and adding supplemental moisture if necessary. Add water as specified for water curing.

G. Sprayed membrane curing compound:

1. Apply curing compound to concrete surface after repairing and patching, and within 1 hour after forms are removed.
 - a. If more than 1 hour elapses after removal of forms, do not use membrane curing compound. Instead, provide water curing for not less than the specified cure period.
 - b. Do not remove sprayed membrane curing compound from concrete before the end of the specified cure period.
 - c. When application of curing compound at concrete joints is accepted by the Engineer, take care to apply curing compound to all surfaces along full profile of joints.
2. Apply curing compound by mechanical, power operated sprayer with mechanical agitator that will uniformly mix all pigment and compound.
 - a. Apply curing compound in at least 2 coats. Each coat shall be applied at the manufacturer's recommended application rate.
 - b. Apply each coat in direction turned 90 degrees from application direction of the preceding coat.

- c. Apply curing compound in sufficient quantity so that concrete has uniform appearance and its natural color is effectively and completely concealed immediately after spraying. This requirement may require additional coats and/or application rates than indicated above.
 - d. Continue to coat and recoat surfaces until specified coverage is achieved and until coating film remains on concrete surfaces.
- 3. Thickness and coverage of curing compound:
 - a. Provide curing compound having film thickness that can be scraped from surfaces at any and all points after drying for at least 24 hours.
 - b. Contractor is cautioned that method of applying curing compound specified in this Section may require more curing compound than normally suggested by manufacturer of curing compound and is more than is customary in the trade. Apply amounts specified in this Section, regardless of manufacturer's recommendations or customary practice.
- 4. If the Contractor desires to use a curing compound other than specified product, coat sample areas of concrete wall with proposed curing compound, and also coat similar adjacent area with the specified compound in the manner specified, for comparison:
 - a. If proposed sample is not equal or better, in the opinion of the Engineer, the proposed substitution will not be allowed.
- 5. Removal of curing compound.
 - a. After curing period is complete, remove curing compound placed on surfaces that will receive additional concrete, including all concrete joint surfaces, by heavy sandblasting or by other means acceptable to the Engineer. Complete removal and cleanup prior to placing any new concrete against the surface.
 - b. Where additional finishes will be applied over concrete surfaces, unless otherwise recommended by the manufacturer of the finish to be applied, remove curing compound by sandblasting. Provide blasting as necessary to fully remove curing compound.
- 6. Prior to final acceptance of the Work, remove, by sandblasting or by other method acceptable to the Engineer, any curing compound on surfaces exposed to process water or exposed to view, so that only natural color of finished concrete is visible and uniform over the entire surface.

3.08 PROTECTION

- A. General:
 - 1. Keep forms in place, as specified in Section 03_11_07 - Concrete Formwork, to provide curing and to protect concrete surfaces and edges from damage.
 - 2. Immediately after forms are removed, carefully examine concrete surfaces, and repair any irregularities in surfaces and finishes as specified.

- B. Loading of concrete members:
 - 1. Placement of loads on or against green concrete is not permitted.
 - 2. Do not place soil against walls, or fill over the top of concrete until conditions designated in the following paragraphs are satisfied:
 - a. Walls have been cast to their full height in the structure and have achieved their minimum specified 28-day compressive strength.
 - b. Connecting slabs and beams that brace the walls are in place, are complete, and (in the case of concrete) have achieved their minimum specified 28-day compressive strength.

3.09 COLD WEATHER CONCRETING

- A. Implement cold weather concreting procedures during periods of cold weather as defined in this Section.
 - 1. Comply with the recommendations of ACI PRC-306 and this Section.
- B. Prepare a cold weather concreting plan. Maintain at least 1 copy of the plan onsite.
 - 1. Include procedures for batching, delivery, placement, curing, protection, and for monitoring and recording the temperature of the concrete and the surrounding environment.
 - 2. Include details of heating equipment, temperature monitoring equipment, and insulation.
 - 3. Describe procedure to be implemented in the event of abrupt changes in weather conditions or of equipment failure.
 - 4. Include detailed description of means and methods that will be implemented to protect the base slab of the wet well from the accumulation of water, snow, and ice during cold weather.
 - 5. Review cold weather concreting plan during pre-construction meeting. Make provisions to address any concerns expressed by the Engineer before beginning concrete placements.
- C. Preparation:
 - 1. Do not place concrete over frozen subgrade materials. Provide insulating material and supplementary heat if required to maintain a thawed surface. Heat subgrade to within 20 degrees Fahrenheit of the temperature of the concrete at time of placement.
 - 2. Do not place concrete around metallic elements whose temperature is less than 40 degrees Fahrenheit. If heating is required, use processes that do not alter the metallurgical properties of the elements.
 - 3. Remove snow, ice, and frost from reinforcement, embedments and forms. Schedule such removal immediately before concrete placement so that surfaces do not refreeze.
 - 4. Continue to heat subgrade and embedments to maintain the required temperature until the concrete is placed.
- D. Batching, delivery, placement and finishing:
 - 1. Accelerating admixtures will not be permitted.

2. Based on temperature of the environment and the surfaces where concrete will be placed, select and maintain concrete temperature as recommended in ACI PRC-306.
 - a. Make provisions for temperature loss during delivery and placing.
 - b. Place concrete at or slightly above the minimum recommended batch temperatures. Do not exceed these minimum values by more than 20 degrees Fahrenheit.
 3. Heating: If temperature of water or aggregates is below 35 degrees Fahrenheit, heat the materials.
 - a. Mixing water: Do not heat above 140 degrees Fahrenheit.
 - b. Aggregates:
 - 1) Heat uniformly to eliminate ice, snow, and frozen lumps of material.
 - 2) Avoid overheating.
 - 3) Do not exceed average temperature of 140 degrees Fahrenheit or spot temperature of 200 degrees Fahrenheit.
 4. Placing:
 - a. Do not place concrete when air temperatures may drop below 10 degrees Fahrenheit unless protected within a heated enclosure.
 - 1) Do not place concrete having a temperature that is more than 20 degrees Fahrenheit above the temperatures in Table 5.
- E. Protection and curing:
1. Protect concrete to provide continuous warm moist curing immediately after placement and during protection period.
 2. Minimum protection period: Greater of 14 days or until concrete reaches 3,500 psi.
 3. For placements of Class M concrete, do not use steam or other concrete heating methods that will increase concrete temperature outside the limits of Section 03_70_30 - Thermal Control of Concrete.
 4. During and immediately after the protection period, maintain temperature in accordance with Table 5 of this Section. Provide record of temperature during placement and curing as specified for temperature monitoring program in Section 03_70_30 - Thermal Control of Concrete.
 - a. Furnish and locate maximum/minimum temperature recording thermometers in sufficient numbers to confirm concrete.

Table 5. Concrete Temperatures - Normal Weight Concrete			
Section Thickness (inches)	<12	12 to <36	36 to <72
During Protection Period: As placed and maintained (minimum)	60°F	55°F	50°F
After Protection Period: Gradual drop during first 24 hours (maximum)	50°F	40°F	35°F

5. Provide plastic sheeting, polystyrene foam sheets, insulating blankets, and supplemental heating to maintain moisture and the specified temperatures during protection.
 - a. Protect insulating blankets from moisture in the concrete and from rain or snow using impermeable sheeting.
 - b. Supplemental heating units:
 - 1) Vent units to outside atmosphere. Do not exhaust heater flue gasses into the enclosed and protected area.

- 2) Make provisions to heat the flow freely within protected area and to maintain a uniform temperature throughout the space.
 - 3) Locate units to avoid local drying or uneven heating of concrete surfaces.
- c. Pay particular attention to maintaining required temperature and moisture at edges and corners.
6. At the end of the protection period, allow concrete to cool gradually to the ambient temperature. Reduce supplemental heat and maintain insulation until concrete is within 20 degrees Fahrenheit of ambient air temperature.
 - a. Maximum temperature drop over the first 24-hour period shall be as specified above.
 - b. Where temperature of concrete exceeds ambient by 20 degrees Fahrenheit or more, loosen forms and leave in place for at least 24 hours before removal.
 - c. If water curing has been used, maintain concrete temperature as specified in the following paragraphs for at least 24 hours after water curing is terminated. Allow water-cured concrete to air dry for at least 3 days before exposure to freezing temperatures.

F. Temperature records:

1. For each area of concrete placed or cured during cold weather, record the temperature of concrete and the ambient environment.
 - a. Use temperature monitoring system specified in Section 03_70_30 - Thermal Control of Concrete.
 - b. Monitor concrete temperature and maintain records in accordance with temperature monitoring program requirements specified in Section 03_70_30 - Thermal Control of Concrete. Make records available for review by the Engineer upon request.
 - c. If monitoring indicates that the minimum temperature of the concrete was not maintained in accordance with Table 5 during the protection period, notify the Engineer within 24 hours.
2. Concrete delivered for placement.
 - a. Upon delivery of concrete to the Site, measure and record temperature in accordance with ASTM C1064.
 - b. Note temperature on the batch ticket.
3. Concrete during the protection period:
 - a. Implement temperature monitoring program as specified in Section 03_70_30 - Thermal Control of Concrete.
4. At the completion of cold weather concreting operations, submit a final compilation of temperature records to the Engineer for Project files, not more than 14 calendar days after the last date concrete was placed.
5. In the event that evaluations of the efficacy of concrete protection and curing are required, the lowest temperature recorded in any placement during each 24-hour period will be assumed to be the temperature at which the entire placement was maintained.
 - a. Protection periods without any temperature records will be assumed to have provided no protection or curing, and the protection period will be extended by 2 days for each day without protection.

3.10 HOT WEATHER CONCRETING

- A. Implement hot weather concrete procedures during periods of hot weather as defined in this Section.
 - 1. Comply with the recommendations of ACI PRC-305 and this Section.
- B. If placements during hot weather are expected, and when requested by the Engineer, prepare a hot weather concreting plan.
 - 1. Maintain at least 1 copy onsite.
 - 2. Provide plan for review if requested by the Engineer.
 - a. Include procedures for batching, delivery, placement, curing, protection, and monitoring and recording the temperature of the concrete and the surrounding environment.
 - b. Describe procedures to be implemented in the event of abrupt changes in weather conditions, or in the event of equipment failure.
 - c. Review hot weather concreting plan during pre-construction meeting. Make provisions to address any concerns expressed by the Engineer before beginning concrete placements.
- C. Preparation:
 - 1. Do not place concrete against forms, reinforcement, or embedments with a surface temperature greater than 120 degrees Fahrenheit.
 - a. If necessary, to maintain maximum concrete temperature during placing, cool forms and reinforcement to temperature below 90 degrees Fahrenheit using water or shades.
 - b. Do not allow water to puddle in forms or placement areas.
 - 2. Moisten forms or subgrade to maintain a saturated surface without standing water or soft spots.
 - 3. Provide windbreaks, shades, fog spray, sprinkling, wet cover, or other means required to protect concrete from premature loss of moisture and rapid temperature gain.
- D. Batching and delivery:
 - 1. Retarding admixtures will not be permitted.
 - 2. Temperature of concrete delivered for placement shall not exceed 90 degrees Fahrenheit.
 - a. Maintain uniform temperature in the mix below this level during batching, delivery, placing, and consolidation.
 - b. Temperature of mix, even if below the maximum allowable temperature specified, shall be maintained at a level to avoid loss of slump, flash setting, or cold joints in placements.
 - 3. If necessary:
 - a. Mix water may be chilled or replaced with ice to maintain mix temperature. Where mix water is replaced with ice, provide replacement at a 1-to-1 ratio by weight.
 - b. Shade transit mixed concrete trucks, or cool mixing outside of container with water to control temperature of concrete.
- E. Placing and finishing:
 - 1. Place and finish concrete promptly. Place so that vertical lift lines will not be visible in exposed concrete surfaces.

2. Provide plastic sheeting, fog nozzles, shades or other means to reduce concrete temperature and protect from moisture loss.
 3. For placements of Class M concrete, use fog sprayers to reduce ambient air temperature and increase humidity during concrete placement.
- F. Protection and curing:
1. Furnish and locate maximum/minimum temperature recording thermometers in sufficient numbers to confirm concrete temperatures over full area and edges of concrete.
 2. Flatwork: Protect and cure using water curing methods as specified in this Section.
 - a. Water curing:
 - 1) Keep concrete continuously wet and make provisions for runoff.
 - 2) For sprinkling or soaker hoses, maintain temperature of water as close as possible to the temperature of the concrete to minimize effects of thermal shock.
 3. Formed surfaces: Protect and cure using forms left in place or membrane curing methods as specified in this Section.
 - a. Cover forms and keep continuously moist for at least 24 hours after placement.
 - b. Loosen forms as soon as this can be accomplished without damaging the concrete.
 - c. Maintain continuously moist surfaces by fogging or spraying with water, or by application of curing compound as specified.

3.11 FIELD QUALITY CONTROL BY CONTRACTOR

- A. Provide quality control over the Work of this Section as required by Section 01_45_17 - Contractor Quality Control.
- B. Temperature monitoring program:
1. Execute temperature monitoring program required in Section 03_70_30 - Thermal Control of Concrete.
- C. Field tests:
1. During progress of construction, provide testing to determine whether the concrete, as being produced, complies with requirements specified.
 2. Sampling and testing shall be performed by the Contractor's testing laboratory. See Section 01_45_24 - Regulatory Quality Assurance - Special Tests and Inspections for requirements.
 - a. Cooperate in testing by allowing free access to the Work for testing laboratory to sample and test materials.
 - b. Provide full access for the Engineer to observe concrete sampling and testing at any time.

- c. Contractor is responsible for providing care of and curing conditions for test specimens in accordance with ASTM C31 until specimens are collected by testing laboratory.
 - d. Provide 4 firmly braced, insulated, heated, closed wooden curing boxes, each sized to hold 10 specimens. Include cold weather temperature and hot weather temperature control thermostat for initial curing and storage from time of fabrication through shipment to the Contractor's testing laboratory.
3. Testing shall include:
- a. Sampling of concrete in accordance with ASTM C172.
 - b. Temperature of concrete at delivery in accordance with the requirements of ASTM C1064 and as specified in this Section.
 - c. Slump of concrete using slump cone in accordance with requirements of ASTM C143. Test slump at the following intervals:
 - 1) At the beginning of each placement.
 - 2) As often as necessary to keep slump within the specified range, but not less than every 6th truck.
 - 3) When requested to do so by the Engineer.
 - 4) Observe concrete during slump test for signs of segregation.
 - a) Observe concrete to see if mortar or moisture flows from slumped concrete.
 - b) Reject concrete if mortar or moisture flows out of mix.
 - d. Unit weight of concrete in accordance with ASTM C138.
 - e. Air entrainment in accordance with ASTM C173. Test air content at the following intervals:
 - 1) At beginning of each placement.
 - 2) As often as necessary to keep entrained air within specified range, but not less than every 6th truck.
 - 3) When requested to do so by the Engineer.
 - 4) Test air entrainment in concrete in accordance with ASTM C173. If air entraining admixtures used for the Work require alternate testing procedures, advise the independent testing laboratory well in advance of the dates of testing, and confirm that appropriate equipment and personnel are provided for the test.
 - 5) Make air test at point of delivery (discharge from mixer). For pumped concrete, make air tests at point of delivery and at point where expelled after pumping for placement.
 - f. Compressive strength in accordance with ASTM C39. Required number of cylinders is as follows:
 - 1) Not less than 6 cylinder specimens, 4 inches in diameter by 8 inches long, will be tested for each 100 cubic yards of each class of concrete or 5,000 square feet of slab or wall, with minimum of 6 specimens for each class of concrete placed; not less than 6 specimens for each half day's placement; and not less than 2 sets of 6 specimens for each structure.
 - 2) One cylinder will be broken at 7 days, 1 at 14 days, and 3 at 28 days. 6th cylinder may be used to evaluate strength after 28 days if requested by the Engineer.

- 3) Retain and store 6th cylinders (tested and untested) at testing laboratory until 56 days. Break 6th cylinder when directed by the Engineer.
 - 4) For concrete with 56-day strength requirement, 1 cylinder will be broken at 14 days, 1 at 28 days, and 3 at 56 days. 6th cylinder may be used to evaluate strength after 56 days if requested by the Engineer.
 - g. Provide full access for the Engineer to observe concrete sampling and testing at any time.
- D. Test completed liquid containment structures listed in Section 01_75_19 - Water Leakage Test for Concrete Structures for watertightness.

3.12 FIELD QUALITY CONTROL BY OWNER

- A. As specified in Section 01_45_17 - Contractor Quality Control.
- B. Special tests and inspections: As specified in Section 01_45_24 - Regulatory Quality Assurance.
- C. Field inspections:
 - 1. Observe construction for conformance to the Contract Documents and the accepted submittals.
 - 2. Records of inspections:
 - a. Provide a record of each inspection.
 - b. Submit copies to the Contractor upon request.
- D. Field tests:
 - 1. Engineer may request, at any time, additional testing to confirm materials being delivered and placed conform to the requirements of the Contract Documents.
 - a. If such additional testing shows that the material do not conform to the specified requirements, the Contractor shall pay the cost of these tests.
 - b. If such additional testing shows that the materials do conform to the specified requirements, the Owner will pay the cost of these tests.

3.13 NON-CONFORMING WORK

- A. Remove and replace or repair non-conforming and defective work.
 - 1. Provide repairs having strength equal to or greater than specified concrete for areas involved.
 - 2. Provide replacement or repair of non-conforming work by means acceptable to the Engineer and at no additional cost to the Owner.
 - 3. Project schedule will not be extended based on work to address non-conforming concrete.
- B. Concrete not conforming to the specified requirements for properties of plastic concrete: Remove from the Site and replace with conforming materials at no additional cost to the Owner.
 - 1. Temperature: Do not use concrete having a temperature above or below the limits specified in this Section.

2. Slump: Do not place concrete that does not conform to requirements for slump.
 3. Air entrainment: Do not use concrete that does not conform to requirements for percentage of entrained air.
- C. Concrete not conforming to the specified requirements for compressive strength:
1. Concrete is expected to reach a compressive strength equal to or greater than the minimum specified compressive strength f'_c in Table 3 of this Section.
 2. Strength of concrete will be considered acceptable if the following conditions are satisfied.
 - a. Averages of all sets of 3 consecutive strength test results is greater than or equal to the specified compressive strength f'_c .
 - b. No individual strength test (average of 3 cylinders) falls below the strength specified in Table 6 of this Section.
 - c. Where relationships between 7-day and 28-day compressive strength, or between 28-day and 56-day compressive strength, have been provided as part of the mix design submittals:
 - 1) 7-day strength may be considered as an indication of 28-day strength provided effects of temperature and humidity between 7 days and 28 days are taken into account.
 - 2) 28-day strength may be considered as indication of 56-day strength provided effects of temperature and humidity between 28 days and 56 days are taken into account.

Table 6. Strength Compliance Requirements	
Minimum Specified Compressive Strength, f'_c (pounds per square inch)	Lower Bound of an Individual Compressive Strength Test (pounds per square inch)
Less than 5,000	$f'_c - 500$
Over 5,000	$f'_c - (0.10 \times f'_c)$

3. Non-compliant strength tests.
 - a. Mark non-compliant strength test reports to highlight the non-complying results and immediately forward copies to all parties on the test report distribution list.
 - b. Initial treatment may consist of additional curing of affected portion(s) followed by not less than 3 cores at each affected area, taken in accordance with ASTM C42 and ACI CODE-318. Obtain the Engineer's acceptance of proposed coring locations before proceeding with that work.
 - c. Submit report of compressive strength testing for the Engineer's review.
 - d. If requested by the Engineer, provide additional cores, and obtain petrographic testing in accordance with ASTM C856. Submit results for the Engineer's review.
 - e. If additional curing does not bring the average strength of 3 cores taken in affected area to at least specified compressive strength f'_c , designate such concrete in affected area will be considered defective.
 - f. Engineer may require the Contractor to strengthen defective concrete by means of additional concrete, additional reinforcing steel, or replacement of defective concrete, all at the Contractor's expense.

- D. Concrete sections or surfaces with honeycombing and voids:
1. Provide repairs having surface appearance and finish consistent with that of the surrounding work and acceptable to the Engineer.
 2. Do not patch, repair, or cover defective work without prior inspection by the Engineer.
 3. Preparation of concrete for repair:
 - a. Make no repair until the Engineer has accepted methods for preparing surfaces and for making and curing repairs.
 - b. Chip out and key-in imperfections in the Work to make them ready for repair.
 - c. Coat bonding surfaces and edges of repair area with one of the following bonding agents as accepted by the Engineer.
 - 1) Epoxy bonding agent as specified in Section 03_63_01 - Epoxies; or,
 - 2) Epoxy resin/portland cement bonding agent as specified in Section 03_63_02 - Epoxy Resin/Portland Cement Bonding Agent.
 4. Methods of repair:
 - a. Dry pack mortar method:
 - 1) Use for holes having depth nearly equal to or greater than least surface dimension of hole, for cone-bolt holes, and for narrow slots cut for repair.
 - 2) Smooth holes: Clean and roughen by heavy sandblasting before repair.
 - 3) Install dry-pack mortar as specified in Section 03_35_29 - Concrete Finishes.
 - b. Cement mortar method:
 - 1) Use for holes too wide to dry pack and too shallow for concrete replacement; and for comparatively shallow depressions, large or small, that extend no deeper than nearest surface reinforcement.
 - 2) Install cement mortar as specified in Section 03_35_29 - Concrete Finishes.
 - c. Concrete replacement:
 - 1) Use when holes extend entirely through the concrete section or when holes are more than 1 square foot in area and extend halfway or more through the section.
 - 2) Form, place, consolidate, and cure concrete of same mix as the surrounding work.
- E. Leaking construction joints and cracks in concrete walls and slabs:
1. Repair cracks that develop in walls or slabs, and repair cracks that show any signs of leakage until all leakage is stopped.
 2. Pressure inject visible cracks in the following areas, other than hairline cracks and crazing, with repair products and methods acceptable to the Engineer.
 - a. Floors and walls of water bearing structures.
 - b. Walls and overhead slabs of passageways and occupied spaces where the opposite face of the member is exposed to weather or may be washed down and where the opposite face does not receive a separate waterproofing membrane.
 - c. Other items not specified to receive separate waterproofing membrane, including slabs over water channels, wet wells, reservoirs, and other similar surfaces.

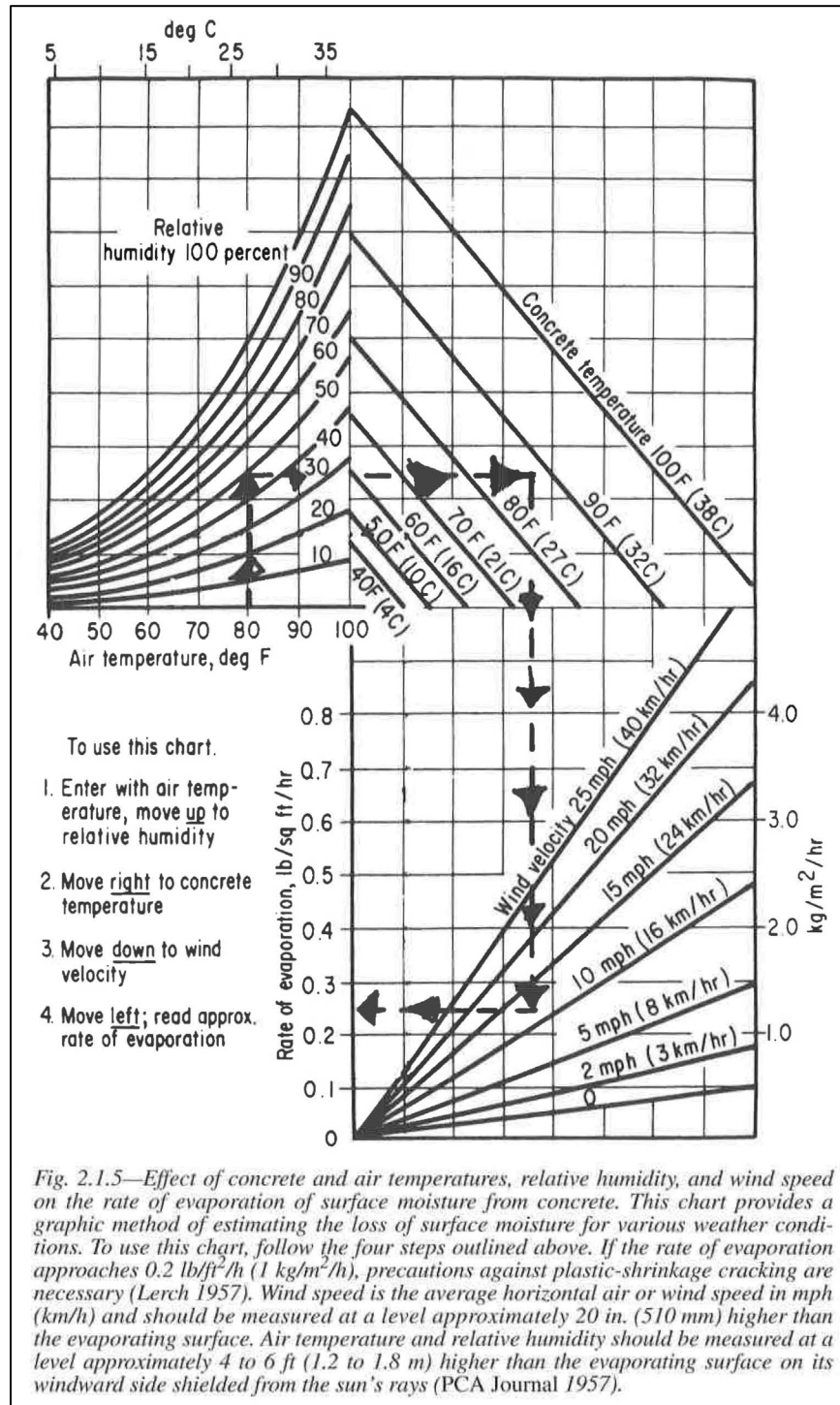
3. Continue pressure injection of cracks as specified until structure is watertight and remains watertight for not less than 1 year after date of Substantial Completion or date of final repair, whichever occurs later in time.
- F. Leaking expansion joints in concrete walls or slabs that include waterstops:
1. Repair any signs of leakage until all leakage is stopped.
 2. Pressure inject visible leaks with epoxy injection system as specified in Section 03_64_24 - Epoxy Injection System.
 3. Continue pressure injection along joints lines as specified until structure is watertight and remains watertight for not less than 1 year after date of Substantial Completion or date of final repair, whichever occurs later in time.
- G. Walls and slabs at overhead channels that leak or sweat because of porosity or cracks too small for successful pressure injection with epoxy.
1. Seal on water or weather side by coating using surface-applied crystalline coating as specified in this Section.
 2. Apply as recommended by manufacturer published instructions. Where concrete continues to sweat or leak, apply additional coats of surface-applied crystalline coating until the sweating or leaks stop.
 3. Continue application of surface-applied crystalline coating until structure is watertight and remains watertight for not less than 1 year after date of Substantial Completion, or date of final repair, whichever occurs later in time.

END OF SECTION

ATTACHMENT A - MENZEL FORMULA AND NOMOGRAPH

MENZEL FORMULA AND NOMOGRAPH

Source: ACI PRC-305



ATTACHMENT B - COARSENESS FACTOR CHART

COARSENESS FACTOR CHART

Source: ACI PRC-302.1-15, Figure 8.9.2.2.

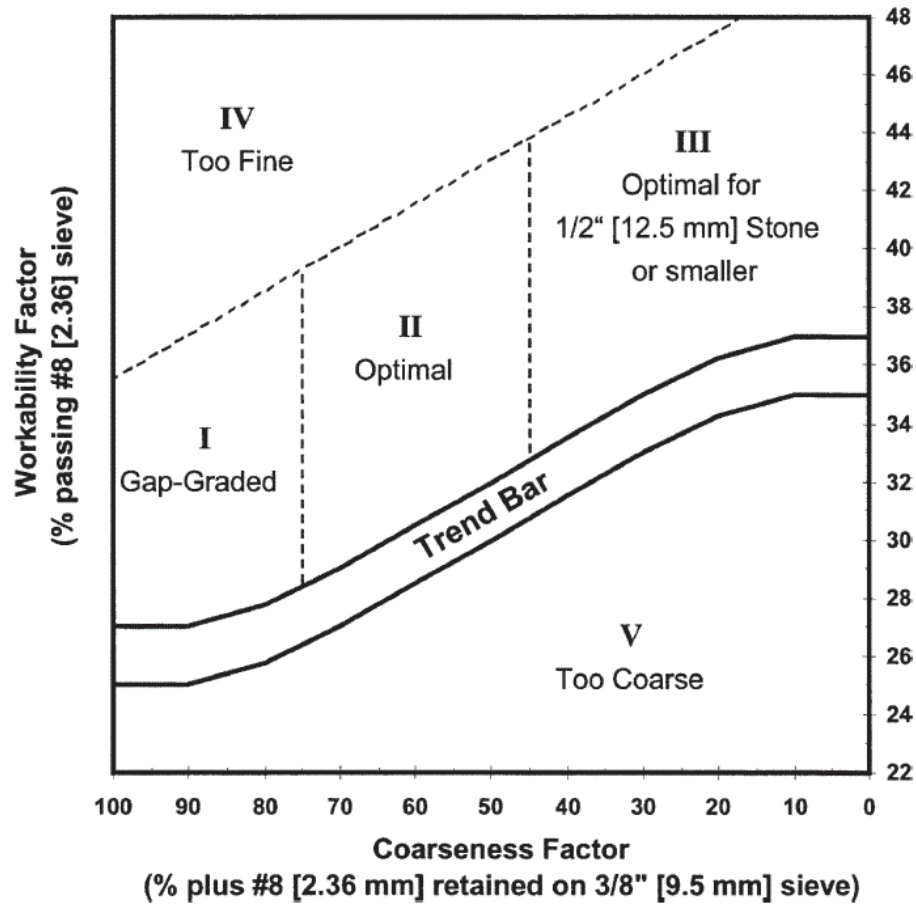
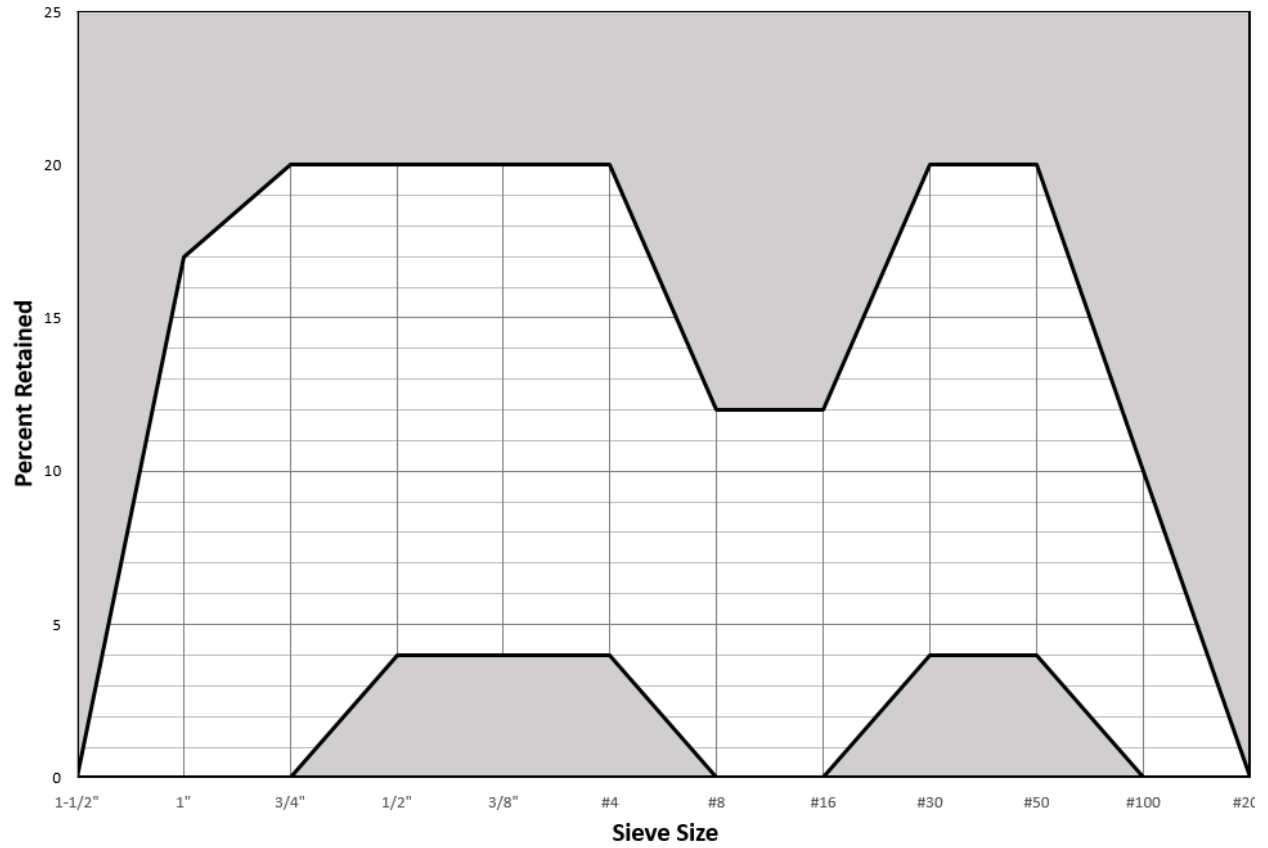


Fig. 8.9.2.2—Coarseness factor chart for evaluating potential performance of mixture.

ATTACHMENT C - COMBINED AGGREGATE GRADATION CHART

COMBINED AGGREGATE GRADATION CHART



ATTACHMENT D - CONCRETE PLACEMENT CHECKLIST

CONCRETE PLACEMENT CHECKLIST

Project: _____ Class of Concrete: _____

Project No: _____ Test Cylinders Taken? Yes: _____ No: _____

Preparation Slab	Contractor	N/A
Compaction Subgrade		
Filter Fabric/Drain Rock-ABC/Separator Fabric		
Drain Rock, Pea Gravel and Void Form		
Starter Wall Forms		
Reinforcing Steel		
Screeds		

Embedded Items	Contractor	N/A
A. Anchor Bolts		
B. Water Stop		
C. Rebar		
D. Electrical		
E. Plumbing Rough-in		
F. Mechanical		
G. HVAC		

Concrete Placement Equip.	Contractor	N/A
A. Crane		
B. Buckets		
C. Hoppers		
D. Vibrators		
E. Elephant trunks		
F. Floodlights		
G. Pump Truck		

Building Department Notification
Date: _____ Time: _____

Prep Wall Concrete	Contractor	N/A
Access To Work		
Ladders Secured		
Clean up and Washed Out		
Reinforcing Steel		

Forms	Contractor	N/A
A. Alignment and Grade		
B. Scaffolding		
C. Sleeves and Wall Castings		
D. Embedded Items		
E. Electrical		
F. Plumbing Rough-in		
G. Piping		

Record of Curing Conditions During Placement
Start: _____ Finish: _____
Date: _____
Time: _____
Weather: _____
Temperature: _____
Comments: _____

Location of Placement _____

The Contractor certifies the above-proposed concrete placement is prepared as indicated and is in accord with the Contract Drawings and Specifications. The Contractor requests permission to begin placement of concrete on the date of _____ at _____. The estimated number of yards is _____. The estimated duration of the placement is _____.

By: _____
Contractor

Released for placement by: _____
Engineer

SECTION 03_31_26

SELF-CONSOLIDATING CONCRETE REQUIREMENTS

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Materials and procedures for producing self-consolidating concrete (SCC).
- B. This Section supplements the requirements of Section 03_30_00 - Cast-in-Place Concrete for those classes of concrete that are designated as SCC mixes. For additional requirements not specified in this Section, see Section 03_30_00 - Cast-in-Place Concrete.

1.02 REFERENCES

- A. ASTM International (ASTM):
 - 1. C172 - Standard Practice for Sampling Freshly Mixed Concrete.
 - 2. C1611 - Standard Test method for Slump Flow of Self-Consolidating Concrete.
 - 3. C1621 - Standard Test Method for Passing Ability of Self-Consolidating Concrete by J-Ring.
 - 4. C1797 - Standard Specification for Ground Calcium Carbonate and Aggregate Mineral Fillers for use in Cement Concrete.
- B. United States Army Corps of Engineers (USACE):
 - 1. CRD-C661-06 - Specification for Anti-Washout Admixtures for Concrete.

1.03 TERMINOLOGY

- A. The words and terms listed below are not defined terms that require initial capital letters, but, when used in this Section, have the indicated meaning.
 - 1. J-ring flow: The distance of lateral flow of concrete using the J-Ring in combination with a slump cone.
 - 2. J-ring test: Test used to determine the passing ability of SCC, or the degree to which the passage of concrete through the bars of the J-Ring apparatus is restricted.
 - 3. Passing ability: The ability of SCC to flow under its own weight (without vibration) and fill completely all spaces within intricate formwork, containing obstacles, such as reinforcement.
 - 4. Self-consolidating concrete (SCC): A highly flowable, non-segregating concrete that can spread into place, fill the formwork, and encapsulate the reinforcement without any mechanical consolidation.
 - 5. Slump spread: The numerical value in inches (mm) of flow determined as the average diameter of the circular deposit of SCC at the conclusion of the slump flow test.
 - 6. Stability: The ability of a concrete mixture to resist segregation of the aggregates from the paste.

7. T_{50} : Time period that a slump spread test of an SCC concrete mix reaches an outer diameter of 20 inches from the time the mold is first raised.
8. Visual stability index (VSI) rating: An assessment of the homogeneity of concrete based on the visual inspection of the concrete sample at the end of the slump flow test.

1.04 ADMINISTRATIVE REQUIREMENTS

- A. The requirements of this Section will require advance planning for preparation and testing of trial batches. Review the mix design and testing requirements carefully, and schedule preparations and testing with sufficient time to complete tests, to obtain the Engineer's review of mixes and testing results, and to complete revisions and re-testing if required.
- B. Pre-installation meetings:
 1. Schedule and conduct pre-installation meeting as specified in Section 03_30_00 - Cast-in-Place Concrete.
 2. Agenda:
 - a. In addition to the requirements specified in Section 03_30_00 - Cast-in-Place Concrete, review the following aspects of SCC:
 - 1) Slump spread limits, visual stability index limits, and field quality control procedures specific to SCC.
 - 2) Forming and placing.
 - 3) Restriction of field addition of water to SCC mixes.

1.05 DELEGATED DESIGN

- A. As specified in Section 01_35_73 - Delegated Design Procedures.
- B. SCC mix designs.

1.06 SUBMITTALS

- A. Furnish Submittals as specified in Section 01_33_00 - Submittal Procedures and Section 01_60_01 - Product Requirements.
- B. Product data:
 1. As specified in Section 03_30_00 - Cast-in-Place Concrete.
 2. Data completely describing any mineral fillers or admixtures not listed in Section 03_30_00 - Cast-in-Place Concrete.
- C. Delegated Design Submittals:
 1. SCC mix designs.
- D. Quality Control Submittals:
 1. Admixture supplier's written instructions for field addition of admixtures.

PART 2 PRODUCTS

2.01 DESIGN AND PERFORMANCE CRITERIA

- A. Provide a highly flowable but cohesive homogeneous concrete mixture that will readily fill voids and irregularly shaped spaces and consolidate under its own weight without application of external energy and without segregation or bleeding, that, when hardened, will have the required strength and durability.
- B. Performance requirements:
 - 1. General:
 - a. Provide concrete composed of cement, supplemental cementitious materials, aggregate, admixtures and water, proportioned and mixed to produce a stable and flowable mixture in accordance with requirements of this Section, and suitable to specific conditions of placement.
 - b. Proportion aggregates to produce a gradation of aggregate that combines fine and coarse aggregate in well-graded proportions that maximizes the concrete workability and minimizes the water demand of the mix.
 - 1) Compressive strength, ratio of water to cementitious materials, maximum chloride content, and air entrainment: As specified in Section 03_30_00 - Cast-in-Place Concrete.
 - 2) Slump flow: 22 to 26 inches when tested in accordance with ASTM C1611.
 - 3) VSI: 1-stable - No evidence of segregation and slight bleeding observed as a sheen on the concrete mass when tested in accordance with ASTM C1611, Appendix X1.
 - 4) T₅₀ value: 2 to 7 seconds when tested in accordance with ASTM C1611, Appendix X1.
 - 5) J-ring value (passing ability): Difference between slump flow and J-ring flow: 0 to 2 inches (no visible blocking to minimal to noticeable blocking).

2.02 MATERIALS - CONCRETE MIX CONSTITUENTS

- A. Admixtures:
 - 1. As specified in Section 03_30_00 - Cast-in-Place Concrete and as follows:
 - a. Do not use admixtures containing chlorides, calculated as chloride ion, in excess of 0.5 percent by weight of cement.
 - b. Use in accordance with the manufacturer's recommendations. Add each admixture to concrete mix separately.
 - c. Admixtures used shall be the same products used in concrete trial batches, or the same products used in concrete represented by submitted field test records.
 - 2. Mineral fillers:
 - a. Not permitted.

2.03 CONCRETE MIXES

- A. Requirements for mix proportioning:
 - 1. Develop and provide mixes that:
 - a. Will readily flow into corners and angles of forms and around reinforcement, without vibration, and without permitting materials to segregate or free water to collect on surface.
 - b. Prevent unnecessary or haphazard changes in the consistency of the concrete supplied.
 - 2. Constituent materials:
 - a. Provide concrete mixes composed of cement, supplemental cementitious materials, blended aggregates, admixtures, and water.
 - 1) Required admixtures are specified in Table 3 of Section 03_30_00 - Cast-in-Place Concrete. Admixtures not specifically required by that table are optional and may be included at the discretion of the Contractor based on the Contractor's planned means and methods of construction.
 - 3. Proportions and consistency:
 - a. Proportion mixture according to provide specific criteria as specified in this Section.
 - b. Use the same constituents and proportions in the trial batches as that to be used in the project, including aggregates, mineral fillers, water, source and type of cement, supplementary cementitious materials, and admixtures, including any site-added admixtures intended to be used.
- B. Concrete mix design documented by field experience: As specified in Section 03_30_00 - Cast-in-Place Concrete.
- C. Concrete mix design documented by trial batch preparation and testing:
 - 1. Mix design and trial batches:
 - a. Prepare preliminary mix design for SCC as specified in Section 03_30_00 - Cast-in-Place Concrete and the supplemental requirements as follows:
 - 1) For each trial batch, make and test specimens to determine and report compressive strength (with relationships for rate of strength gain between testing ages), slump flow, visual stability index, and passing ability.
 - a) If trial batches do not produce concrete conforming to the specified requirements, change mix proportions and, if necessary, sources of materials.
 - b) Make additional trial batches and perform additional tests until a batch that conforms to requirements specified in this Section is produced.
 - 2. Testing:
 - a. Compressive strength: As specified in Section 03_30_00 - Cast-in-Place Concrete.
 - b. Chloride content: As specified in Section 03_30_00 - Cast-in-Place Concrete.
 - c. Slump spread:
 - 1) Determine slump spread, visual stability index, and T_{50} in accordance with ASTM C1611.
 - 2) Acceptance criterion: As specified in this Section.

- d. Passing ability: In accordance with ASTM C1621.
- e. Acceptance criteria: As specified in this Section.

PART 3 EXECUTION

3.01 PREPARATION

- A. As specified in Section 03_30_00 - Cast-in-Place Concrete and the following:
 - 1. Ensure that formwork is adequate to resist the additional form pressure due to SCC.

3.02 MIXING AND TRANSPORTING

- A. As specified in Section 03_30_00 - Cast-in-Place Concrete.
- B. Concrete delivery:
 - 1. Water may not be added to SCC concrete at the Site.
 - 2. Addition of admixtures in the field is permitted only with prior approval by the Engineer and when the following conditions are satisfied:
 - a. Dosage and mixing is personally overseen by the concrete supplier's trained technologist and the admixtures supplier's representative.
 - b. Adequate mixing time is provided after addition of admixtures in accordance with the written recommendations of the admixture supplier's representative.
 - c. Slump flow at discharge after additions/modifications conforms to the requirements of this Section.

3.03 PLACING AND CONSOLIDATING

- A. Concrete placement:
 - 1. Do not place concrete with slump flow outside the limits specified in this Section.
 - 2. Deposit SCC sufficiently close to its final position to avoid segregation caused excessive flowing.
 - a. Do not deposit concrete in large quantities in one place and then allow material to flow along forms in a manner that exceeds the capabilities of the concrete to maintain a cohesive and homogeneous condition.
 - 3. Place SCC that readily flows against forms and concrete surfaces and consolidates under its own weight, leaving no voids or honeycomb.
- B. Consolidating concrete:
 - 1. Do not apply external energy in the form of mechanical vibration to SCC unless the concrete has a lower-than-expected slump flow. If mechanical vibration is incorporated to assist consolidation in the event of lower slump flow than expected, do not excessively vibrate and cause segregation.
 - 2. Allow concrete to flow around reinforcement, pipes, conduits, embedments, or other shapes built into the Work.
 - 3. Make concrete solid, compact, and smooth. If for any reason surfaces or interiors have voids or are in any way defective, repair such concrete in manner acceptable to the Engineer.

3.04 FIELD QUALITY CONTROL BY CONTRACTOR

- A. Provide quality control over the Work of this Section as required by Section 01_45_17 - Contractor Quality Control Plan.
- B. Field tests:
 - 1. Testing shall include:
 - a. Sampling of concrete in accordance with ASTM C172.
 - b. Slump flow of concrete using slump cone in accordance with requirements of ASTM C1611. Test slump flow at the following intervals:
 - 1) At the beginning of each placement.
 - 2) Until testing shows 2 consecutive batches are produced within specifications.
 - 3) As often as necessary to keep slump flow within the specified range, but not less than every 6th truck.
 - 4) When requested to do so by the Engineer.
 - 5) Observe concrete during slump flow test for signs of segregation and record the visual stability index.
 - 6) Measure and record the T_{50} value.
 - c. Passing ability of concrete at delivery in accordance with the requirements of ASTM C1621. Test passing ability at the following intervals:
 - 1) At the beginning of each placement.
 - 2) Until testing shows 2 consecutive batches are produced within specifications.
 - 3) As often as necessary to keep passing ability within the specified range, but not less than every 6th truck.
 - 4) When requested to do so by the Engineer.
 - d. Temperature, unit weight, air entrainment, and compressive strength as specified in Section 03_30_00 - Cast-in-Place Concrete.
 - e. Provide full access for the Engineer to observe concrete sampling and testing at any time.

END OF SECTION

SECTION 03_35_29

CONCRETE FINISHES

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Concrete finishes.

1.02 REFERENCES

- A. American Concrete Institute (ACI):
 - 1. 117-10 - Specification for Tolerances for Concrete Construction and Materials and Commentary.
- B. ASTM International (ASTM):
 - 1. C404 - Standard Specification for Aggregates for Masonry Grout.
 - 2. C1059 - Standard Specification for Latex Bonding Agents for Bonding Fresh to Hardened Concrete.
- C. International Concrete Repair Institute (ICRI):
 - 1. Guideline No. 301.2: Selecting and Specifying Concrete Surface Preparation for Sealers, Coatings, and Polymer Overlays.

1.03 TERMINOLOGY

- A. The words and terms listed below are not defined terms that require initial capital letters, but, when used in this Section, have the indicated meaning.
 - 1. Grade line: A reference line that separates surfaces considered to be above grade from those considered to be below grade. Located 12 inches below finished grades at the perimeter of the structure.
 - 2. Water line: A reference line that separates surfaces considered to be above the water level (and visible in the finished work) from those considered to be below the water level (and not visible in the finished work). For each water-bearing cell of a structure, defined as a line located 2 feet below the normal operating water level in that cell.

1.04 SUBMITTALS

- A. Furnish Submittals as specified in Section 01_33_00 - Submittal Procedures.
- B. Product data.

1.05 QUALITY ASSURANCE

- A. Qualifications:
 - 1. Finishing personnel:
 - a. Use qualified flatwork finishers.
 - b. Finishing supervisor must have at least 5 years of experience finishing concrete.
- B. Mockups:
 - 1. Construct mockup panels showing finishing of formed surfaces for review by the Engineer.
 - a. Demonstrate concrete finishes for vertical surfaces:
 - 1) Construct mockup panels for F4 and F5 finishes and tie-hole repairs.
 - 2. Construct mockup slabs showing finishing of unformed surfaces for review by the Engineer.
 - a. Demonstrate concrete finishes for horizontal surfaces:
 - 1) Construct mockup slabs for S1, S2, S4, and S5 finishes.
 - 3. Include the following elements in mockup panels and slabs.
 - a. Concrete joints:
 - 1) Horizontal and vertical joints of the types included in the Work.
 - b. Concrete repairs:
 - 1) Repairs using materials and procedures proposed for the Work.
 - 4. Construct mockup panels and slabs at the beginning of the Project for review by the Engineer.
 - 5. Panels and portions thereof accepted by the Engineer will serve as the standard of quality and workmanship for the Work.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. Packing and shipping:
 - 1. Deliver and store packaged materials in original containers until ready for use.

PART 2 PRODUCTS

2.01 FINISHING MORTAR

- A. Materials for mortar:
 - 1. As specified in Section 03_30_00 - Cast-in-Place Concrete, unless otherwise noted.
 - a. Where surfaces will be visible in the finished work, use same cement and aggregates used for concrete batches in that area.
 - b. Add white cement if required to match color of cured mortar(s) to surrounding concrete.
 - 2. Bonding agent:
 - a. Acrylic latex bonding agent/admixture for portland cement concrete in accordance with ASTM C1059, Type II (Non-redispersable).
- B. Cement mortar (M1 mortar):
 - 1. Constituent materials: Portland cement, fine aggregate (sand), water.

2. Proportions:
 - a. Ratio of sand to cementitious materials: Same as that used in the surrounding concrete.
 - b. Ratio of water to cementitious materials: Not greater than that used in the surrounding concrete, and not less than that required for hydration of the cement.
- C. Dry-pack mortar (M2 mortar):
 1. Constituent materials: Portland cement, fine aggregate (sand), water.
 2. Proportions:
 - a. By volume: 1 part portland cement and 2 parts sand.
 - b. Water: Only enough that the resulting mix, after being hand-formed into a ball, will not crumble when touched.
- D. Mortar mix for F4 finish (M4 mortar):
 1. Constituent materials: Portland cement, sand, water, and bonding agent.
 - a. Sand: In accordance with ASTM C404 and with not less than 90 percent by weight passing the No. 100 screen.
 - b. Bonding agent: Acrylic latex.
 2. Proportions:
 - a. By volume: 1 part portland cement and 1-1/2 parts fine sand.
 - b. Water: Enough water and emulsified bonding agent for the resulting mix to have the consistency of thick paint.
- E. Mortar mix for F5 finish (M5 mortar):
 1. Constituent materials: Portland cement, sand, water, and bonding agent.
 - a. Sand: In accordance with ASTM C404 and with not less than 90 percent by weight passing the No. 16 screen.
 - b. Bonding agent: Acrylic latex.
 2. Proportions:
 - a. By volume: 1 part portland cement and 1-1/2 parts fine sand.
 - b. Water: Enough water and emulsified bonding agent for the resulting mix to have the consistency of thick paint. Adjust consistency if required.

2.02 EVAPORATION RETARDANT

- A. As specified in Section 03_30_00 - Cast-in-Place Concrete.

2.03 NON-SLIP ABRASIVE

- A. Type: Aluminum oxide abrasive of size 8/16, having structure of hard aggregate. Homogeneous, non-glazing, rust-proof, and unaffected by freezing, moisture, and cleaning compounds.
- B. Manufacturers: One of the following or equal:
 1. Abrasive Materials Incorporated, Hillsdale, MI.
 2. Exolon Company, Tonawanda, NY.

2.04 CONCRETE SEALERS

- A. Floor sealer and dust-proofer:
 - 1. Non-membrane forming, breathable, non-yellowing, penetrating sealer designed to densify and seal a cured concrete surface.
 - 2. Low odor, VOC content of 0 grams per liter, and stable when exposed to ultraviolet radiation from sunlight.
 - 3. Manufacturers: One of the following or equal:
 - a. Dayton Superior, Day-Chem Sure Hard Densifier (J-17).
 - b. Euclid Chemical Company, Euco Diamond Hard.
 - c. L&M Construction Chemicals, Seal Hard.
 - d. W.R. Meadows, Liqui-Hard.

PART 3 EXECUTION

3.01 CONCRETE FINISHING - FORMED SURFACES

- A. Scope:
 - 1. Finish formed surfaces with one of the finishes specified in the following paragraphs and as indicated in the Schedule of Concrete Finishes in this Section.
 - 2. Formed surfaces are those surfaces that the plastic concrete is placed against a temporary containment surface that will be removed after the concrete sets and takes its final form.
- B. General:
 - 1. Provide setting and curing time from casting of concrete to removal of forms as specified in Section 03_30_00 - Cast-in-Place Concrete.
 - 2. Provide curing after removal of forms as specified in Section 03_30_00 - Cast-in-Place Concrete.
 - 3. Materials and mixes for finishes:
 - a. Surfaces visible in the finished work, including surfaces above the water line as specified in this Section.
 - 1) Match the color of cured mortar(s) to the surrounding concrete. Adjust mixes as specified in Part 2 of this Section until the match acceptable to the Engineer is obtained.
 - 4. Surface preparation for finishing:
 - a. Filling form tie holes:
 - 1) Snap ties:
 - a) Break off ties and remove tie ends and forming cones from concrete.
 - b) Prepare cone-shaped tie holes:
 - (1) Roughen by heavy sandblast.
 - (2) Clean with compressed air to remove dust and debris.
 - c) Coat cone-shaped tie hole surfaces with epoxy bonding agent specified in Section 03_63_01 - Epoxies.
 - d) Fill cone-shaped tie holes with dry-pack mortar.
 - 2) Taper ties:
 - a) Remove forms and taper ties from concrete.

- b) Prepare taper tie holes:
 - (1) Roughen by heavy sandblast.
 - (2) Clean with compressed air to remove dust and debris.
 - c) After cleaning, drive a neoprene plug into each of taper tie holes.
 - (1) Final location of the neoprene plug: Center third of wall thickness.
 - (2) Locate steel rod in cylindrical recess and drive against middle of plug. Do not drive against the flat area outside cylindrical recess.
 - d) Coat taper tie hole surface with epoxy bonding agent specified in Section 03_63_01 - Epoxies.
 - e) Fill taper tie hole with dry-pack mortar.
 - (1) Place dry-pack mortar in holes in layers with thickness not exceeding tie hole diameter and heavily compact each layer.
 - (2) Dry-pack hole on the outside of the face of the wall no sooner than 7 days after hole on the inside of the face of the wall has been dry packed.
 - b. Grinding:
 - 1) Where grinding of concrete surfaces is permitted:
 - a) Perform grinding using an iron-free wheel, such as an aluminum oxide wheel, to avoid entrapment of particles that produce rust stains.
 - b) At locations where plastic-protected reinforcing bar supports are used, limit grinding to a maximum depth of 1/16 inch.
 - c. Mortar fill at depressions:
 - 1) Unless otherwise specified, moisture condition depressions and surrounding surfaces prior to, during, and after filling.
 - a) Thoroughly wet surface and maintain visible water for at least 30 minutes.
 - b) Just before placing grout, remove visible water to provide "saturated surface dry" condition.
 - c) Provide and maintain moist curing conditions for at least 7 days after placement.
- C. F1 finish: "Rough Form Finish":
 - 1. Repair defective work.
 - 2. Remove fins and other projections larger than 1 inch.
 - 3. Fill tie holes using plastic M2 (dry-pack) mortar.
 - 4. After removal of any form release agents and curing compounds, fill voids and depressions larger than 1-1/2 inch wide or 1/2 inch deep using M2 (dry-pack) mortar.
 - 5. Surface irregularity: Not exceeding a 1-inch gap when measured over the length of a 5-foot straightedge.
- D. F2 finish: "Form Finish":
 - 1. Repair defective work.
 - 2. Remove fins and other projections larger than 1/4 inch.
 - 3. Fill tie holes using M2 (dry-pack) mortar.

4. After removal of any form release agents and curing compounds, fill voids and depressions.
 - a. Larger than 3/4 inch wide or 1/2 inch deep: Fill using M1 mortar.
 - b. Larger depressions: Fill using M2 (dry-pack) mortar.
 5. Surface irregularity: Not exceeding a 1/4-inch gap when measured over the length of a 5-foot straightedge.
- E. F3 finish: "Smooth Form Finish":
1. Repair defective work.
 2. Remove fins and other projections larger than 1/8 inch.
 3. Fill tie holes using M2 (dry-pack) mortar.
 4. After removal of any form release agents and curing compounds, fill depressions:
 - a. Larger than 3/4 inch wide or 1/2 inch deep: Fill using M1 mortar.
 - b. Larger depressions: Fill using M2 (dry-pack) mortar.
 5. Topcoat tie holes and fill depressions with M1 mortar to provide a uniform appearance.
 6. Leave surfaces with texture that is generally smooth and uniform in appearance.
 7. Surface irregularity: Not exceeding a 1/8-inch gap when measured over the length of a 5-foot straightedge.
- F. F4 finish: "Rubbed Finish":
1. As specified for F3 finish, except prepare surfaces and fill depressions 1/16 inch or larger in depth or width as follows.
 2. Fill depressions.
 - a. "Brush-off" sandblast surfaces to expose depressions and voids near the surface of the concrete.
 - b. Thoroughly wet surfaces and begin filling depressions while surfaces are still damp.
 - c. Use clean burlap, sponge rubber floats, or trowels to rub plastic M4 mortar over the entire surface to be finished. Fill pits, holes, and depressions.
 - d. Wipe surfaces clean. Do not leave any mortar on the surface, except that within the depressions.
 - e. Cure: Moist cure surfaces.
- G. F5 finish: "Stoned Finish":
1. As specified for F3 finish, except add stoned finish as follows:
 2. Fill depressions:
 - a. Wet surfaces thoroughly with brush.
 - b. Rub wetted surfaces with a hard wood float dipped in water containing 2 pounds of portland cement per gallon of water.
 - c. Rub surfaces until form marks and projections are removed.
 - d. Using a brush, spread plastic grindings from the rubbing operation uniformly over the surface. Work the material in to fill pits and small voids.
 - e. Cure: Moist cure brushed surfaces for at least 72 hours.
 3. Finish surfaces:
 - a. After curing, obtain final finish by rubbing with a No. 50 grit carborundum stone.
 - b. Continue rubbing until entire surface has a smooth texture and is uniform in color.
 - c. Cure: Continue curing for remainder of specified time.

4. If surfaces have become too hard to finish as specified in the preceding paragraphs, the following alternative procedure may be used:
 - a. Sandblast and wash related surfaces exposed to view, whether finished or not.
 - b. While surfaces are still damp, rub surface with M5 mortar.
 - c. Finish by rubbing surface with No. 60 grit carborundum stone. Add M5 mortar until surface is evenly filled without excess mortar. Continue stoning until surface is hard.
 - d. Moist cure surface for 72 hours.
 - e. After curing, make surface smooth in texture and uniform in color by rubbing with a No. 50 or No. 60 grit carborundum stone.
 - f. Continue curing until 7-day curing period is complete.

3.02 CONCRETE FINISHING - UNFORMED SURFACES

- A. Scope:
 1. Finish unformed surfaces with one of the finishes specified in the following paragraphs and as indicated in the Schedule of Concrete Finishes in this Section.
 2. Unformed surfaces are those surfaces that are not cast against a temporary containment and the specified finish is achieved by tooling.
- B. General:
 1. Concrete placement:
 - a. Place concrete at a rate that allows spreading, straight-edging, and initial floating before bleed water appears.
 - 1) Consider characteristics of concrete mixes used, including potential for accelerating or retarding effects of admixtures, fly ash, and temperatures, on plans for and scheduling of placement and finishing.
 - b. Place, consolidate, strike-off, and screed concrete level to bring surfaces to required planes and lines. Eliminate high and low spots.
 - c. Strike tops of walls and similar surfaces smooth and finish as specified to a texture consistent with that of adjacent formed surfaces.
 - d. After screeding, apply evaporation retardant to concrete surface if weather conditions will result in rapid evaporation of moisture from the surface of the concrete. Do not work evaporation retardant into the surface of the concrete.
 2. Floating and re-straightening:
 - a. Float concrete to compact and consolidate the surface.
 - b. Initial floating:
 - 1) Provide initial floating immediately after screeding.
 - 2) Perform by hand using a wide bull float, darby, or highway straightedge.
 - 3) Complete before excess moisture or bleed water is present on the surface.
 - c. Wait for concrete to stiffen and for the bleed water to stop rising and dissipate before proceeding with edging, hand-tooled jointing, and second floating.

- d. After initial floating, apply evaporation retardant to concrete surface if weather conditions will result in rapid evaporation of moisture from the surface of the concrete. Do not work evaporation retardant into the surface of the concrete.
 - e. Second floating:
 - 1) Do not commence until bleed water has dissipated and concrete has stiffened enough to support weight of finishers and finishing equipment.
 - 2) May be by hand, or, if accepted by the Engineer, may be done using a bladed power float equipped with float shoes, or a power disk float.
 - 3) Float surfaces to a true, even plane, with no coarse aggregate visible.
 - 4) Evaporation retardant may not be applied after second floating.
 - f. Flatness:
 - 1) Specified tolerances for flatness may require re-straightening of the surface between first and second floating operations and before steel troweling. Re-straighten concrete as required.
 - 2) Modify power equipment with alternate float shoes or other equipment if required to achieve specified flatness.
 - 3. Troweling: Where finishes require troweling, conform to the following requirements:
 - a. After surface moisture from floating has disappeared, steel trowel to a smooth, hard, dense concrete surface.
 - b. Provide at least 2 trowelings.
 - 1) Avoid excessive troweling.
 - 2) Use smaller trowels for successive troweling.
 - 3) Make each successive troweling perpendicular to the previous pass.
 - c. Do not add dry cement or additional water to the surface during troweling.
 - d. In lieu of hand steel troweling, a power machine for finishing concrete may be used if accepted by the Engineer.
 - 1) Do not use power machine if concrete has not attained the set necessary to permit finishing without introduction of high and low spots into the concrete surface.
 - 2) Use equipment in full compliance with the manufacturer's recommendations.
 - 3) Use smaller blades or higher pressure for each successive troweling.
 - 4) Hand trowel areas of the concrete not accessible to power equipment.
 - 5) Tolerances for flatness specified may require re-straightening of the surface during finishing. Modify power equipment with alternate shoes or other equipment if required to achieve these requirements.
 - e. Finishing with a fresno trowel or finishing to a "fresno finish" is not allowed.
 - 4. Finishing tolerances:
 - a. Slabs sloped to drain: Finish surfaces to adequately drain toward designated points or lines, regardless of tolerances specified.
- C. S1 finish: "Scratch Finish":
- 1. Place, consolidate, and screed concrete level.
 - 2. Provide initial floating of concrete.
 - 3. Provide surface in accordance with the "Conventional" floor flatness tolerance requirements of ACI 117 using the manual straightedge method (maximum 1/2-inch gap in 10 feet at 90 percent of locations; maximum 3/4-inch gap at any location), unless otherwise specified.

4. Before final set, roughen the surface with rakes.
 - a. For sloped surfaces, rake grooves in the direction of drainage.
 - b. Provide roughness equivalent to CSP 6 surface as designated by ICRI Guideline 310.2.
 5. Pressure wash surface to remove laitance before placing grout or toppings.
- D. S2 finish: "Floated Finish":
1. Place, consolidate, and screed concrete to required elevations and slopes.
 2. Provide initial and second floatings of concrete. Float to a uniform texture.
 3. Provide surface in accordance with the "Flat" floor flatness tolerance requirements of ACI 117 using the manual straightedge method (maximum 1/4-inch gap in 10 feet at 90 percent of locations; maximum 3/8-inch gap at any location), unless otherwise specified.
 4. Remove laitance and leave surface clean.
- E. S3 finish: "Steel Trowel Finish":
1. Place, consolidate, and screed concrete to required elevations and slopes.
 2. Provide S2 Floated Finish.
 3. Provide 2 trowelings.
 4. Provide finish in accordance with the "Flat" floor flatness tolerance requirements of ACI 117 (maximum 1/4-inch gap in 10 feet), unless otherwise specified.
- F. S4 finish: "Steel Trowel Finish - Free of Trowel Marks":
1. Finish as specified for S3 Steel Trowel Finish, except that final troweling shall remove all trowel marks from the slab surface.
- G. S5 finish: "Broomed Finish":
1. Finish as specified for S2 Floated Finish, except modify as follows:
 2. Finish surface by drawing a fine-hair broom lightly across the freshly floated surface.
 - a. Provide resulting roughness for a non-skid surface. Finishing and roughness is subject to review and acceptance by the Engineer.
 - b. Direction of brooming:
 - 1) General:
 - a) In same direction of and parallel to expansion joints.
 - b) Perpendicular to primary direction of traffic.
 - 2) For sloped slabs, parallel to the direction of drainage.
 - 3) For round roof slabs, in the radial direction.
- H. S6 finish: "Non-Slip Abrasive Finish":
1. Place, consolidate, and screed concrete to required elevations and slopes.
 2. Provide initial floating of surface.
 3. Prepare and apply abrasive as recommended by the manufacturer.
 - a. Apply using a shake screen or other accepted method to ensure even coverage without segregation of the abrasive.
 - b. Install abrasive at a rate of 25 pounds for each 100 square feet of surface area.
 4. After concrete has hardened enough to support the weight of a person and unless otherwise specified by the abrasive manufacturer, apply approximately 2/3 of the abrasive material required for coverage.
 5. Finish as specified for S2 Floated Finish, except that re-floating is not required.

6. Apply remaining abrasive material at right angles to the first application and in locations necessary to provide the minimum specified thickness.
7. Immediately after the second application, re-float the surface to embed abrasive.
8. Finish as specified for S2 Steel Trowel Finish. Trowel abrasive into the surface, properly exposing material to produce a non-slip finish.

3.03 FIELD QUALITY CONTROL

- A. Provide field quality control for the Work of this Section as specified in Section 01_45_17 - Contractor Quality Control Plan.
- B. Field quality control by the Contractor:
 1. Field inspections and testing:
 - a. Submit records of inspections and testing to the Engineer within 24 hours after completion.
 2. Manufacturer's services.
 - a. Non-slip abrasive finish. Before beginning installation, conduct pre-installation meeting with the manufacturer's technical representative to review product use and installation requirements.
- C. Field quality control by the Owner:
 1. Special inspections, special tests, and structural observation:
 - a. Not required.
 2. Field inspections:
 - a. Observe construction for conformance to the Contract Documents and the accepted Submittals.
 - b. Provide record of each inspection. Submit copies to the Engineer upon request.

3.04 NON-CONFORMING WORK

- A. Unsatisfactory finishes that have hardened will require removal, grinding, topping, or other correction acceptable to the Engineer.
- B. Requirements as specified in Section 03_30_00 - Cast-In-Place Concrete.

3.05 SCHEDULE OF CONCRETE FINISHES

- A. Formed surfaces: As specified in Table A below.
- B. Unformed surfaces: As specified in Table B below.

Table A: Concrete Finishes - Formed Surfaces				
Elements	Location	Surface Exposure	Finish	Notes
Exterior Surfaces:				
Walls, columns, slab edges	Wet structure	Above grade or water line		
		Exposed to view	F4	
		Covered	F2	1a
		Below grade or water line		
		No coating	F1	
		Bituminous coating	F2	
		Waterproofing	F3	
	Dry structure	Above grade line		
		Exposed to view	F4	
		Covered	F2	1a
		Below grade line		
		No coating	F1	
		Bituminous coating	F2	
		Waterproofing	F3	
Interior Surfaces:				
Walls, columns, slab edges	Wet structure	Open basin		
		Above water line	F4	
		Below water line	F3	
		Covered basin		
		Above water line	F3	
		Below water line	F3	
	Dry structure	Exposed to view	F4	
		Covered	F2	1b
Overhead slabs and beams	Wet structure	Open basin	F3	1c, 1d
		Covered basin	F2	1d
	Dry structure	Exposed	F3	1c, 1d
		Covered by ceiling	F1	1d
Notes:				
(1a) Coverings include additional surfaces applied over the concrete, such as veneer, stucco, plaster, etc.				
(1b) Coverings include additional surfaces applied over the concrete, such as veneer, stucco, plaster, furring strips with drywall, etc.				
(1c) Applies to overhead surfaces visible from normal pedestrian travel routes.				
(1d) At overhead slabs and beams, patch tie holes on sides of members.				

Table B: Concrete Finishes - Unformed Surfaces				
Element	Location	Exposure	Finish	Notes
Exterior Surfaces:				
Footings	Extensions	Exposed	S3	
		Covered by soil	S2	
Slabs and beams - exposed	Walking or possible walking paths	Tops of treatment structures	S5	2a, 2b, 2g, 2h
		Stairs and landings	S5	
	Roofs	Exposed	S5	
		Covered by roofing	S2	
Slabs and beams - submerged	Unless otherwise noted	All	S3	2g
Walls, corbels	Top of wall or corbel	All	S3	One troweling
Sidewalks	All		S5	
Equipment slabs	All		S5	
Interior Surfaces:				
Floor slabs, includes flat and sloping surfaces	Wet structure	Exposed		
		Basins and channels	S3	
		Covered		
		To receive concrete fill	S1	2f
	Dry structure	Exposed		
		Pipe galleries	S4	2c
		Stairs and landings	S4	2d
		Shops and garages	S4	
		Equipment rooms	S4	
		Covered		
		Tile on mortar bed	S2	
		Resilient flooring	S3	
		Carpet	S3	
Notes:				
(2a) Includes slabs covering tanks, basins, channels and similar structures.				
(2b) Includes tops of walls or beams that serve as walkways.				
(2c) In galleries with slabs subject to wetting, provide broom finish (S5) where indicated on the Drawings.				
(2d) Provide broom finish (S5) where indicated on the Drawings.				
(2e) (2f)Finish for concrete fill: See floor slab, wet structure, exposed basins and channels.				
(2g) Slabs include flat and sloping surfaces.				
(2h) Includes top of vault slabs exposed to traffic.				

END OF SECTION

SECTION 03_48_53

PRECAST CONCRETE UTILITY STRUCTURES AND PRODUCTS

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Precast concrete products manufactured to ASTM industry standards.
- B. Alternates:
 - 1. Contractor may propose to construct cast-in-place structures in lieu of the precast structures specified.
 - a. Obtain the Engineer's acceptance of this alternative before submitting, providing, or installing.
 - b. Submit full information on design and detailing of proposed alternatives, including design details and drawings of the same types required by this Section for precast structures.

1.02 REFERENCES

- A. American Association of State Highway Transportation Officials (AASHTO):
 - 1. Standard Specifications for Highway Bridges.
- B. American Concrete Institute (ACI):
 - 1. 318 - Building Code Requirements for Structural Concrete and Commentary.
 - 2. 350 - Code Requirements for Environmental Engineering Concrete Structures.
- C. ASTM International (ASTM):
 - 1. A48 - Standard Specification for Gray Iron Castings.
 - 2. C94 - Standard Specification for Ready-Mixed Concrete.
 - 3. C443 - Standard Specification for Joints for Concrete Pipe and Manholes Using Rubber Gaskets.
 - 4. C857 - Standard Practice for Minimum Structural Design Loading for Underground Precast Concrete Utility Structures.
 - 5. C858 - Standard Specification for Underground Precast Concrete Utility Structures.
 - 6. C890 - Standard Practice for Minimum Structural Design Loading for Monolithic or Sectional Precast Concrete Water and Wastewater Structures.
 - 7. C891 - Standard Practice for Installation of Underground Precast Concrete Utility Structures.
 - 8. C913 - Standard Specification for Precast Concrete Water and Wastewater Structures.
 - 9. C990 - Standard Specification for Joints for Concrete Pipe, Manholes, and Precast Box Sections Using Preformed Flexible Joint.
 - 10. C1037 - Standard Practice for Inspection of Underground Precast Concrete Utility Structures.

11. C1244 - Standard Test Method for Concrete Sewer Manholes by the Negative Air Pressure (Vacuum) Test Prior to Backfill.
 12. C1260 - Standard Test Method for Potential Alkali Reactivity of Aggregates.
 13. C1293 - Standard Test Method for Determination of Length Change of Concrete Due to Alkali-Silica Reaction.
 14. C1433 - Standard Specification for Precast Reinforced Concrete Monolithic Box Sections for Culverts, Storm Drains, and Sewers.
 15. C1567 - Standard Test Method for Determining the Potential Alkali-Silica Reactivity of Combinations of Cementitious Materials and Aggregate (Accelerated Mortar-Bar Method).
 16. C1778 - Standard Guide for Reducing the Risk of Deleterious Alkali-Aggregate Reaction in Concrete.
- D. National Fire Protection Association (NFPA):
1. 70 - National Electrical Code (NEC).
- E. National Precast Concrete Association (NPCA).
- F. Society of Cable Telecommunications Engineers (SCTE):
1. 77 - Specification for Underground Enclosure Integrity.

1.03 TERMINOLOGY

- A. The words and terms listed below are not defined terms that require initial capital letters, but, when used in this Section, have the indicated meaning.
1. Culvert: A single cell precast box element open on opposing faces intended to be used to form a linear structure to convey stormwater or sewage.
 2. Drainage inlet: A drainage structure that collects and diverts stormwater into a below grade conveyance system.
 3. Handhole: An enclosure for use in underground electrical systems that has been sized and detailed to allow personnel to reach into, but not enter, the enclosure to install, operate, or maintain equipment or wiring or both.
 4. Manhole: An enclosure for use in underground systems that has been sized and detailed to allow personnel to enter the enclosure to access, install, operate, or maintain equipment, wiring, or clean or service piping. As specified in this Section, manhole may refer to a sewer manhole, stormwater manhole, or electrical manhole.
 5. Precast concrete: A concrete fabrication designed by a qualified engineer and subsequently fabricated at a qualified fabrication site, which is usually located some distance from the site where the fabrication will be installed.
 6. Vault: A below grade enclosure designed to house equipment or instrumentation.

1.04 DELEGATED DESIGN

- A. As specified in Section 01_35_73 - Delegated Design Procedures.
- B. Shop Drawings and calculations for precast concrete utility products.

1.05 SUBMITTALS

- A. Furnish Submittals as specified in Section 01_33_00 - Submittal Procedures and Section 01_60_01 - Product Requirements.
- B. Product data:
 - 1. Manufacturer's catalog data, details, and warranties for the following items.
 - a. Materials of construction.
 - b. Joint details and joint-sealing materials.
 - c. Data for hatches or covers and frames.
 - d. Threaded lifting inserts.
- C. Delegated Design Submittals:
 - 1. Shop Drawings:
 - a. Dimensioned plans, sections, and details drawn to scale for each structure, including:
 - 1) Layout plan for that structure.
 - 2) Sizes, locations, and vertical positions of pipe penetrations, duct bank windows, and knockout panels.
 - 3) Locations and details for access openings and sumps.
 - 4) Details of structural reinforcement showing bar size and spacing; true position of reinforcement in structural members with clear concrete cover at both inside and outside faces; location, bar size, and spacing of added reinforcement around openings; and other details relevant to design and fabrication of the structure.
 - 5) Details of joints between adjacent precast sections, including provisions for overlap and for placement of sealants.
 - 2. Calculations:
 - a. Submit calculations that demonstrate the adequacy of the precast to support the required loads:
 - 1) Temporary loads during manufacture, including casting, handling, transportation, and installation.
 - 2) Specified final soil, fluid, and live loads.
 - 3) Calculations will be filed for record. Review comments will not be returned.
 - 3. Concrete mix design.
 - a. Certification from the manufacturer's engineer that the concrete mix used for manufacture is in accordance with the specified ASTM standard, the additional durability performance requirements, and the aggregate reactivity mitigation requirements listed in this Section. Certification shall include the following aggregate reactivity data:
 - 1) Sources, grading, and specific gravities of aggregates.
 - 2) Aggregate reactivity data.
 - a) ASTM C1260 and ASTM C1293 test results for:
 - (1) Coarse aggregate.
 - (2) Fine aggregate.
 - b) If reactivity test results of either coarse or fine aggregates indicates a potential for reactivity, indicate the method by which the risk reduction measures of ASTM C1778 are satisfied. See Design and Performance Criteria in this Section for durability requirements.

- c) Freeze-thaw durability: Submit data demonstrating that the concrete mix will provide the specified freeze-thaw durability.
- D. Installation instructions:
 - 1. Detail the complete installation of the equipment, including rigging, moving, and setting into place.
 - 2. Provide manufacturer's installation instructions.
 - 3. Instructions for operation and maintenance of hatches.
- E. Quality Control Submittals:
 - 1. Test reports:
 - a. Manufacturer's tests for compressive strength of concrete used in products, made in accordance with the specified ASTM requirements.
 - b. Reinforcing steel: Mill certificates.
 - c. Manufacturer's inspection reports in accordance with ASTM C1037.
 - 2. Certificates:
 - a. Manufacturer's current plant certification under NPCA for the products to be supplied.
 - 1) Certification shall be current and in effect at the time products are manufactured.
 - b. Manufacturer's certification that the precast products are in accordance with the requirements of the standard specified in Part 2.
- F. Project record documents:
 - 1. Final, revised plans and details of as-constructed precast concrete products if requested for record by the Engineer.

1.06 QUALITY ASSURANCE

- A. Qualifications:
 - 1. Manufacturer:
 - a. Holding current NPCA plant certification for the products produced.
 - b. Demonstrating at least 5 years of experience in the design, production, and installation of products of the type required for this Work.
 - c. Capable of providing structural designs in the state where the products will be installed.
 - d. Providing inspection during fabrication and handling in accordance with the requirements of ASTM C1037.
 - e. Provide permanent quality control department and laboratory facility capable of performing inspections and testing as specified in this Section.
 - 2. Installer:
 - a. Capable of providing equipment of adequate capacity and mobility to handle and set units with proper bearing on the subgrade and without damage to the unit.

1.07 DELIVERY, STORAGE, AND HANDLING

- A. As specified in Section 01_60_01 - Product Requirements, and the manufacturer's instructions.

- B. Packing, shipping, handling, and unloading:
 - 1. Package and brace structures to avoid damage during shipping and handling.
 - 2. Furnish crane or forklift for unloading and setting of the precast concrete products. Equipment shall be rated to lift the intended load.
 - 3. Transport and handle precast products in accordance with the manufacturer's instructions.
 - a. Where lifting devices are provided in precast sections, such lifting devices shall be used as intended.
 - b. Where no lifting devices are provided, follow the manufacturer's recommendations for lifting procedures to provide proper support during lifting.
 - c. Dragging or dropping of precast concrete products are not permitted.
- C. Acceptance at Site:
 - 1. Structures delivered to the Site with cracks, damage, and damaged or missing accessories shall be removed from the Site and replaced at no additional cost to the Owner.
 - 2. Furnish labor necessary to assist the Engineer in inspecting manholes upon delivery.
- D. Storage and protection:
 - 1. Store precast concrete utility structures, products, and their appurtenances in areas protected from damage due to weather and Site operations.

1.08 PROJECT OR SITE CONDITIONS

- A. As specified in Section 01_81_50 - Design Criteria.

1.09 SEQUENCING

- A. Coordinate installation of precast electrical handholes and manholes with duct banks specified in Section 26_05_44 - Duct Banks.

1.10 WARRANTY

- A. As specified in Section 01_78_36 - Warranties and Bonds.
- B. Provide the manufacturer's standard warranty for precast products and accessories.

PART 2 PRODUCTS

2.01 GENERAL

- A. As specified in Section 01_60_01 - Product Requirements.

2.02 DESIGN AND PERFORMANCE CRITERIA

- A. Design, manufacture, and install precast concrete members as indicated on the Drawings and specified.

- B. Design and detail precast concrete members and connections to withstand design loads indicated, to maintain clearances at openings; to allow for fabrication and installation tolerances.
 - 1. Analyze and design structures, including the effects of 2-way action (plate action) and of load transfer around current and future openings.
 - 2. Where structures include panels designed for future removal (knockout panels), design structures for loads and stresses with any combination of any or all such panels in place or removed.
 - 3. Design structures in accordance with the requirements of ACI 318 or AASHTO Standard Specifications for Highway Bridges and this Section.
 - 4. Provide reinforcement at areas subject to tensile stress when loaded with the specified loads and combinations thereof.
- C. Unless otherwise indicated on the Drawings, design precast products as follows:
 - 1. Use roadway load designation for all utility structures located in or within 15 feet of roadways.
 - 2. Use sidewalk load designation for all utility structures that do not require roadway designation.
- D. Structural analysis, including loads on structures, and design:
 - 1. For structures designated to be in accordance with ASTM C857, follow the requirements of that standard, except as modified in this Section as follows:
 - a. Vehicle and pedestrian loadings in the following paragraphs need not be additive, however, structures designated for roadway loading shall also support sidewalk loads.
 - 1) Sidewalk: Load from regular pedestrian traffic with considerations for occasional non-deliberate vehicular traffic: Designation A-0.3 in ASTM C857, Table 1 (300-psf uniform load).
 - 2) Roadway: Load from heavy, frequently repeated vehicle traffic: Designation A-16 in ASTM C857, Table 1 (AASHTO HS20-44).
 - b. Lateral earth pressure loads: Determine in accordance with the following requirements. Include effects of groundwater and seismic accelerations on lateral earth pressures.
 - 1) Equivalent lateral pressure: 100 pounds per square foot per foot of depth (triangular distribution).
 - 2) Surface surcharge load:
 - a) Backfill-induced live load surcharge of 200 pounds per square foot (rectangular distribution).
 - b) In accordance with ASTM C857 Vehicle Load Designation A-16 for Roadway, or A-0.3 for Sidewalk, where such surcharge exceeds backfill loads described in the preceding paragraph.
 - 3) Groundwater effects:
 - a) Include effects from groundwater and soils saturated by flooding using design elevations specified in Section 01_81_50 - Design Criteria to site finished grade elevation.
 - b) Use equivalent lateral pressure of 100 pounds per square foot per foot of depth (triangular distribution) for soil below the design groundwater elevation.
 - 4) Seismic design:
 - a) As specified in Section 01_81_50 - Design Criteria.

- b) On opposite sides of the structure that are perpendicular to the direction of acceleration, include equivalent lateral pressure (inverted fluid pressure distribution), beginning with a pressure of 0 at the base of the structure, and increasing at a rate of 11 pounds per square foot per foot of rise toward the ground surface.
 - c) Apply seismic effects as additive force on side where the soil mass is being accelerated toward the structure, and as subtractive force on the opposite side where the soil mass is being accelerated away from the structure.
 - c. Groundwater and flood loads - buoyancy effects:
 - 1) As specified in Section 01_81_50 - Design Criteria, for design groundwater and design flood elevations.
 - 2) Buoyancy: For groundwater and flood conditions, provide factor of safety against flotation of at least 1.20.
 - a) If the weight of soil overlying footing projections on the structure is considered to resist flotation, use a buoyant unit weight of soil equal to not more than 30 pounds per cubic foot.
 - d. Soil-bearing pressure at base:
 - 1) Maximum 1,000 pounds per square foot total pressure on prepared subgrade soils.
 - e. Lifting and handling loads:
 - 1) Make provision in the design for the effects of loads or stresses that may be imposed on structures during fabrication, transportation, or installation.
 - f. Load combinations:
 - 1) Design structures to sustain the specified loads individually or in combination.

E. Materials:

- 1. Proportion cement, supplemental cementitious materials, aggregates, admixtures, and water in accordance with the specified ASTM standard.
- 2. Proportion cement, supplemental cementitious materials, aggregates, admixtures, and water that provides at least the minimum level of durability performance required in accordance with ACI CODE-350 for the following exposure category:
 - a. Freeze-thaw resistance: Exposure Category: EF2.
- 3. Aggregate reactivity.
 - a. If reactivity test results of either coarse or fine aggregates indicate a potential for reactivity, the concrete mix design shall be proportioned with an appropriate supplemental cementitious material to mitigate the potential risk of aggregate silica reaction in accordance with either the performance-based approach or the prescriptive-based approach of ASTM C1778.
 - 1) If the performance-based approach is used, ASTM C1567 and ASTM C1293 test results must be available.
 - 2) If the prescriptive-based approach is used, the following parameters shall be assumed:
 - a) Concrete is exposed to humid air, buried, or immersed.

- b) Structure classification based on the severity of consequences:
SC3 (Precast elements in which economic costs of replacement are severe).

2.03 GENERAL

- A. Identification markings: Provide identification marks on the exterior of bases, risers, grade rings, and include the following information:
 - 1. Date of manufacture of the item.
 - 2. Name or trademark of the manufacturer.
 - 3. Internal dimensions in inches.
 - 4. Number of the precast structure as indicated on the Drawings.
- B. Precast products shall be solid walled construction.
 - 1. Where penetrations of the precast concrete walls are required for piping, conduit, or ductbanks, such penetrations shall be accommodated through precast openings or core-drilled sections.
 - 2. Wall openings shall be smooth and free of surface irregularities and without exposed steel reinforcing.
 - 3. Precast need not be designed to resist thrust from piping passing through the vault unless indicated on the Drawings.
 - 4. Coordinate opening locations with piping or ductbank arrangement as indicated on the Drawings.
- C. Joints in precast products:
 - 1. Construct floors as a monolith. Where sump or low-point drain is included, slope floor to that point.
 - 2. Where joints are designed in precast concrete products, such joints shall be interlocking to secure proper alignment between members and prevent migration of soil or water through the joint. Provide structures with non-skid, shiplap or tongue and groove joints between sections.
 - 3. Joints shall be sized sufficiently to reinforce the section against localized distress during transportation and handling and against excess contact bearing pressures through the joint.
 - 4. Seal joints watertight with precast concrete joint sealant as specified in this Section.
 - 5. Provide structures with watertight joints between sections and detailed to minimize water infiltration at duct bank and conduit penetrations.

2.04 PRECAST CONCRETE ELECTRICAL MANHOLES AND HANDHOLES

- A. Precast concrete manholes and handholes include reinforced precast box sections comprised of one or more components that, when properly assembled in the field, form a vault that may be used to route electrical conduits and conductors or house electrical or instrumentation equipment.
- B. Design basis:
 - 1. As specified in Section 26_05_00 - Common Work Results for Electrical for general requirements for electrical work.
 - 2. Furnish products of nominal sizes as indicated on the Drawings.

3. Precast concrete manholes and handholes in accordance with the requirements of ASTM C858.
 4. In accordance with the requirements of the NEC.
 5. Structural design in accordance with the requirements of ASTM C857 and specified in this Section.
 6. Install embedded items with provisions for drainage to remove dripping or standing water, and to minimize corrosion.
 - a. Pulling irons may not be placed on the floor or in pockets that will collect water.
 - b. Detail bottom of cable rack channels to provide a downward sloping sill at the bottom of each vertical channel, so that the channel slot drains toward the floor.
- C. Manufacturers:
1. One of the following or equal:
 - a. Jensen Precast.
 - b. Oldcastle Precast.
- D. Materials:
1. Concrete in accordance with ASTM C858 and as specified in this Section.
- E. Tests and inspections:
1. In accordance with ASTM C858 and ASTM C1037.

2.05 APPURTENANCES

- A. Floor access doors:
1. Aluminum plate hinged floor access door (hatch) as specified in Section 08_31_14 - Floor Access Doors with load rating as follows:
 - a. Heavy duty for covers at locations designated for roadway loads.
 - b. Medium duty or stronger for covers at locations designated for sidewalk loads.
 2. Minimum access door size not less than 36 inches square, unless otherwise indicated on the Drawings.
 3. Provide bearing surface with pre-installed continuous elastomeric gasket to minimize water infiltration at lid.
 4. Provide skid-resistant lid with cast-in or machined-in grid pattern and the word "ELECTRICAL" in block letters at least 1.5 inches high.

2.06 OTHER MATERIALS

- A. Coatings:
1. Dampproofing: As specified in Section 07_11_00 - Dampproofing.
 2. Blended amine cured epoxy as specified in Section 09_96_01 - High-Performance Coatings.
- B. Joint sealant:
1. Preformed, cold applied flexible joint sealant in accordance with ASTM C990 and ASTM C443.

2. Manufacturers:
 - a. One of the following or equal.
 - 1) Henry Corp., Ram-Nek.
 - 2) Kent Seal - Hamilton Kent Corp.
3. Physical properties:
 - a. Hydrocarbon content: 50 to 70 percent.
 - b. Inert mineral filler: 30 to 50 percent by weight.
 - c. Volatile matter: 2.0 to 3.0 percent by weight lost when heated for 5 hours at 325 degrees Fahrenheit.
 - d. Specific gravity: 1.20 to 1.35 at 77 degrees Fahrenheit.
 - e. Ductility: 5.0 at 77 degrees Fahrenheit.
 - f. Softening point: 320 degrees Fahrenheit.
 - g. Sag or flow: None.
 - h. Chemical resistance: No reaction when exposed for 30 days by 5 percent sulfuric acid, potassium hydroxide, caustic potash, and hydrochloric acid; and saturated hydrogen sulfide solution.
4. Precast concrete joint sealer primer: As recommended by the precast concrete joint sealer manufacturer.

2.07 SOURCE QUALITY CONTROL

- A. Source Testing (Factory Acceptance Tests):
 1. As specified in Section 01_75_17 - Commissioning.
 2. Precast concrete manholes:
 - a. Perform pre-production and post-production tests by the manufacturer.
 - b. Examine each completed manhole section for dimensional requirements, strength, and workmanship.
 - c. Complete required testing in accordance with ASTM C478.
 3. All tools and equipment shall have current calibrations.
 4. Furnish test reports and the Manufacturer's Certificate of Source Testing.

PART 3 EXECUTION

3.01 GENERAL

- A. Furnish and install precast concrete products as indicated on the Drawings and specified.
- B. Manufacturer shall make available services of representative throughout the project duration when deemed necessary by the Engineer.

3.02 PREPARATION

- A. Site preparation:
 1. Excavate and prepare exposed subgrade as indicated on the Drawings and as specified.
 2. Install and compact foundation layer as indicated on the Drawings and specified.
 3. Level foundation materials so that structures will be set plumb and duct banks will be at proper grade and alignment.
 - a. Install with uniform bearing on foundation materials.

- b. Wedging or blocking of base sections for leveling over the foundation materials will not be permitted.

3.03 INSTALLATION

A. General:

1. Protect precast concrete utility structures from displacement, flooding, or flotation.
2. Install structures in accordance with ASTM C891 and as specified in this Section.
 - a. In the event of conflicts, the more restrictive provisions shall apply.
3. Clean and prime joints between adjacent precast sections.
 - a. Install joint sealant between sections in accordance with the manufacturer's instructions and provide watertight joints.
4. Set manhole covers and floor access doors at elevations indicated on the Drawings.
 - a. Lay grade rings in joint sealant with sides plumb and tops level. Securely attach frames to top of precast structures or grade rings.
5. Penetrations:
 - a. Holes for duct banks, piping, and other penetrations may not be cut into precast products unless they are located at designated locations shown on the Shop Drawings or at knockout panels cast into the structure during manufacturing.
 - b. Carefully remove concrete from knockout panel areas with saws.
 - 1) Ensure that break-back does not extend beyond the designated limits of the knockout panel.
 - c. Coat any reinforcement cut or exposed during removal of knockout panel sections with minimum 2 coats of high solids epoxy as specified in Section 09_96_01 - High-Performance Coatings.
 - 1) Apply epoxy coating applied over and at least 1 inch past the perimeter of the reinforcement.
6. Install duct banks, conduit, and pipe penetrations in accordance with the penetration details indicated on the Drawings.
 - a. Place joint fillers, caulks, and sealants before coating exterior concrete surface with bituminous dampproofing.
7. Fill blockouts that were provided for threaded lifting inserts or other temporary purposes with non-shrink cement grout using procedures as specified in Section 03_60_00 - Grouting, unless otherwise detailed by the manufacturer.
8. After structures are set and before backfilling, coat exterior below-grade surfaces (around the sidewalls, over the top slab, around any vertical risers to grade, and to face of grade rings) with 2 heavy coats of bituminous dampproofing as specified in Section 07_11_00 - Dampproofing.
 - a. Mask over at least 1 inch back from joint caulks or sealants and prevent dampproofing from coming in contact with those materials.
 - b. Apply dampproofing in accordance with the coating manufacturer's instructions and at a rate of 40 to 60 square feet per gallon per coat.
 - c. Allow dampproofing to dry sufficiently before backfilling.
9. Coat interior of precast products as specified in Section 09_96_01 - High-Performance Coatings.
10. Backfill precast concrete products as specified in Section 31_00_00 - Earthwork.

- B. Site tolerances:
 - 1. Set precast concrete products plumb and true at locations indicated on the Drawings.
 - 2. Tolerances on placing:
 - a. Horizontal location: Within 1 inch.
 - b. Vertical elevation: Within 1/2 inch.
 - c. Plumb: Within 1/8 inch over 10 feet.

3.04 REPAIR/RESTORATION

- A. Repair cracks or blemishes in concrete as specified in Section 03_30_00 - Cast-in-Place Concrete.

3.05 FIELD QUALITY CONTROL

- A. As specified in Section 01_45_17 - Contractor Quality Control Plan.
- B. Field quality control by Contractor.
- C. Field quality control by Owner:
 - 1. Special tests and inspections: As specified in Section 01_45_24 - Regulatory Quality Assurance.
 - 2. Field tests:
 - a. Engineer may request, at any time, additional testing to confirm materials being delivered and placed conform to the requirements of the Contract Documents.
 - 1) If such additional testing shows that the material do not conform to the specified requirements, the Contractor shall pay the cost of these tests.
 - 2) If such additional testing shows that the materials do conform to the specified requirements, the Owner will pay the cost of these tests.

3.06 ADJUSTING

- A. After final grading is complete, adjust access covers to grade.

3.07 CLEANING

- A. Remove concrete spoil, other construction material, forms, debris, silt, dust, and other foreign material.
- B. Pressure wash interior of structures if required to provide clean interior surfaces.
 - 1. Block drains and provide pumps to remove washwater from structures.
 - 2. Do not permit washwater to drain into subgrade soils.

3.08 SCHEDULES

- A. See Drawings for Electrical Handhole and Electrical Manhole Schedule.

END OF SECTION

SECTION 03_60_00

GROUTING

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Preblended grout:
 - a. Non-shrink cement grout.
 - 1) General use.
 - b. Non-shrink epoxy grout.
 - 1) General use.
 - 2. Site-proportioned grout:
 - a. Neat cement grout.
 - b. Epoxy grout.

1.02 REFERENCES

- A. American Concrete Institute (ACI).
- B. ASTM International (ASTM):
 - 1. C109 - Standard Test Method for Compressive Strength of Hydraulic Cement Mortars (using 2-inch cube specimens).
 - 2. C144 - Standard Specification for Aggregate for Masonry Mortar.
 - 3. C150 - Standard Specification for Portland Cement.
 - 4. C404 - Standard Specification for Aggregates for Masonry Grout.
 - 5. C531 - Standard Test Method for Linear Shrinkage and Coefficient of Thermal Expansion of Chemical-Resistant Mortars, Grouts, Monolithic Surfacing, and Polymer Concretes.
 - 6. C579 - Standard Test Method for Compressive Strength of Chemical-Resistant Mortars, Grouts, and Monolithic Surfacing and Polymer Concretes.
 - 7. C827 - Standard Test Method for Change in Height at Early Ages of Cylindrical Specimens of Cementitious Mixtures.
 - 8. C939 - Standard Test Method for Flow of Grout for Preplaced-Aggregate Concrete (Flow Cone Method).
 - 9. C1107 - Standard Specification for Packaged Dry, Hydraulic-Cement Grout (Non-shrink).
 - 10. C1181 - Standard Test Methods for Compressive Creep of Chemical-Resistant Polymer Machinery Grouts.
 - 11. C1437 - Standard Test Method for Flow of Hydraulic Cement Mortar.
- C. International Concrete Repair Institute (ICRI):
 - 1. 310.2R - Selecting and specifying Concrete Surface Preparations for Sealers, Coatings, Polymer Overlays, and Concrete Repair.
- D. Society for Protective Coatings (SSPC):
 - 1. SP 1 - Solvent Cleaning.

1.03 TERMINOLOGY

- A. The words and terms listed below are not defined terms that require initial capital letters, but, when used in this Section, have the indicated meaning.
1. Grout consistency. From most flowable to least flowable:
 - a. Fluid:
 - 1) Forms a nearly level surface without vibration or rodding.
 - 2) Efflux time is between 10 and 30 seconds when tested by the flow cone method in accordance with ASTM C939.
 - b. Flowable:
 - 1) Forms a nearly level surface when lightly rodded.
 - 2) Efflux time is greater than 30 seconds when tested by the flow cone method in accordance with ASTM C939.
 - 3) Flow is 125 to 145 percent when tested by the flow table method in accordance with ASTM C1437, modified in accordance with applicable provisions of ASTM C1107 (5 drops of flow table in 3 seconds).
 - c. Plastic:
 - 1) Flow is 100 to 125 percent when tested by the flow table method in accordance with ASTM C1437, modified in accordance with applicable provisions of ASTM C1107 (5 drops of flow table in 3 seconds).
 - d. Stiff plastic:
 - 1) Flow is 50 to 99 percent when tested by the flow table method in accordance with ASTM C1437, modified in accordance with applicable provisions of ASTM C1107 for plastic mixes.
 - e. Dry pack:
 - 1) Grout that can be molded in closed fist without showing water when squeezed, and without crumbling when pressure is released.
 - 2) Flow is 0, or near 0 percent, when tested by the flow table method in accordance with ASTM C1437, modified in accordance with applicable provisions of ASTM C1107 for plastic mixes.
 2. Preblended grout: Grout with constituent materials proportioned, thoroughly blended, and packaged by a manufacturer for the addition of water (cement-based grout) or catalysts (epoxy-based grout) at the construction site.

1.04 ADMINISTRATIVE REQUIREMENTS

1.05 SUBMITTALS

- A. Furnish Submittals as specified in Section 01_33_00 - Submittal Procedures.
- B. Product data:
1. As specified in Section 01_60_01 - Product Requirements.
 2. Preblended grouts:
 - a. Manufacturer's instructions for preparation of surface receiving grout.
 - b. Manufacturer's instruction for mixing, placement, and curing of grout.
 3. Site-mixed grouts:
 - a. Product data for materials used in mixes.
 - 1) As specified in Section 03_30_00 - Cast-in-Place Concrete, for Submittal requirements for cementitious materials, aggregates, and water.

- b. Mix designs with proportions of materials to be used.
- c. Test results demonstrating compliance with grout properties specified.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. As specified in Section 01_60_01 - Product Requirements and the manufacturer's instructions.

1.07 PROJECT OR SITE CONDITIONS

- A. As specified in Section 01_81_50 - Design Criteria.

1.08 WARRANTY

- A. As specified in Section 01_78_36 - Warranties and Bonds.

PART 2 PRODUCTS

2.01 GENERAL

- A. As specified in Section 01_60_01 - Product Requirements.
- B. Locations of use:
 - 1. See Schedules at the end of Part 3 of this Section.

2.02 PREBLENDED GROUT

- A. Non-shrink cement grout:
 - 1. General requirements:
 - a. Hydraulic-cement based, pre-proportioned, pre-blended, and pre-packaged mix, requiring only the addition of water.
 - b. In accordance with ASTM C1107.
 - c. Non-metallic: Containing no metallic particles, such as aluminum powder, and no metallic aggregate, such as iron filings.
 - d. Allowing for the addition of non-reactive mineral aggregate when recommended by the manufacturer for placements with increased thermal mass due to depth or volume.
 - e. Consistency:
 - 1) Manufacturer's mixing instructions allow for mixing to consistencies required for placement.
 - a) "Fluid," "flowable," or "plastic," as defined in ASTM C1107.
 - b) "Stiff plastic" or "dry pack" as specified in this Section.
 - f. Temperatures:
 - 1) Installation and curing: Manufacturer's recommendations allow mixing, placing, and curing at temperatures ranging from 45 to 90 degrees Fahrenheit.
 - 2) Service: After 28 days curing, suitable for exposure to temperatures of at least 400 degrees Fahrenheit.

- g. Working time:
 - 1) Provides designated consistency for at least 20 minutes after mixing at the temperature where grout will be installed.
- h. Dimensional stability:
 - 1) Height change: Positive expansion in accordance with the requirements of ASTM C1107 for early height change, and for height change during moist curing.
- 2. Non-shrink cement grout - General use (NSCG):
 - a. Additional requirements:
 - 1) Compressive strength: In accordance with the following when tested in accordance with ASTM C109, as modified in ASTM C1107:

NSCG: Minimum Compressive Strength (psi)	
	Fluid
1 day	3,500
3 days	4,400
7 days	6,500
28 days	7,500

- b. Manufacturers: One of the following or equal:
 - 1) Dayton Superior, 1107 Advantage Grout.
 - 2) Euclid Chemical Co., NC Grout.
 - 3) Five Star Products, Inc., Five Star Grout.
 - 4) L&M Construction Chemicals, Inc., Duragrout.
 - 5) Master Builder Solutions (MBCC Group), MasterFlow 713.
 - 6) Sika Corporation, SikaGrout 212.
 - 7) US Spec, GP Grout.

B. Non-shrink epoxy grout:

- 1. General requirements:
 - a. System consisting of epoxy resin and hardener plus aggregate.
 - 1) Epoxy: 100 percent solids, 2-component thermosetting resin and hardener.
 - 2) Aggregate: Non-reactive mineral material provided by the manufacturer.
 - b. Pre-proportioned and pre-packaged for mixing.
 - c. Non-metallic: Containing no metallic aggregate such as aluminum or iron filings.
 - d. Allowing for the addition of mineral aggregate when recommended by the manufacturer for placements with increased thermal mass due to depth or volume.
 - e. Consistency: Flowable as required for the conditions of placement.
 - f. Working time: Retains consistency for placement for at least 15 minutes after mixing at the temperature where the grout will be installed.
 - g. Temperature:
 - 1) Installation and curing: Manufacturer's recommendations allow mixing, placing, and curing at temperatures ranging from 45 to 90 degrees Fahrenheit.
 - 2) Service temperature: Cured material suitable for exposure to temperatures up to 140 degrees Fahrenheit.

- h. Consistency and working time:
 - 1) Flowable for at least 10 minutes after mixing with catalyst when tested at 60 degrees Fahrenheit.
- i. Dimensional stability:
 - 1) Shrinkage or expansion: In accordance with at least one of the following:
 - a) Shrinkage: Less than 0.0006 inches per inch when tested in accordance with ASTM C531.
 - b) Expansion: Positive expansion when tested in accordance with ASTM C827.
 - 2) Compressive creep: In accordance with at least one of the following:
 - a) Not exceeding 0.004 inches per inch when tested in accordance with ASTM C1181 under constant load of 600 pounds per square inch at 140 degrees Fahrenheit.
 - b) Not exceeding 0.002 inches per inch when tested in accordance with ASTM C1181 under constant load of 400 pounds per square inch at 140 degrees Fahrenheit.
 - 3) Coefficient of thermal expansion:
 - a) Not exceeding 0.000019 inches per inch per degree Fahrenheit when tested in accordance with ASTM C531, Method B.
- 2. Non-shrink epoxy grout - General use (NSEG):
 - a. Additional requirements:
 - 1) Compressive strength: Minimum when tested in accordance with ASTM C579, Method B.

NSEG: Minimum Compressive Strength (psi)	
	Fluid
1 day	9,000
7 days	11,500

- b. Manufacturers: One of the following or equal:
 - 1) Dayton Superior, J55/Pro-Poxy 2000.
 - 2) Euclid Chemical Co., E3-Flowable Grout.
 - 3) Five Star Products, Inc., Five Star DP Epoxy Grout.
 - 4) Laticrete/L&M Construction Chemicals, Inc., EpogROUT 758.
 - 5) Master Builder Solutions (MBCC Group), MasterFlow 648.
 - 6) Sika Corporation, Sikadur-42 Grout-Pak.
 - 7) US Spec, EPG 2000.

2.03 SITE-PROPORTIONED GROUT

- A. Neat cement grout (NCG):
 - 1. Description: Mixture of portland cement and water.
 - 2. Materials:
 - a. Cement: In accordance with ASTM C150.
 - 1) Match type used in concrete placed against the joint.
 - b. Water: Potable water.
 - 3. Proportioning ratios:
 - a. Use water-to-cementitious materials ratio that is no more than that specified for the plastic concrete that will be placed against the grout.

- B. Epoxy grout:
 - 1. Description: Mixture of epoxy or epoxy gel and sand.
 - 2. Materials:
 - a. Epoxy and epoxy gel: As specified in Section 03_63_01 - Epoxies.
 - b. Sand: Clean, bagged, and kiln-dried silica sand.
 - 1) Gradation in accordance with ASTM C404, Size No. 2.
 - 3. Proportioning:
 - a. Horizontal work: 1 part epoxy with not more than 2 parts sand.
 - b. Vertical and overhead work: 1 part epoxy gel with not more than 2 parts sand.

2.04 MATERIALS SPECIFIED ELSEWHERE

- A. Grout and mortar for masonry unit construction:
 - 1. As specified in Section 04_05_17 - Mortar and Masonry Grout.

PART 3 EXECUTION

3.01 PREPARATION

- A. General:
 - 1. Protect surfaces adjacent to grouting operations. Prevent grout staining.
 - 2. Preblended grout:
 - a. Refer to the manufacturers' product literature for limits on physical or environmental conditions associated with storage and use of products.
 - b. Review any special conditions with manufacturers, prior to installation of products. Document discussions and submit records to the Engineer.
- B. Surface preparation:
 - 1. General:
 - a. Remove grease, oil, dirt, dust, ice and frost, curing compounds, laitance, paint, and other deleterious materials that reduce grout bond to substrate.
 - 2. Concrete surfaces receiving grout:
 - a. Roughen surface in accordance with the grout manufacturer's recommendations.
 - 1) Take care during surface preparation to avoid microcracking of the base materials.
 - 2) Roughen concrete surfaces in contact with grout to surface profile CSP-6 in accordance with ICRI 310.2R.
 - 3) Remove loose or broken concrete.
 - 3. Concrete surfaces receiving cement-based grouts:
 - a. Saturate concrete surface receiving the grout, and adjacent concrete surfaces 6 inches beyond limits of grout, with clean water or not less than 24 hours before grout placement.
 - b. Immediately prior to grout placement, remove standing water from concrete and anchor holes. Use clean rags or oil-free compressed air to leave saturated surface-dry (SSD) condition.
 - 4. Concrete surfaces receiving epoxy-based grouts:
 - a. Do not wet surfaces with water. Provide dry surface with moisture content not exceeding the grout manufacturer's recommended limits.

- b. Prepare surfaces as recommended by the grout manufacturer.
 - c. Before placing epoxy-based grouts, wet surfaces with epoxy:
 - 1) Horizontal work: Wet with epoxy used for epoxy grout.
 - 2) Vertical and overhead work: Wet with epoxy gel compatible with epoxy used in epoxy grout.
- C. Base plates:
 - 1. For large or complex base plates, including base plates with shear lugs:
 - a. Provide plates with air relief holes at least 1/8 inch in diameter and spaced to prevent entrapment of air for complete filling under the plate.
 - 2. Remove grease, oil, dirt, dust, ice and frost, debris, and other materials that would contaminate grout or result in uneven bearing below plates.
 - a. Clean anchor holes and block-outs.
 - b. Clean surfaces in accordance with SSPC-SP 1.
 - 3. Base plates over non-shrink epoxy grout:
 - a. At locations where equipment will be removed for maintenance or replacement, coat base plate with 2 coats of heavy duty paste wax to prevent bonding to grout.
- D. Forms for grout:
 - 1. Construct forms:
 - a. With adequate strength and stiffness to withstand grout placement and consolidation procedures without deformation.
 - b. That provide a smooth and uniform finish for grout surfaces.
 - c. That are liquid tight. Caulk cracks and joints with elastomeric sealant compatible with the grout to be placed.
 - d. That allow venting of displaced air.
 - e. That allow grout to flow horizontally beyond the perimeter of the base plate a distance not less than the thickness of the grout or 1 inch.
 - f. Line forms with polyethylene, or coat with 2 coats of heavy paste wax, to allow for easy form release.
 - 2. Construct forms with "head box":
 - a. Make head box continuous over entire length of one side of form.
 - 1) For larger placements, space head boxes to maintain continuous flow of grout from one side of the base plate to the other.
 - b. Make head box height sufficient to force grout to flow under full dimensions of base and to the surrounding form faces.
 - c. Position bottom of head box not less than 4 to 6 inches higher than bottom of the base plate.

3.02 INSTALLATION

- A. General:
 - 1. Maintain temperature of grouts, their constituent materials, and surfaces receiving the grouts within the manufacturer's specified limits during grout mixing, placement, and curing.
- B. Mixing:
 - 1. General:
 - a. Mix grouts to uniform consistency and to provide uniform distribution of constituent materials throughout the mix before beginning placement.

- b. Where grout includes aggregate, mix until aggregate is uniformly wetted and dispersed in the mix.
 - c. Avoid overworking and entrapment of air in the mix.
 - 2. Preblended grout:
 - a. Mix products in accordance with the manufacturer's instructions.
 - 1) Comply with the manufacturer's recommendations for conditioning of materials prior to mixing.
 - 2) Mix in complete units. Do not mix partial batches.
 - 3) Do not vary ratio of components from the manufacturer's instructions.
 - b. Non-shrink cement grout:
 - 1) Pre-measure water for mixing. Do not exceed the manufacturer's recommended water content for the mix consistency to be used.
 - 2) Do not re-temper by adding water as the mix stiffens.
 - c. Non-shrink epoxy grout:
 - 1) Manufacturer's reported working time may vary significantly from working time for actual on-site conditions.
 - 2) Make preparations to mix, place, and consolidate grout rapidly and within actual on-site working time.
 - 3) Do not add solvents to adjust consistency.
 - 3. Site-proportioned grout:
 - a. Cement grouts:
 - 1) Use mortar mixer with moving paddles.
 - 2) Pre-wet mixer and empty excess water before beginning mixing.
 - 3) Do not retemper by adding more water after grout stiffens.
 - b. Epoxy grout.
 - 1) Blend epoxy and aggregates in accordance with the epoxy manufacturer's recommendations for extending grout.
- C. Placement:
 - 1. General:
 - a. Place grout:
 - 1) Only after location, leveling, and alignment of structural elements and equipment is within required tolerances.
 - 2) Only after verifying compliance of grout substrates and environmental conditions.
 - 3) Immediately after mixing, and in a continuous placement.
 - b. Flowable grout:
 - 1) Fill head boxes and work grout down so it flows under base plate.
 - 2) At all times, keep the level of grout in the head box above the bearing surface of the base plate, sole plate, or skid.
 - 3) Maintain hydraulic pressure and continuous flow of grout from head box to opposite side of forms without trapping air or forming voids.
 - 4) Completely fill grout space, placing grout only to the bottom edge of bearing or base plates.
 - 5) Vibrate, rod, or chain flowable and plastic grout to facilitate grout flow, consolidate grout, and remove trapped air.
 - c. Dry pack grout:
 - 1) Pack into confined space, without voids, using tamping or ramming procedures recommended by the grout manufacturer.

2. Preblended grout:
 - a. General:
 - 1) Place grout within the manufacturer's recommended working time for the temperature conditions during installation.
 - b. Non-shrink cement grout:
 - 1) After grout reaches initial set, remove forms and trim vertical edges of grout at a 45-degree angle sloping out and down from bottom edge of base plate to top of support.
 - 2) Finish cut surface to uniform texture.
 - c. Non-shrink epoxy grout:
 - 1) Do not trim edges of grout after it sets. Construct forms using chamfered edges built into the formwork to create sloped edge at perimeter.
 3. Site-proportioned grout:
 - a. General:
 - 1) Do not place grout more than 30 minutes after mixing.
 - b. Neat cement grout:
 - 1) As specified in Section 03_30_00 - Cast-in-Place Concrete.
 - c. Epoxy grout:
 - 1) Place as indicated on the Drawings.
- D. Curing:
1. Cement based grouts:
 - a. Keep continuously wet for minimum of 7 days after initial set.
 - 1) Use wet burlap, soaker hose, sun shading, ponding, or a combination of these methods.
 - b. Temperature: Maintain temperature of grout, substrate, and elements:
 - 1) Cold weather:
 - a) Above 70 degrees Fahrenheit for a minimum of 24 hours after placement to avoid damage from freezing.
 - b) Above 40 degrees Fahrenheit until grout has attained compressive strength of 3,000 pounds per square inch, but not less than 7 days.
 - 2) Hot weather:
 - a) Below 90 degrees Fahrenheit for a minimum of 72 hours after placement.
 2. Epoxy-based grouts:
 - a. Cure grouts in accordance with the manufacturers' recommendations.
 - b. Temperature: Maintain temperature of grout, substrate, and elements:
 - 1) Cold weather:
 - a) Above 70 degrees Fahrenheit for a minimum of 48 hours after placement.
 - 2) Hot weather:
 - a) Below 80 degrees Fahrenheit for a minimum of 24 hours after placement.

3.03 FIELD QUALITY CONTROL

- A. Provide field quality control over the Work of this Section as specified in Section 01_45_17 - Contractor Quality Control Plan.

- B. Field quality control by the Contractor:
1. Inspections: Observe grout mixing and placement to confirm:
 - a. Product or mix installed at each location.
 - b. Preblended grouts:
 - 1) Mixing of full volume of prepackaged materials.
 - 2) Mixed and placed within the manufacturer's recommended temperature and working time limits.
 - 3) Cement-based: Addition of water complies with the manufacturer's instructions for specified strength and required consistency.
 - c. Complete and uniform filling of spaces designed for grouting.
 - d. Curing and protection as specified.
 2. Field testing - Preblended grout:
 - a. Not required.
 3. Field testing - Site-mixed grouts:
 - a. Neat cement grout: Not required.
 - b. Epoxy grout: Not required.
- C. Field quality control by the Owner:
1. Special inspections:
 - a. Observe structure bearing plates and equipment base plates for presence of grout and for complete filling of grout spaces.

3.04 CLEANING

- A. Remove grout from adjacent surfaces.

3.05 SCHEDULES

- A. Install grout at locations indicated on the Drawings.
- B. General applications for products specified in this Section are specified in the General Applications for Grout Materials table below.
1. Where specified grout or repair materials are not indicated on the Drawings or in the other Sections of the Specifications, confirm requirements with the Engineer before installation.

General Applications for Grout Materials	
Product	Application
Preblended Grouts	
Non-shrink cement grout	General use (NSCG): • Below base plates and bearing plates for structural framing. • Below equipment bases, sole plates and skids unless otherwise indicated on the Drawings. • Locations indicated on the Drawings.

General Applications for Grout Materials	
Product	Application
Site-proportioned Grouts	
Neat cement grout	For spreading over construction joints and cold joints in concrete placements (not for other uses).
Epoxy grout	For filling divots where reinforcement or embedded metallic materials are burned back behind the face of concrete or masonry. Other locations indicated on the Drawings.

END OF SECTION

SECTION 03_63_01

EPOXIES

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Epoxy.
 - 2. Epoxy gel.
 - 3. Epoxy bonding agent.

1.02 REFERENCES

- A. ASTM International (ASTM):
 - 1. C881 - Standard Specification for Epoxy-Resin-Base Systems for Concrete.
 - 2. C882 - Standard Test Method for Bond Strength of Epoxy-Resin Systems Used with Concrete by Slant Shear.
 - 3. D638 - Standard Test Method for Tensile Properties of Plastics.
 - 4. D695 - Standard Test Method for Compressive Properties of Rigid Plastics.

1.03 SUBMITTALS

- A. Submit as specified in Section 01_33_00 - Submittal Procedures.
- B. Product data:
 - 1. Manufacturer's data completely describing epoxy materials:
 - 2. Evidence of conformance to ASTM C881. Include manufacturer's designations of type, grade, class, and color.
 - 3. Documentation that materials meet or exceed the specified strength and performance characteristics. Indicate test methods and test results.
- C. Installation instructions:
 - 1. Provide manufacturer's installation instructions.

PART 2 PRODUCTS

2.01 DESIGN AND PERFORMANCE CRITERIA

- A. Performance requirements:
 - 1. Provide epoxy materials that are new.
 - 2. Store and use products within limitations in accordance with the manufacturer.
 - 3. Perform and conduct Work of this Section in a neat, orderly manner.

2.02 MATERIALS

A. General:

1. Moisture tolerant, water-insensitive, two-component epoxy resin adhesive material containing 100 percent solids, and meeting or exceeding the performance properties specified when tested in accordance with the standards specified.

B. Epoxy: Low viscosity product in accordance with ASTM C881; Types I, II, and IV; Grade 1; Class C, except as modified in this Section.

1. Manufacturers: One of the following, or equal:
 - a. Dayton Superior, Unitex Pro-Poxy 100.
 - b. Master Builders Solutions/Sika, MasterInject 1380.
 - c. Sika Corporation, Sikadur 35 Hi-Mod LV.
2. Required properties:

Table 1. Material Properties - Epoxy		
Property	Test Method	Required Results ("neat")
Tensile Strength (7-day)	ASTM D638	7,000 pounds per square inch, minimum.
Compressive Yield Strength (7-day)	ASTM D695	10,000 pounds per square inch, minimum.
Bond Strength (hardened concrete to hardened concrete after 2-day cure)	ASTM C882	1,000 pounds per square inch, minimum. Concrete failure before failure of epoxy.
Viscosity (mixed)		250 to 550 centipoise
<u>Notes:</u> (1) Testing results are for materials installed and cured at a temperature between 72 and 78 degrees Fahrenheit for 7 days, unless otherwise noted.		

C. Epoxy gel: Non-sagging product in accordance with ASTM C881, Types I and IV, Grade 3, Class C.

1. Manufacturers: One of the following, or equal:
 - a. Dayton Superior, Sure Anchor J50.
 - b. Master Builders Solutions/Sika, MasterEmaco ADH 327.
 - c. Sika Corp., Sikadur 31, Hi-Mod Gel.
2. Required properties:

Table 2. Material Properties - Epoxy Gel		
Property	Test Method	Required Results ("neat")
Tensile Strength (7-day)	ASTM D638	2,000 pounds per square inch, minimum.
Compressive Yield Strength (7-day)	ASTM D695	8,000 pounds per square inch, minimum.
Bond Strength (14-day)	ASTM C882	1,500 pounds per square inch, minimum.
<u>Notes:</u> (1) Testing results are for materials installed and cured at a temperature between 72 and 78 degrees Fahrenheit for 7 days, unless otherwise noted.		

- D. Epoxy bonding agent: Non-sagging product in accordance with ASTM C881, Type II, Grade 2, Class C.
1. Manufacturers: One of the following, or equal:
 - a. Dayton Superior, Sure Bond J58.
 - b. Master Builders Solutions/Sika, MasterEmaco ADH 326.
 - c. Sika Chemical Corp., Sikadur 32 Hi-Mod LPL.
 2. Required properties:

Table 3. Material Properties - Epoxy Bonding Agent		
Property	Test Method	Required Results
Tensile Strength (7-day)	ASTM D638	3,300 pounds per square inch, minimum.
Compressive Yield Strength (7-day)	ASTM D695	8,300 pounds per square inch, minimum.
Bond Strength (14-days)	ASTM C882	1,800 pounds per square inch, minimum. Concrete failure before failure of epoxy bonding agent.
Pot Life	-	Minimum 60 minutes at 73 degrees Fahrenheit.
Notes: (1) Testing results are for materials installed and cured at a temperature between 72 and 78 degrees Fahrenheit for 7 days, unless otherwise noted.		

PART 3 EXECUTION

3.01 INSTALLATION

- A. Install and cure epoxy materials in accordance with the manufacturer's installation instructions.
- B. Epoxy:
1. Apply in accordance with the manufacturer's installation instructions.
- C. Epoxy gel:
1. Apply in accordance with the manufacturer's installation instructions.
 2. Use for vertical or overhead work, or where high viscosity epoxy is required.
 3. Epoxy gel used for vertical or overhead work may be used for horizontal work.
- D. Epoxy bonding agent:
1. Apply in accordance with the manufacturer's installation instructions.
 2. Will not be required for filling form tie holes or for normal finishing and patching of similar sized small defects.

END OF SECTION

SECTION 03_63_02

EPOXY RESIN/PORTLAND CEMENT BONDING AGENT

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes: Epoxy resin/portland cement bonding agent.

1.02 REFERENCES

- A. ASTM International (ASTM):
 - 1. C109 - Standard Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2-in. Cube Specimens).
 - 2. C348 - Standard Test Method for Flexural Strength of Hydraulic-Cement Mortars.
 - 3. C496 - Standard Test Method for Splitting Tensile Strength of Cylindrical Concrete Specimens.
 - 4. C882 - Standard Test Method for Bond Strength of Epoxy-Resin Systems Used with Concrete by Slant Shear.
- B. Federal Highway Administration (FHWA):
 - 1. FHWA-RD-86-193 - Highway Concrete Pavement Technology Development and Testing Volume V: Field Evaluation of SHRP C9206 Test Sites (Bridge Deck Overlays).

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Sika Corp., Sika Armatec 110.
- B. Substitutions: The use of other than the specified product will be considered, providing the Contractor requests its use in writing to the Engineer. This request shall be accompanied by:
 - 1. A certificate of compliance from an approved independent testing laboratory that the proposed substitute product meets or exceeds specified performance criteria, tested in accordance with the specified test standards.
 - 2. Documented proof that the proposed substitute product has a 1-year proven record of performance of bonding portland cement mortar/concrete to hardened portland cement mortar/concrete, confirmed by actual field tests and 5 successful installations that the Engineer can investigate.

2.02 MATERIALS

- A. Epoxy resin/portland cement adhesive:
 - 1. Component "A" shall be an epoxy resin/water emulsion containing suitable viscosity control agents. It shall not contain butyl glycidyl ether.

2. Component "B" shall be primarily a water solution of a polyamine.
3. Component "C" shall be a blend of selected portland cements and sands.
4. The material shall not contain asbestos.

2.03 DESIGN AND PERFORMANCE CRITERIA

- A. Properties of the mixed epoxy resin/portland cement adhesive:
 1. Pot life: 75 to 105 minutes.
 2. Contact time: 24 hours.
 3. Color: Dark gray.
- B. Properties of the cured epoxy resin/portland cement adhesive:
 1. Compressive strength in accordance with ASTM C109:
 - a. 3 days: 4,500 pounds per square-inch minimum.
 - b. 7 days: 6,500 pounds per square-inch minimum.
 - c. 28 days: 8,500 pounds per square-inch minimum.
 2. Splitting tensile strength in accordance with ASTM C496:
 - a. 28 days: 600 pounds per square-inch minimum.
 3. Flexural strength:
 - a. 1,100 pounds per square-inch minimum in accordance with ASTM C348.
 4. Bond strength in accordance with ASTM C882 modified at 14 days:
 - a. 0 hours open time: 2,800 pounds per square-inch minimum.
 - b. 24 hours open time: 2,600 pounds per square-inch minimum.
 5. The epoxy resin/portland cement adhesive shall not produce a vapor barrier.
 6. Material must be proven to prevent corrosion of reinforcing steel when tested under the procedures as set forth by the FHWA Program Report Number FHWA-RD-86-193. Proof shall be in the form of an independent testing laboratory corrosion report showing prevention of corrosion of the reinforcing steel.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Mixing the epoxy resin: Shake contents of Component "A" and Component "B." Empty all of both components into a clean, dry mixing pail. Mix thoroughly for 30 seconds with a jiffy paddle on a low speed with 400 to 600 revolutions per minute drill. Slowly add the entire contents of Component "C" while continuing to mix for a minimum of 3 minutes and until uniform with no lumps. Mix only the quantity that can be applied within its pot life.
- B. Placement procedure:
 1. Apply to prepared surface with stiff-bristle brush, broom, or "hopper-type" spray equipment:
 - a. For hand applications: Place fresh plastic concrete/mortar while the bonding bridge adhesive is wet or dry, up to 24 hours.
 - b. For machine applications: Allow the bonding bridge adhesive to dry for 12 hours minimum.

- C. Adhere to all limitations and cautions for the epoxy resin/portland cement adhesive in the manufacturer's current printed literature.

3.02 CLEANING

- A. Leave finished work and work area in a neat, clean condition without evidence of spillovers onto adjacent areas.

END OF SECTION

SECTION 03_64_24
EPOXY INJECTION SYSTEM

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Epoxy injection system.

1.02 REFERENCES

- A. ASTM International (ASTM):
 - 1. C881 - Standard Test Method for Epoxy-Resin-Base Bonding Systems for Concrete.
 - 2. C882 - Standard Test Method for Bond Strength of Epoxy-Resin Systems Used With Concrete by Slant Shear.
 - 3. D638 - Standard Test Method for Tensile Properties of Plastics.
 - 4. D648 - Standard Test Method for Deflection Temperature of Plastics Under Flexural Load in the Edgewise Position.
 - 5. D695 - Standard Test Method for Compressive Properties of Rigid Plastics.
 - 6. D790 - Standard Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials.

1.03 SUBMITTALS

- A. Submit as specified in Section 01_33_00 - Submittal Procedures.
- B. Product data:
 - 1. Manufacturer's data completely describing epoxy injection system materials and including test methods and results for strength in tension, flexure, compression and bond; flexural modulus of elasticity; coefficient of thermal expansion; and elongation.
- C. Quality control submittals:
 - 1. Certificates of Compliance.
 - 2. Manufacturer's Instructions.
- D. Special procedure submittals:
 - 1. Protection plan for surrounding areas and non-cementitious surfaces.

1.04 QUALITY ASSURANCE

- A. Products:
 - 1. Provide materials that are new and use them within shelf-life limitations set forth by manufacturer.

- B. Qualifications:
 - 1. Installer:
 - a. Minimum 5 years' experience in concrete repair, with focus on application of similar systems and products to projects of similar size and scope.
- C. Pre-installation meeting:
 - 1. At least 1 week prior to commencing work of this Section, convene a meeting at the project site to review and discuss the following:
 - a. Surface preparation.
 - b. Substrate conditioning and pre-treatment.
 - c. Installation procedures.
 - d. Environmental conditions (including weather forecast) and curing requirements.
 - e. Testing and inspection procedures.
 - f. Protection of surrounding surfaces and equipment.

1.05 DELIVERY, STORAGE, AND HANDLING

- A. Deliver materials in manufacturer's original, unopened, undamaged containers with identification labels intact. Labels shall include product identification, batch numbers, and shelf-life information.
- B. Store materials off the ground and away from moisture and direct sunlight, and at temperatures within manufacturer's recommended range.
- C. Pre-condition materials to manufacturer's recommended temperatures before mixing and using.

1.06 PROJECT CONDITIONS

- A. Take precautions to protect surfaces and equipment in the work area from damage and staining.

PART 2 PRODUCTS

2.01 MATERIALS

- A. General:
 - 1. Repair materials shall be free of chlorides or alkalis (except for those attributed to water).
 - 2. To ensure compatibility of materials and methods, a single manufacturer shall produce and provide all products used together in a single area of concrete repair.
- B. Manufacturers: One of the following, or equal:
 - 1. Master Builders Solutions/Sika, MasterInject 1500.
 - 2. Sika Chemical Corp., Sikadur 35 Hi-Mod LV.
- C. Epoxy:
 - 1. In accordance with ASTM C881, Types I, II and IV, Grade 1, Class C.

2. Water-insensitive 2-component low viscosity, epoxy adhesive material containing 100 percent solids and meeting or exceeding the following characteristics when tested in accordance with standards specified:

Table 1. Epoxy, Physical Properties		
Characteristic	Test Method	Required Results, minimum^{(1),(2)}
Viscosity (mixed)	–	250 to 375 centipoises
Tensile Strength	ASTM D638	7,500 pounds per square inch
Tensile Elongation at Break	ASTM D638	1 percent
Compressive Strength	ASTM D695	11,000 pounds per square inch
Compressive Modulus	ASTM D695	2.5 x 10 ⁵ pounds per square inch
Bond Strength, slant shear, hardened concrete to hardened concrete	ASTM C882	1,500 pounds per square inch at 2 days at minimum 73 degrees Fahrenheit. Concrete shall fail before failure of epoxy.
Heat Deflection Temperature	ASTM D648	124 degrees Fahrenheit
Notes: (1) Properties for mixes with neat epoxy. (2) Results after 7-day cure at temperature between 72 and 78 degrees Fahrenheit, unless otherwise noted.		

2.02 EQUIPMENT

- A. Injection pump:
 1. Use positive displacement injection pump with interlock to provide in-line mixing and metering system for 2 component epoxy.
 2. Use pressure hoses and injection nozzle designed to properly mix of 2 components of epoxy.
 3. Standby injection unit may be required.

PART 3 EXECUTION

3.01 PREPARATION

- A. Surface preparation:
 1. Confirm that surface temperature and moisture conditions are within manufacturer's recommended limits. Condition surfaces to within those limits before commencing epoxy injection.
 2. Sweep or clean area in vicinity of cracks that will be injected with epoxy. Leave area in generally clean condition after epoxy injection is complete.
 3. Clean cracks so they are free from dirt, laitance, and other loose matter.

3.02 INSTALLATION

- A. Install and cure epoxy materials in accordance with manufacturer's installation instructions.

- B. Mixing:
 - 1. Mix epoxy in accordance with manufacturer's installation instructions.
 - 2. Do not use solvents to thin epoxy system materials introduced into cracks or joints.
- C. Injection:
 - 1. Apply adequate surface seal to crack to prevent leakage of epoxy.
 - 2. Establish injection points at distance along crack not less than thickness of cracked member.
 - 3. Crack injection sequence:
 - a. Inject epoxy into crack or joint at first port with sufficient pressure to advance epoxy to adjacent port. Start at lowest port along the injection line and work upwards.
 - b. Seal original port and shift injection to next adjacent port where epoxy appears.
 - c. Continue port-to-port injection until crack has been injected for its entire length.
 - d. For small amounts of epoxy, or where excessive pressure developed by injection pump might further damage structure, premixed epoxy and use hand caulking gun to inject epoxy if acceptable to the Engineer.
 - e. Seal ports, including adjacent locations where epoxy seepage occurs, as necessary to prevent drips or run out.
 - f. After epoxy injection is complete, remove surface seal material, and refinish concrete in area where epoxy was injected to match existing concrete. Leave finished work and work area in a neat, clean condition.

3.03 FIELD QUALITY ASSURANCE

- A. Provide Contractor quality control as specified in Section 01_45_17 - Contractor Quality Control Plan.
- B. Field inspections and testing:
 - 1. Submit records of inspections and tests to Engineer within 24 hours after completion.
- C. Manufacturer's services.
 - 1. Pre-installation meeting: Provide manufacturer's technical representative to attend pre-installation meeting specified in this Section.

3.04 FIELD QUALITY CONTROL

- A. Provide Owner's quality assurance for the Work of this Section as specified in Section 01_45_17 - Contractor Quality Control Plan.
- B. Special inspections special tests, and structural observation:
 - 1. Not required.
- C. Field inspections:
 - 1. Preparation.
 - a. Review manufacturer's product data and installation instructions.

2. Required inspections.
 - a. Observe surfaces to be injected for temperature and moisture conditions and for surface preparation.
 - b. Observe conditioning and mixing of epoxy resin components.
 - c. Observe injection procedures for filling cracks.
3. Records of inspections:
 - a. Provide record of each inspection.
 - b. Submit to Engineer upon request.

3.05 NON-CONFORMING WORK

- A. Rework surface finishes that do not match surrounding concrete to the satisfaction of the Engineer at no additional cost to the Owner.

END OF SECTION

SECTION 03_70_30

THERMAL CONTROL OF CONCRETE

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Monitoring and control of concrete hydration temperatures during set and curing.

1.02 DELEGATED DESIGN

- A. As specified in Section 01_35_73 - Delegated Design Procedures.
- B. Thermal control plan.

1.03 SUBMITTALS

- A. Furnish Submittals as specified in Section 01_33_00 - Submittal Procedures and Section 01_60_01 - Product Requirements.
- B. Product data.
- C. Delegated Design Submittals:
 - 1. Thermal control plan.
- D. Temperature monitoring program.
- E. Temperature monitoring data:
 - 1. Tabular data of hourly concrete temperature for each temperature sensor.
 - 2. Tabular data for hourly concrete temperature differential for each temperature sensor.
 - 3. Plot of temperature and temperature differential for each temperature sensor.
- F. Cooling pipe system, if used:
 - 1. Layout showing pipe sizes and material(s), connections, positions and spacing within the concrete, methods of support, and system for monitoring temperature of water in cooling pipes.
 - 2. Grout material for filling pipes.

1.04 QUALITY ASSURANCE

- A. Engineer in responsible charge of development of the thermal control plan shall be a professional engineer and have the following qualifications:
 - 1. At least 10 years recent experience in completion of thermal control plans.
 - 2. Completion of thermal control plans of at least 20 successful projects. Provide contact references for at least 5 projects in the last 2 years.

3. Engineer has determined that the following engineers are qualified to develop thermal control plans:
 - a. Beton Consulting Engineers.
 - b. MJ2 Consulting, PLLC.
4. Contractor's request to use alternate engineers may be considered if qualifications and examples of work product are submitted to the Engineer for approval as follows:
 - a. Cover letter listing the proposed engineer's qualifications.
 - b. Examples of thermal control plans for 5 previous projects, including project name, date, location, and name of contact with telephone number. Include field records of thermal monitoring showing actual deviations from the thermal predictions.
5. Contractor's proposed alternate engineer will be reviewed by the Engineer. Engineer's decision of the alternate engineer's qualifications will be final.

PART 2 PRODUCTS

2.01 DESIGN AND PERFORMANCE CRITERIA

- A. Design requirements:
 1. Thermal control plan:
 - a. General:
 - 1) The thermal control plan shall provide a prediction of thermal rise based on a rational approach such as the procedure described in PRC-207.2 or based on tests that determine the adiabatic thermal rise, or a combination of the two. The prediction shall include the following effects, as a minimum: cement type and fineness, pozzolan type and fineness, concrete mix proportions, concrete temperature at delivery, and heat dissipation of the concrete mix. The estimation of the heat dissipation properties of the concrete shall be determined by a rational analysis such as the methodology presented in PRC-207.2 or by testing. Deviations from PRC-207.2 shall be justified in the plan.
 - 2) Thermal control plan shall include the following as a minimum:
 - a) Based on the range of average daily ambient air temperatures and initial concrete temperature at point of placement, calculate the following for each concrete placement:
 - (1) Maximum anticipated concrete temperature.
 - (2) Time from concrete placement until maximum concrete temperature occurs.
 - (3) Maximum anticipated concrete differential temperature.
 - (4) Time from concrete placement until maximum anticipated concrete differential temperature occurs.
 - (5) Length of thermal control period.
 - b) Concrete mix design as specified in Section 03_30_00 - Cast-in-Place Concrete.
 - c) Duration and method of curing.
 - d) Procedures to control concrete temperature at time of placement.

- e) Methods of controlling maximum concrete differential temperature.
 - (1) Include minimum temperature of adjacent concrete at construction joints.
 - f) Temperature sensor types and placement locations.
 - g) Temperature monitoring and recording system.
 - h) Field measures to ensure conformance with maximum concrete temperature and maximum concrete temperature differential requirements.
 - i) Corrective measures to take if it appears specified concrete maximum temperature and maximum concrete differential temperature will be exceeded.
 - j) Description of formwork removal procedures to ensure differential temperature at temporarily exposed concrete surface will not exceed the limit and how curing will be maintained.
 - 3) Difference in temperature between concrete interior and surface temperatures shall not exceed 35 degrees Fahrenheit.
 - 4) Allow interior of concrete to cool down and stabilize.
 - 5) Maximum allowable concrete temperature: 145 degrees Fahrenheit.
 - 6) Do not place concrete until the Engineer has accepted in writing.
 - b. Pre-cooling of concrete:
 - 1) Cool concrete mix prior to placement by the following means:
 - a) Cool batch water.
 - b) Ice may be substituted for portion of batch water.
 - c) Continuously spray coarse aggregate with water to cool aggregate. Adjust batch water content to account for added water content in aggregate due to use of cooling water.
 - d) Nitrogen injection.
 - e) Alternative means proposed by the Contractor that are acceptable to the Engineer.
 - c. Post-cooling of concrete:
 - 1) Use embedded thin-walled steel piping for circulating water to control temperature gain in previously cast concrete.
 - 2) Clearly indicate in the thermal control plan if cooling piping will be embedded in concrete.
 - 3) Do not install embedded piping within top 20 inches of slab or wall.
 - 4) Operate cooling pipe system for duration of cooling period. Cooling period shall be a minimum of 14 days.
 - 5) After use of cooling pipes to cool concrete is complete, fill pipes with grout.
 - a) Flowable non-shrink cement grout with minimum specified 28-day compressive strength not less than that of the surrounding concrete.
2. Temperature monitoring program:
- a. Temperature monitoring and recording system:
 - 1) Consist of temperature sensors connected to data acquisition system capable of transmitting, storing, and downloading data to computer.
 - 2) Locate temperature sensors so that maximum temperature difference within mass concrete element can be monitored.

- 3) At a minimum, furnish and install sensors to monitor concrete temperatures at the center of the placement, at the most exposed face of the placement, and at the most exposed corner of the placement.
- 4) In addition to the sensor locations listed above, furnish and install 2 backup sensors.
 - a) Provide 1 backup sensor near the center of placement.
 - b) Provide the second sensor near the sensor at the face of the placement.
- 5) Secure sensors within formwork before the Engineer's inspection.
- b. Temperature control period (general):
 - 1) For concrete placements of mass concrete placed during cold weather, the control period shall be the greater of the requirements for mass concrete and the requirements for cold weather.
- c. Temperature control period (for mass concrete):
 - 1) Monitor and maintain temperature control measures until the following requirements are met:
 - a) Maximum internal concrete temperature has been reached and temperature is falling.
 - b) Difference between interior concrete temperature and the average daily air temperature is less than allowable temperature difference for 3 consecutive days.
 - c) 5 days have elapsed since concrete was placed.
 - d) Forecast air temperature is not expected to fall less than 35 degrees Fahrenheit below the maximum interior temperature.
 - e) There are no adjacent mass concrete elements to be cast.
- d. Temperature control period (for cold weather concreting):
 - 1) Monitor and maintain temperature control measures for the duration of the protection period specified in Section 03_30_00 - Cast-in-Place Concrete.
- e. Temperature monitoring procedures:
 - 1) Begin data logging of sensors a minimum of 1 hour before concrete placement.
 - 2) Monitor concrete temperatures during the temperature control period.
 - 3) Do not place adjacent concrete placements during the temperature control period.
- f. Concrete consolidation:
 - 1) Use methods that prevent damage to temperature monitoring and recording system.
- g. Temperature sensor and wiring:
 - 1) Protect wiring connected to temperature sensors cast into concrete to prevent movement.
 - 2) Keep wire runs as short as possible.
 - 3) Do not allow ends of temperature sensors to come into contact with supports concrete forms or reinforcing bars.
- h. Equipment failure:
 - 1) When any equipment used in temperature control, monitoring, and recording system fails during concrete construction operation, take immediate measures to correct situation in accordance with the thermal control plan.
 - 2) Failure to conform to temperature requirements will be cause for rejection of concrete.

2.02 MATERIALS

- A. Concrete admixtures:
 - 1. Air entraining admixture:
 - a. As specified in Section 03_30_00 - Cast-in-Place Concrete.
 - 2. Retarding admixture:
 - a. Set retarding admixture may be used to control set time and minimize premature setting of concrete and formation of cold joints.
 - b. As specified in Section 03_30_00 - Cast-in-Place Concrete.
 - 3. Water reducing admixture:
 - a. As specified in Section 03_30_00 - Cast-in-Place Concrete.
 - 4. Accelerating admixtures:
 - a. Do not use.
- B. Aggregates:
 - 1. As specified in Section 03_30_00 - Cast-in-Place Concrete.
- C. Cement:
 - 1. As specified in Section 03_30_00 - Cast-in-Place Concrete.
- D. Coal ash:
 - 1. As specified in Section 03_30_00 - Cast-in-Place Concrete.
- E. Concrete insulating blankets:
 - 1. Commercially available, with R-value required in the thermal control plan.
- F. Water and ice:
 - 1. Mixing water: As specified in Section 03_30_00 - Cast-in-Place Concrete.
 - 2. Water for making ice: Meet requirements of mixing water as specified in Section 03_30_00 - Cast-in-Place Concrete.
 - 3. Ice may be substituted for mixing water on 1-to-1 ratio based on weight.

2.03 TEMPERATURE MONITORING SYSTEM

- A. Manufacturers: One of the following or equal:
 - 1. FLIR Systems, Inc., Engius IntelliRock II System.
 - 2. LumiCon, A Brickeye Brand, LumiSense.
 - 3. The Transtec Group, Inc., Command Center.
 - 4. Giatec Scientific, Inc., Smartrock.
- B. Temperature logger:
 - 1. Consist of temperature sensor, microprocessor, and battery encased in polyester resin for protection.
 - 2. Calculate and store temperature readings of concrete.
 - 3. Maximum wire length in concrete: 50 feet.
 - 4. Capable of logging temperature hourly for 28 days.

- C. Handheld reader:
 - 1. Use to communicate with and collect data from temperature loggers embedded in concrete.
 - 2. Use to instruct loggers to begin reading, download data from loggers, and upload logger data to computer.
 - 3. Logger data storage: 999 logger downloads.
- D. Software:
 - 1. Use system software to transfer data from handheld reader to computer in secure, unalterable, electronic files.

2.04 MIXES

- A. As specified in Section 03_30_00 - Cast-in-Place Concrete for Class M concrete.

PART 3 EXECUTION

3.01 PREPARATION

- A. Temperature sensor installation:
 - 1. Secure sensors within formwork before the Engineer's inspection.
 - 2. Protect wiring connected to temperature sensors cast into concrete to prevent movement.
 - 3. Keep wire runs as short as possible.
 - 4. Do not allow ends of temperature sensors to come into contact with supports concrete forms or reinforcing bars.
 - 5. Do not secure sensors to reinforcing at lap splices or other areas of reinforcing congestion identified by the Engineer.

3.02 INSTALLATION

- A. Concrete placement:
 - 1. As specified in Section 03_30_00 - Cast-in-Place Concrete, except as modified in this Section.
 - 2. Preheat previously placed adjacent concrete to temperature above freezing.
 - 3. Do not place non-mass concrete with mass concrete.
 - 4. Do not place non-mass concrete until after thermal control period for adjoining mass concrete is complete.
- B. Curing concrete:
 - 1. Water cure or plastic membrane cure as specified in Section 03_30_00 - Cast-in-Place Concrete as soon as possible following placement of concrete.
 - a. If water curing is used, use methods that minimize differential temperature between curing water and concrete.
 - b. Consider type of curing in the thermal control plan.
 - 2. Cold weather concreting:
 - a. As specified in Section 03_30_00 - Cast-in-Place Concrete, except do not use steam or other concrete heating methods that will increase concrete temperature outside range as specified in this Section.

3. Hot weather concreting:
 - a. As specified in Section 03_30_00 - Cast-in-Place Concrete.
 - b. Use fog sprayers to reduce ambient air temperature and increase humidity during concrete placement.
- C. Insulation:
 1. If insulation is required by the thermal control plan, install insulation on the following during the thermal control period:
 - a. Formed surfaces.
 - b. Finished surface such as top of slabs.
 - c. Temporary surfaces such as construction joints.
 - d. Reinforcing bars protruding from concrete placements.
 - e. Steel braces and catwalk supports attached to formwork.
 - f. Pipes protruding from concrete placement.
 - g. Conduits protruding from concrete placement.
 - h. Minimum of 3 feet past concrete placement onto previously placed adjacent concrete.
 - i. Other items protruding from concrete that would contribute to heat loss from concrete.
 2. Install insulation blankets on complete area of formwork that extends past concrete placement.
 - a. Install insulation blankets tightly against formwork to prevent air movement between insulating blankets and forms.
 - b. Install insulation on formwork before placing mass concrete.
 3. Install insulation on finished surfaces when:
 - a. Finishing is complete.
 - b. Concrete has sufficient strength to prevent damage due to installation of insulation.
 - c. Before excessive temperature differential develops.
 4. Protruding reinforcing bars, conduits, and pipes:
 - a. For 1-inch diameter, or minimum dimension, and smaller, insulate for minimum of 3 feet from face of concrete placement.
 - b. For diameter, or minimum dimension, greater than 1 inch, insulate for minimum of 6 feet from face of concrete placement.
 - c. Use insulation with R-value equal to or greater than required for adjacent surface of concrete placement.
 - d. Install insulation before placing mass concrete.
 5. Insulation shall remain in place until end of the thermal control period.
- D. Cold weather concreting:
 1. As specified in Section 03_30_00 - Cast-in-Place Concrete, except do not use steam or other concrete heating methods that will increase concrete temperature outside range as specified in this Section.
- E. Hot weather concreting:
 1. As specified in Section 03_30_00 - Cast-in-Place Concrete.
 2. Use fog sprayers to reduce ambient air temperature and increase humidity during concrete placement.

3.03 FIELD QUALITY CONTROL

- A. Provide quality control over the Work of this Section as required by Section 01_45_00 - Quality Control.
- B. Temperature monitoring program:
 - 1. Use temperature monitoring system to measure concrete temperatures in interior and near surface of concrete.
 - 2. Continuously monitor temperature of the interior of the concrete and surfaces of concrete during temperature control period.
 - 3. Temperature monitoring data not conforming to requirements of this Section:
 - a. Stop placing concrete.
 - b. Concrete not conforming to temperature requirements of this Section will be rejected. Remove rejected concrete at the Contractor's expense.
 - c. Modify the thermal control plan and calculations to correct problem and resubmit.
 - d. Do not place concrete until revised thermal control plan and calculations have been submitted and accepted by the Engineer.
- C. Concrete placement temperatures:
 - 1. Measure and record concrete temperature at point of placement.
- D. Reporting:
 - 1. If monitoring indicates that the maximum concrete temperature or the maximum concrete differential temperature exceed the limits of this Specification, notify the Engineer within 24 hours.
 - 2. After the temperature control period is complete, submit the temperature record for each placement to the Engineer for Project files within 14 calendar days.

END OF SECTION

SECTION 04_05_17

MORTAR AND MASONRY GROUT

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Mortar and grout for masonry construction.

1.02 REFERENCES

- A. ASTM International (ASTM):
 - 1. C143 - Standard Test Method for Slump of Hydraulic-Cement Concrete.
 - 2. C144 - Standard Specification for Aggregate for Masonry Mortar.
 - 3. C150 - Standard Specification for Portland Cement.
 - 4. C207 - Standard Specification for Hydrated Lime for Masonry Purposes.
 - 5. C270 - Standard Specification for Mortar for Unit Masonry.
 - 6. C404 - Standard Specification for Aggregates for Masonry Grout.
 - 7. C476 - Standard Specification for Grout for Masonry.
 - 8. C595 - Standard Specification for Blended Hydraulic Cements.
 - 9. C780 - Standard Test Method for Preconstruction and Construction Evaluation of Mortars for Plain and Reinforced Unit Masonry.
 - 10. C1019 - Standard Test Method for Sampling and Testing Grout.
 - 11. C1384 - Standard Specification for Admixtures for Masonry Mortars.
 - 12. C1586 - Standard Guide for Quality Assurance of Mortars.
 - 13. C1714 - Standard Specification for Preblended Dry Mortar Mix for Unit Masonry.

1.03 TERMINOLOGY

- A. The words and terms listed below are not defined terms that require initial capital letters, but, when used in this Section, have the indicated meaning.
 - 1. Alkali: Sum of sodium oxide and potassium oxide calculated as sodium oxide.

1.04 SUBMITTALS

- A. Furnish Submittals as specified in Section 01_33_00 - Submittal Procedures.
- B. Product data:
 - 1. Submit data completely describing products and demonstrating compliance with the requirements specified in this Section.
 - 2. Data for products in the mix for mortar and masonry grout shall be submitted concurrently with that mix design.
 - 3. Admixtures:
 - a. For each admixture included in mixes, submit the manufacturer's product data demonstrating compliance with standards specified.

- C. Design mixes:
 - 1. Preblended dry packaged mortar.
 - 2. Ready-mix plant-batched grout.
- D. Certificates:
 - 1. Cementitious materials:
 - a. Certification that portland cement complies with ASTM C150 or blended cement complies with ASTM C595.
 - 2. Aggregates:
 - a. Certification that aggregate for mortar complies with ASTM C144.
 - b. Certification that coarse and fine aggregates for grout complies with ASTM C404.
 - 3. Admixtures:
 - a. Certification of compliance with specified ASTM standard.
 - b. Certification of chloride limits.
- E. Source Quality Control Submittals:
 - 1. Mortar trial batch test results.
 - a. Mortar test results.
 - 2. Grout trial batch test results.
 - a. Grout test results.
- F. Field Quality Control Submittals:
 - 1. Truck batch tickets for each load of grout delivered to the Site, whether accepted or rejected.
 - 2. Mortar test results.
 - 3. Grout test results.

1.05 QUALITY ASSURANCE

- A. Pre-installation meetings: As specified in Section 04_22_00 - Concrete Unit Masonry.
- B. Materials for mortar and grout: Do not change source of materials which will affect the appearance of finished work after the work has started unless acceptable to the Engineer.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. As specified in Section 01_60_01 - Product Requirements and the manufacturer's instructions.
- B. Packing and shipping:
 - 1. Deliver, store, and handle materials in a manner that prevents damage and inclusion of foreign substances.
 - 2. Deliver and store packaged materials in original containers until ready for use.
 - 3. Deliver aggregate to the mixing site and handle in such manner that variations in moisture content will not interfere with steady production of mortar and grout of specified degree of uniformity and slump.

- C. Acceptance at Site:
 - 1. Reject material containers or materials showing evidence of water or other damage.
 - 2. Do not accept or incorporate into the work mortar and grout that does not comply with the specified requirements for water content or slump.

1.07 PROJECT OR SITE CONDITIONS

- A. As specified in Section 01_81_50 - Design Criteria.
- B. Environmental requirements:
 - 1. Cold weather:
 - a. Cold weather construction: In accordance with the building code as specified in Section 01_41_00 - Regulatory Requirements.
 - b. Provide adequate equipment for heating mortar and grout materials when air temperature is below 40 degrees Fahrenheit.
 - 1) Temperatures of separate materials, including water, shall not exceed 140 degrees Fahrenheit when placed in mixer.
 - 2) Maintain mortar temperature on boards above freezing.
 - 2. Hot weather:
 - a. Wet mortar board before loading and cover mortar to retard drying when not being used.

PART 2 PRODUCTS

2.01 GENERAL

- A. As specified in Section 01_60_01 - Product Requirements.
- B. Provide mortar and grout with a homogeneous mixture that, when cured and hardened, will have required strength, watertightness, and durability.

2.02 MATERIALS

- A. Water:
 - 1. For mortar and grout mixes and for washing aggregate: Clean and free from oil and deleterious amounts of alkali, acid, organic matter, or other substances from a municipal potable water source.
- B. Cementitious material:
 - 1. Portland cement: Type II, in accordance with ASTM C150.
 - 2. Blended cement: Type IL in accordance with ASTM C595.
- C. Hydrated lime:
 - 1. Type S in accordance with ASTM C207.
- D. Aggregate for mortar:
 - 1. Fine aggregate: Sand in accordance with ASTM C144.

- E. Aggregate for grout:
 - 1. Fine aggregate: Size No. 2 in accordance with ASTM C404.
 - 2. Coarse aggregate: Size No. 8 in accordance with ASTM C404.
- F. Admixtures:
 - 1. Do not include admixtures, other than those specified, unless written acceptance has been obtained from the Engineer during Submittal of mix designs.
 - 2. Compatible with mortar or grout constituents and with other admixtures.
 - 3. All admixtures in a given mix, except mortar color admixture, shall be products of the same manufacturer to ensure compatibility.
 - a. Manufacturers: One of the following or equal.
 - 1) Euclid Chemical.
 - 2) GCP Applied Technologies (formerly W.R. Grace).
 - 3) Master Builders Solutions/Sika.
 - 4. Mortar water repellent admixture:
 - a. In accordance with ASTM C1384.
 - b. Containing workability agents that improve water repellency and bond to concrete products manufactured with integral water repellent.
 - c. Compatible with the masonry product to which it will bond.
 - d. Shall not contribute more than 65 parts per million (ppm) water soluble chloride or 90 ppm acid soluble chloride to the grout.
 - 5. Other admixtures:
 - a. Prohibited, unless accepted by the Engineer.
- G. Other materials:
 - 1. Prohibited, unless acceptable to the Engineer.

2.03 MIXES

- A. Masonry mortar mix: Cement-lime mortar shall be furnished as a preblended dry packaged product as follows:
 - 1. Preblended dry packaged mortar:
 - a. Provide a mix of dry aggregate, cement, and hydrated lime proportioned to achieve the following property requirements of Type S cement-lime mortar in accordance with ASTM C270.
 - 1) Minimum average compressive strength at 28 days: 1,800 psi.
 - 2) Minimum water retention: 75 percent.
 - 3) Maximum air content: 12 percent.
 - b. Preblended mortar shall be thoroughly blended at a factory in accordance with ASTM C1714 and delivered in individual packages not exceeding 100 pounds.
 - c. Packages delivered to the Site with damage that allow loss of the dry contents shall not be incorporated into the work and shall be removed from the Site.

- B. Grout mix: Grout shall be furnished batched at a ready-mixed plant and delivered to the Site as follows.
 - 1. Ready-mix plant-batched grout:
 - a. Furnish fine or coarse conventional masonry grout as specified in this Section containing aggregates, cement, and water produced in accordance with ASTM C476.
 - b. Grout shall achieve a compressive strength of 2,000 psi at 28 days when tested in accordance with ASTM C1019.
 - c. Slump: 8 to 11 inches when tested in accordance with ASTM C143, unless otherwise accepted by the Engineer.

2.04 SOURCE QUALITY CONTROL

- A. Tests:
 - 1. Trial batches:
 - a. Have trial batches of preblended dry packaged mortar and grout prepared by a testing laboratory acceptable to the Engineer.
 - b. Prepare trial batches with sufficient quantity to determine strength, slump, workability, and consistency and to provide sufficient material for tests.
 - 2. Mortar trial batch testing:
 - a. Source testing of preblended dry packaged mortar to confirm property specifications shall disclose the materials and volumetric proportions in accordance with ASTM C1586, section 5.2.
 - b. Aggregate ratio test of mortar: In accordance with ASTM C780, Annex A4, by a testing laboratory acceptable to the Engineer.
 - c. Cost of tests and trial batches shall be paid by the Contractor.
 - 3. Grout trial batch testing:
 - a. Compressive strength testing: In accordance with ASTM C1019 by a testing laboratory acceptable to the Engineer.
 - b. Cost of tests and trial batches shall be paid by the Contractor.

PART 3 EXECUTION

3.01 MIXING AND TRANSPORTING

- A. Mortar mixing:
 - 1. General:
 - a. Mix on jobsite in accordance with ASTM C270.
 - b. Mix in mechanical mixer and only in quantities needed for immediate use. Do not exceed the rated capacity of the mechanical mixer.
 - c. Mix for minimum 3 minutes, and maximum of 5 minutes after materials have been added to mixer.
 - d. Water shall be mixed with the dry ingredients in sufficient amount to provide a workable mixture which will adhere to the surfaces of masonry units.
 - e. Whenever 90 minutes has elapsed since last batch was mixed, completely empty mixer drum of materials and wash down before placing next batch of materials.
 - f. Use no mortar which has been standing for more than 1 hour after being mixed.

2. Site-batched mortar:
 - a. Measurement by volume: Measurement of constituents shall be accomplished by the use of a container of known capacity.
 - 1) Counting shovels of constituents into the mixer is not considered use of a container of a known capacity.
 3. Preblended dry packaged mortar:
 - a. Mix only full packages of preblended mortar. Do not mix partial packages.
 - b. Add no other materials, including admixtures, to preblended mortar, except water.
- B. Grout mixing:
1. Ready-mix plant-batched grout:
 - a. Mix masonry grout in a ready mix batch plant in accordance with ASTM C476.
 - b. Upon delivery to the Site, furnish to the Engineer a delivery ticket for each batch of grout within 24 hours after delivery. Include the following information on each ticket:
 - 1) Time of day grout was batched, and time of day that discharge from the truck is complete.
 - 2) Printed record of the individual weight of each of the following constituents in the batch: Fine aggregate, coarse aggregate, cement, admixture, and water.
 - 3) Type of grout specified in Part 2 of this Section.
 - 4) Type, brand, and quantity of each admixture in the batch.
 - 5) Volume of grout delivered in the batch.
 - 6) Numerical sequence of the batch delivered for that placement.
 - c. Addition of admixtures in the field is not permitted.
 - d. Maximum time to placement of grout remains 90 minutes after water is initially added to the mix, not 90 minutes after any field additions or adjustments.
- C. Conveying mortar and masonry grout:
1. Convey from mixer to location of final use by methods that prevent separation or loss of materials.
 2. Use equipment for chutes, pumps, and conveying of mortar and grout of such size and design as to ensure practically continuous flow, from mixer to the point of placement, without separation of materials.
 3. Keep equipment for conveying mortar and grout thoroughly clean by washing and scraping upon completion of any day's placement.

3.02 INSTALLATION

- A. Use coarse grout for hollow cell masonry units with minimum 4-inch cell dimensions in both horizontal directions.
1. Calculate cell dimension for this criterion by subtracting diameter(s) of any horizontal reinforcement crossing the cell from clear cell dimensions of the masonry unit.

3.03 FIELD QUALITY CONTROL

- A. Provide field quality control over the Work of this Section as specified in Section 01_45_17 - Contractor Quality Control Plan.
- B. Field quality control by Contractor:
 - 1. During progress of construction, provide testing to determine whether the mortar and masonry grout, as being produced, complies with requirements specified.
 - a. Cooperate in testing by allowing free access to the Work for testing laboratory to sample and test materials.
 - b. Provide full access for the Engineer to observe sampling and testing at any time.
 - 2. Sampling and testing shall be performed by the Contractor's testing laboratory. Requirements as specified in Section 01_45_24 - Regulatory Quality Assurance - Special Tests and Inspections.
 - 3. Provide full access for the Engineer to observe sampling and testing at any time.
 - 4. Include the following, as specified in this Section and Section 01_45_24 - Regulatory Quality Assurance.
 - a. Sampling of mortar in accordance with ASTM C780.
 - b. Sampling of grout in accordance with ASTM C1019.
 - c. Test mortar and grout at the following intervals:
 - 1) At the beginning of each placement.
 - 2) At least 2 test specimens of grout and mortar will be made per week.
 - 3) When there is reason to suspect there is a change in materials or performance of the mix.
 - 4) When requested to do so by the Engineer.
 - d. Field testing:
 - 1) Mortar testing:
 - a) Aggregate ratio testing: In accordance with ASTM C780, Annex A4.
 - 2) Grout testing:
 - a) Compressive strength testing: In accordance with ASTM C1019.
 - b) Slump test: In accordance with ASTM C143.
 - 5. Do not use grout and mortar that does not meet specification.
 - a. Remove such mortar and grout from the Project Site.
 - 6. Assume responsibility for care of and providing proper curing conditions for test specimens.
- C. Field quality control by Owner:
 - 1. As specified in Section 01_45_24 - Regulatory Quality Assurance, and as indicated on the Drawings.

3.04 ADJUSTING

- A. Repair of defective masonry:
 - 1. Remove and replace or repair defective work.
 - 2. Do not patch, repair, or cover defective work without inspection by the Engineer.
 - 3. Provide repairs having strength equal to or greater than specified strength for areas involved.

END OF SECTION

SECTION 04_05_18

ADHESIVE BONDING REINFORCING BARS AND ALL THREAD RODS IN MASONRY

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Bonding reinforcing bars and all thread rods in masonry using injectable, 2 component adhesive.

1.02 REFERENCES

- A. American National Standards Institute (ANSI):
 - 1. B212.15 - Cutting Tools - Carbide-Tipped Masonry Drills and Blanks for Carbide-Tipped Masonry Drills.
- B. ICC Evaluation Service, Inc. (ICC-ES):
 - 1. AC58 - Acceptance Criteria for Adhesive Anchors in Masonry Elements.
- C. Society for Protective Coatings (SSPC):
 - 1. Surface Preparation Standards (SP).
 - a. SP-1 - Solvent Cleaning.

1.03 TERMINOLOGY

- A. The words and terms listed below are not defined terms that require initial capital letters, but, when used in this Section, have the indicated meaning.
 - 1. Evaluation Report: Prepared by ICC-ES, or by other testing agency acceptable to the Engineer and to the Authority Having Jurisdiction, that documents testing and review of the adhesive product to confirm that it conforms to the requirements of ICC-ES AC58.

1.04 SUBMITTALS

- A. Furnish Submittals as specified in Section 01_33_00 - Submittal Procedures and Section 01_60_01 - Product Requirements.
- B. Product data: Furnish technical data for adhesives, including:
 - 1. Independent testing laboratory results indicating allowable loads in tension and shear for masonry walls of the types included in the Work, with load modification factors for temperature, spacing, edge distance, and other installation variables.
 - 2. Handling and storage instructions.
 - 3. Installation instructions.

- C. Quality Control Submittals:
 - 1. Special inspection: Detailed instructions for special inspection to comply with the building code specified in Section 01_41_00 - Regulatory Requirements and as required by the Evaluation Report for each product.
 - 2. Evaluation Report confirming that the product complies with the requirements of ICC-ES AC58.

1.05 DELIVERY, STORAGE, AND HANDLING

- A. As specified in Section 01_60_01 - Product Requirements and the manufacturer's instructions.
- B. Store and protect as follows, unless the manufacturer has more stringent requirements:
 - 1. Store adhesive components on pallets or shelving in a covered-storage area protected from weather.
 - 2. Control temperature to maintain storage within the manufacturer's recommended temperature range.
 - a. If products are stored at temperatures outside the manufacturer's recommended range, test components prior to use by methods acceptable to the Engineer to determine if the products still meet specified requirements.
 - 3. Dispose of products that have passed their expiration date.

1.06 PROJECT OR SITE CONDITIONS

- A. As specified in Section 01_81_50 - Design Criteria.
- B. Seismic design category (SDC) for structures: As specified in Section 01_81_50 - Design Criteria.

PART 2 PRODUCTS

2.01 GENERAL

- A. Like items of materials: Use end products of one manufacturer to achieve structural compatibility and single-source responsibility.

2.02 ADHESIVE FOR SELF-CONTAINED CARTRIDGE SYSTEM

- A. Shall have a current Evaluation Report demonstrating compliance with the requirements of ICC-ES AC58.
- B. Materials:
 - 1. 2-component structural adhesive, insensitive to moisture, and gray in color.
 - 2. Cure temperature, pot life, and workability: Compatible with intended use and environmental conditions.

- C. Packaging:
 - 1. Furnished in disposable, side-by-side cartridges with resin and hardener components isolated until mixing through manufacturer's static mixing nozzle.
 - a. Nozzle designed to thoroughly blend the components, in the proper mixing ratio, for injection from the nozzle directly into prepared hole.
 - b. Provide nozzle extensions as required to allow full-depth insertion and filling from the bottom of the hole.
 - 2. Container markings: Include manufacturer's name, product name, batch number, mix ratio by volume, product expiration date, ANSI hazard classification, and appropriate ANSI handling precautions.
- D. For installation in solid masonry and solid-grouted masonry (concrete or brick):
 - 1. Manufacturers: One of the following or equal:
 - a. Hilti, Inc., HY-270 Adhesive Anchor System.
 - b. Simpson Strong-Tie Co., Inc., ET-HP Anchoring Adhesive.
 - c. USP Structural Connectors, CIA-GEL 7000 Masonry Epoxy Adhesive.

2.03 ALL THREAD RODS

- A. As specified in Section 05_12_00 - Structural Steel Framing.

2.04 REINFORCING BARS

- A. As specified in Section 04_05_23 - Masonry Accessories.

2.05 REPAIR MATERIALS

- A. Dry-pack mortar: As specified in Section 03_35_29 - Concrete Finishes.
- B. Epoxy grout: As specified in Section 03_60_00 - Grouting.

PART 3 EXECUTION

3.01 GENERAL

- A. Unless otherwise required for "Conditions of Use" in the Evaluation Report submitted, prepare and install holes, adhesive, and inserts (all thread rods or reinforcing bars) in accordance with the manufacturer's recommendations and this Section.
 - 1. In the event of conflicts, the more restrictive provisions shall govern.
- B. Do not install adhesive-bonded all thread rods or reinforcing bars in upwardly inclined and overhead applications.

3.02 PREPARATION

- A. Prior to completing the manufacturer's on-site training specified in this Section, do not:
 - 1. Drill holes for reinforcing bars or all thread rods.
 - 2. Mix or install adhesive in holes.

- B. Review the manufacturer's installation instructions and "Conditions of Use" stipulated in the Evaluation Report before beginning Work.
- C. Confirm that adhesive and substrate receiving adhesive are within the manufacturer's recommended temperature range and will remain so during the cure time for the product.

3.03 HOLE LAYOUT AND INSTALLATION

- A. Drilling holes:
 - 1. Determine location of reinforcing bars or other obstructions with a non-destructive indicator device. Mark locations with on the surface of the masonry using removable construction crayon, or other method acceptable to the Engineer.
 - 2. Do not damage or cut existing reinforcing bars, electrical conduits, or other items embedded in the masonry without prior acceptance by the Engineer.
- B. Hole drilling equipment:
 - 1. Electric or pneumatic rotary impact type.
 - a. Set drill to "rotation only" mode, or to "rotation plus hammer" mode in accordance with the manufacturer's installation instructions and the requirements of the Evaluation Report.
 - 2. Where edge distances are less than 2 inches and "rotation plus hammer" mode is permitted, use lighter impact equipment to prevent micro-cracking and spalling from drilling.
 - 3. Drill bits: Carbide-tipped in accordance with ANSI B212-15.
 - 4. Hollow drill bits with flushing air systems are preferred. Air supplied to hollow drill bits shall be free of oil, water, or other contaminants that will reduce bond.
- C. Hole diameter: As recommend in the manufacturer's installation instructions and the Evaluation Report.
- D. Hole depth: As recommended by the manufacturer's installation instructions to provide minimum effective embedment indicated on the Drawings.
- E. Obstructions in drill path:
 - 1. If an existing reinforcing bar or other obstruction is hit while drilling hole, stop drilling and fill the hole with dry-pack mortar. Relocate the hole to miss the obstruction and drill to the required depth.
 - a. Allow dry-pack mortar to cure to strength equal to that of the surrounding masonry before resuming drilling in that area.
 - b. Epoxy grout may be substituted for dry-pack mortar when acceptable to the Engineer.
 - 2. Avoid drilling an excessive number of adjacent holes that would weaken the structural member and endanger the stability of the structure. Obtain the Engineer's acceptance of distance between abandoned and relocated holes.
 - 3. When existing reinforcing steel is encountered during drilling and when acceptable to the Engineer, enlarge the hole by 1/8 inch, core through the existing reinforcing steel at the larger diameter, and resume drilling at original hole diameter.

- F. Cleaning holes:
1. Insert air nozzle to bottom of hole and blow out loose dust.
 - a. Use compressed air that is free of oil, water, or other contaminants.
 - b. Provide minimum air pressure of 90 pounds per square inch for not less than 4 seconds.
 2. Using a stiff bristle brush of diameter that provides contact around the full perimeter of the hole, vigorously brush the hole to dislodge compacted drilling dust.
 - a. Insert brush to the bottom of the hole and withdraw using a simultaneous twisting motion.
 - b. Repeat at least 4 times.
 3. Repeat the preceding steps as required to remove drilling dust or other material that will reduce bond, and as required by the manufacturer and the Evaluation Report.
 4. Leave prepared hole clean and dry.

3.04 INSTALLATION OF ADHESIVE AND INSERTS

- A. Clean and prepare inserts:
1. Prepare embedded length of reinforcing bars and all thread rods by cleaning to bare metal. Inserts shall be free of oil, grease, paint, dirt, mill scale, rust, or other coatings that will reduce bond.
 2. Solvent-clean prepared reinforcing bars and all thread rods over their embedment length in accordance with SSPC SP-1. Provide an oil and grease-free surface for bonding of adhesive to steel.
- B. Fill holes with adhesive:
1. Solid or solid-grouted masonry:
 - a. Only when dry. Do not fill with adhesive when the hole is filled with water or damp except with written authorization by the Engineer.
 - b. Starting at the bottom of the hole: Before inserting the reinforcing bar or all thread rod.
 - c. Without creating air voids as nozzle is withdrawn.
 - d. Fill with sufficient adhesive so that excess is extruded out of the hole when the reinforcing bar or all thread rod is inserted into the hole.
 - e. Where metal or plastic screens are required for use in masonry (units with hollow cells or holes, and multi-wythe brick walls), fill screen with adhesive and insert into hole in accordance with the manufacturer's recommendations.
- C. Install reinforcing bars and all thread rods:
1. Install to depth, spacing, and locations as indicated on the Drawings.
 2. Insert into hole in accordance with the manufacturer's recommended procedures. Confirm that insert has reached the designated embedment in the hole and that adhesive completely surrounds the embedded portion.
 3. Clean excess adhesive from the mouth of the hole.

- D. Curing and loading:
 - 1. Provide curing conditions recommended by the adhesive manufacturer for the period required to fully cure the adhesive at the actual temperature of the masonry.
 - 2. Do not disturb or load anchors until the manufacturer's recommended cure time has elapsed.

3.05 FIELD QUALITY CONTROL

- A. As specified in Section 01_45_17 - Contractor Quality Control Plan.
- B. Manufacturers' services:
 - 1. Before beginning installation, furnish adhesive manufacturer's representative to conduct on-site training in proper storage and handling of adhesive, drilling and cleaning of holes, and preparation and installation of reinforcing bars and all thread rods.
 - a. Provide notice of training to the Engineer and special inspector not less than 10 working days before training occurs. Engineer and special inspector may attend training sessions.
 - 2. Submit record, signed by the Engineer, listing the Contractor's personnel who completed the training. Only qualified personnel who have completed the manufacturer's on-site training shall perform installations.
 - 3. Do not install holes or adhesive until training is complete.

3.06 FIELD QUALITY ASSURANCE

- A. Owner's representative will provide on-site inspection and field quality assurance.
- B. Special inspection:
 - 1. As specified in Section 01_45_24 - Regulatory Quality Assurance.
 - 2. Unless otherwise indicated on the Drawings or in this Section, provide periodic special inspection as required by the "Conditions of Use" in the Evaluation Report for the product installed.
 - 3. Provide a written record of each inspection using form acceptable to the Engineer and the Authority Having Jurisdiction.
 - 4. Preparation:
 - a. Review Drawings and Specifications for the Work being observed.
 - b. Review the adhesive manufacturer's recommended installation and evaluation report's special inspection procedures.
 - 5. Provide an initial inspection by for each combination of masonry type and reinforcing bar or all thread rod being installed.
 - a. During initial inspection, observe the following for compliance with installation requirements. Furnish report of inspection that includes the following items:
 - 1) Masonry construction: Type and thickness; whether fully or partially grouted; locations and types of voids and holes in units.
 - 2) Environment: Temperature and moisture conditions of masonry base material and work area.

- 3) Holes: Locations, spacing, edge distances; verification of drill bit compliance with ANSI B212.15; cleaning equipment and procedures; cleanliness of hole.
 - a) Before placing adhesive, confirm that depth and preparation of holes conforms to requirements of the Contract Documents, installation recommendations of the manufacturer, and “Conditions of Use” specified in the Evaluation Report.
 - 4) Adhesive: Product manufacturer and name; lot number and expiration date; temperature of product at installation; installation procedures. Note initial set times observed during installation.
 - 5) Embedded reinforcing bars and all thread rods: Material diameter and length; steel grade and/or strength; cleaning and preparation; cleanliness at insertion; minimum effective embedment.
6. Subsequent installations of the same reinforcing bars or threaded rods in the same masonry may be performed without the presence of the special inspector, provided that:
- a. There is no change in the personnel performing the installation, the type or details of the masonry receiving the insert, the adhesive or the reinforcing bars and all thread rods being used. Changes in any of these items shall require a new initial inspection.
 - b. For ongoing installations over a period of time, the special inspector visits the Site at least once per day during each day of installation to observe the Work for compliance with material requirements and installation procedures.

END OF SECTION

SECTION 04_05_23
MASONRY ACCESSORIES

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Anchor bolts.
 - 2. Control joint key.
 - 3. Reinforcing bars.
 - 4. Wire joint reinforcement.
 - 5. Through-wall flashing.
 - 6. Weep holes.

1.02 REFERENCES

- A. American Welding Society (AWS):
 - 1. D1.4 - Structural Welding Code - Reinforcing Steel.
- B. ASTM International (ASTM):
 - 1. A615 - Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement.
 - 2. A641 - Standard Specification for Zinc-Coated (Galvanized) Carbon Steel Wire.
 - 3. A951 - Standard Specification for Masonry Joint Reinforcement.
 - 4. A1064 - Standard Specification for Carbon-Steel Wire and Welded Wire Reinforcement, Plain and Deformed, for Concrete.
 - 5. C549 - Standard Specification for Perlite Loose Fill Insulation.
 - 6. D2000 - Standard Classification System for Rubber Products in Automotive Applications.
 - 7. D2287 - Standard Specification for Nonrigid Vinyl Chloride Polymer and Copolymer Molding and Extrusion Compounds.

1.03 SUBMITTALS

- A. Furnish Submittals as specified in Section 01_33_00 - Submittal Procedures and Section 01_60_01 - Product Requirements.
- B. Reinforcing bars:
 - 1. Changes to reinforcing steel Contract Drawing requirements:
 - a. Indicate in separate letter submitted with Shop Drawings any changes of requirements indicated on the Drawings for reinforcing steel.
 - b. Such changes will not be acceptable unless the Engineer has accepted such changes in writing.

- c. Reinforcement detail drawings:
 - 1) Review of reinforcement Shop Drawings by the Engineer will be limited to general compliance with the Contract Documents.
- d. Welding procedures.

C. Product data.

1.04 DELIVERY, STORAGE, AND HANDLING

- A. As specified in Section 01_60_01 - Product Requirements.
- B. Packing and shipping:
 - 1. Deliver bars bundled and tagged with identifying tags.

PART 2 PRODUCTS

2.01 GENERAL

- A. Drawings contain notes concerning amount of reinforcement and placing, details of reinforcement at wall corners and intersections, and details of extra reinforcement around openings in masonry.

2.02 MANUFACTURED UNITS

- A. Anchor bolts:
 - 1. Cast-in/built-in steel anchors: As specified in Section 05_05_24 - Mechanical Anchoring and Fastening to Concrete and Masonry.
 - a. Includes anchor bolts, anchor rods, deformed bar anchors, and welded studs.
 - 2. Post-installed steel anchors: As specified in Section 05_05_24 - Mechanical Anchoring and Fastening to Concrete and Masonry.
 - a. Includes concrete anchors for concrete masonry, and screw anchors for concrete masonry.
- B. Control joint key: Key of the width and shape as indicated on the Drawings.
 - 1. PVC in accordance with ASTM D2000 or ASTM D2287.
 - 2. Manufacturers: One of the following or equal:
 - a. Hohmann & Barnard, VS Standard.
 - b. Southern Metals and Plastics, No. CJ1.
 - c. Wire-Bond, No. 2901.
- C. Reinforcing bars:
 - 1. Deformed bars in accordance with ASTM A615, Grade 60.
 - 2. Provide reinforcing steel that is of quality specified, free from excessive rust or scale or any defects affecting its usefulness.

- D. Wire joint reinforcement:
1. Single wythe ladder type: In accordance with ASTM A951 with ASTM A1064, 3/16-inch wire side rails and 9-gauge cross ties, sized to suit application, and galvanized in accordance with ASTM A641, Class 1 (minimum 0.1 ounce of zinc per square foot).
 - a. Manufacturers: One of the following or equal:
 - 1) Heckmann Building Products, No. 1100 Ladder Type Wall Reinforcement (9-gauge standard, other diameters special order).
 - 2) Hohmann & Barnard, 220 Ladder Mesh Reinforcement.
 - 3) Wire-Bond, Ladder Type, Series 200.
 2. Ladder type with adjustable veneer anchor: In accordance with ASTM A951 with ASTM A1064, 3/16-inch wire side rails and 9-gauge cross ties with double eye arrangement matched to compatible pintle style veneer anchor, sized to suit application, and galvanized in accordance with ASTM A641, Class 1 (minimum 0.1 ounce of zinc per square foot).
 - a. Manufacturers: One of the following or equal:
 - 1) Heckman Building Products: No. 1300 and No. 263.
 - 2) Hohman & Barnard: 270-2X Ladder Eye-Wire.
 - 3) Wire-Bond: Series 800 Ladder Hook and Eye.
- E. Through-wall flashing:
1. 1-piece, Type 304 stainless steel with pre-formed 1/2-inch hemmed drip edge.
 2. As specified in Section 07_60_00 - Flashing and Sheet Metal for general fabrication and installation requirements.
- F. Weep holes: 3/8-inch cellular drainage structure to fit in head joint of veneer units to promote drainage of the air space cavity.
1. Manufacturers: One of the following or equal:
 - a. Hohmann & Barnard, Quadro-Vent.
 - b. Wire-Bond, #3601 Cell-Vent.
 2. Manufactured of ultraviolet-light resistant polypropylene cellular 3/8 inch thick.
 3. Color selected from the manufacturer's standard colors to most closely match the selected mortar color.
 4. Size shall match the depth and height of the veneer units selected.

2.03 FABRICATION

- A. Reinforcing bars:
1. Cut and bend bars in accordance with the building code specified in Section 01_41_00 - Regulatory Requirements.
 2. Bend bars cold.
 3. Provide bars free from defects, kinks and from bends not indicated on the Drawings.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Reinforcing bars:
 - 1. Verify that bars are new stock free from rust scale, loose mill scale, excessive rust, dirt, oil, and other coatings which adversely affect bonding capacity when placed in the Work.

3.02 PREPARATION

- A. Reinforcing bars:
 - 1. Thoroughly clean any bars that have rust scale, loose mill scale, or thick rust coat.
 - a. Thin coating of red rust resulting from short exposure will not be considered objectionable.
 - 2. Remove concrete or other deleterious coatings from dowels and other projecting bars by wire brushing or sandblasting before bars are embedded in subsequent masonry placement.

3.03 INSTALLATION

- A. Reinforcing bars:
 - 1. No field bending of bars will be allowed.
 - 2. Welding:
 - a. Weld reinforcing bars where indicated on the Drawings or acceptable to the Engineer.
 - b. Perform welding in accordance with AWS D1.4.
 - c. Do not tack weld reinforcing bars.
- B. Placing reinforcing bars:
 - 1. Accurately place bars and adequately secure them in position.
 - 2. Overlap bars at splices as indicated on the Drawings or specified.
 - 3. If not indicated on the Drawings, lap splice bars in masonry in accordance with the building code specified in Section 01_41_00 - Regulatory Requirements.

END OF SECTION

SECTION 04_22_00
CONCRETE UNIT MASONRY

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Concrete masonry units and accessories.

1.02 REFERENCES

- A. ASTM International (ASTM):
 - 1. C90 - Standard Specification for Loadbearing Concrete Masonry Units.
 - 2. C140 - Standard Test Methods for Sampling and Testing Concrete Masonry Units and Related Units.
 - 3. C426 - Standard Test Method for Linear Drying Shrinkage of Concrete Masonry Units.
- B. The Masonry Society (TMS):
 - 1. 602 - Specification for Masonry Structures.

1.03 TERMINOLOGY

- A. The words and terms listed below, are not defined terms that require initial capital letters, but, when used in this Section have the indicated meaning.
 - 1. Grout lift height: The height of grout placed in a single continuous operation within the grout pour height.
 - 2. Grout pour height: Entire height of the masonry to be grouted prior to the construction of additional masonry.
 - 3. Mortar smears: Mortar paste smeared across the permanent masonry construction during construction and absorbed into the masonry pores.
 - 4. Mortar splash: Mortar dropped splashed onto the permanent masonry construction at the base of the wall or off the scaffolding.
 - 5. Mortar stains: Mortar paste left after mortar tags are removed.
 - 6. Mortar tag: Excess mortar between masonry units worked out of the joints during tooling or striking.

1.04 SUBMITTALS

- A. Furnish Submittals as specified in Section 01_33_00 - Submittal Procedures.
- B. Product data:
 - 1. Submit manufacturer's product data for block.
 - 2. Submit manufacturer's product data for proposed cleaning agent.

- C. Shop Drawings:
 - 1. Include elevations of each wall indicating type and layout of units, including type of mortar joints, bond pattern, reinforcing steel, connecting dowels, joint reinforcement, grouted cells, and control joints.
- D. Samples: Include samples of stretcher units in sufficient quantity to illustrate color range.
- E. Test reports:
 - 1. Compressive strength.
 - 2. Linear shrinkage.
 - 3. Moisture content as a percentage of total absorption.
 - 4. Total absorption.
 - 5. Unit weight.
- F. Manufacturer's instructions:
 - 1. Submit printed or written recommendations from the masonry unit manufacturer of the cleaning procedures and cleaning agents appropriate for each type of masonry unit included in the Work.
- G. Quality assurance Submittals:
 - 1. If requested by the Engineer, submit a record of the installer's evidence of qualifications.
 - 2. If requested by the Engineer, submit a record of the masonry cleaner's evidence of qualifications.

1.05 QUALITY ASSURANCE

- A. Qualifications:
 - 1. Installer:
 - a. Mason shall hold an appropriate contractor's license in the state where the Work will be constructed.
 - b. Mason shall have not less than 5 years' experience and completed a minimum of 20 projects, at least 5 of which included the type of masonry units specified for this Work.
 - 2. Masonry cleaner qualifications:
 - a. Shall have not less than 5 years' experience and completed a minimum of 20 projects , at least 5 of which included the type of masonry units specified for this Work.
- B. Mockup:
 - 1. A minimum 2 weeks to starting construction of masonry, construct minimum 4 foot inches by 4 foot inches square mockup.
 - a. Mockup shall be constructed by the mason who will be performing the Work.
 - 2. Intended for use as the project standard of workmanship, construction, quality, appearance, and material selection.
 - 3. Use accepted materials containing each different kind and color of concrete masonry units to illustrate wall design.
 - 4. Constructed by the mason who will be performing the Work.

5. Cleaned with the exact equipment, products, and methods submitted and cleaned by the individual who will perform the Work.
 6. When accepted, mockup will be standard of comparison for remainder of masonry work.
 - a. May be accepted by the Engineer with exceptions that will not be accepted in the final construction.
 - 1) In such cases, those areas of the mockup not accepted will be clearly identified by the Engineer.
 7. When not accepted by the Engineer, construct another mockup.
 8. Upon completion of the Project, dispose of mockups in legal manner at offsite location.
- C. Pre-installation conference: Conduct as specified in Section 01_31_19 - Project Meetings.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. Transport and handle concrete masonry units as required to prevent discoloration, chipping, and breakage.
- B. Store masonry units off the ground in a dry location, covered and protected from absorbing moisture.
 1. Locate storage piles, stacks, and bins to protect materials from heavy traffic.
 2. If masonry units are delivered in shrink-wrapped packaging and condensation develops, remove shrink-wrap packaging.
- C. Remove masonry units that are chipped, cracked, and otherwise defective from jobsite upon discovery.

1.07 ENVIRONMENTAL REQUIREMENTS

- A. Cold weather requirements:
 1. Provide adequate equipment for constructing and protecting masonry when air temperature is:
 - a. Below 40 degrees Fahrenheit as follows:
 - 1) Remove frozen snow and ice from surfaces to receive masonry.
 - 2) Do not use masonry units having visible snow or ice on the surface or containing frozen moisture.
 - 3) Do not lay masonry units that have a temperature of 20 degrees Fahrenheit or below.
 - b. 32 degrees Fahrenheit to 40 degrees Fahrenheit:
 - 1) As required above and as follows:
 - a) Heat aggregates and/or mix water to provide mortar between 40 degrees Fahrenheit and 120 degrees Fahrenheit.
 - b) Heat aggregates and/or mix water to provide grout between 32 degrees Fahrenheit and 120 degrees Fahrenheit.
 - c) Do not heat any constituents above 140 degrees Fahrenheit.
 - d) Protect newly constructed masonry work by covering surfaces with a weatherproof covering for 48 hours after completion.

- c. 25 degrees Fahrenheit to 32 degrees Fahrenheit:
 - 1) As required above and as follows:
 - a) Furnish mortar at point of use above 32 degrees Fahrenheit until immediately prior to incorporation into the Work.
 - b) Heat aggregates and/or mix water to provide grout between 70 degrees Fahrenheit and 120 degrees Fahrenheit until immediately prior to incorporation into the Work.
 - c) Protect newly constructed masonry work by covering surfaces with a weatherproof covering for 48 hours after completion.
- d. 20 degrees Fahrenheit to 25 degrees Fahrenheit:
 - 1) As required above and as follows:
 - a) Heat masonry units and adjoining completed Work to a minimum temperature of 40 degrees Fahrenheit.
 - b) Use enclosures or wind breaks when wind speeds exceed 15 mph.
 - c) Heat masonry to a minimum of 40 degrees Fahrenheit and maintain prior to grouting.
 - d) Protect newly constructed masonry work by covering surfaces with weatherproof, insulating concrete blankets for 48 hours after completion.
- e. Below 20 degrees Fahrenheit:
 - 1) As required above and as follows:
 - a) Provide an auxiliary heated enclosure that maintains the ambient air temperature above 32 degrees Fahrenheit.
 - (1) Heat shall not vent combustion products into the enclosure.
 - (2) Maintain specified temperature for a minimum 48 hours after completion of masonry work.

B. Hot weather requirements:

- 1. Provide adequate equipment for constructing and protecting masonry as follows:
 - a. When the air temperature exceeds 90 degrees Fahrenheit with a wind speed greater than 8 mph, or when the air temperature exceeds 100 degrees Fahrenheit:
 - 1) Maintain sand for mortar and grout in damp, loose piles. Shade material stockpiles and mixing equipment from direct sunlight.
 - 2) Provide mortar and grout below 120 degrees Fahrenheit.
 - 3) Flush mixer and mortar containers with cool water before use.
 - 4) Wet mortarboard before loading and cover mortar to retard drying when not being used.
 - 5) Do not spread mortar beds more than 48 inches ahead of placing masonry units.
 - 6) Place masonry units within 1 minute of spreading mortar.
 - 7) Use mortar within 1 hour of initial mixing.
 - 8) Protect masonry from drying by frequently fogging or sprinkling so walls will always be visibly damp for minimum 3 days.

- b. When the air temperature exceeds 105 degrees Fahrenheit with a wind speed greater than 8 mph, or when the air temperature exceeds 115 degrees Fahrenheit:
 - 1) As required above and as follows:
 - a) Use water less than 70 degrees Fahrenheit to batch mortar and grout. Ice is permitted to precool the mix water but must be fully melted before adding to other constituents.

1.08 SEQUENCING AND SCHEDULING

- A. Order concrete masonry units well before start of installation to ensure adequate time for manufacturing and minimum 28 days for curing and drying before start of installation. Protect from weather after curing period to avoid moisture increase.

PART 2 PRODUCTS

2.01 MANUFACTURED UNITS

- A. Hollow load bearing concrete masonry units:
 - 1. Density classification: Normal weight in accordance with ASTM C90, with minimum net area compressive strength as follows:
 - a. Average of 3 units: 2,000 pounds per square inch.
 - b. Any individual unit: 1,800 pounds per square inch.
 - 2. Surface texture: Precision (smooth face) with dense faces suitable for painting where scheduled to be painted. Split face where left exposed.
 - 3. Color: Integral, natural gray of concrete.
 - 4. Typical size: 12 inches wide by 8 inches high by 16 inches long, and 8 inches wide by 8 inches high by 8 inches long, unless otherwise indicated on the Drawings, or other sizes as needed to minimize cutting.
 - 5. Special sizes and shapes: As required for window and door openings, bond beams, piers, lintels, control joints, and other special applications to minimize cutting.
 - 6. Manufacturers: One of the following or equal:
 - a. Basalite.
- B. Mortar and grout: As specified in Section 04_05_17 - Mortar and Masonry Grout.
- C. Anchor bolts: As specified in Section 05_05_24 - Mechanical Anchoring and Fastening to Concrete and Masonry.
- D. Steel reinforcement: As specified in Section 04_05_23 - Masonry Accessories.
- E. Wall ties: As specified in Section 04_05_23 - Masonry Accessories.

PART 3 EXECUTION

3.01 PREPARATION

- A. Protection:
 - 1. Protect adjacent construction with appropriate means from mortar droppings and other effects of laying of concrete masonry units.
- B. Surface preparation:
 - 1. Thoroughly clean foundations of laitance, grease, oil, mud, dirt, mortar droppings, and other matter that will reduce bond.
 - 2. Examine foundation to confirm it is constructed within tolerance for masonry Work. Confirm dowels are installed in correct locations and with proper projection for the required lap splice before beginning laying masonry units.
 - 3. Place sand, straw, sawdust or other similar material on the floor around the base of walls to protect floors and walls.

3.02 INSTALLATION

- A. General:
 - 1. Standard level of quality: Furnish conventional quality work having no more than 5 percent of the units in the completed Work exhibiting one or more of the following defects:
 - a. Chips larger than 1 inch in any direction.
 - b. Cracks wider than 0.02 inch and longer than 25 percent of the nominal height of the unit.
 - c. Completed Work shall not show chips, cracks, or other imperfections when viewed from a distance of 20 feet under diffused lighting.
- B. Temporary forms and shores:
 - 1. Where required, construct forms to the shapes indicated on the Drawings:
 - a. Construct forms sufficiently rigid to prevent deflection which may result in cracking or other damage to supported masonry and sufficiently tight to prevent leakage of mortar and grout.
 - b. Do not remove supporting forms or shores until the supported masonry has acquired sufficient strength to support safely its weight and any construction loads to which it may be subjected.
 - 1) Wait at least 24 hours after grouting masonry columns or walls before applying uniform loads.
 - 2. Wait at least 72 hours before applying concentrated loads.
- C. Laying of masonry units - General:
 - 1. Lay concrete masonry units dry. Units having wet surfaces over 50 percent or more of its surface area may not be placed. Wet surfaces are distinguished from damp surfaces as those which do not darken when additional water is applied.
 - 2. Lay units in uniform and true courses, level, plumb, and without projections or offset of adjacent units.
 - 3. Lay units to preserve unobstructed vertical continuity of cells to be filled with grout or insulation.

4. When possible, use full units of the proper size in lieu of cut units. Cut units as required to form chases, openings, for anchorage, and for other appurtenances.
 - a. Cut and fit units with power-driven carborundum or diamond disc blade saw.
 5. Align vertical cells to be filled with grout to maintain clear, unobstructed continuous vertical cell measuring not less than 2.5 inches by 3 inches.
 6. Lay concrete masonry units in running bond pattern, unless otherwise indicated on the Drawings.
 7. Where practical, protect completed Work from mortar splash by placing thin plastic sheeting around the base of walls.
- D. Mortar joints:
1. Make joints straight, clean, smooth, and uniform in thickness. Bond shall be plumb throughout.
 2. Make vertical and horizontal joints 3/8 inch thick.
 3. Butter vertical head joints for thickness equal to face shell thickness of units, and shove joints tightly together so that mortar bonds to both masonry units.
 4. Solidly fill joints from face of units to inside face of cells.
 5. Where fresh masonry joins totally or partially set masonry, clean and roughen set masonry before laying new units.
 6. Lay units to avoid formation of cracks when units are placed.
 7. Keep cells of units as free of mortar as possible as masonry wall height increases.
 8. When positions of units shift after mortar has stiffened, bond is broken, or cracks are formed, relay units in new mortar.
 9. Tool exposed joints, slightly concave. Strike concealed joints flush.
- E. Masonry control joints:
1. Provide in masonry walls at locations indicated on the Drawings.
 2. Make full height and continuous in appearance.
 3. Run bond beams and bond beam reinforcing bars continuously through control joints.
 4. Insert control joint filler in joints as wall is constructed.
 5. Apply sealant as specified in Section 07_92_00 - Joint Sealants.
- F. Openings and lintels:
1. Place horizontal reinforcement in fully grouted bond beam units.
 2. Use lintel block units where underside of lintel will be exposed.
 3. Provide minimum of 8-inch bearing at each end of lintel.
 4. Embed reinforcing bars minimum 24 inches or 48-bar diameters, whichever is longer, into wall past edges of openings or as indicated on the Drawings:
 - a. At corners, provide 90-degree bend with equivalent total embedment.
- G. Embedments:
1. Steel door frames:
 - a. Anchor and fully grout jambs and head of steel doorframes connected to concrete unit masonry.
 - b. Fill frames with grout as each 2 feet of concrete unit masonry is laid.
 2. Bearing plates:
 - a. Provide minimum of 12 inches of grouted concrete unit masonry below steel bearing plates and beams bearing on masonry walls.

3. Anchor bolts:
 - a. Hold in place with template during grouting to ensure precise alignment.
 - b. Do not cut or ream members being anchored or use other means to accommodate misaligned anchor bolts in roof deck support angles.
 - c. Provide minimum 6-inch wide grouted concrete unit masonry entirely around anchor bolts and other attachment devices.
 4. Enclosures:
 - a. Where concrete masonry units enclose conduit, pipes, stacks, ducts, and similar items, construct chases, cavities, and similar spaces as required, whether or not such spaces are indicated on the Drawings.
 - b. Point openings around flush mounted electrical outlet boxes with mortar, including flush joints above boxes.
 - c. Do not cover enclosures until inspected and when appropriate, tested.
 5. Conduits and electrical boxes:
 - a. See Drawings for details of conduit installation in masonry.
 6. Other embedded items:
 - a. Build in wall plugs, accessories, flashings, pipe sleeves, and other items required to be built-in as the masonry work progresses.
 7. Miscellaneous:
 8. Build in required items, such as anchors, flashings, sleeves, frames, structural steel, lintels, anchor bolts, and metal fabrications, as required for complete installation.
- H. Daily cleaning:
1. Remove mortar tags and smears daily with a non-metallic tool.
 - a. Removed after they initially set but shall not be permitted to remain more than 24 hours.
 2. Turn scaffold planks over at the end of the workday to avoid mortar splashes from wet weather.
 - a. Cover tops of walls at the end of the workday and other work stoppages to prevent entry of water into the partially completed masonry.
 3. Seal cleanouts after inspection and before grouting.
- I. Grouting and reinforcement:
1. Where horizontal and vertical bars are spliced, the lap splice length shall be in accordance with TMS 602 and as indicated on the Drawings.
 2. Hold vertical reinforcing bars in position at top and bottom and at intervals not exceeding 200-bar diameters.
 - a. Use steel wire bar positioners to position bars.
 - b. Tie reinforcing bars to dowels with wire ties.
 3. Obtain acceptance of reinforcement placement before grouting.
 - a. Grouting:
 - 1) Grout pour height shall be limited to a maximum of 5.33 feet, unless the Contractor submits sufficient evidence to the Engineer for review and acceptance that the requirements of TMS 602 as it relates to grout pour height can be met.
 - 2) Grout lift height shall be limited to a maximum of 5.33 feet, unless the Contractor submits sufficient evidence to the Engineer for review and acceptance that the requirements of TMS 602 as it relates to grout lift height can be met.
 - 3) Slushing with mortar will not be permitted.

- 4) Allow hollow unit masonry to cure at least 24 hours prior to grouting.
 - 5) Each lift shall be allowed to set for 10 minutes after initial consolidation of grout before successive lift is placed.
 - 6) Full height of each section of wall shall be grouted in 1 day.
4. Placement:
- a. Use a hand bucket, concrete hopper, or grout pump.
 - b. Do not pump grout through aluminum tubes.
 - c. Operate pumps to produce a continuous stream of grout without air pockets.
 - d. Upon completion of each day's pumping, eject grout from pipeline without contamination or segregation of the grout. Remove from Site and dispose. Do not incorporate into masonry work.
 - e. Place grout so as to completely fill the grout spaces without segregation of the aggregates.
 - f. Remove grout spills immediately by hand washing with a bucket and brush.
 - g. Fill spaces and cells solidly with grout.
 - h. Grout in cells shall have full contact with surface of concrete footings.
 - i. Time constraints:
 - 1) When grouting stops for 1 hour or longer, form horizontal construction joints by stopping grout placement 1-1/2 inches below top of uppermost unit containing grout.
 - 2) Place grout in final position within 1-1/2 hours after mixing. Place grout so as to completely fill the grout spaces without segregation of the aggregates.
 - j. Consolidation:
 - 1) Standard masonry grout:
 - a) Do not insert vibrators into lower grout placements that are in a semi-solidified state.
 - b) After placement, consolidate grout using mechanical immersion vibrators designed for consolidating grout.
 - c) Maintain at least 1 spare vibrator at the Site at all times.
 - d) Apply vibrators at uniformly spaced points not further apart than the visible effectiveness of the machine.
 - e) Limit duration of vibration to time necessary to produce satisfactory consolidation without causing segregation.
 - f) Reconsolidate grout after initial water loss and settlement has occurred.

3.03 TOLERANCES

- A. Masonry tolerances: Lay masonry plumb, true to line, and with courses level. Keep bond pattern plumb throughout. Lay masonry within the following tolerances:
1. Maximum variation from the plumb in the lines and surfaces of columns, walls, and in the flutes and surfaces of fluted or split faced blocks:
 - a. In adjacent masonry units: 1/8 inch.
 - b. In 10 feet: 1/4 inch.
 - c. In any story or 20 feet maximum: 3/8 inch.
 - d. In 40 feet or more: 1/2 inch.

2. Maximum variations from the level or grades indicated on the Drawings for exposed lintels, sills, parapets, horizontal grooves, and other conspicuous lines:
 - a. In any bay or 10 feet maximum: 1/4 inch.
 - b. In 40 feet or more: 1/2 inch.
3. Maximum variations of the linear building lines from established position in plan and related portion of columns, walls, and partitions:
 - a. In any bay or 20 feet maximum: 1/2 inch.
 - b. In 40 feet or more: 3/4 inch.
4. Maximum variation of top surface of bearing walls from level:
 - a. In any bay or 20 feet maximum: 1/4 inch.
 - b. In 40 feet or more: 1/2 inch.
5. Maximum variation in cross sectional dimensions of columns and in thickness of walls:
 - a. Minus: 1/4 inch.
 - b. Plus: 1/2 inch.
6. Mortar bed joint thickness between masonry courses:
 - a. Plus or minus: 1/8 inch.

3.04 FINAL CLEANING

A. General:

1. Patch exposed concrete masonry units at completion of the Work and in such manner that patching will be indistinguishable from similar surroundings and adjoining construction.
2. Final cleaning shall be performed within 7 to 14 days after construction of masonry work.
3. Protect adjacent materials and equipment that may be damaged by cleaning.
4. Pre-wet masonry before applying cleaning agent but do not saturate masonry.
5. Remove mortar stains, smears, and splash, efflorescence, and grout stains on exposed surfaces with the submitted cleaning agent as directed by the masonry unit manufacturer's recommendations.
6. Do not use muriatic acid as cleaning agent.
7. Cleaning agents shall be applied when the masonry surface and air temperatures are at least 50 degrees Fahrenheit.
 - a. Dilute cleaning agents in accordance with the manufacturer's recommendations.
 - b. Do not allow cleaning agents to dry on the masonry.
8. Clean wall from the top to the bottom, without overlapping areas being cleaned for consistency.
9. If pressure cleaning equipment is used, the following limitations shall be observed:
 - a. Apply cleaning agent to pre-wetted wall with low pressure (less than 50 pounds per square inch).
 - b. Use a 25-degree to 50-degree flared-tip nozzle (not a pointed tip).
 - c. Maintain a consistent distance from the spray nozzle to the masonry surface no closer than 12 inches.
 - 1) Masonry cleaner shall use a combination of pressure, nozzle, and distance from tip to masonry that does not damage the masonry surface.
10. Rinse cleaning agents off the wall with potable water.
11. Dispose of debris, refuse, and surplus material offsite legally.

3.05 FIELD QUALITY CONTROL

- A. Site tests:
 - 1. Owner will have tests performed by an independent laboratory.
 - 2. Have minimum 3 concrete masonry units of each type proposed for the Project tested in accordance with ASTM C90, ASTM C140, and ASTM C426 to verify conformance to Specifications.
 - 3. Tests shall include compressive strength, linear shrinkage, moisture content as percent of total absorption, total absorption, and unit weight.
- B. Special inspection:
 - 1. As specified in Section 01_45_24 - Regulatory Quality Assurance.
 - 2. Owner will employ a qualified masonry special inspector for continuous special inspection of the masonry work.
 - a. Acceptance by a state or municipality having a program of examining and certifying masonry inspectors will be considered adequate qualifications.
 - b. Masonry inspector shall be at the Site during masonry construction and perform the following duties:
 - 1) Review Drawings and Specifications and meet with the Contractor to discuss requirements before Work commences.
 - 2) Before masonry work commences, the Contractor and the Contractor's Quality Control Representative shall attend meeting with the Engineer to review the requirements for surveillance and quality control of the masonry work.
 - 3) Check brand and type of cement, lime (if used), and source of sand.
 - 4) Verify that foundation is clean, rough, and ready to receive units.
 - 5) Check reinforcing steel dowels for correct location, straightness, proper alignment, spacing, size, and length.
 - 6) Observe field proportioning of mortar. Visually check aggregate to determine uniformity of grading, cleanliness, and moisture.
 - 7) Verify that joints are full of mortar and kept tight during Work.
 - a) Inspect grout cells to verify that fins will not interfere with grouting.
 - b) Verify that masons keep grout cells clean of mortar droppings and inspect to determine compliance.
 - 8) Continuously observe placing of grout.
 - 9) Perform or supervise performance of required sampling and testing.
 - 3. Keep complete record of inspections. Report daily to the Building Official, Contractor's Quality Control Representative, Engineer, and Owner the progress of the masonry inspection.

3.06 PROTECTION

- A. Provide temporary protection for exposed masonry corners subject to damage.
- B. Bracing:
 - 1. Unless wall is adequately supported by permanent supporting elements so wall will not overturn or collapse, adequately brace masonry walls over 8 feet in height to prevent overturning and to prevent collapse.
 - 2. Keep bracing in place until permanent supporting elements of structure are in place.

- C. Limited access zone:
1. Establish prior to start of masonry wall construction.
 2. Zone shall be immediately adjacent to wall and equal to height of wall to be constructed plus 4 feet by entire length of wall on unscaffolded side of wall.
 3. Limit access zone to workers actively engaged in constructing wall. Do not permit other persons to enter zone.
 4. Keep zone in place until wall is adequately supported or braced by permanent supporting elements to prevent overturning and collapse.

END OF SECTION

SECTION 05_05_24

MECHANICAL ANCHORING AND FASTENING TO CONCRETE AND MASONRY

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes requirements for:
 - 1. Cast-in anchors and fasteners.
 - 2. Post-installed steel anchors and fasteners.
 - 3. Appurtenances for anchoring and fastening.

1.02 REFERENCES

- A. American Concrete Institute (ACI):
 - 1. 355.2 - Qualification of Post-Installed Mechanical Anchors in Concrete and Commentary.
- B. American National Standards Institute (ANSI):
 - 1. B212.15 - Cutting Tools - Carbide-tipped Masonry Drills and Blanks for Carbide-tipped Masonry Drills.
- C. ASTM International (ASTM):
 - 1. A36 - Standard Specification for Carbon Structural Steel.
 - 2. A53 - Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless.
 - 3. A108 - Standard Specification for Steel Bars, Carbon and Alloy, Cold Finished.
 - 4. A123 - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
 - 5. A153 - Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
 - 6. A240 - Standard Specification for Chromium and Chromium Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications.
 - 7. A380 - Standard Practice for Cleaning, Descaling, and Passivation of Stainless Steel Parts, Equipment, and Systems.
 - 8. B633 - Standard Specification for Electrodeposited Coatings of Zinc on Iron and Steel.
 - 9. F436 - Standard Specification for Hardened Steel Washers.
 - 10. F593 - Standard Specification for Stainless Steel Bolts, Hex Cap Screws and Studs.
 - 11. F594 - Standard Specification for Stainless Steel Nuts.
 - 12. F1554 - Standard Specification for Anchor Bolts, Steel, 36, 55 and 105-ksi Yield Strength.
 - 13. F2329 - Standard Specification for Zinc Coating, Hot-Dip, Requirements for Application to Carbon and Alloy Steel Bolts, Screws, Washers, Nuts, and Special Threaded Fasteners.

- D. International Code Council Evaluation Service, Inc. (ICC-ES):
1. AC193 - Acceptance Criteria for Mechanical Anchors in Concrete Elements.

1.03 TERMINOLOGY

- A. The words and terms listed below are not defined terms that require initial capital letters, but, when used in this Section, have the indicated meaning.
1. Built-in anchor: Headed bolt or assembly installed in position before filling surrounding masonry units with grout.
 2. Cast-in anchor: Headed bolt or assembly installed in position before placing plastic concrete around.
 3. Overhead installations: Fasteners installed on overhead surfaces where the longitudinal axis of the fastener is more than 45 degrees above a horizontal line so the fastener resists sustained tension loads.
 4. Passivation: Chemical treatment of stainless steel with a mild oxidant for the purpose of enhancing the spontaneous formation of the steel's protective passive film.
 5. Post-installed anchor: Fastener or assembly installed in hardened concrete or finished masonry construction, typically by drilling into the structure and inserting a steel anchor assembly.
 6. Terms relating to structures or building environments as used with reference to anchors and fasteners:
 - a. Corrosive locations: Describes interior and exterior locations as follows:
 - 1) Locations used for delivery, storage, transfer, or containment (including spill containment) of chemicals used for plant treatment processes.
 - 2) Exterior and interior locations at the following treatment structures:
 - 3) Source Water Pump Station
 - b. Wet and moist locations: Describes locations, other than "corrosive locations," that are submerged, are immediately above liquid containment structures, or are subject to frequent wetting, splashing, or wash down. Includes:
 - 1) Exterior portions of buildings and structures.
 - 2) Liquid-containing structures:
 - a) Locations at and below the maximum operating liquid surface elevation.
 - b) Locations above the maximum operating liquid surface elevation and:
 - (1) Below the top of the walls containing the liquid.
 - (2) At the inside faces and underside surfaces of a structure enclosing or spanning over the liquid (including walls, roofs, slabs, beams, or walkways enclosing the open top of the structure).
 - 3) Liquid handling equipment:
 - a) Bases of pumps and other equipment that handles liquids.
 - 4) Indoor locations exposed to moisture, splashing, or routine wash down during normal operations, including floors with slopes toward drains or gutters.
 - 5) Other locations indicated on the Drawings.

- c. Other locations:
 - 1) Interior dry areas where the surfaces are not exposed to moisture or humidity in excess of typical local environmental conditions.

1.04 DELEGATED DESIGN

- A. As specified in Section 01_35_73 - Delegated Design Procedures.
- B. Calculations.

1.05 SUBMITTALS

- A. General:
 - 1. Submit as specified in Section 01_33_00 - Submittal Procedures and Section 01_60_01 - Product Requirements.
- B. Product data:
 - 1. Cast-in anchors:
 - a. Manufacturer's data, including catalog cuts showing anchor sizes and configuration, materials, and finishes.
 - 2. Post-installed anchors:
 - a. For each anchor type, manufacturer's data, including catalog cuts showing anchor sizes and construction, materials and finishes, and load ratings.
- C. Delegated Design Submittals:
 - 1. When requesting product substitutions for post installed anchors, submit calculations, indicating the diameter, effective embedment depth and spacing of the proposed anchors, and demonstrating that the substituted product will provide load resistance that is equal to or greater than that provided by the anchors listed in this Section.
- D. Samples:
 - 1. Samples of each type of anchor, including representative diameters and lengths, if requested by the Engineer.
- E. Certificates:
 - 1. Cast-in anchors:
 - a. Mill certificates for steel anchors that will be supplied to the Site.
 - 2. Post-installed anchors:
 - a. Manufacturer's statement or certified test reports demonstrating that anchors that will be supplied to the Site comply with the materials properties specified.
- F. Test reports:
 - 1. Post-installed anchors: For each anchor type used for the Work:
 - a. Current ICC-ES report (ESR demonstrating):
 - 1) Acceptance of that anchor for use under the building code specified in Section 01_41_00 - Regulatory Requirements.

- G. Manufacturer's instructions:
 - 1. Requirements for storage and handling.
 - 2. Recommended installation procedures, including details on drilling, hole size (diameter and depth), hole cleaning and preparation procedures, anchor insertion, and anchor tightening.
 - 3. Requirements for inspection or observation during installation.
- H. Qualification statements:
 - 1. Post-installed anchors: Installer qualifications:
 - a. Submit list of personnel performing installations. Include letter of training from manufacturer indicating date of manufacturer's training for each installer.

1.06 QUALITY ASSURANCE

- A. Qualifications:
 - 1. Post installed anchors shall be in accordance with building code specified in Section 01_41_00 - Regulatory Requirements.
- B. Special inspection:
 - 1. Provide special inspection of post-installed anchors as specified in Section 01_45_24 - Regulatory Quality Assurance and this Section.

1.07 DELIVERY, STORAGE, AND HANDLING

- A. As specified in Section 01_60_01 - Product Requirements.
- B. Deliver post-installed anchors in manufacturer's standard packaging with labels visible and intact. Include manufacturer's installation instructions.
- C. Handle and store anchors and fasteners in accordance with manufacturer's recommendations and as required to prevent damage.
- D. Protect anchors from weather and moisture until installation.

1.08 PROJECT OR SITE CONDITIONS

- A. As specified in Section 01_81_50 - Design Criteria.
- B. Seismic Design Category (SDC) for structures is indicated on the Drawings.

PART 2 PRODUCTS

2.01 MANUFACTURED UNITS

- A. General:
 - 1. Furnish threaded fasteners with flat washers and hex nuts fabricated from materials corresponding to the material used for threaded portion of the anchor.
 - a. Cast-in anchors: Provide flat washers and nuts as listed in the ASTM standard for the anchor materials specified.
 - b. Post-installed anchors: Provide flat washers and nuts supplied for that product by the manufacturer of each anchor.
 - 2. Size of anchors and fasteners, including diameter and length or minimum effective embedment depth: As indicated on the Drawings or as specified in this Section. In the event of conflicts, contact the Engineer for clarification.
 - 3. Where anchors and connections are not specifically indicated on the Drawings or specified, their material, size and form shall be equivalent in quality and workmanship to items specified.
- B. Materials:
 - 1. Provide and install anchors of materials as specified in this Section.

2.02 CAST-IN ANCHORS AND FASTENERS

- A. Anchor bolts:
 - 1. Straight steel rod having one end with an integrally forged head, and one threaded end. Embedded into concrete with the headed end cast into concrete at the effective embedment depth indicated on the Drawings or specified, and with the threaded end left to project clear of concrete face as required for the connection to be made.
 - 2. Furnish anchor bolts with heavy hex forged head or equivalent acceptable to the Engineer.
 - a. Rods or bars with angle bend for embedment in concrete (i.e., "L" or "J" shaped anchor bolts) are not permitted in the Work.
 - 3. Materials:
 - a. Ship anchor bolts with properly fitting nuts attached.
 - b. Type 316 stainless steel:
 - 1) Bolts: ASTM F593, Group 2, Condition CW, coarse threads.
 - 2) Nuts: ASTM F594. Match alloy (group and UNS designation) and threads of bolts.
 - 3) Washers: Type 316 stainless steel.
 - c. Galvanized steel:
 - 1) Hot-dip galvanized coating in accordance with ASTM F2329.
 - 2) Bolts: ASTM F1554, Grade 36 heavy hex, coarse thread.
 - 3) Nuts: ASTM A563, Grade A, heavy hex, threads to match bolt.
 - 4) Washers: ASTM F436, Type 1.

2.03 POST-INSTALLED ANCHORS AND FASTENERS - ADHESIVE

- A. Epoxy bonding of reinforcing bars, all thread rods, and threaded inserts in concrete: As specified in Section 03_21_17 - Adhesive-Bonded Reinforcing Bars and All Thread Rods in Concrete.

- B. Epoxy bonding of reinforcing bars, all thread rods, and threaded inserts in masonry:
As specified in Section 04_05_18 - Adhesive Bonding Reinforcing Bars and All Thread Rods in Masonry.

2.04 POST-INSTALLED ANCHORS AND FASTENERS - MECHANICAL

A. General:

1. Post-installed anchors shall hold a current ICC Evaluation Service report demonstrating acceptance for use under the building code specified in Section 01_41_00 - Regulatory Requirements.
 - a. Acceptance report shall indicate acceptance of the product for use under the following conditions:
 - 1) In regions of concrete where cracking has occurred or may occur.
 - 2) To resist short-term loads due to wind forces.
 - 3) To resist short-term loading due to seismic forces for the Seismic Design Category of the structure where the product will be used.

B. Concrete anchors:

1. Post-installed anchor assembly consisting of a threaded stud and a surrounding wedge expansion sleeve that is forced outward by torquing the center stud to transfer loads from the stud to the concrete through bearing, friction, or both. Sometimes referred to as “expansion anchors” or “wedge anchors”:
 - a. Do not use slug-in, lead cinch, and similar systems relying on deformation of lead alloy or similar materials to develop holding power.
2. Concrete expansion bolts for anchorage to concrete:
 - a. Shall have a current ICC-ES report demonstrating that the anchors have been tested and qualified for performance in both cracked and un-cracked concrete, and for short-term loading due to wind and seismic forces for Seismic Design Categories A through F in accordance with ACI 355.2 and with ICC-ES AC193 (including all mandatory tests and optional tests for seismic tension and shear in cracked concrete).
 - b. Performance in the current ICC-ES report shall be “Category 1” as defined in ACI 355.2.
 - c. Manufacturers: One of the following:
 - 1) Hilti, Kwik Bolt TZ2 Wedge Anchor.
 - 2) Simpson Strong-Tie, Strong-Bolt 2 Wedge Anchor.
 - d. Materials. Integrally threaded stud, wedge, washer, and nut:
 - 1) Stainless steel: Type 316.
 - 2) Galvanized: Carbon steel, zinc plated in accordance with ASTM B633, minimum 5 microns (Fe/Zn 5).
3. Concrete anchors for anchorage to concrete masonry (fully grouted cells):
 - a. Shall have a current ICC-ES report demonstrating that the anchors have been tested and qualified in accordance with ICC-ES AC01, including all mandatory tests and optional seismic tests.
 - b. Manufacturers: One of the following or equal:
 - 1) DEWALT/Powers, Power-Stud+ SD1.
 - 2) Hilti, Kwik TZ2 Wedge Anchor.
 - 3) Simpson Strong-Tie, Strong-Bolt 2 Wedge Anchor.

- c. Materials. Integrally threaded stud, wedge, washer, and nut:
 - 1) Stainless steel: Type 316.
 - 2) Galvanized: Carbon steel, zinc plated in accordance with ASTM B633, minimum 5 microns (Fe/Zn 5) or mechanically galvanized in accordance with ASTM B695, Class 55, Type 1.
- C. Flush shells:
 - 1. Post-installed anchor assembly consisting of an internally threaded mandrel that is forced into a pre-drilled concrete hole with a setting tool until the top of the anchor is flush with the face of the concrete. Once installed, a removable threaded bolt is installed in the mandrel.
 - 2. Flush shell anchors are not permitted in the Work.

2.05 APPURTENANCES FOR ANCHORING AND FASTENING

- A. Anchor bolt sleeves:
 - 1. Fabricated steel sleeves:
 - a. Construct as specified in Section 05_50_00 - Metal Fabrications.
 - b. Fabricate to the following dimensions unless otherwise indicated on the Drawings:
 - 1) Inside diameter: At least 2 inches greater than bolt diameter.
 - 2) Inside length: Not less than 10-bolt diameters.
 - 3) Bottom plate:
 - a) Square plate with dimensions equal to the outside diameter of the sleeve plus 1/2 inch each side.
 - b) Thickness equal to or greater than one-half of the anchor bolt diameter.
 - c. Carbon steel:
 - 1) Fabricated from ASTM A36 plate and ASTM A53, Grade B pipe.
 - 2) Welded connections: Conform to requirements of AWS D1.1.
 - 3) Hot dip galvanized in accordance with ASTM A153.
 - d. Stainless steel:
 - 1) Fabricated from ASTM A240 plate and pipe. Type 304L or Type 316L to match type of the anchor bolt.
 - 2) Welded connections: In accordance with AWS D1.6.
- B. Isolating sleeves and washers:
 - 1. Manufacturers: One of the following or equal:
 - a. Allied Corrosion Industries.
 - b. Central Plastics Co.
 - 2. Sleeves: Mylar, 1/32-inch thick, 4,000 volts per mil dielectric strength, of proper size to fit bolts and extending half way into both steel washers.
 - 3. One sleeve required for each bolt.
 - 4. Washers: Inside diameter of washers shall fit over the isolating sleeve, and both the steel and isolating washers shall have the same inside diameter and outside diameter.
 - a. Proper size to fit bolts.
 - b. Two 1/8-inch-thick steel washers for each bolt.
 - c. G3 Phenolic: 2 insulating washers are required for each bolt:
 - 1) Thickness: 1/8 inch.
 - 2) Base material: Glass.

- 3) Resin: Phenolic.
 - 4) Water absorption: 2 percent.
 - 5) Hardness (Rockwell): 100.
 - 6) Dielectric strength: 450 volts per mil.
 - 7) Compression strength: 50,000 pounds per square inch.
 - 8) Tensile strength: 20,000 pounds per square inch.
 - 9) Maximum operating temperature: 350 degrees Fahrenheit.
- C. Coating for repair of galvanized surfaces:
- 1. Manufacturers: The following or equal:
 - a. Jelt, Galvinox.
- D. Thread coating: For use with threaded stainless steel fasteners:
- 1. Manufacturers: One of the following or equal:
 - a. Bostik, Never-Seez.
 - b. Oil Research, Inc., WLR No. 111.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Examine Work in place to verify that it is satisfactory to receive the Work of this Section. If unsatisfactory conditions exist, do not begin this Work until such conditions have been corrected.

3.02 INSTALLATION - GENERAL

- A. Where anchors and fasteners are not specifically indicated on the Drawings or specified, make attachments with materials specified in this Section.
- B. Substitution of anchor types:
- 1. Post-installed anchors may not be used as an alternative to cast-in/built-in anchors at locations where the latter are indicated on the Drawings.
 - 2. Cast-in/built-in anchors may be used as an alternative to post-installed mechanical anchors at locations where the latter are indicated on the Drawings.
- C. Protect products from damage during installation. Protect threads and threaded ends.
- D. Accurately locate and position anchors and fasteners:
- 1. Unless otherwise indicated on the Drawings, install anchors perpendicular to the surfaces from which they project.
 - 2. Install anchors so that at least 2 threads, but not more than 1/2 inch of threaded rod, projects past the top nut.

- E. Interface with other products:
 - 1. Where steel anchors come in contact with dissimilar metals (aluminum, stainless steel, etc.), use stainless steel anchors and separate or isolate dissimilar metals using isolating sleeves and washers.
 - 2. Prior to installing nuts, coat threads of stainless steel fasteners with thread coating to prevent galling of threads.

3.03 INSTALLATION - CAST-IN ANCHORS

- A. General:
 - 1. Accurately locate cast-in and built-in anchors.
 - a. Provide anchor setting templates to locate anchor bolts and anchor rods. Secure templates to formwork.
 - b. Brace or tie off embedments as necessary to prevent displacement during placement of plastic concrete or of surrounding masonry construction.
 - c. Position and tie cast-in and built-in anchors in place before beginning placement of concrete or grout. Do not “stab” anchors into plastic concrete, mortar, or grout.
 - d. Do not allow cast-in anchors to touch reinforcing steel. Where cast-in anchors are within 1/4 inch of reinforcing steel, isolate the metals by wrapping the anchors with a minimum of 4 wraps of 10-mil polyvinyl chloride tape in area adjacent to reinforcing steel.
 - 2. For anchoring at machinery bases subject to vibration, use 2 nuts, with 1 serving as a locknut.
 - 3. Where anchor bolts or anchor rods are indicated on the Drawings as being for future use, thoroughly coat exposed surfaces that project from concrete or masonry with non-oxidizing wax. Turn nuts down full length of the threads, and neatly wrap the exposed thread and nut with a minimum of 4 wraps of 10-mil waterproof polyvinyl tape.
- B. Anchor bolts:
 - 1. Minimum effective embedment: 10-bolt diameters, unless a longer embedment is indicated on the Drawings.
 - 2. Where indicated on the Drawings, set anchor bolts in galvanized steel or stainless steel sleeves to allow for adjustment.
 - a. Seal top of sleeve to prevent grout from filling sleeve.
- C. Anchor rods:
 - 1. Install as specified for anchor bolts.

3.04 INSTALLATION - POST-INSTALLED ADHESIVE ANCHORS

- A. Epoxy and acrylic adhesive bonding of reinforcing bars, all thread rods, and internally threaded inserts in concrete: As specified in Section 03_21_17 - Adhesive-Bonded Reinforcing Bars and All Thread Rods in Concrete.
- B. Epoxy and acrylic adhesive bonding of reinforcing bars, all thread rods, and internally threaded inserts in masonry: As specified in Section 04_05_18 - Adhesive Bonding Reinforcing Bars and All Thread Rods in Masonry.

3.05 INSTALLATION - POST-INSTALLED MECHANICAL ANCHORS

- A. General:
 - 1. Install anchors in accordance with the manufacturer's instructions, ACI 355.2, the anchor's ICC-ES report. Where conflict exists between the ICC-ES report and the requirements specified in this Section, the requirements of the ICC-ES report shall control.
 - 2. Where anchor manufacturer recommends the use of special tools and/or specific drill bits for installation, provide and use such tools.
 - 3. After anchors have been positioned and inserted into concrete or masonry, do not:
 - a. Remove and reuse/reinstall anchors.
 - b. Loosen or remove bolts or studs.
- B. Holes drilled into concrete and masonry:
 - 1. Do not drill holes in concrete or masonry until the material has achieved its minimum specified compression strength (f'_c or f'_m).
 - 2. Accurately locate holes:
 - a. Before drilling holes, use a reinforcing bar locator to identify the position of reinforcing steel, conduit, and other embedded items within a 6-inch radius of each proposed hole.
 - b. If the hole depth exceeds the range of detection for the rebar locator, the Engineer may require radiographs of the area designated for investigation before drilling commences.
 - 3. Exercise care to avoid damaging existing reinforcement and other items embedded in concrete and masonry.
 - a. If embedments are encountered during drilling, immediately stop work and notify the Engineer. Await the Engineer's instructions before proceeding.
 - 4. Unless otherwise indicated on the Drawings, drill holes perpendicular to the concrete surface into which they are placed.
 - 5. Drill using anchor manufacturer's recommended equipment and procedures:
 - a. Unless otherwise recommended by the manufacturer, drill in accordance with the following:
 - 1) Drilling equipment: Electric or pneumatic rotary type with light or medium impact. Where edge distances are less than 2 inches, use lighter impact equipment to prevent micro-cracking and concrete spalling during drilling process.
 - 2) Drill bits: Carbide-tipped in accordance with ANSI B212.15. Hollow drills with flushing air systems are preferred.
 - 6. Drill holes at manufacturer's recommended diameter and to depth required to provide the effective embedment indicated.
 - 7. Clean and prepare holes as recommended by the manufacturer and as required by the ICC-ES report for that anchor.
 - a. Unless otherwise recommended by anchor manufacturer, remove dust and debris using brushes and clean compressed air.
 - b. Repeat cleaning process as required by the manufacturer's installation instructions.
 - c. When cleaning holes for stainless steel anchors, use only stainless steel or non-metallic brushes.

- C. Insert and tighten (or torque) anchors in accordance with the manufacturer's installation instructions.
 - 1. Once anchor is tightened (torque), do not attempt to loosen or remove its bolt or stud.
- D. Concrete anchors: Minimum effective embedment lengths unless otherwise indicated on the Drawings:

Concrete Anchors			
Nominal Diameter	Minimum Effective Embedment Length		Minimum Member Thickness
	In Concrete	In Grouted Masonry	
3/8 inch	2-1/2 inch	2-5/8 inch	8 inch
1/2 inch	3-1/2 inch	3-1/2 inch	8 inch
5/8 inch	4-1/2 inch	4-1/2 inch	10 inch
3/4 inch	5 inch	5-1/4 inch	12 inch

- E. Flush shell anchors:
 - 1. Not permitted in the Work.
 - 2. If equipment manufacturer's installation instructions recommend the use of flush shell anchors, contact the Engineer for instructions before proceeding.

3.06 FIELD QUALITY CONTROL

- A. Provide quality control over the Work of this Section as specified in Section 01_45_17 - Contractor Quality Control Plan.
 - 1. Expenses associated with Work described by the following paragraphs shall be paid by the Contractor.
- B. Post-installed anchors:
 - 1. Review anchor manufacturer's installation instructions and requirements of the Evaluation Service report (hereafter referred to as "installation documents") for each anchor type and material.
 - 2. Observe hole-drilling and cleaning operations for conformance with the installation documents.
 - 3. Certify in writing that the depth and location of anchor holes, and the torque applied for setting the anchors conforms to the requirements of the installation documents.

3.07 FIELD QUALITY ASSURANCE

- A. Owner's representative will provide on-site observation and field quality assurance for the Work of this Section.
 - 1. Expenses associated with work described by the following paragraphs shall be paid by the Owner.
- B. Field inspections and special inspections:
 - 1. Required inspections: Observe construction for conformance to the approved Contract Documents, the accepted Submittals, and the manufacturer's installation instructions for the products used.

2. Record of inspections:
 - a. Maintain record of each inspection.
 - b. Submit copies to the Engineer upon request.
 3. Statement of special inspections: At the end of the Project, prepare and submit to the Engineer and the authority having jurisdiction inspector's statement that the Work was constructed in general conformance with the approved Contract Documents, and that deficiencies observed during construction were resolved.
- C. Special inspections: Anchors cast into concrete and built into masonry.
1. Provide special inspection during positioning of anchors and placement of concrete or masonry (including mortar and grout) around the following anchors:
 - a. Anchor bolts.
 2. During placement, provide continuous special inspection at each anchor location to verify that the following elements of the installation conform to the requirements of the Contract Documents.
 - a. Anchor:
 - 1) Type and dimensions.
 - 2) Material: Galvanized steel, Type 304 stainless steel or Type 316 stainless steel, as specified in this Section or indicated on the Drawings.
 - 3) Positioning: Spacing, edge distances, effective embedment, and projection beyond the surface of the construction.
 - 4) Reinforcement at anchor: Presence, positioning, and size of additional reinforcement at anchors indicated on the Drawings.
 3. Following hardening and curing of the concrete or masonry surrounding the anchors, provide periodic special inspection to observe and confirm the following:
 - a. Base material (concrete or grouted masonry):
 - 1) Solid and dense concrete or grouted masonry material within required distances surrounding anchor.
 - 2) Material encapsulating embedment is dense and well-consolidated.
- D. Special inspections: Post-installed mechanical anchors placed in hardened concrete and in grouted masonry.
1. Provide special inspection during installation of the following anchors:
 - a. Concrete anchors.
 2. Unless otherwise noted, provide periodic special inspection during positioning, drilling, placing, and torquing of anchors.
 - a. Provide continuous special inspection for post-installed anchors in "overhead installations" as defined in this Section.
 3. Requirements for periodic special inspection:
 - a. Verify items listed in the following paragraphs for conformance to the requirements of the Contract Documents and the Evaluation Service report for the anchor being used. Observe the initial installation of each type and size of anchor, and subsequent installation of the same anchor at intervals of not more than 4 hours.
 - 1) Any change in the anchors used, in the personnel performing the installation, or in procedures used to install a given type of anchor shall require a new "initial inspection".
 - b. Substrate: Concrete or masonry surfaces receiving the anchor are sound and of a condition that will develop the anchor's rated strength.

- c. Anchor:
 - 1) Manufacturer, type, and dimensions (diameter and length).
 - 2) Material (galvanized, Type 304 stainless steel, or Type 316 stainless steel).
- d. Hole:
 - 1) Positioning: Spacing and edge distances.
 - 2) Drill bit type and diameter.
 - 3) Diameter, and depth.
 - 4) Hole cleaned in accordance with the manufacturer's required procedures. Confirm multiple repetitions of cleaning when recommended by the manufacturer.
 - 5) Anchor's minimum effective embedment.
 - 6) Anchor tightening/installation torque.
- 4. Requirements for continuous special inspection:
 - a. Special inspector shall observe all aspects of anchor installation, except that holes may be drilled in their absence provided that they confirm the use of acceptable drill bits before drilling, and later confirms the diameter, depth, and cleaning of drilled holes.
- E. Field tests:
 - 1. Owner's Representative may, at any time, request testing to confirm that materials being delivered and installed conform to the requirements of the Specifications.
 - a. If such additional testing shows that the materials do not conform to the specified requirements, the Contractor shall pay the costs of these tests.
 - b. If such additional testing shows that the materials do conform to the specified requirements, the Owner shall pay the costs of these tests.

3.08 NON-CONFORMING WORK

- A. Remove misaligned or non-performing anchors.
- B. Fill empty anchor holes and repair failed anchor locations using non-shrink cement grout as specified in Section 03_60_00 - Grouting, unless otherwise directed by the Engineer.
- C. If more than 10 percent of all tested anchors of a given diameter and type fail to achieve their specified torque or proof load, the Engineer will provide directions for required modifications. Make such modifications, up to and including replacement of all anchors, at no additional cost to the Owner.

3.09 SCHEDULES

- A. Galvanized: Provide and install galvanized carbon steel anchors at the following locations:
 - 1. Locations not requiring stainless steel.
 - 2. At locations indicated on the Drawings.

B. Provide and install anchor materials as scheduled in the following table.

Required Anchoring Materials by Location			
Location/Exposure		Materials	Notes
1.	Anchors into concrete and grouted masonry for attachment of carbon steel, including structural steel and other steel fabrications:		
a.	Interior dry areas	Carbon steel - galvanized	
b.	Locations with galvanized steel structures or fabrications	Stainless steel - Type 304 or 316	1
c.	Exterior and interior wet and moist locations	Stainless steel - Type 316	1
d.	Corrosive locations	Stainless steel - Type 316	1
2.	Anchors into concrete and grouted masonry for attachment of aluminum, stainless steel, or fiber-reinforced plastic (FRP) shapes and fabrications:		
a.	Interior dry areas	Stainless steel - Type 304 or 316	1
b.	Exterior and interior wet and moist locations	Stainless steel - Type 316	1
c.	Corrosive locations	Stainless steel - Type 316	1
3.	Anchors for attaching equipment and its appurtenances:		
a.	All locations	Stainless steel - Type 316 (unless Type 304 is specifically indicated in the specifications for the equipment.)	1
Notes: (1) Where anchors are in contact with a metal that differs from that of the anchor, provide isolation sleeves and washers.			

END OF SECTION

SECTION 05_12_00

STRUCTURAL STEEL FRAMING

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Structural steel shapes and plate.
 - 2. Fasteners and structural hardware:
 - a. All thread rods.
 - b. High-strength bolts.
 - 3. Welding.
 - 4. Bolting.

1.02 REFERENCES

- A. American Institute of Steel Construction (AISC):
 - 1. 303 - Code of Standard Practice for Steel Buildings and Bridges.
 - 2. 360 - Specification for Structural Steel Buildings.
- B. American Iron and Steel Institute (AISI):
 - 1. Steel alloys (types) as indicated.
- C. American Welding Society (AWS):
 - 1. A5.1 - Specification for Carbon Steel Electrodes for Shielded Metal Arc Welding.
 - 2. A5.17 - Specification for Carbon Steel Electrodes and Fluxes for Submerged Arc Welding.
 - 3. A5.20 - Specification for Carbon Steel Electrodes for Flux Cored Arc Welding.
 - 4. D1.1 - Structural Welding Code - Steel.
- D. ASTM International (ASTM):
 - 1. A6 - Standard Specification for General Requirements for Rolled Structural Steel Bars, Plates, Shapes, and Sheet Piling.
 - 2. A36 - Standard Specification for Carbon Structural Steel.
 - 3. A123 - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
 - 4. A153 - Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
 - 5. A194 - Standard Specification for Carbon and Alloy Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both.
 - 6. A500 - Standard Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes.
 - 7. A501 - Standard Specification for Hot-Formed Welded and Seamless Carbon Steel Structural Tubing.
 - 8. A563 - Standard Specification for Carbon and Alloy Steel Nuts.
 - 9. A992 - Standard Specification for Structural Steel Shapes.
 - 10. F436 - Standard Specification for Hardened Steel Washers.

11. F959 - Standard Specification for Compressible-Washer-Type Direct Tension Indicators for Use with Structural Fasteners.
 12. F2329 - Standard Specification for Zinc Coating, Hot-Dip, Requirements for Application to Carbon and Alloy Steel Bolts, Screws, Washers, Nuts, and Special Threaded Fasteners.
 13. F3125 - Standard Specification for High Strength Structural Bolts, Steel and Alloy Steel, Heat Treated, 120 ksi and 150 ksi Minimum Tensile Strength.
- E. Research Council on Structural Connections (RCSC):
1. Specification for Structural Joints Using High-Strength Bolts (RCSC Specification).

1.03 TERMINOLOGY

- A. The words and terms listed below are not defined terms that require initial capital letters, but, when used in this Section, have the indicated meaning.
1. Snugtight: At bolted joints, the tightness attained with a few impacts of an impact wrench, or by the full effort of an ironworker using a spud wrench to bring the connected plies into firm contact.

1.04 SUBMITTALS

- A. Furnish Submittals as specified in Section 01_33_00 - Submittal Procedures and Section 01_60_01 - Product Requirements.
- B. Product data:
- C. Shop Drawings:
1. Fabrication and erection drawings.
- D. Quality Control Submittals:
1. Welding procedure specifications (WPS) in accordance with AWS D1.1.
 - a. Submit WPS for each type of welded joint used, whether prequalified or qualified by testing.
 - 1) State electrode manufacturer and specific electrodes used.
 - 2) Indicate required AWS qualification for joint.
 - b. Submit WPS with Shop Drawings that indicate those welds.
 - c. Submit Procedure Qualification Record (PQR) in accordance with AWS D1.1 for welding procedures qualified by testing.
 2. Welder qualifications: For each welding process and position:
 - a. Welder's qualification certificates.
 - b. Contractor's statement that certificate will be "in effect" at the time(s) welding will be performed based on the "Period of Effectiveness" provisions of AWS D1.1.
- E. Test reports:
1. Certified copies of mill tests and analyses made in accordance with applicable ASTM standards, or reports from a recognized commercial laboratory, including chemical and tensile properties of each shipment of structural steel or part thereof having common properties.

1.05 QUALITY ASSURANCE

- A. Welding:
1. Perform welding of structural metals in accordance with AWS D1.1 using welders who have current AWS qualification certificate for the process, position, and joint configuration to be welded.
 2. Make welding procedure specifications available at the locations where welding is performed.
 3. Notify the Engineer at least 24 hours before starting shop or field welding.
 4. Engineer may check materials, equipment, and qualifications of welders.
 5. Remove welders performing unsatisfactory Work, or require requalification.
 6. Engineer may use gamma ray, magnetic particle, dye penetrant, trepanning, or other aids to visual inspection to examine any part of welds or all welds.
 7. Contractor shall bear costs of retests on defective welds.
 8. Contractor shall also bear costs in connection with qualifying welders.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. As specified in Section 01_60_01 - Product Requirements.
- B. Packing and shipping: Deliver structural steel free from mill scale, rust, and pitting.
- C. Storage and protection: Until erection and painting, protect from weather items not galvanized or protected by a shop coat of paint.

PART 2 PRODUCTS

2.01 MATERIALS

- A. Unless otherwise specified or indicated on the Drawings, materials shall be in accordance with the following:

Item	ASTM Standard	Class, Grade, Type, or Alloy Number
Carbon Steel		
Plate, bars, rolled shapes (except W and WT shapes), and miscellaneous items	A36	–
Rolled W and WT shapes	A992	Grade 50
Hollow structural sections/HSS: Round, square, or rectangular (including “pipe” where indicated for structural members and supports)	A500	Grade C

2.02 FASTENERS AND STRUCTURAL HARDWARE

- A. General:
1. Materials: Of domestic manufacture.
 2. Where fasteners and hardware are specified to be galvanized, hot-dip galvanize in accordance with ASTM A153 or ASTM F2329, unless otherwise specified.

- B. All thread rods:
 - 1. Carbon steel:
 - a. In accordance with ASTM A36 unless otherwise indicated on the Drawings.
 - b. Nuts: ASTM A194.
 - c. Washers: ASTM F436.
 - 2. Galvanized carbon steel:
 - a. In accordance with ASTM A36 unless otherwise indicated on the Drawings and hot dip galvanized in accordance with ASTM A153.
 - b. Nuts: ASTM A194; hot-dip galvanized in accordance with ASTM A153.
 - c. Washers: ASTM F436; hot-dip galvanized in accordance with ASTM A153.

- C. Anchor bolts, anchor rods, and post-installed steel anchors: As indicated on the Drawings and as specified in Section 05_05_24 - Mechanical Anchoring and Fastening to Concrete and Masonry.

- D. High-strength bolts:
 - 1. Provide high-strength bolt assembly with nuts, hardened flat washers, and compressible-washer-type direct tension indicators.
 - 2. Carbon steel: Uncoated:
 - a. Bolts: Plain heavy hex structural bolts in accordance with ASTM F3125, Grade A325, Type 1.
 - b. Nuts: Heavy hex nuts in accordance with ASTM A563, Grade C.
 - c. Washers:
 - 1) Adjacent to normal, oversized, and short-slotted holes: Circular, square or rectangular beveled, clipped, or extra thick washers in accordance with ASTM F436, Type 1. Flat circular washers unless otherwise indicated on the Drawings.
 - 2) Adjacent to long slotted holes: Fabricated from 5/16-inch-thick plate in accordance with ASTM A36.
 - d. Load indicator devices: At slip critical connections, provide one of the following devices at each bolt:
 - 1) Compressible-washer-type direct tension indicators (DTI): In accordance with ASTM F959, Type 325-1.
 - 2) Twist-off type tension-control bolt assemblies: ASTM F3125, Grade F1852.

2.03 ISOLATING SLEEVES AND WASHERS

- A. As indicated on the Drawings and as specified in Section 05_05_24 - Mechanical Anchoring and Fastening to Concrete and Masonry.

2.04 GALVANIZED SURFACE REPAIR

- A. Manufacturers: The following or equal:
 - 1. Jelt, Galvinox.

2.05 SUPPLEMENTARY PARTS

- A. Furnish as required for complete structural steel erection, whether or not such parts and Work are specified or indicated on the Drawings.

2.06 FABRICATION

- A. Shop assembly:
 - 1. Fabricate structural steel in accordance with AISC 360 and AISC 303 unless otherwise specified or modified by applicable regulatory requirements.
 - 2. Where anchors, connections, or other details of structural steel are not specifically indicated on the Drawings or specified, their material, size and form shall be equivalent in quality and workmanship to items specified.
 - 3. Round off sharp and hazardous projections and grind smooth.
 - 4. Take measurements necessary to properly fit work in the field. Take responsibility for and be governed by the measurements and proper working out of all the details.
 - 5. Take responsibility for correct fitting of metalwork.
 - 6. Welded connections:
 - a. In accordance with AWS requirements for the metals to be welded.
 - b. Weld only in accordance with approved welding procedure specifications.
 - c. Keep welding procedure specifications readily available for welders and inspectors during fabrication processes.
- B. Galvanized carbon steel:
 - 1. Where galvanizing is required, hot-dip structural steel after fabrication in accordance with ASTM A123.
 - 2. Do not electro-galvanize or mechanically-galvanize unless specified or accepted by the Engineer.
 - 3. Re-straighten galvanized items that bend or twist during galvanizing.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Verification of conditions: Examine Work in place to verify that it is satisfactory to receive the Work of this Section. If unsatisfactory conditions exist, do not begin this Work until such conditions have been corrected.

3.02 ERECTION

- A. General:
 - 1. Fabricate structural and foundry items to true dimensions without warp or twist.
 - 2. Form welded closures neatly and grind off smooth where weld material interferes with fit or is unsightly.
 - 3. Install structural items accurately and securely, true to level, plumb, in correct alignment and grade, with all parts bearing or fitting structure or equipment for which intended.
 - 4. Do not shift out of alignment, re-drill, re-shape, or force fit fabricated items.
 - 5. Place anchor bolts or other anchoring devices accurately and make surfaces that bear against structural items smooth and level.
 - 6. Rigidly support and brace components to preserve straight, level, even, and smooth lines.
 - a. Install non-shrink grout as indicated on the Drawings.
 - b. Keep items braced until grout has hardened for 48 hours minimum.

7. Erect structural steel in accordance with AISC 303 unless otherwise specified or modified by applicable regulatory requirements.
 8. Where anchors, connections, and other details of structural steel erection are not specifically indicated on the Drawings or specified, form, locate, and attach with equivalent in quality and workmanship to items specified.
 9. Round off sharp or hazardous projections and grind smooth.
 10. Paint or coat steel items as specified in Section 09_96_01 - High-Performance Coatings.
- B. Welding: General:
1. Make welds full penetration type, unless otherwise indicated on the Drawings.
 2. Remove backing bars and weld tabs after completion of weld. Repair defective welds observed after removal of backing bars and weld tabs.
- C. Welding: Carbon steel:
1. In accordance with AWS D1.1:
 - a. Weld ASTM A36 and ASTM A992 structural steel and ASTM A500 and ASTM A501 structural tubing with electrodes in accordance with AWS A5.1, using E70XX electrodes; AWS A5.17, using F7X-EXXX electrodes; or AWS A5.20, using E7XT-X electrodes.
- D. Interface with other products:
1. Where steel members and fasteners come in contact with dissimilar metals (aluminum, stainless steel, etc.), separate or isolate the dissimilar metals with isolating sleeves and washers as specified in Section 05_05_24 - Mechanical Anchoring and Fastening to Concrete and Masonry.
- E. Fasteners: General:
1. Install bolts to project 2 threads minimum, but 1/2 inch maximum beyond nut.
 2. Anchor bolts and anchor rods: Install as specified in Section 05_05_24 - Mechanical Anchoring and Fastening to Concrete and Masonry.
 - a. Unless otherwise specified, tighten nuts on anchor bolts and anchor rods specified in Section 05_05_24 - Mechanical Anchoring and Fastening to Concrete and Masonry to the "snugtight" condition.
 3. All thread rods in drilled holes bonded to concrete with adhesive: Install as specified in Section 03_21_17 - Adhesive-Bonded Reinforcing Bars and All Thread Rods in Concrete.
 4. All thread rods in drilled holes bonded to masonry with adhesive: Install as specified in Section 04_05_18 - Adhesive Bonding Reinforcing Bars and All Thread Rods in Masonry.
- F. Fasteners: High-strength carbon steel bolts:
1. Connections with high-strength bolts shall be in accordance with the RCSC Specification for Structural Joints Using High-Strength Bolts.
 2. Joints: Slip-critical.
 - a. Confirm that faying surfaces at connections are free of dirt and other foreign material, have been blast cleaned, and are free of coatings and inadvertent overspray in accordance with the RCSC Specification.

- b. Furnish hardened flat washers in accordance with ASTM F436:
 - 1) On outer plies with slotted holes.
 - 2) When one or more plies of the connected material has a yield strength less than 40 ksi.
 - 3) Under element, nut, or bolt head, turned in tightening.
- c. Install tension indicator washers, placed in accordance with ASTM F959, Figure X1, to confirm adequate tightening of bolts.
- d. Tighten bolts to full pretension.

3.03 FIELD QUALITY CONTROL

- A. As specified in Section 01_45_17 - Contractor Quality Control Plan.

3.04 FIELD QUALITY ASSURANCE

- A. As specified in Section 01_45_17 - Contractor Quality Control Plan.
- B. Special inspections, special tests, and structural observation:
 - 1. As specified in Section 01_45_24 - Regulatory Quality Assurance.

END OF SECTION

SECTION 05_14_05
STRUCTURAL ALUMINUM

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Structural aluminum products, including sheet, pipe, extrusions, and associated accessories.

1.02 REFERENCES

- A. American Welding Society (AWS):
 - 1. A5.10 - Specification for Bare Aluminum and Aluminum-Alloy Welding Electrodes and Rods.
 - 2. D1.2 - Structural Welding Code - Aluminum.
- B. ASTM International (ASTM):
 - 1. B209 - Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate.
 - 2. B221 - Standard Specification for Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes.
 - 3. B308 - Standard Specification for Aluminum-Alloy 6061-T6 Standard Structural Profiles.

1.03 SUBMITTALS

- A. Furnish Submittals as specified in Section 01_33_00 - Submittal Procedures.
- B. Quality Control Submittals:
 - 1. Test Reports: Certified copies of mill tests or reports from a recognized commercial laboratory, including chemical and tensile properties of each shipment of structural metal or part thereof having common properties.
 - a. Tests and analyses shall be made in accordance with applicable ASTM standards.
 - 2. Welder's certificates.

1.04 QUALITY ASSURANCE

- A. Qualifications:
 - 1. Perform welding of structural metals with welders who have current AWS certificate for the type of welding to be performed.
 - 2. Notify the Engineer 24 hours minimum before starting shop or field welding.
 - 3. Engineer may check materials, equipment, and qualifications of welders.
 - 4. Remove welders performing unsatisfactory work or require to requalify.
 - 5. Engineer may use gamma ray, magnetic particle dye penetrant, or other aids to visual inspection to examine any part of welds or all welds.

6. Contractor shall bear costs of retests on defective welds.
7. Contractor shall bear costs in connection with qualifying welders.

PART 2 PRODUCTS

2.01 MATERIALS

- A. Structural sheet aluminum: ASTM B209, Alloy 6061-T6.
- B. Structural aluminum: ASTM B308, Alloy 6061-T6.
- C. Extruded aluminum: ASTM B221, Alloy 6063-T42.
- D. Isolating sleeves and washers:
 1. As indicated on the Drawings and as specified in Section 05_05_24 - Mechanical Anchoring and Fastening to Concrete and Masonry.
- E. Miscellaneous materials:
 1. Furnish supplementary parts necessary to complete each item even where such work is neither definitely indicated on the Drawings nor specified.
 2. Size, form, attachment, and location shall conform to the best of current practice.
 3. In accordance with applicable ASTM standards for materials not otherwise specified.

2.02 FABRICATION

- A. Aluminum layout:
 1. Center punch hole centers, and punch or scribe cutoff lines, except where marks would remain on fabricated material.
 2. Apply temperature correction where necessary in layout of critical dimensions. Use a coefficient of expansion of 0.000013 per degree of Fahrenheit.
- B. Cutting aluminum:
 1. Material 1/2 inch thick or less: Shear, saw, or cut with a router.
 2. Material more than 1/2 inch thick: Saw or rout.
 3. Make cut edges true and smooth, free from excessive burrs or ragged breaks.
 4. Avoid reentrant cuts wherever possible. Where used, fillet by drilling prior to cutting.
 5. Do not flame cut aluminum alloys.
 6. Punch or drill rivet or bolt holes to finished size before assembly:
 - a. Make finished diameter of holes for bolts 1/16 inch maximum larger than nominal bolt diameter.
 - b. Make holes cylindrical and perpendicular to principal surface.
 - c. Do not permit holes to drift in a manner to distort metal.

- C. Aluminum forming and assembly:
 - 1. Do not heat structural aluminum, except as follows:
 - a. Heat aluminum to 400 degrees Fahrenheit for 30 minutes maximum, to facilitate bending or welding.
 - b. Heat only when proper temperature controls and supervision can ensure that limitations on temperature and time are observed.
- D. Before assembly, remove chips lodged between contacting surfaces.
- E. Welding aluminum:
 - 1. Perform welding of aluminum in accordance with AWS D1.2.
 - 2. Preparation:
 - a. Remove dirt, grease, forming or machining lubricants, and organic materials from areas to be welded by cleaning with a suitable solvent or by vapor degreasing.
 - b. Additionally, etch or scratch brush to remove oxide coating just prior to welding when inert gas tungsten arc welding method is used.
 - c. Oxide coating may not need to be removed if welding is performed by automatic or semi-automatic inert gas shielded metal arc.
 - d. Suitably prepare edges to ensure 100 percent penetration in butt welds by sawing, chipping, machining, or shearing. Do not cut with oxygen.
 - 3. Filler metal: Aluminum alloys in accordance with AWS A5.10 and AWS classification ER 4043, ER 5654, ER 5554, ER 5183, ER 5356, or ER 5556.
 - 4. Perform welding of structures which are to be anodized using filler alloys which will not discolor when anodized, AWS ER 5654, ER 5554, ER 5183, ER 5356, or ER 5556.
 - 5. Perform welding by using a non-consumable tungsten electrode with filler metal in an inert gas atmosphere (TIG) or using a consumable filler metal electrode in an inert gas atmosphere (MIG).
 - 6. Do not use welding process that requires use of a welding flux.
 - 7. Neatly make welded closures.
 - 8. Where weld material interferes with fit or is unsightly in appearance, grind it smooth.
 - 9. Make welds full penetration welds unless otherwise indicated on the Drawings.

2.03 FINISHES

- A. Coating for aluminum in contact with concrete or masonry:
 - 1. Epoxy mastic.
 - a. As specified in Section 09_96_01 - High-Performance Coatings, coating system EPX-M-5.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Examine Work in place to verify that it is satisfactory to receive the Work of this Section. If unsatisfactory conditions exist, do not begin this Work until such conditions have been corrected.

3.02 INSTALLATION

- A. Install structural aluminum products as indicated on the Drawings and specified.
- B. Install structural aluminum products accurately and securely, true to level, plumb, in correct alignment and grade, with all parts bearing or fitting structure or equipment for which intended.
- C. Do not cock out of alignment, redrill, reshape, or force fit fabricated items.
- D. Place anchor bolts or other anchoring devices accurately and make surfaces that bear against structural items smooth and true to level.
- E. Rigidly support and brace components to preserve straight, level, even, smooth lines.
 - 1. Install non-shrink grout as indicated on the Drawings.
 - 2. Keep items braced until grout has hardened for a minimum of 48 hours.
- F. Interface with other products:
 - 1. Where aluminum comes in contact with dissimilar metals, use stainless steel bolts or anchors and separate or isolate the dissimilar metals with isolating sleeves and washers as specified in Section 05_05_24 - Mechanical Anchoring and Fastening to Concrete and Masonry.
 - 2. Coat those parts of aluminum that will be cast into concrete or that will be in contact with concrete, grout, masonry, wood, or other materials that will cause the aluminum to corrode, as specified in Section 09_96_01 – High-Performance Coatings.

END OF SECTION

SECTION 05_21_19

OPEN WEB STEEL JOIST FRAMING

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Open web steel joists, joist girders, and accessories.
 - 2. Welding and bolts for connections at joists and joist girders.

1.02 REFERENCES

- A. American Welding Society (AWS):
 - 1. A2.4 - Standard Symbols for Welding, Brazing, and Non-Destructive Examination.
 - 2. D1.1 - Structural Welding Code - Steel.
- B. ASTM International (ASTM):
 - 1. A563 - Standard Specification for Carbon and Alloy Steel Nuts.
 - 2. F436 - Standard Specification for Hardened Steel Washers.
 - 3. F3125 - Standard Specification for High Strength Structural Bolts, Steel and Alloy Steel, Heat Treated, 120 ksi and 150 ksi Minimum Tensile Strength.
- C. Occupational Safety and Health Administration (OSHA):
 - 1. Code of Federal Regulations (CFR), Title 29 - Labor, Chapter XVII.
 - a. Part 1926.757 - Steel Erection; Open Web Steel Joists.
- D. Society for Protective Coatings (SSPC):
 - 1. Paint 15 - Steel Joist Shop Primer/Metal Building Primer.
 - 2. SP 15 - Commercial Grade Power tool Cleaning.
- E. Steel Joist Institute (SJI):
 - 1. Code of Standard Practice:
 - a. COSP - Code of Standard Practice for Steel Joists and Joist Girders.
 - 2. Standard Specifications:
 - a. K Series - Standard Specifications for Open Web Steel Joists.
 - b. LH/DLH Series - Standard Specifications for Longspan Steel Joists, LH-Series and Deep Longspan Steel Joists, DLH-Series.
 - c. JG Series - Standard Specification for Joist Girders.
 - 3. Standard Load Tables:
 - a. Standard Specification Load Tables and Weight Tables for Steel Joists and Joists Girders.
 - 4. Technical Digests:
 - a. TD 8 - Welding of Open-Web Steel Joists and Joist Girders.
 - b. TD 9 - Handling and Erection of Steel Joists and Joist Girders.

1.03 TERMINOLOGY

- A. The words and terms listed below are not defined terms that require initial capital letters, but, when used in this Section, have the indicated meaning.
 - 1. SJI Standard Specifications: Refers to one or more of the following documents corresponding to the joist type indicated on the Drawings:
 - a. K Series - Standard Specifications for Open Web Steel Joists.
 - b. LH/DLH Series - Standard Specifications for Longspan Steel Joists, LH-Series and Deep Longspan Steel Joists, DLH-Series.
 - c. JG Series - Standard Specification for Joist Girders.
 - 2. SJI Standard Load Tables: Refers to one of the following documents corresponding to the joist type indicated on the Drawings:
 - a. Standard Load Tables, Open Web Steel Joists, K-Series (LRFD and ASD).
 - b. Standard Load Tables, Longspan Steel Joists, LH-Series (LRFD and ASD).
 - c. Standard Load Tables, Deep Longspan Steel Joists, DLH Series (LRFD and ASD).
 - 3. Steel joists: As referred to in this Section, includes joists, K series joist substitutes, joist girders, and joist headers.

1.04 DELEGATED DESIGN

- A. As specified in Section 01_35_73 - Delegated Design Procedures.
- B. Joist calculations.

1.05 SUBMITTALS

- A. Furnish Submittals as specified in Section 01_33_00 - Submittal Procedures.
- B. Product data:
 - 1. Manufacturer's specifications and installation instructions for each type of joist and accessories.
 - 2. Coatings:
 - a. Shop coating: Manufacturer's product data sheets indicating type and characteristics of applied coatings, and recommendations for preparation and materials for finished coatings.
- C. Shop Drawings:
 - 1. General:
 - a. Fabrication drawings/schedules, and erection/layout drawings for joists and related miscellaneous metal work.
 - b. Clearly indicate the portion of the Work covered by each Submittal and location of each member in the Work.
 - c. Mark the number or tags on joists and fabrications shall be the same mark numbers indicated on fabrication schedules and erection drawings.
 - d. Indicate shop and field welds using symbols in accordance with AWS A2.4. Indicate net weld lengths.
 - 2. Fabrication drawings/schedules:
 - a. Detail each piece or assembly to be incorporated into the Work.

- b. For each joist type and size, and for each accessory, indicate:
 - 1) SJI standard designations, including depth and chord size.
 - 2) Identification mark number.
 - 3) Loading criteria and camber.
 - 4) Configuration and details, including joist elevation view, bearing seats, end conditions, chord extensions, and details of internal joints, welds, and splices (if any).
 - 5) Dimensions, both overall and internal.
 - 6) Methods of connecting, anchoring, fastening, bracing, bridging, and attaching.
 - 7) Coatings and surface preparation.
 - 3. Erection/layout drawings:
 - a. Indicate placement of each piece shown in the fabrication drawings/schedules or listed in the bill of materials.
 - b. Show layout of joists with mark numbers; methods of framing at openings; locations, types, and connection details for bridging; details of connections between joists and supporting joist girders, joist headers, framing, or structures; and accessories.
 - c. Indicate erection sequence and requirements for temporary bracing.
 - d. Show requirements for field welding and bolting.
 - e. Show profiles and deflection criteria under live and total loads for joist configurations not specifically listed in SJI Standard Load Tables.
 - f. List loads used in the design of steel joists.
 - 1) Show loads and position of loads from mechanical and electrical equipment supported by the joists and framing.
- D. Delegated Design Submittals:
 - 1. Submit calculations for each joist type and span, documenting adequacy to resist uniform and concentrated loads indicated on the Drawings; locations, sizes and types of bridging for resisting downward and uplift loads; and adequacy of connections of joists and bridging.
- E. Certificates/certifications:
 - 1. SJI membership: Submit evidence of the manufacturer's current membership in SJI and of the manufacturer's qualifications to produce members of the types specified and required for the Work.
 - 2. SJI compliance: At the completion of manufacturer, for each joist type and load case provided, submit the manufacturer's certificate of compliance stating that design and fabrication of members was performed in accordance with SJI Standard Specifications and the approved Shop Drawings. Include manufacturer's statements that:
 - a. Welders performing shop welding for joists hold current qualification for the types of welding and welding positions required for the Work.
 - b. Manufacturer has completed in-plant before shipment to verify compliance of materials and workmanship with the requirements of SJI Standard Specifications for the products produced.
 - 3. Quality control program: Submit evidence of active participation in a nationally recognized program for quality control of steel fabrication.
 - 4. Field welding: Submit welder qualification certificates in accordance with AWS D1.1 for the types of welding and welding positions required for the Work.

- F. Test and inspection reports:
 - 1. Mill test reports: Submit manufacturer's certificates, indicating ASTM standards, structural strength, and material properties for steel used in the joists and bridging.
 - 2. Inspections:
 - a. Source quality control.
 - 1) Submit reports of manufacturer's in-plant inspections for compliance with SJI Standard Specifications.
 - b. Field quality control:
 - 1) Submit Installation and Welding Inspection Report as specified in Attachment A - Installation and Welding Inspection Report.
 - c. Field quality assurance:

1.06 QUALITY ASSURANCE

- A. Design and fabricate joists in compliance with the following and as specified in this Section:
 - 1. SJI Standard Specifications.
 - 2. SJI Standard Load Tables.
 - 3. SJI Code of Standard Practice.
- B. Qualifications:
 - 1. Manufacturers:
 - a. Holding current membership in the Steel Joist Institute and a recognized fabricator of structural steel joists conforming to the SJI Standard Specifications, the SJI Standard Load Tables, and the SJI Code of Practice.
 - 2. Installer/Erector:
 - a. Field welding: Qualified procedures and welders in accordance with AWS D1.1. Provide welders qualified within the last 12 months preceding the date of joist erection.
- C. Regulatory requirements:
 - 1. In accordance with OSHA requirements for steel erection, including specific requirements for joists and framing.
- D. Inspection:
 - 1. Inspect joists in accordance with SJI Standard Specifications.
 - 2. Inspect fabrication as specified in Part 2, Source Quality Control.
 - 3. Provide inspections for Field Quality Control and Field Quality Assurance as specified in Part 3, Execution.
- E. Pre-installation conference:
 - 1. Coordinate with the requirements of Section 05_31_00 - Steel Deck.
 - 2. Schedule and conduct pre-installation conference at least 2 weeks prior to installation of joists.
 - a. Provide additional conferences if necessary to discuss or coordinate specific conditions of installation.
 - 3. Required attendees:
 - a. Contractor.
 - b. Steel joist manufacturer's technical representative.

- c. Steel joist installer's job superintendent.
- d. Subcontractor(s) providing and installing coatings under Division 9.
- 4. Agenda:
 - a. Joist Submittals.
 - b. Deck placing and fastening procedures.
 - c. Manufacturer's recommended inspections and inspection procedures.
 - d. Requirements and coordination for quality control inspections and quality assurance (including special inspections).
 - e. Other Specification requirements requiring coordination between parties to the Work.
- 5. Prepare and submit minutes of the pre-installation conference as specified in Section 01_31_19 - Project Meetings.

1.07 DELIVERY, STORAGE, AND HANDLING

- A. Transport, deliver, store, and handle steel joists as recommended in SJI specifications, and as required to avoid stresses and to prevent damage to materials and coatings.
- B. Observe delivered materials for damage before and after unloading, and note any permanent bends, deformations, broken welds, or other damage on the receiving documents.
- C. Store joists off the ground, protected from weather and corrosion, and under watertight covering sloped to drain.
 - 1. Support by means that will protect members from distortion and damage.
 - 2. Store joists with top chord down and with plane of joist vertical.
 - 3. For deep joists that shipped on their sides, store joists with plane of joist horizontal.

1.08 WARRANTY

- A. As specified in Section 01_78_36 - Warranties and Bonds.
- B. Special warranty:
 - 1. Duration: 5 years on joists.

PART 2 PRODUCTS

2.01 DESIGN AND PERFORMANCE CRITERIA

- A. Pre-engineered, pre-fabricated open-web steel joists, joist girders, and accessories designed and fabricated to the requirements of the SJI and details as specified in this Section and indicated on the Drawings.

- B. Design requirements:
1. Design joists and bridging in accordance with current SJI Specifications and load tables to support loads indicated based on the depth, spacing, and deflections, indicated.
 - a. Maximum deflection under live load:
 - 1) Roof joists/Joist girders: Span divided by 240 ($L/240$).
 - b. Minimum design loads as indicated on the Drawings:
 - 1) Dead load.
 - 2) Live load.
 - 3) Snow load.
 - 4) Wind load (net uplift).
 - 5) Axial tension and compression forces applied to the truss at end connections.
 - c. Provide standard camber based on SJI Standard Specifications unless otherwise indicated on the Drawings.
 - 1) In no case shall joists be manufactured with negative (downward) camber.
 2. Joist chord extensions:
 - a. Top chord: Capable of withstanding the loads indicated for the joist plus any concentrated loads indicated. Brace to prevent lateral torsional buckling of the extension under loads.
 - b. Bottom chord: Capable of supporting weight of ceilings or other items indicated. Extending to within 1 inch of interior finished wall surface unless otherwise indicated on the Drawings.
 3. Provide horizontal and diagonal bridging as required by the SJI Standard Specifications, as indicated on the Drawings, and as required to maintain stability under gravity, uplift, erection, and construction loadings.
 4. Provide end anchorage details to secure and/or stabilize joists at supports, and to transfer any loads indicated on the Drawings.
 5. Provide header units to support joists at openings in floor or roof framing not framed with structural steel shapes.
 6. Accessories:
 - a. Provide miscellaneous items, including splice plates, reinforcing angles, and bolts required to complete the installation.
 - b. Provide supplemental steel framing to support steel deck where normal deck bearing is precluded by other framing members and minor openings.

2.02 MATERIALS

- A. Steel joists:
1. Type, chord configuration, depth, and bearing as indicated on the Drawings.
 2. Comply with SJI Standard Specifications for joist series and for joist girders.
 3. Details: Provide the following.
 - a. Chord members: Rolled double angle sections only. Rod or bar members are not permitted.
 - b. Chord extensions: Joists.
 - 1) Bottom chord (ceiling) extensions: Where indicated on the Drawings.
 - 2) Top chord extensions: "S-Type" or "R-Type" as indicated on the Drawings.

- c. Chord extensions: Joist girders.
 - 1) Joist girder bottom chord extension with vertical slip connection at and stabilizer plate that is fastened to supporting structure.
- B. Bridging:
 - 1. In accordance with SJI Standard Specifications for type of joist, chord size, spacings, spans and uplift loads indicated on the Drawings.
 - 2. Anchored to walls, girders, and roof deck as indicated.
- C. Coatings:
 - 1. Shop paint. In accordance with SSPC-Paint 15.
- D. Fasteners:
 - 1. Anchor bolts and anchor rods to concrete and masonry: As specified in Section 05_05_24 - Mechanical Anchoring and Fastening to Concrete and Masonry.
 - 2. Bolts: Pre-tensioned bolted connections.
 - a. Provide high-strength bolt assembly with hardened flat washers and nuts. Provide uncoated components unless galvanized coating is indicated on the Drawings.
 - b. Uncoated:
 - 1) Bolts: Plain, heavy hex structural bolts in accordance with ASTM F3125, Grade A325, Type 1.
 - 2) Nuts: Heavy hex nuts in accordance with ASTM A563, Grade C.
 - 3) Washers: Circular flat washers in accordance with ASTM F436.
- E. Accessories:
 - 1. Bearing plates: As specified in Section 05_50_00 - Metal Fabrications.

2.03 FABRICATION

- A. Fabricate steel joist in accordance with SJI Standard Specifications to details indicated on the Drawings.
- B. Provide horizontal or diagonal type cross bridging for joists.
- C. Provide end anchorage, including bearing plates, to secure joists to adjacent construction as indicated on the Drawings.
- D. Coatings:
 - 1. Shop primer:
 - a. After delivery, remove shipping primer and prepare joists and accessories for re-priming and finish coating specified in Section 09_96_01 - High-Performance Coatings.

2.04 SOURCE QUALITY CONTROL

- A. Tests and inspections:
 - 1. Provide joist manufacturer's inspection as required by SJI Standard Specifications. Submit inspection results.

2. Special inspection - Fabrication. Requirements of the building code specified in Section 01_41_00 - Regulatory Requirements for special inspection of fabricated structural items shall be considered to be satisfied when the manufacturer is registered and approved to perform steel fabrication work in accordance with a quality control program that is certified by the Steel Joist Institute (SJI), the American Institute of Steel Construction (AISC), the City of Los Angeles Department of Building and Safety (COLA), or similar program acceptable to building official and the Engineer.

PART 3 EXECUTION

3.01 GENERAL

- A. Furnish and erect steel joists accordance with the requirements of SJI's Code of Standard Practice for Steel Joists and Joist Girders.

3.02 PREPARATION

- A. Field verify dimensions and elevations of structural elements supporting the joists and joist girders.
 1. Establish lines and elevations within tolerances before beginning erection.
 2. Make bearing surfaces true and uniform.
 3. Do not begin placement of steel joists until supporting work is in place and secured.
- B. Clean bearing surfaces of joists and supporting members before erection and as required during erection to maintain solid contact between members.
- C. Do not permit erection of steel deck until joists are connected and bridging is in place.

3.03 INSTALLATION

- A. Erection:
 1. Place and secure steel joists in accordance with SJI Standard Specifications, approved erection drawings, and these Specifications.
 2. Allow for loads from erection procedures, but do not load joists until fastening is complete.
 3. Provide sufficient temporary bracing to maintain joists and supporting framing safe, plumb, and in true alignment until completion of erection and installation of permanent bridging and bracing.
- B. Installation of joists and bridging:
 1. Do not start placement of steel joists until supporting work is in place, adjusted to specified tolerances, and secured.
 2. Do not field modify, alter, or repair joists unless specific written instructions have been received from the joist manufacturer and submitted to the Engineer. Such instructions shall bear the seal and signature of the joist manufacturer's registered design professional licensed in the state where the joists are installed.

3. Place joists on supporting surfaces, adjust, and accurately align to required elevation, location and spacing before permanently fastening.
 - a. Set joists plumb and level (with indicated allowances for camber).
 - b. Set "tag end" of joists at location shown on the erection plans.
 - c. Adjust bearing shoe elevations to provide full bearing after joists and supporting members have been plumbed and positioned, but before final tightening of connections and before any loads are imposed.
 - d. Solidly pack areas under bearing plates using materials and procedures indicated on the Drawings.
 4. Install bridging in accordance with OSHA 29 CFR-1926.757d and SJI Standard Specifications to provide lateral stability for the joists before slacking of hoisting lines. Quantity of bolted diagonal erection bridging shall be in accordance with SJI Standard Specifications.
 5. Install bridging simultaneously with joist erection and before construction loads are applied. Anchor ends of bridging lines at top and bottom chords where terminating at walls or beams. Quantity, size, and sequence for installing bridging shall be in accordance with SJI Standard Specifications.
 6. Erection stability and handling shall be in accordance with SJI Standard Specifications.
- C. Fastening joists:
1. Each joist must be attached at a minimum of one end immediately upon placement in the final erection position and before additional joists are placed.
 2. When field welding joists, weld to supporting steel framework in accordance with SJI Standard Specifications and as indicated on the Drawings.
 - a. Coordinate welding sequence and procedure with placing of joists.
 - b. In accordance with AWS D1.1.
 - c. Length of field welds applied to the top and bottom chords of joists shall not exceed 1/2 of the width of the steel member.
 3. When bolting joists, bolt to supporting steel framework in accordance with SJI Standard Specifications.
- D. Coating:
1. Deliver joists coated or uncoated as indicated on the Drawings and specified.
 2. Where members are painted or coated in place, do not begin preparation or coating until units are in place; properly, completely, and permanently fastened, and accepted by the Engineer.
 3. Prepare, prime, and finish as specified in Section 09_96_01 - High-Performance Coatings.
 4. Perform surface preparation and coating application under environmentally controlled field conditions, or in an off-site paint shop.

3.04 TOLERANCES

- A. As indicated in SJI Standard Specifications, unless otherwise noted.
- B. Deviation from straight line between opposite ends of any installed joist: Maximum 3/8 inch in 10 feet.

3.05 REPAIR

- A. Do not install damaged joists or accessories. Remove such materials from the Site and replace with new materials.
- B. Repair rust spots and coatings damaged by handling, welding, or other erection and fastening processes.
- C. After erection, touch-up rust spots, connections, field welds, and abraded areas of members using specified coatings.
 - 1. Clean and prepare damaged areas.
 - 2. Apply coating at the same thickness as that applied before erection.
 - 3. Feather edges of repairs to provide a uniform appearance after repair.
 - a. Clean and prepare surfaces using SSPC-SP 15 procedures.
 - b. Apply coating of same product and color as member. Apply primer and finish coat(s).

3.06 FIELD QUALITY CONTROL

- A. Provide field quality control over the Work of this Section as required by Section 01_45_17 - Contractor Quality Control Plan.
- B. Field tests and inspections:
 - 1. High-strength bolting:
 - a. Confirm use of specified bolts and nuts.
 - b. Pre-tensioned connections:
 - 1) Confirm that plies of the connected elements have been brought into firm contact by the tightened connection.
 - 2) Confirm bolts pretension using turn-of-the nut method, twist-off type tension controlled nut, or direct-tension indicator washer. Do not use calibrated wrench.
 - 2. Welding - Field welds.
 - a. Perform observations and testing in the presence of the Engineer.
 - b. Visual observation:
 - 1) Visually examine welds in accordance with AWS D1.1.
 - 2) Quality of welds and standards for acceptance shall be in accordance with AWS D1.1, Visual Inspection Acceptance Criteria Table.
 - c. Test results:
 - 1) Submit records of testing to the Engineer within 24 hours after testing.
 - 3. After erection, observe installation for conformance with this Specification.

3.07 FIELD QUALITY ASSURANCE

- A. Provide field quality assurance over the Work of this Section as required by Section 01_45_17 - Contractor Quality Control Plan.
- B. Special inspections, special tests and structural observation:
 - 1. Provide as required by Section 01_45_24 - Regulatory Quality Assurance.

- C. Field inspections:
1. Required inspections:
 - a. Observe construction for conformance to the Contract Documents and the accepted Shop Drawings.
 - 1) Confirm that joist and accessory locations and tags (marks) match those indicated on the erection drawings.
 - 2) Confirm that joists are installed in vertical alignment and without lateral sweep.
 - 3) Confirm that joist spacing conforms to erection drawings.
 - 4) Confirm that bridging lines, spacing, and connections/anchoring conform to erection drawings.
 - b. Visually inspect field bolting, including bolt tightness.
 - c. Visually inspect field welding using AWS certified welding inspectors in accordance with AWS D1.1.
 - 1) In accordance with AWS D1.1.
 - 2) Mark welds observed.
 2. Records of inspections:
 - a. Provide record of each inspection.
 - b. Submit copies to the Engineer upon request.
- D. Field testing.

END OF SECTION

ATTACHMENT A - INSTALLATION AND WELDING INSPECTION REPORT

INSTALLATION AND WELDING INSPECTION REPORT

Project:	
Client:	
Permit No.:	Structure:
Contractor:	
Date:	Weather:
Weather:	Temp (min/max):
Dwg. Ref:	
Location:	

ELEMENTS INSPECTED	REF ⁽¹⁾	CONFORMS?		
		Yes	No	Comments ⁽²⁾
Member Installation:				
Joist and accessory locations, tags, and tagged end locations conform to erection drawings.	1			
Joist spacing conforms to erection drawings.	1			
Joists and accessories are installed in horizontal and vertical alignment and without lateral sweep.	1			
Joist bearing length on supporting members conforms to erection drawings and details.	1a			
Joist and accessory installations conform to specified tolerances.				
Bridging:				
Bridging locations, types (horizontal or diagonal), and member sizes conform to erection drawings.	1b			
Bridging connections to joists conforms to erection drawings.	1b			
Bridging connections to and terminations at ends/walls conforms to erection drawings.	1b			
Field Welding:				
Welds at locations indicated on erection drawings.				
Weld size and length as indicated on erection drawings.	1a			
Quality of welds complies with AWS D1.1 - Visual Inspection Acceptance Criteria Table	1a			
(Continued, next page)				

Inspector:

Name (printed):

Signature:

Date:

Company (printed):

SECTION 05_31_00

STEEL DECKING

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes: Steel deck for floors and roofs, and associated accessories.

1.02 REFERENCES

- A. ASTM International (ASTM):
 - 1. A653 - Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process.
- B. American Welding Society (AWS):
 - 1. D1.3 - Structural Welding Code - Sheet Steel.

1.03 SUBMITTALS

- A. Product data.
- B. Shop drawings.

1.04 DELIVERY, STORAGE, AND HANDLING

- A. Storage and protection:
 - 1. Store steel deck at the site stacked on platforms or pallets and covered with tarpaulins or other suitable weathertight covering.
 - 2. Do not use steel deck for storage or working platform.
 - 3. Remove damaged, unlabeled, untagged, rusty, and deteriorated steel deck material from the job site.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. One of the following or equal:
 - 1. ASC Profiles.
 - 2. Verco Manufacturing Co.
 - 3. Canam Steel Corp.

2.02 MATERIALS

- A. Sheet steel: ASTM A653, G 90 minimum coating designation.

2.03 FABRICATION

- A. Steel deck shall be formed:
 - 1. So every sheet is identical and will register perfectly with adjacent sheets.
 - 2. In accordance with building code as specified in Section 01_41_00 - Regulatory Requirements.
- B. Decking used with concrete fill shall be deformed to develop composite action between the deck and the concrete.
- C. Furnish minimum gauge, deck thickness, section modulus, moment of inertia, and allowable diaphragm shear per foot of deck width that is not less than for type deck sections indicated on the Drawings.
- D. Treat exposed roof deck with phosphate.
- E. Furnish roof deck ready to receive field painting without further pretreatment. Paint exposed roof deck in accordance with Contract Documents.
- F. Accessories:
 - 1. Furnish all accessories indicated on the Drawings or needed to complete work.
 - 2. Minimum required gauges:
 - a. Sump pans: 14 gauge.
 - b. All other accessories: 20 gauge unless otherwise indicated on the Drawings.
- G. Welding and electrodes: In accordance with AWS D1.3.
- H. Furnish roof decking in lengths to minimize number of splices.
- I. Furnish steel deck complete, including cutting, shaping, fitting, drilling, welding, ridge plates, valley plates, reinforcing plates for openings, and miscellaneous pieces necessary for proper installation.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Verification of conditions: Examine work in place to verify that it is satisfactory to receive the work of this Section. If unsatisfactory conditions exist, do not begin this work until such conditions have been corrected.

3.02 INSTALLATION

- A. Decking shall span over at least 3 spans wherever possible.
- B. Do not damage or overload roof deck during installation.
- C. Do not use steel deck for storage or as a working platform until sheets have been welded in position.

- D. Do not exceed maximum uniformly distributed load of 20 pounds per square foot.
- E. Install decking in straight and continuous rows as far as practicable, with ribs at right angles to supporting members.
- F. For each end of deck section, provide 3 inches minimum bearing on supports. For sections that abut each other, each piece shall bear a minimum of 3 inches on the support. This requires a 6-inch minimum flange width. For cases where the minimum bearing cannot be obtained, notify the Engineer.
- G. Electric arc weld deck sections to bearing plates, supports at butt joints, at intermediate supports, side supports, and at end supports as indicated on the Drawings. Do not burn through the deck. Remove all slag.
- H. Fasten the longitudinal joints between deck sections together by the method indicated on the Drawings.
- I. Neatly cut and fit openings in roof deck and reinforce with structural steel members as indicated on the Drawings.
- J. Paint welds as specified.
- K. Install roof deck free of dents and bent members.
- L. Reinforce all holes and openings in steel deck as indicated on the Drawings.
- M. Piping, conduit, equipment, and other services: Do not hang from decking.
- N. Install all accessories required to complete work.

3.03 REPAIR OF GALVANIZING AND COATING

- A. Touch-up damage to galvanized surfaces, including cut edges and holes, with zinc rich primer.
- B. Repair damage to factory-applied coating system in accordance with the manufacturer's printed recommendations.

3.04 CLEANUP

- A. After erection, remove weld spatter, grease, and oil from decking.

END OF SECTION

SECTION 05_50_00
METAL FABRICATIONS

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Concrete inserts.
 - 2. Handrails and guardrails.
 - 3. Ladders.
 - 4. Manhole frames and covers.
 - 5. Metal gratings.
 - 6. Metal tread plate.
 - 7. Preformed channel pipe supports.
 - 8. Miscellaneous metals.
 - 9. Associated accessories to the above items.

1.02 REFERENCES

- A. Aluminum Association (AA):
 - 1. DAF-45: Designations from Start to Finish.
 - a. M12-C22-A41.
- B. American Association of State Highway and Transportation Officials (AASHTO):
 - 1. Standard Specifications for Highway Bridges.
- C. American Welding Society (AWS):
 - 1. A2.4 - Standard Symbols for Welding, Brazing, and Nondestructive Examination.
- D. ASTM International (ASTM):
 - 1. A36 - Standard Specification for Carbon Structural Steel.
 - 2. A48 - Standard Specification for Gray Iron Castings.
 - 3. A53 - Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded, and Seamless.
 - 4. A123 - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
 - 5. A240 - Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels for General Applications.
 - 6. A276 - Standard Specification for Stainless Steel Bars and Shapes.
 - 7. A307 - Standard Specification for Carbon Steel Bolts and Studs, 60,000 PSI Tensile Strength.
 - 8. A380 - Standard Practice for Cleaning, Descaling, and Passivation of Stainless Steel Parts, Equipment, and Systems.
 - 9. A489 - Standard Specification for Carbon Steel Lifting Eyes.
 - 10. A500 - Standard Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes.

11. A501 - Standard Specification for Hot-Formed Welded and Seamless Carbon Steel Structural Tubing.
12. A635 - Standard Specification for Steel, Sheet and Strip, Heavy-Thickness Coils, Hot-Rolled, Alloy, Carbon, Structural, High-Strength Low-Alloy, and High-Strength Low-Alloy with Improved Formability, General Requirements for.
13. A653 - Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process.
14. A992 - Standard Specification for Structural Steel Shapes.
15. B209 - Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate.
16. B221 - Standard Specification for Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes.
17. B308 - Standard Specification for Aluminum-Alloy 6061-T6 Standard Structural Profiles.
18. B429 - Standard Specification for Aluminum-Alloy Extruded Structural Pipe and Tube.
19. F593 - Standard Specification for Stainless Steel Bolts, Hex Cap Screws and Studs.
20. F3125 - Standard Specification for High Strength Structural Bolts, Steel and Alloy Steel, Heat Treated, 120 ksi and 150 ksi Minimum Tensile Strength.

E. Occupational Safety and Health Administration (OSHA).

1.03 TERMINOLOGY

- A. The words and terms listed below are not defined terms that require initial capital letters, but, when used in this Section, have the indicated meaning.
1. Passivation: Removal of exogenous iron or iron compounds from the surface of a stainless steel by means of chemical dissolution resulting from treatment with an acid solution that removes the surface contamination but does not significantly affect the stainless steel itself.

1.04 SUBMITTALS

- A. Product data:
1. Handrails and guardrails.
 2. Manhole frames and covers.
 3. Metal grating.
- B. Shop Drawings:
1. Handrails and guardrails:
 - a. Including details on connection attachments, gates, kick plates, ladders, and angles.
 - b. Indicate profiles, sizes, connection attachments, reinforcing, anchorage, size and type of fasteners, and accessories.
 - c. Include erection drawings, elevations, and details where applicable.
 - d. Indicate welded connections using standard AWS A2.4 welding symbols. Indicate net weld lengths.
 2. Ladders.
 3. Metal grating.

4. Metal tread plate.
 5. Miscellaneous metals.
- C. Samples:
1. Guardrails with specified finishes.
- D. Quality Control Submittals:
1. Design data.
 2. Test reports:
 - a. Guardrails: 3 copies of certified tests performed by an independent testing laboratory certifying that guardrails meet current state and OSHA strength requirements.
 - b. Gratings:
 - 1) Grating manufacturers' calculations showing that gratings will meet specified design load, stress, and deflection requirements for each size grating for each span.
 - 2) Reports of tests performed.

PART 2 PRODUCTS

2.01 MATERIALS

- A. Unless otherwise specified or indicated on the Drawings, structural and miscellaneous metals in accordance with the standards of the ASTM, including the following:

Item	ASTM Standard No.	Class, Grade Type, or Alloy No.
Cast Iron		
Cast iron	A48	Class 40B
Steel		
Galvanized sheet iron or steel	A653	Coating G90
Coil (plate)	A635	—
Structural plate, bars, rolled shapes, and miscellaneous items (except W shapes)	A36	—
Rolled W shapes	A992	Grade 50
Standard bolts, nuts, and washers	A307	—
High strength bolts, nuts, and hardened flat washers	F3125, Grade A325	—
Eyebolts	A489	Type 1
Tubing, cold-formed	A500	—
Tubing, hot-formed	A501	—
Steel pipe	A53	Grade B

Item	ASTM Standard No.	Class, Grade Type, or Alloy No.
Stainless Steel		
Plate, sheet, and strip	A240	Type 304 ⁽¹⁾ or 316 ⁽²⁾
Bars and shapes	A276	Type 304 ⁽¹⁾ or 316 ⁽²⁾
Bolts (Type 304)	F593	Group 1 Condition CW
Bolts (Type 316)	F593	Group 2 Condition CW
Aluminum		
Flashing sheet aluminum	B209	Alloy 5005-H14, 0.032 inches minimum thickness
Structural sheet aluminum	B209	Alloy 6061-T6
Structural aluminum	B209, B308	Alloy 6061-T6
Extruded aluminum	B221	Alloy 6063-T42
<u>Notes:</u> (1) Use Type 304L if material will be welded. (2) Use Type 316L if material will be welded.		

1. Stainless steels are designated by type or series defined by ASTM.
2. Where stainless steel is welded, use low-carbon stainless steel.

2.02 MANUFACTURED UNITS

- A. Concrete inserts:
 1. For supporting pipe and other applications are specified in Section 40_05_07.01 - Pipe Supports.
- B. Ladders:
 1. General:
 - a. Type: Safety type in accordance with local, state, and OSHA standards as minimum. Furnish guards for ladder wells.
 - b. Size: 18 inches wide between side rails of length, size, shape, detail, and location indicated on the Drawings.
 2. Aluminum ladders:
 - a. Material: 6063-T5 aluminum alloy.
 - b. Rungs:
 - 1) 1-inch minimum solid square bar with 1/8-inch grooves in top and deeply serrated on all sides.
 - 2) Capable of withstanding 1,000-pound load without failure.
 - c. Side rails: Minimum 4-inch by 1/2-inch flat bars.
 - d. Finish of aluminum components:
 - 1) Anodized finish, 0.7 mil thick, applied to exposed surfaces after cutting.
 - a) AA DAF-45 Specification M12-C22-A41: Mechanical finish non specular as fabricated, chemical finish-medium matte, anodic coating-clear Class I Architectural.
 - 2) Pretreat aluminum for cleaning and removing markings before anodizing.

- e. Fabrication:
 - 1) Welded construction, of size, shape, location, and details indicated on the Drawings.
 - 2) For fixed ladders over 24 feet high, provide a fall prevention system designed in accordance with state and OSHA requirements.
 - f. Fall prevention system: Including, but not limited to, railing, brackets, clamps, 2 sleeves, and 2 belts, in accordance with OSHA safe climbing requirements:
 - 1) Manufacturers: One of the following or equal:
 - a) North Consumer Products, Saf-T-Climb.
 - b) Swager Communications, Climbers Buddy System.
- C. Manhole frames and covers:
- 1. Material: Gray iron castings, in accordance with ASTM A48, Class 30-B.
 - 2. Type: Heavy-duty traffic type, with combined minimum set weight of 265 pounds.
 - 3. Machine horizontal and vertical bearing surfaces to fit neatly, with easily removable cover bearing firmly in frame without rocking.
 - 4. Frame:
 - a. Bottom flange type.
 - b. Approximately 4-1/2-inches frame height.
 - c. Dimensions as indicated on the Drawings.
 - 1) Minimum inside clear dimension may not be smaller than nominal diameter minus 2 inches.
 - 5. Cover:
 - a. Skid-resistant grid pattern design stamped with name of utility service provided by manhole, such as ELECTRICAL, SEWER, TELEPHONE, or WATER.
 - b. Solid type without ventilation holes.
 - 6. Finish: Unpainted.
- D. Metal gratings:
- 1. General:
 - a. Fabricate grating to cover areas indicated on the Drawings.
 - b. Unless otherwise indicated on the Drawings, grating over an opening shall cover entire opening.
 - c. Make cutouts in grating where required for equipment access or protrusion, including valve operators or stems, and gate frames.
 - d. Band ends of grating and edges of cutouts in grating:
 - 1) End banding: 1/4 inch less than height of grating, with top of grating and top edge of banding flush.
 - 2) Cutout banding: Full height of grating.
 - 3) Use banding of same material as grating.
 - 4) Panel layout: Enable installation and subsequent removal of grating around protrusions or piping.
 - 5) Openings 6 inches and larger: Lay out grating panels with edges of 2 adjacent panels located on centerline of opening.
 - 6) Openings smaller than 6 inches: Locate opening at edge of single panel.

- 7) Where an area requires more than 1 grating section to cover area, clamp adjacent grating sections together at 1/4-points with fasteners acceptable to the Engineer.
 - 8) Fabricate steel grating sections in units weighing not more than 50 pounds each.
 - 9) Fabricate aluminum grating sections in units of weighing not more than 50 pounds each.
 - 10) Gaps between adjacent grating sections shall not be more than the clear spacing between bearing bars.
 - e. When requested by the Engineer, test 1 section of each size grating for each span length involved on the job under full load:
 - 1) Furnish a suitable dial gauge for measuring deflections.
 - f. Grating shall be aluminum, unless otherwise specified or indicated on the Drawings.
2. Aluminum grating:
 - a. Material for gratings, shelf angles, and rebates: 6061-T6 or 6063-T6 aluminum alloy, except crossbars may be 6063-T5 aluminum alloy.
 - b. Shelf angle concrete anchors: Type 304 or Type 316 stainless steel.
 - c. Grating rebate rod anchors: 6061-T6 or 6063-T6 aluminum alloy.
 - d. Bar size and spacing: As determined by the manufacturer to enable grating to support design load.
 - e. Design live load: A minimum of 100 pounds per square foot uniform live load on entire grating area, but not less than the live load indicated on the Drawings for the area where grating is located.
 - f. Maximum fiber stress for design load: 12,000 pounds per square inch.
 - g. Maximum deflection due to design load: 1/240 of grating clear span.
 - h. Maximum spacing of main grating bars: 1-1/8 inches clear between bars.
 - i. Minimum grating height: 1-1/2 inches.
 - j. Manufacturers: The following or equal:
 - 1) Harsco Industrial IKG, Swaged Aluminum I-Bar with striated finish.
 3. Heavy-duty steel grating:
 - a. Fabricated from structural steel and designed in accordance with AASHTO Standard Specifications for Highway Bridges, using H-20 loading.
 - b. Hot-dip galvanized after fabrication in accordance with ASTM A123.
 - c. Manufacturers: One of the following or equal:
 - 1) Reliance Steel Products Co., Heavy-Duty Steel Grating.
 - 2) Seidelhuber Metal Products, Inc., equivalent product.
- E. Metal tread plate:
1. Having a raised figured pattern on one surface to provide improved traction.
- F. Preformed channel pipe supports:
1. As specified in Section 40_05_07.03 - Preformed Channel Pipe Support System.
- G. Miscellaneous aluminum:
1. Fabricate aluminum products, not covered separately in this Section, in accordance with the best practices of the trade and field assemble by riveting or bolting.
 2. Do not weld or flame cut.

- H. Miscellaneous cast iron:
1. Tough, gray iron, free from cracks, holes, swells, and cold shuts.
 2. Quality such that hammer blow will produce indentation on rectangular edge of casting without flaking metal.
 3. Before leaving the foundry, clean castings and apply 16-mil dry film thickness coating of coal-tar epoxy, unless otherwise specified or indicated on the Drawings.
- I. Miscellaneous stainless steel:
1. Provide miscellaneous stainless steel items not specified in this Section as indicated on the Drawings or specified elsewhere.
 - a. Fabricate and install in accordance with the best practices of the trade.
 2. Cleaning and passivation:
 - a. Following shop fabrication of stainless steel members, clean and passivate fabrications.
 - b. Finish requirements: Remove free iron, heat tint oxides, weld scale and other impurities, and obtain a passive finished surface.
 - c. Provide quality control testing to verify effectiveness of cleaning agents and procedures and to confirm that finished surfaces are clean and passivated.
 - 1) Conduct sample runs using test specimens with proposed cleaning agents and procedures as required to avoid adverse effects on surface finishes and base materials.
 - d. Pre-clean, chemically descale (pickle), and final clean fabrications in accordance with the requirements of ASTM A380 to remove deposited contaminants before shipping.
 - 1) Passivation by citric acid treatment is not allowed.
 - a) If degreasing is required before cleaning to remove scale or iron oxide, cleaning (pickling) treatments with citric acid are permissible; however, these treatments shall be followed by inorganic cleaners such as nitric-hydrofluoric acid.
 - 2) Provide acid descaling (pickling) in accordance with Table A1.1 of Annex A1 of ASTM A380.
 - 3) After pickling, final cleaning of stainless steel shall be in accordance with Part II of Table A2.1 of Annex A2 of ASTM A380.
 - e. After cleaning, inspect using methods specified for "gross inspection" in ASTM A380.
 - f. Improperly or poorly cleaned and passivated materials shall not be shipped and will not be accepted at the job site.
- J. Miscellaneous structural steel:
1. Provide miscellaneous structural steel items not specified in this Section as indicated on the Drawings or specified elsewhere.
 - a. Fabricate and install in accordance with the best practices of the trade.
- K. Isolating sleeves and washers:
1. As indicated on the Drawings and as specified in Section 05_05_24 - Mechanical Anchoring and Fastening to Concrete and Masonry.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Verification of conditions:
 - 1. Examine work in place to verify that it is satisfactory to receive the Work of this Section.
 - 2. If unsatisfactory conditions exist, do not begin this work until such conditions have been corrected.

3.02 INSTALLATION

- A. General:
 - 1. Install products as indicated on the Drawings, and in accordance with Shop Drawings and the manufacturer's printed instructions, as applicable, except where specified otherwise.
 - 2. Interface between materials:
 - a. Dissimilar metals: Where steel comes in contact with dissimilar metals (aluminum, stainless steel, etc.), separate or isolate the dissimilar metals.
 - 1) Make application so that the isolating or protective barrier is not visible in the completed construction.
 - 2) Isolating sleeves and washers: As specified in Section 05_05_24 - Mechanical Anchoring and Fastening to Concrete and Masonry.
 - b. Aluminum in contact with concrete or masonry: Coat aluminum surfaces as specified in Section 09_96_01 - High Performance Coatings.
 - c. Aluminum in contact with concrete or masonry.
- B. Ladders:
 - 1. Secure to supporting surface with bent plate clips providing minimum 8 inches between supporting surface and center of rungs.
 - 2. Where exit from ladder is forward over top rung, extend side rails 3 feet-3 inches minimum above landing, and return the rails with a radius bend to the landing.
 - 3. Where exit from ladder is to side, extend ladder 5 feet-6 inches minimum above landing and rigidly secure at top.
 - 4. Erect rail straight, level, plumb, and true to position indicated on the Drawings:
 - a. Correct deviations from true line or grade which are visible to the eye.
- C. Manhole frames and covers:
 - 1. Installation: As recommended by the manufacturer.
- D. Metal gratings:
 - 1. General:
 - a. Allow 1/8-inch maximum clearance between ends of grating and inside face of vertical leg of shelf angles.
 - b. Horizontal bearing leg of shelf angles shall be 2 inches minimum.
 - c. Install aluminum plate or angles where necessary to fill openings at changes in elevation and at openings between equipment and grating.
 - d. Install angle stops at ends of grating.
 - e. Installed grating shall not slide out of rebate or off support.
 - f. Weld stops in place, unless otherwise specified or indicated on the Drawings.

- g. Top surfaces of grating sections adjacent to each other shall lie in same plane.
 - 2. Aluminum grating:
 - a. Support on aluminum shelf angles or rebates.
 - 3. Heavy-duty steel grating:
 - a. Support on hot-dip galvanized structural steel rebates embedded and anchored in concrete.
 - b. Use for roadways, traffic areas, and where indicated on the Drawings.
- E. Stainless steel:
 - 1. Welding:
 - a. Passivate field-welded surfaces:
 - 1) Provide cleaning, pickling and passivating as specified in this Section.
 - 2) Clean using Derustit stainless steel cleaner, or equal.

END OF SECTION

SECTION 05_51_50

LADDERS

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Aluminum access ladder.
- B. Vertical fall arrest system.
- C. Horizontal fall arrest system.
- D. Security door.

1.02 RELATED SECTIONS

- A. Section 05_50_00 - Metal Fabrications: Fasteners and installation requirements used to attach ladders to structure.

1.03 REFERENCES

- A. AA - Aluminum Association.
- B. ASTM B 209 - Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate.
- C. ASTM B 221 - Standard Specification for Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes.
- D. OSHA 1910.27 - Fixed Ladders.

1.04 SUBMITTALS

- A. Submit under provisions of Section 01_33_00 - Submittal Procedures.
- B. Product Data: Manufacturer's data sheets on each product.
- C. Shop Drawings:
 - 1. Detail fabrication and erection of each ladder indicated. Include plans, elevations, sections, and details of metal fabrications and their connections.
 - 2. Provide templates for anchors and bolts specified for installation under other Sections.
 - 3. Provide reaction loads for each hanger and bracket.
- D. Qualification Data:
 - 1. Refer to Quality Assurance provisions for submittal requirements evidencing experience, certifications and resources.

1.05 QUALITY ASSURANCE

- A. Manufacturer Qualifications: A firm experienced in producing aluminum metal ladders similar to those indicated for this Project:
 - 1. Record of successful in-service performance.
 - 2. Sufficient production capacity to produce required units.
 - 3. Professional engineering competent in design and structural analysis to fabricate ladders in compliance with industry standards and local codes.
- B. Installer Qualifications: Competent and experienced firm capable of selecting fasteners and installing ladders to attain designed operational and structural performance.
- C. Product Qualification: Product design shall comply with OSHA 1910.27 minimum standards for ladders.
- D. Mock-Up: Provide a mock-up for evaluation of surface preparation techniques and application workmanship:
 - 1. Install ladder in area designated by Engineer.
 - 2. Do not proceed with remaining work until workmanship and installation are approved by Engineer.
 - 3. Rework mock-up as required to produce acceptable work.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. Store products in manufacturer's unopened packaging until ready for installation.

1.07 PROJECT CONDITIONS

- A. Field Measurements: Verify dimensions by field measurement before fabrication:
 - 1. Established Dimensions: Where field measurements cannot be made without delaying the Work, indicate established dimensions on shop drawing submittal and proceed with fabrication.

1.08 WARRANTY

- A. Manufacturer has responsibility for an extended Corrective Period for work of this Section for a period of 5 years commencing on the shipment date of the product against all the conditions indicated below, and when notified in writing from Owner, manufacturer shall promptly and without inconvenience and cost to Owner correct said deficiencies.
- B. Defects in materials and workmanship.
 - 1. Deterioration of material and surface performance below minimum OSHA standards as certified by independent third party testing laboratory. Ordinary wear and tear, unusual abuse or neglect excepted.
 - 2. Within the warranty period, the manufacturer shall, at its option, repair, replace, or refund the purchase price of defective ladder.

- C. Manufacturer shall be notified immediately of defective products, and be given a reasonable opportunity to inspect the goods prior to return. Manufacturer will not assume responsibility, or compensation, for unauthorized repairs or labor. Manufacturer makes no other warranty, expressed or implied, to the merchantability, fitness for a particular purpose, design, sale, installation, or use, of the ladder; and shall not be liable for incidental or consequential damages, losses of or expenses, resulting from the use of ladder products.

PART 2 PRODUCTS

2.01 PERFORMANCE

- A. Delegated Design: Engage a qualified professional engineer, as defined in Section 01_35_73 - Delegated Design Procedures to design ladder, platform, guards including attachment to building construction and fall arrest systems.
- B. Structural Performance of Ladder, Guards and Fall Arrest Systems: Ladder and guards, including attachment to building construction, and vertical and horizontal fall arrest systems withstand the effects of gravity loads and the loads and stresses within limits and under conditions indicated in Section 01_81_50 - Design Criteria.

2.02 MANUFACTURERS

- A. Acceptable Manufacturer: O’Keeffe’s, Inc.; 100 N Hill Drive, Suite 12, Brisbane, CA 94005.
- B. Requests for substitutions will be considered in accordance with provisions of Section 01_60_01 - Product Requirements.

2.03 APPLICATIONS/SCOPE

- A. Fixed Ladder Design:
 - 1. Landing platform is required at top of the ladder.
 - 2. Rail and harness fall arrest system:
 - a. Fixed Ladder Bottom Bracket:
 - b. Bottom floor supported bracket.
- B. Fixed Access Ladder:
 - 1. Heavy Duty Tubular Rail.
 - a. Model 501 as manufactured by O’Keeffe’s Inc.

2.04 FINISHES

- A. Mill finish. As extruded.

2.05 MATERIALS

- A. Exterior roof access ladder:
 - 1. Aluminum Sheet: Alloy 5005-H34 to comply with ASTM B209.
 - 2. Aluminum Extrusions: Alloy 6063-T6 to comply with ASTM B221.

2.06 FABRICATION

- A. Rungs: Not less than 1-1/4 inches (32 mm) in section and 18-3/8 inches (467 mm) long, formed from tubular aluminum extrusions. Squared and deeply serrated on all sides.
 - 1. Rungs shall withstand a 1,500-pound (454 kg) load without deformation or failure.
- B. Heavy Duty Tubular Side Rails: Assembled from two interlocking aluminum extrusions no less than 1/8-inch (3-mm) wall thickness by 3 inches (76 mm) wide. Construction shall be self-locking stainless steel fasteners, full penetration TIG welds and clean, smooth and burr-free surfaces.
- C. Walk-Through Rail and Roof Rail Extension: Not less than 3 feet 6 inches (1,067 mm) above the landing and shall be fitted with deeply serrated, square, tubular grab rails.
- D. Landing Platform: 1-1/2 inches (38 mm) or greater diameter, tubular aluminum guardrails and decks of serrated aluminum treads.
- E. Vertical Rail and Harness Fall Arrest System: Supplied in accordance with OSHA regulation 1910.27; permanently mounted to ladder rungs and complete with necessary components.
 - 1. Provide 3M DBI-SALA Lad-Saf Flexible Vertical Safety System or equal.
- F. Horizontal Rail and Harness Fall Arrest System: Extruded aluminum rail system permanently mounted to roof and complete with necessary components.
 - 1. Provide 3M DBI-SALA UniRail Horizontal Lifeline System or equal.
- G. Security Door for Heavy Duty Tubular Rail: 90 inches tall, lockable, mill finish.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Coordinate anchorages. Furnish setting drawings, templates, and anchorage structural loads for fastener resistance.
- B. Do not begin installation until supporting structure is complete and ladder installation will not interfere with supporting structure work.
- C. If supporting structure is the responsibility of another installer, notify Engineer of unsatisfactory supporting work before proceeding.

3.02 INSTALLATION

- A. Install in accordance with manufacturer's instructions and in proper relationship with adjacent construction.

3.03 PROTECTION

- A. Protect installed products until completion of project.
- B. Touch-up, repair or replace damaged products before Substantial Completion.

END OF SECTION

SECTION 06_10_00

ROUGH CARPENTRY

PART 1 GENERAL

1.01 SUMMARY

- A. Section Includes:
 - 1. Wood blocking, cants, and nailers.
 - 2. Wood furring and grounds.

1.02 ACTION SUBMITTALS

- A. Product Data:
 - 1. For each type of process and factory-fabricated product.
 - 2. For preservative-treated wood products.

1.03 INFORMATIONAL SUBMITTALS

- A. Material Certificates:
 - 1. For preservative-treated wood products. Indicate type of preservative used and net amount of preservative retained.
- B. Evaluation Reports: For the following, from ICC-ES:
 - 1. Wood-preservative-treated wood.
 - 2. Fire-retardant-treated wood.

PART 2 PRODUCTS

2.01 WOOD PRODUCTS, GENERAL

- A. Lumber: Comply with DOC PS 20 and applicable rules of grading agencies indicated. If no grading agency is indicated, comply with the applicable rules of any rules-writing agency certified by the ALSC Board of Review. Grade lumber by an agency certified by the ALSC Board of Review to inspect and grade lumber under the rules indicated.
 - 1. Factory mark each piece of lumber with grade stamp of grading agency.
 - 2. Dress lumber, S4S, unless otherwise indicated.
- B. Maximum Moisture Content:
 - 1. Boards: 19 percent.
 - 2. Dimension Lumber: 19 percent unless otherwise indicated.

2.02 PRESERVATIVE TREATMENT

- A. Preservative Treatment by Pressure Process: AWP A U1; Use Category UC2 for interior construction not in contact with ground, Use Category UC3b for exterior construction not in contact with ground, and Use Category UC4a for items in contact with ground.
 - 1. Preservative Chemicals: Acceptable to authorities having jurisdiction and containing no arsenic or chromium.
- B. Kiln-dry lumber after treatment to a maximum moisture content of 19 percent. Do not use material that is warped or that does not comply with requirements for untreated material.
- C. Mark lumber with treatment quality mark of an inspection agency approved by the ALSC Board of Review.
- D. Application: Treat all rough carpentry unless otherwise indicated.
 - 1. Wood cants, nailers, curbs, equipment support bases, blocking, stripping, and similar members in connection with roofing, flashing, vapor barriers, and waterproofing.
 - 2. Wood sills, sleepers, blocking, furring, stripping, and similar concealed members in contact with masonry or concrete.
 - 3. Wood framing and furring attached directly to the interior of below-grade exterior masonry or concrete walls.

2.03 FIRE-RETARDANT-TREATMENT

- A. General: Where fire-retardant-treated materials are indicated, materials are to comply with requirements in this article, that are acceptable to authorities having jurisdiction, and with fire-test-response characteristics specified as determined by testing identical products per test method indicated by a qualified testing agency.
- B. Fire-Retardant-Treated Lumber and Plywood by Pressure Process: Products with a flame-spread index of 25 or less when tested according to ASTM E84, and with no evidence of significant progressive combustion when the test is extended an additional 20 minutes, and with the flame front not extending more than 10.5 feet beyond the centerline of the burners at any time during the test.
 - 1. Exterior Type: Treated materials are to comply with requirements specified above for fire-retardant-treated lumber and plywood by pressure process after being subjected to accelerated weathering according to ASTM D2898. Use for exterior locations and where indicated.
 - 2. Interior Type A: Treated materials are to have a moisture content of 28 percent or less when tested according to ASTM D3201/D3201M at 92 percent relative humidity. Use where exterior type is not indicated.
- C. Kiln-dry lumber after treatment to maximum moisture content of 19 percent. Kiln-dry plywood after treatment to maximum moisture content of 15 percent.
- D. Identify fire-retardant-treated wood with appropriate classification marking of qualified testing agency.

- E. Application: Treat all rough carpentry unless otherwise indicated.
 - 1. Concealed blocking.
 - 2. Roof construction.

2.04 MISCELLANEOUS LUMBER

- A. Provide miscellaneous lumber indicated and lumber for support or attachment of other construction, including the following:
 - 1. Blocking.
 - 2. Nailers.
 - 3. Cants.
 - 4. Furring.
 - 5. Grounds.
- B. Dimension Lumber Items: Construction or No. 2 grade lumber of any species.
- C. Concealed Boards: 19 percent maximum moisture content and the following species and grades:
 - 1. Western woods; Construction or No. 2 Common grade; WCLIB or WWP.

2.05 FASTENERS

- A. General: Fasteners are to be of size and type indicated and comply with requirements specified in this article for material and manufacture. Provide nails or screws, in sufficient length, to penetrate not less than 1-1/2 inches into wood substrate.
 - 1. Where rough carpentry is exposed to weather, in ground contact, pressure-preservative treated, or in area of high relative humidity, provide fasteners with hot-dip zinc coating complying with ASTM A153/A153M.

2.06 MISCELLANEOUS MATERIALS

- A. Flexible Flashing: Composite, self-adhesive, flashing product consisting of a pliable, butyl rubber or rubberized-asphalt compound, bonded to a high-density polyethylene film, aluminum foil, or spunbonded polyolefin to produce an overall thickness of not less than 0.025 inch.
- B. Adhesives for Gluing Furring and Sleepers to Concrete or Masonry: Formulation complying with ASTM D3498 that is approved for use indicated by adhesive manufacturer.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Set work to required levels and lines, with members plumb, true to line, cut, and fitted. Fit rough carpentry accurately to other construction. Locate furring, nailers, blocking, grounds, and similar supports to comply with requirements for attaching other construction.

- B. Do not splice structural members between supports unless otherwise indicated.
- C. Comply with AWP4 M4 for applying field treatment to cut surfaces of preservative-treated lumber.
- D. Where wood-preservative-treated lumber is installed adjacent to metal decking, install continuous flexible flashing separator between wood and metal decking.
- E. Securely attach rough carpentry work to substrate by anchoring and fastening as indicated, complying with the following:
 - 1. Table 2304.9.1, "Fastening Schedule," in ICC's International Building Code (IBC).
 - 2. Table R602.3(1), "Fastener Schedule for Structural Members," and Table R602.3(2), "Alternate Attachments," in ICC's International Residential Code for One- and Two-Family Dwellings.
 - 3. ICC-ES evaluation report for fastener.

3.02 PROTECTION

- A. Protect wood that has been treated with inorganic boron (SBX) from weather. If, despite protection, inorganic boron-treated wood becomes wet, apply EPA-registered borate treatment. Apply borate solution by spraying to comply with EPA-registered label.
- B. Protect rough carpentry from weather. If, despite protection, rough carpentry becomes wet, apply EPA-registered borate treatment. Apply borate solution by spraying to comply with EPA-registered label.

END OF SECTION

SECTION 06_16_00

SHEATHING

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Composite nail base insulated wall sheathing.
 - 2. Composite nail base insulated roof sheathing.

1.02 ACTION SUBMITTALS

- A. Product data:
 - 1. For each type of process and factory-fabricated product.

1.03 INFORMATIONAL SUBMITTALS

- A. Evaluation Reports: For the following, from ICC-ES:
 - 1. Wood-preservative-treated plywood.
 - 2. Fire-retardant-treated plywood.

PART 2 PRODUCTS

2.01 PERFORMANCE REQUIREMENTS

- A. Fire-Resistance Ratings: As tested in accordance with ASTM E119; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.
 - 1. Fire-Resistance Ratings: Indicated by design designations from UL's "Fire Resistance Directory" or from the listings of another qualified testing agency.
- B. Structural Performance: Provide roofing systems capable of withstanding the effects of the following loads:
 - 1. Wind Loads: As indicated on the Drawings.
 - 2. Deflection Limits: For wind loads, no greater than 1/240 of the span.

2.02 PRESERVATIVE-TREATED PLYWOOD

- A. Preservative Treatment by Pressure Process: AWP A U1; Use Category UC2 for interior construction not in contact with ground, Use Category UC3b for exterior construction not in contact with ground, and Use Category UC4a for items in contact with ground.
- B. Mark plywood with appropriate classification marking of an inspection agency acceptable to authorities having jurisdiction.
- C. Application: Treat all plywood unless otherwise indicated.

2.03 FIRE-RETARDANT-TREATED PLYWOOD

- A. General: Where fire-retardant-treated materials are indicated, use materials complying with requirements in this article that are acceptable to authorities having jurisdiction and with fire-test-response characteristics specified as determined by testing identical products per test method indicated by a qualified testing agency.
- B. Fire-Retardant-Treated Plywood by Pressure Process: Products with a flame-spread index of 25 or less when tested in accordance with ASTM E84, and with no evidence of significant progressive combustion when the test is extended an additional 20 minutes, and with the flame front not extending more than 10.5 feet beyond the centerline of the burners at any time during the test.
 - 1. Exterior Type: Treated materials are to comply with requirements specified above for fire-retardant-treated plywood by pressure process after being subjected to accelerated weathering in accordance with ASTM D2898. Use for exterior locations and where indicated.
 - 2. Design Value Adjustment Factors: Treated lumber plywood is to be tested in accordance with ASTM D5516 and design value adjustment factors are to be calculated in accordance with ASTM D6305. Span ratings after treatment are to be not less than span ratings specified.
- C. Kiln-dry material after treatment to a maximum moisture content of 15 percent.
- D. Identify fire-retardant-treated plywood with appropriate classification marking of qualified testing agency.
- E. Application: Treat all plywood unless otherwise indicated.

2.04 COMPOSITE NAIL BASE INSULATED WALL SHEATHING

- A. Plywood-Surfaced, Polyisocyanurate-Foam Sheathing: ASTM C1289, Type V with DOC PS 2, Exposure 1 plywood on one face.
 - 1. Basis-of-Design Product: Subject to compliance with requirements, provide Hunter Panels; Xci Ply or a comparable product by one of the following:
 - a. Atlas Molded Products, a division of Atlas Roofing Corporation.
 - b. Cornell Performance Building Products, a Subsidiary of GAF.
 - c. Johns Manville; a Berkshire Hathaway company.
 - d. Rmax, Inc.
 - e. The Dow Chemical Company.
 - 2. Polyisocyanurate-Foam Thickness: 4 inches.
 - 3. Plywood Nominal Thickness: 3/4 inch.

2.05 COMPOSITE NAIL BASE INSULATED ROOF SHEATHING

- A. Plywood-Surfaced, Polyisocyanurate-Foam Sheathing: ASTM C1289, Type V with DOC PS 2, Exposure 1 plywood on one face.
 - 1. Basis-of-Design Product: Subject to compliance with requirements, provide Hunter Panels; H-Shield NB or a comparable product by one of the following:
 - a. Atlas Molded Products, a division of Atlas Roofing Corporation.
 - b. Cornell Performance Building Products, a Subsidiary of GAF.

- c. Johns Manville; a Berkshire Hathaway company.
- d. Rmax, Inc.
- e. The Dow Chemical Company.
- 2. Polyisocyanurate-Foam Thickness: 3 inches; 1-layer composite nail base insulated roof sheathing and one layer insulation only, 6 inches total.
- 3. Plywood Nominal Thickness: 3/4 inch.

2.06 FASTENERS

- A. General: Provide fasteners of size and type indicated that comply with requirements specified in this article for material and manufacture.
 - 1. For roof sheathing, provide fasteners with hot-dip zinc coating complying with ASTM A153/A153M.
- B. Roof Fasteners shall be approved Hunter Panel SIP/SD Panel Fasteners for steel deck application. Fasteners have a 3/16-inch shank and are corrosion resistant with oversized heads. Length of fasteners shall be as recommended by panel manufacturer. Use of 2-inch round plates shall not be required.
 - 1. See TER 2101-01 by DrJ Engineering for penetration and fastening schedule requirements.
- C. Wall Fasteners shall be approved Hunter Panels fasteners. Fasteners are corrosion resistant with oversized heads. Length of fasteners shall be as recommended by the panel manufacturer.
 - 1. Hunter SIP/SD: Concrete and CMU (pre-drilling required).

2.07 WATER RESISTIVE BARRIER

- A. Xci VP-SA-WRB, vapor permeable air and water resistive barrier available from Hunter Panels.
 - 1. A 23-mil thickness self-adhered vapor-permeable membrane for use as an air and water resistive barrier in exterior walls.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Do not begin installation until substrates have been properly prepared.
- B. Verify deck, adjacent materials, and structural backing are dry and ready to receive insulation.
- C. Verify deck surface is flat, free of fins, protrusions and irregularities.
- D. Verify that all exterior wall assembly construction has been completed to the point where the insulation may correctly be installed.
- E. Verify that mechanical and electrical services in walls have been installed and tested and, if appropriate, verify that adjacent materials and finishes are dry and ready to receive insulation.

3.02 INSTALLATION, GENERAL

- A. Install in accordance with manufacturer's instructions.
- B. Do not use materials with defects that impair quality of sheathing or pieces that are too small to use with minimum number of joints or optimum joint arrangement. Arrange joints so that pieces do not span between fewer than 3 support members.
- C. Cut panels at penetrations, edges, and other obstructions of work; fit tightly against abutting construction unless otherwise indicated.
- D. Securely attach to substrate by fastening as indicated, complying with the following:
 - 1. Table 2304.10.1, "Fastening Schedule," in the ICC's International Building Code.
 - 2. ICC-ES evaluation report for fastener.
- E. Do not bridge building expansion joints; cut and space edges of panels to match spacing of structural support elements.

3.03 ROOF INSTALLATION

- A. For multiple layered installations, install the base layer of panels loose-laid, and stagger the joints of subsequent layers in accordance with good roofing practice. Fasten panels through the top nailable surface and also through the wood block panel spacers using approved threaded fasteners.
- B. Coordinate roof sheathing installation with flashing and joint-sealant installation so these materials are installed in sequence and manner that prevent exterior moisture from passing through completed assembly.
- C. Only install enough sheathing per day that can be covered the same day by a completed roof covering material.

3.04 WALL INSTALLATION

- A. Install in exterior spaces without gaps or voids. Do not compress insulation.
- B. Trim insulation neatly to fit spaces. Insulate miscellaneous gaps and voids.
- C. Fit insulation tight in spaces and tight to exterior side of mechanical and electrical services within plane of insulation.
- D. Insulation must be protected from open flame and stored in accordance with the manufacturer's instructions.
- E. Fasten composite insulation to the structural base wall. Coordinate with the cladding or wall finish manufacturer for the attachment requirements over insulation panels. Contact manufacturer for guidance when determining fastening pattern.

END OF SECTION

SECTION 07_11_00

DAMPPROOFING

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Dampproofing.

1.02 REFERENCES

- A. ASTM International (ASTM):
 - 1. D1227 - Standard Specification for Emulsified Asphalt Used as a Protective Coating for Roofing.

1.03 ADMINISTRATIVE REQUIREMENTS

- A. Pre-installation meeting:
 - 1. As specified in Section 01_31_19 - Project Meetings.
 - 2. Prior to beginning Work, convene a meeting to review conditions, installation procedures, schedules, and coordination with other Work.
 - 3. Convene a minimum of 2 weeks prior to starting Work.

1.04 SUBMITTALS

- A. Furnish Submittals as specified in Section 01_33_00 - Submittal Procedures.
- B. Product data.
 - 1. Manufacturer's data sheets on each product to be used, including:
 - a. Preparation instructions and recommendations.
 - b. Storage and handling requirements and recommendations.
 - c. Installation methods.
- C. Warranty:
 - 1. Sample warranty identifying the terms and conditions stated in the warranty article.

1.05 DELIVERY, STORAGE, AND HANDLING

- A. Store materials in original, unopened containers in accordance with the manufacturer's printed instructions.

1.06 ENVIRONMENTAL REQUIREMENTS

- A. Do not apply bituminous dampproofing when temperatures are 40 degrees Fahrenheit or lower, or when rain is forecast for the 24 hours following application.

PART 2 PRODUCTS

2.01 MATERIALS

- A. Dampproofing: ASTM D1227, Asbestos Free, Emulsified Asphalt Coatings:
 - 1. Manufacturers: One of the following or equal:
 - a. Karnak Corp., Karnak 220 AF.
 - b. W.R. Meadows, Inc., Sealastic Type 2 Asphalt Emulsion Dampproofing.
- B. Sealing mastic:
 - 1. Compatible with dampproofing and free of toxic solvents with thick mastic consistency and smooth and uniform in composition.
 - 2. As recommended by the dampproofing manufacturer.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Verify that conditions are satisfactory for application of products in accordance with the manufacturer's recommendations.
- B. Verify that surfaces to receive dampproofing are clean, dry, reasonably smooth, free of dust, dirt, voids, cracks, or sharp projections.

3.02 APPLICATION

- A. Completely cover surfaces to receive dampproofing with 2 coats:
 - 1. Applied by brush or spray.
 - 2. Apply dampproofing at the manufacturer's recommended rate of application or minimum 2 gallons per 100 square feet, whichever is greater.
- B. Extend dampproofing to 6 inches above finish grade.
- C. Apply each coat evenly so surfaces have uniform black appearance.
- D. Apply second coat at right angles to first, allowing not less than 24 hours between coats.
- E. Seal around items and services projecting through dampproofing surfaces in accordance with the manufacturer's recommendations.
- F. Ensure sealed areas are moisture tight.
- G. Backfill completely against dampproofing application within time recommended by the manufacturer.

END OF SECTION

SECTION 07_41_15

SOFFIT PANELS

PART 1 GENERAL

1.01 SUMMARY

- A. Section Includes:
 - 1. Metal soffit panels.

1.02 PREINSTALLATION MEETINGS

- A. Preinstallation Conference: Conduct conference at Project site.

1.03 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Shop Drawings: Include fabrication and installation layouts of metal panels; details of edge conditions, joints, panel profiles, corners, anchorages, attachment system, trim, flashings, closures, and accessories; and special details.
- C. Samples: For each type of metal panel indicated.

1.04 INFORMATIONAL SUBMITTALS

- A. Product test reports.
- B. Warranties: Samples of special warranties.

1.05 CLOSEOUT SUBMITTALS

- A. Maintenance data.

1.06 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of metal panel systems that fail in materials or workmanship within specified warranty period.
 - 1. Warranty Period: 2 years from date of Substantial Completion.
- B. Special Warranty on Panel Finishes: Manufacturer's standard form in which manufacturer agrees to repair finish or replace metal panels that show evidence of deterioration of factory-applied finishes within specified warranty period.
 - 1. Finish Warranty Period: 20 years from date of Substantial Completion.

PART 2 PRODUCTS

2.01 PERFORMANCE REQUIREMENTS

- A. Structural Performance: Provide metal panel systems capable of withstanding the effects of the following loads, based on testing according to ASTM E1592:
 - 1. Wind Loads: As indicated on the Drawings.
 - 2. Other Design Loads: As indicated on the Drawings.
 - 3. Deflection Limits: For wind loads, no greater than 1/180 of the span.
- B. Air Infiltration: Air leakage of not more than 0.06 cubic feet per minute per square foot when tested according to ASTM E283 at the following test-pressure difference:
 - 1. Test-Pressure Difference: 6.24 pounds-force per square foot.
- C. Water Penetration under Static Pressure: No water penetration when tested according to ASTM E331 at the following test-pressure difference:
 - 1. Test-Pressure Difference: 6.24 pounds-force per square foot.
- D. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes by preventing buckling, opening of joints, overstressing of components, failure of joint sealants, failure of connections, and other detrimental effects. Base calculations on surface temperatures of materials due to both solar heat gain and nighttime-sky heat loss.
 - 1. Temperature Change (Range): 120 degrees Fahrenheit, ambient; 180 degrees Fahrenheit, material surfaces.

2.02 METAL SOFFIT PANELS

- A. Provide metal soffit panels designed to be installed by lapping and interconnecting side edges of adjacent panels and mechanically attaching through panel to supports using concealed fasteners in side laps. Include accessories required for weathertight installation.
- B. Metal Soffit Panels: Match material of metal roof panels.
 - 1. Finish: Match finish and color of metal roof panels.
 - 2. Sealant: Factory applied within interlocking joint.
- C. V-Groove-Profile Metal Soffit Panels: Solid panels formed with vertical panel edges and intermediate stiffening ribs symmetrically spaced between panel edges; with a V-groove joint between panels.
 - 1. Basis-of-Design Product: Subject to compliance with requirements, provide Berridge Manufacturing Company; Berridge L-Panel or a comparable product by one of the following:
 - a. ATAS International, Inc.
 - b. Englert, Inc.
 - c. Fabral; a brand of OmniMax International.
 - d. PAC-CLAD; Petersen Aluminum Corporation; a Carlisle company.
 - 2. Material: Same material, finish, and color as metal roof panels.

3. Metallic-Coated Steel Sheet: Zinc-coated (galvanized) steel sheet complying with ASTM A653/A653M, G90 coating designation, or aluminum-zinc alloy-coated steel sheet complying with ASTM A792/A792M, Class AZ50 coating designation; structural quality. Prepainted by the coil-coating process to comply with ASTM A755/A755M.
 - a. Nominal Thickness: 0.022 inch.
 - b. Exterior Finish: 2-coat fluoropolymer.
 - c. Color: As selected by Architect from manufacturer's full range.
4. Panel Coverage: 12 inches.
5. Panel Height: 1 inch.

2.03 MISCELLANEOUS MATERIALS

- A. Miscellaneous Metal Subframing and Furring: ASTM C645, cold-formed, metallic-coated steel sheet, ASTM A653/A653M, G90 hot-dip galvanized coating designation or ASTM A792/A792M, Class AZ50 aluminum-zinc-alloy coating designation unless otherwise indicated. Provide manufacturer's standard sections as required for support and alignment of metal panel system.
- B. Panel Accessories: Provide components required for a complete, weathertight panel system including trim, clips, flashings, sealants, gaskets, fillers, closure strips, and similar items. Match material and finish of metal panels unless otherwise indicated.
 1. Closure Strips: Closed-cell, expanded, cellular, rubber or crosslinked, polyolefin-foam or closed-cell laminated polyethylene; minimum 1-inch-thick, flexible closure strips; cut or premolded to match metal panel profile. Provide closure strips where indicated or necessary to ensure weathertight construction.
- C. Flashing and Trim: Provide flashing and trim formed from same material as metal panels as required to seal against weather and to provide finished appearance. Finish flashing and trim with same finish system as adjacent metal panels.
- D. Panel Fasteners: Self-tapping screws designed to withstand design loads. Provide exposed fasteners with heads matching color of metal panels by means of plastic caps or factory-applied coating. Provide EPDM or PVC sealing washers for exposed fasteners.
- E. Panel Sealants: Provide sealant types recommended by manufacturer that are compatible with panel materials, are nonstaining, and do not damage panel finish.
 1. Sealant Tape: Pressure-sensitive, 100 percent solids, gray polyisobutylene compound sealant tape with release-paper backing; 1/8 inch thick.
 2. Joint Sealant: ASTM C920; as recommended in writing by metal panel manufacturer.
 3. Butyl-Rubber-Based, Solvent-Release Sealant: ASTM C1311.

2.04 FABRICATION

- A. Fabricate and finish metal panels and accessories at the factory, by manufacturer's standard procedures and processes, as necessary to fulfill indicated performance requirements demonstrated by laboratory testing. Comply with indicated profiles and with dimensional and structural requirements.

- B. On-site fabrication: Subject to compliance with requirements of this Section, metal panels may be fabricated on-site using UL-certified, portable roll-forming equipment if panels are of same profile and warranted by manufacturer to be equal to factory-formed panels. Fabricate according to equipment manufacturer's written instructions and to comply with details shown.
- C. Provide panel profile, including major ribs and intermediate stiffening ribs, if any, for full length of panel.
- D. Fabricate metal panel joints with factory-installed captive gaskets or separator strips that provide a weathertight seal and prevent metal-to-metal contact, and that minimize noise from movements.
- E. Sheet Metal Flashing and Trim: Fabricate flashing and trim to comply with manufacturer's recommendations and recommendations in SMACNA's "Architectural Sheet Metal Manual" that apply to design, dimensions, metal, and other characteristics of item indicated.

2.05 FINISHES

- A. Panels and Accessories:
 - 1. Two-Coat Fluoropolymer: AAMA 621. Fluoropolymer finish containing not less than 70 percent polyvinylidene fluoride (PVDF) resin by weight in color coat. Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions.
 - 2. Concealed Finish: White or light-colored acrylic or polyester backer finish.

PART 3 EXECUTION

3.01 PREPARATION

- A. Miscellaneous Supports: Install subframing, furring, and other miscellaneous panel support members and anchorages according to ASTM C754 and metal panel manufacturer's written recommendations.
 - 1. Soffit Framing: Wire tie or clip furring channels to supports, as required to comply with requirements for assemblies indicated.

3.02 INSTALLATION

- A. Metal Soffit Panels: Fasten metal panels to supports with fasteners at each lapped joint at location and spacing recommended by manufacturer.
 - 1. Apply panels and associated items true to line for neat and weathertight enclosure.
 - 2. Provide metal-backed washers under heads of exposed fasteners bearing on weather side of metal panels.

3. Locate and space exposed fasteners in uniform vertical and horizontal alignment. Use proper tools to obtain controlled uniform compression for positive seal without rupture of washer.
 4. Install screw fasteners with power tools having controlled torque adjusted to compress washer tightly without damage to washer, screw threads, or panels. Install screws in predrilled holes.
- B. Watertight Installation:
1. Apply a continuous ribbon of sealant or tape to seal lapped joints of metal panels, using sealant or tape as recommend by manufacturer on side laps of nesting-type panels and elsewhere as needed to make panels watertight.
 2. Provide sealant or tape between panels and protruding equipment, vents, and accessories.
 3. At panel splices, nest panels with minimum 6-inch end lap, sealed with sealant and fastened together by interlocking clamping plates.
- C. Accessory Installation: Install accessories with positive anchorage to building and weathertight mounting, and provide for thermal expansion. Coordinate installation with flashings and other components.
- D. Flashing and Trim: Comply with performance requirements, manufacturer's written installation instructions, and SMACNA's "Architectural Sheet Metal Manual." Provide concealed fasteners where possible, and set units true to line and level as indicated. Install work with laps, joints, and seams that are permanently watertight.

3.03 CLEANING

- A. Remove temporary protective coverings and strippable films, if any, as metal panels are installed unless otherwise indicated in manufacturer's written installation instructions. On completion of metal panel installation, clean finished surfaces as recommended by metal panel manufacturer. Maintain in a clean condition during construction.

END OF SECTION

SECTION 07_42_13
FORMED METAL WALL PANELS

PART 1 GENERAL

1.01 SUMMARY

- A. Section Includes:
 - 1. Concealed-fastener, lap-seam metal wall panels.

1.02 PREINSTALLATION MEETINGS

- A. Preinstallation Conference: Conduct conference at Project site.

1.03 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Shop Drawings: Include fabrication and installation layouts of metal panels; details of edge conditions, joints, panel profiles, corners, anchorages, attachment system, trim, flashings, closures, and accessories; and special details.
- C. Samples: For each type of metal panel indicated.

1.04 INFORMATIONAL SUBMITTALS

- A. Product test reports.
- B. Warranties: Samples of special warranties.

1.05 CLOSEOUT SUBMITTALS

- A. Maintenance data.

1.06 QUALITY ASSURANCE

- A. Installer Qualifications: An entity that employs installers and supervisors who are trained and approved by manufacturer.

1.07 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of metal panel systems that fail in materials or workmanship within specified warranty period:
 - 1. Warranty Period: 2 years from date of Substantial Completion.

- B. Special Warranty on Panel Finishes: Manufacturer's standard form in which manufacturer agrees to repair finish or replace metal panels that show evidence of deterioration of factory-applied finishes within specified warranty period:
 - 1. Finish Warranty Period: 20 years from date of Substantial Completion.

PART 2 PRODUCTS

2.01 PERFORMANCE REQUIREMENTS

- A. Structural Performance: Provide metal panel systems capable of withstanding the effects of the following loads, based on testing according to ASTM E1592:
 - 1. Wind Loads: As indicated on Drawings.
 - 2. Other Design Loads: As indicated on Drawings.
 - 3. Deflection Limits: For wind loads, no greater than 1/180 of the span.
- B. Air Infiltration: Air leakage of not more than 0.06 cubic feet per minute per square foot when tested according to ASTM E283 at the following test-pressure difference:
 - 1. Test-Pressure Difference: 6.24 pounds-force per square foot.
- C. Water Penetration under Static Pressure: No water penetration when tested according to ASTM E331 at the following test-pressure difference:
 - 1. Test-Pressure Difference 6.24 pounds-force per square foot.
- D. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes by preventing buckling, opening of joints, overstressing of components, failure of joint sealants, failure of connections, and other detrimental effects. Base calculations on surface temperatures of materials due to both solar heat gain and nighttime-sky heat loss:
 - 1. Temperature Change (Range): 120 degrees Fahrenheit, ambient; 180 degrees Fahrenheit material surfaces.

2.02 CONCEALED-FASTENER, LAP-SEAM METAL WALL PANELS

- A. Provide factory-formed metal panels designed to be field assembled by lapping and interconnecting side edges of adjacent panels and mechanically attaching through panel to supports using concealed fasteners in side laps. Include accessories required for weathertight installation.
- B. Board and Batten, Concealed-Fastener Metal Wall Panels: Formed with vertical panel edges and:
 - 1. Basis-of-Design Product: Subject to compliance with requirements, provide PAC-CLAD; Board and Batten or a comparable product by one of the following:
 - a. Central States.
 - b. Western States Metal Roofing.
 - 2. Metallic-Coated Steel Sheet: Zinc-coated (galvanized) steel sheet complying with ASTM A653/A653M, G90 (Z275) coating designation; structural quality. Prepainted by the coil-coating process to comply with ASTM A755/A755M:
 - a. Nominal Thickness: 24-gauge.

- b. Exterior Finish: 2-coat fluoropolymer.
 - c. Color: Timber Series, Tan Timber.
 - 3. Panel Coverage: 16 inches.
 - 4. Panel Height: 3/4 inch.
- C. Ship Lap, Concealed-Fastener Metal Wall Panels: Formed with vertical panel edges and a stepped profile between panel edges, resulting in a wide reveal joint between panels:
- 1. Basis-of-Design Product: Subject to compliance with requirements, provide PAC-CLAD; Highline S2 or a comparable product by one of the following:
 - a. Central States.
 - b. Western States Metal Roofing.
 - 2. Metallic-Coated Steel Sheet: Zinc-coated (galvanized) steel sheet complying with ASTM A653/A653M, G90 (Z275) coating designation; structural quality. Prepainted by the coil-coating process to comply with ASTM A755/A755M:
 - a. Nominal Thickness: 22-gauge.
 - b. Exterior Finish: 2-coat fluoropolymer.
 - c. Color: Timber Series, Tan Timber.
 - 3. Panel Coverage: 12 inches.
 - 4. Panel Height: 1-3/8 inches.

2.03 MISCELLANEOUS MATERIALS

- A. Miscellaneous Metal Subframing and Furring: ASTM C645, cold-formed, metallic-coated steel sheet, ASTM A653/A653M, G90 (Z275) hot-dip galvanized coating designation unless otherwise indicated. Provide manufacturer's standard sections as required for support and alignment of metal panel system.
- B. Panel Accessories: Provide components required for a complete, weathertight panel system including trim, copings, fasciae, mullions, sills, corner units, clips, flashings, sealants, gaskets, fillers, closure strips, and similar items. Match material and finish of metal panels unless otherwise indicated:
- 1. Closures: Provide closures at eaves and rakes, fabricated of same metal as metal panels.
 - 2. Backing Plates: Provide metal backing plates at panel end splices, fabricated from material recommended by manufacturer.
 - 3. Closure Strips: Closed-cell, expanded, cellular, rubber or crosslinked, polyolefin-foam or closed-cell laminated polyethylene; minimum 1-inch-thick, flexible closure strips; cut or premolded to match metal panel profile. Provide closure strips where indicated or necessary to ensure weathertight construction.
- C. Flashing and Trim: Provide flashing and trim formed from same material as metal panels as required to seal against weather and to provide finished appearance. Locations include, but are not limited to, bases, drips, sills, jambs, corners, endwalls, framed openings, rakes, fasciae, parapet caps, soffits, reveals, and fillers. Finish flashing and trim with same finish system as adjacent metal panels.

- D. Panel Fasteners: Self-tapping screws designed to withstand design loads. Provide exposed fasteners with heads matching color of metal panels by means of plastic caps or factory-applied coating. Provide EPDM or PVC sealing washers for exposed fasteners.
- E. Panel Sealants: Provide sealant type recommended by manufacturer that are compatible with panel materials, are nonstaining, and do not damage panel finish:
 - 1. Sealant Tape: Pressure-sensitive, 100 percent solids, gray polyisobutylene compound sealant tape with release-paper backing; 1/2 inch wide and 1/8 inch thick.
 - 2. Joint Sealant: ASTM C920; as recommended in writing by metal panel manufacturer.
 - 3. Butyl-Rubber-Based, Solvent-Release Sealant: ASTM C1311.

2.04 FABRICATION

- A. Fabricate and finish metal panels and accessories at the factory, by manufacturer's standard procedures and processes, as necessary to fulfill indicated performance requirements demonstrated by laboratory testing. Comply with indicated profiles and with dimensional and structural requirements.
- B. Provide panel profile, including major ribs and intermediate stiffening ribs, if any, for full length of panel.
- C. Fabricate metal panel joints with factory-installed captive gaskets or separator strips that provide a weathertight seal and prevent metal-to-metal contact, and that minimize noise from movements.
- D. Sheet Metal Flashing and Trim: Fabricate flashing and trim to comply with manufacturer's recommendations and recommendations in SMACNA's "Architectural Sheet Metal Manual" that apply to design, dimensions, metal, and other characteristics of item indicated.

2.05 FINISHES

- A. Panels and Accessories:
 - 1. Two-Coat Fluoropolymer: AAMA 621. Fluoropolymer finish containing not less than 70 percent polyvinylidene fluoride (PVDF) resin by weight in color coat.
 - 2. Concealed Finish: White or light-colored acrylic or polyester backer finish.

PART 3 EXECUTION

3.01 PREPARATION

- A. Miscellaneous Supports: Install subframing, furring, and other miscellaneous panel support members and anchorages according to ASTM C754 and metal panel manufacturer's written recommendations.

3.02 INSTALLATION

- A. Lap-Seam Metal Panels: Fasten metal panels to supports with fasteners at each lapped joint at location and spacing recommended by manufacturer:
 - 1. Lap ribbed or fluted sheets one full rib. Apply panels and associated items true to line for neat and weathertight enclosure.
 - 2. Provide metal-backed washers under heads of exposed fasteners bearing on weather side of metal panels.
 - 3. Locate and space exposed fasteners in uniform vertical and horizontal alignment. Use proper tools to obtain controlled uniform compression for positive seal without rupture of washer.
 - 4. Install screw fasteners with power tools having controlled torque adjusted to compress washer tightly without damage to washer, screw threads, or panels. Install screws in predrilled holes.
 - 5. Flash and seal panels with weather closures at perimeter of all openings.
- B. Watertight Installation:
 - 1. Apply a continuous ribbon of sealant or tape to seal lapped joints of metal panels, using sealant or tape as recommend by manufacturer on side laps of nesting-type panels; and elsewhere as needed to make panels watertight.
 - 2. Provide sealant or tape between panels and protruding equipment, vents, and accessories.
 - 3. At panel splices, nest panels with minimum 6-inch end lap, sealed with sealant and fastened together by interlocking clamping plates.
- C. Accessory Installation: Install accessories with positive anchorage to building and weathertight mounting, and provide for thermal expansion. Coordinate installation with flashings and other components.
- D. Flashing and Trim: Comply with performance requirements, manufacturer's written installation instructions, and SMACNA's "Architectural Sheet Metal Manual." Provide concealed fasteners where possible, and set units true to line and level as indicated. Install work with laps, joints, and seams that are permanently watertight.

3.03 CLEANING

- A. Remove temporary protective coverings and strippable films, if any, as metal panels are installed, unless otherwise indicated in manufacturer's written installation instructions. On completion of metal panel installation, clean finished surfaces as recommended by metal panel manufacturer. Maintain in a clean condition during construction.

END OF SECTION

SECTION 07_60_00

FLASHING AND SHEET METAL

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes: flashing, sheet metal, and associated accessories.

1.02 REFERENCES

- A. Aluminum Association (AA).
- B. ASTM International (ASTM):
 - 1. A240 - Standard Specification for Chromium and Chromium-nickel Stainless Steel Plate, Sheet, and Strip For Pressure Vessels and General Applications.
 - 2. A653 - Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process.
 - 3. B32 - Standard Specification for Solder Metal.
 - 4. B209 - Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate.
 - 5. B221 - Standard Specification for Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes.
 - 6. B224 - Standard Classification of Coppers.
 - 7. B370 - Standard Specification for Copper Sheet and Strip for Building Construction.
 - 8. B749 - Standard Specification for Lead and Lead Alloy Strip, Sheet, and Plate Products.
 - 9. D226 - Standard Specification for Asphalt-Saturated Organic Felt Used in Roofing and Waterproofing.
 - 10. D4586 - Standard Specification for Asphalt Roof Cement, Asbestos-Free.
- C. Sheet Metal and Air Conditioning Contractors National Association, Inc. (SMACNA).

1.03 SUBMITTALS

- A. Product data.
- B. Shop drawings: Show fabrication details, material profiles, connections, jointing pattern, jointing details, fastening methods, isolation methods, and installation details.
- C. Manufacturer's Installation Instructions.

1.04 SEQUENCING AND SCHEDULING

- A. Coordinate sheet metal installation with installation of materials specified in Sections 04_22_00 - Concrete Unit Masonry, 06_10_00 - Rough Carpentry, and 07_92_00 - Joint Sealants.

1.05 DELIVERY, STORAGE, AND HANDLING

- A. Stack preformed material to prevent twisting, bending, or abrasion, and to provide ventilation.
- B. Prevent contact with materials during storage which may cause discoloration, staining, or damage.

PART 2 PRODUCTS

2.01 MATERIALS

- A. Galvanized steel sheet, precoated: ASTM A653, G-90; 26-gauge core steel.

2.02 ACCESSORIES

- A. Fasteners and metal washers: Types best suited for purpose, of same material as sheet metal being fastened or of composition that will not support electrolysis, such as Type 18-8 stainless steel for fastening aluminum.
- B. Sealer washers: Rubber type, minimum 0.040 inch thick.
- C. Underlayment: ASTM D226; Number 30 asphalt saturated roofing felt.
- D. Protective backing paint: Bituminous.
- E. Slip sheet: Rosin sized building paper.
- F. Bedding compound: Rubber-asphalt type.
- G. Roof cement: ASTM D4586, plastic asphaltic cement.
- H. Solder: ASTM B32.

2.03 FABRICATION

- A. Form sheet metal true to shape, accurate in size, square, and free from distortion or defects.
- B. Form rises and angles into flashing true and straight, with exposed surfaces free from waves and buckles.
- C. Fabricate cleats and starter strips of same material as sheet, minimum 3 inches wide, interlockable with sheet.
- D. Form pieces in longest practical lengths. Size and space joints to provide adequate movement for thermal expansion and contraction.
- E. Hem exposed edges on underside 1/2 inch; miter and seam corners.
- F. Form material with cover plate seams.

- G. Fabricate corners from 1 piece with minimum 18-inch-long legs; seam for rigidity, seal with sealant.
- H. Fabricate vertical faces with bottom edge formed outward 1/4 inch and hemmed to form drip.

2.04 FINISH

- A. Prepare and prime exposed ferrous metal surfaces.
- B. Backpaint concealed metal surfaces with protective backing paint to minimum dry film thickness of 15 mil.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Verify roof openings, curbs, pipes, sleeves, ducts, or vents through roof are solidly set, cant strips and reglets in place, and nailing strips located.
- B. Verify membrane termination and base flashings are in place, sealed, and secure.

3.02 INSTALLATION

- A. Install flashing and sheet metal in accordance with AA and SMACNA references, and when in connection with roofing, roofing manufacturer's specifications.
- B. Install sheet metal to even smooth, sound, thoroughly clean and dry surfaces, free from defects that could affect installation.
- C. Install flashings where necessary to provide leakproof conditions.
- D. Isolate dissimilar metals from direct contact with protective backing paint.
- E. Install starter, edge strips, and cleats before starting installation.
- F. Perform cutting, fitting, drilling, and other operations in connection with sheet metal required to accommodate work of other sections.
- G. Install sealer washers under metal washers or fastener heads where weathertightness is required.
- H. Install surface mounted reglets true to lines and levels. Seal top of reglets with sealant.
- I. Secure flashings in place using concealed fasteners. Use exposed fasteners only in locations acceptable to the Engineer.
- J. Seam and seal joints. Make connections watertight and weathertight.

- K. Apply roof cement compound between metal flashings and felt flashings.
 - 1. Fit flashings tight in place.
 - 2. Make corners square, surfaces true and straight in planes, and line accurate to profiles.
- L. Seal metal joints watertight.

END OF SECTION

SECTION 07_61_13

STANDING-SEAM METAL ROOF PANELS

PART 1 GENERAL

1.01 SUMMARY

- A. Section Includes:
 - 1. Standing-seam metal roof panels.
 - 2. Underlayment.

1.02 PREINSTALLATION MEETINGS

- A. Preinstallation Conference: Conduct conference at Project site.

1.03 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Shop Drawings: Include fabrication and installation layouts of metal panels; details of edge conditions, joints, panel profiles, corners, anchorages, attachment system, trim, flashings, closures, and accessories; and special details.
- C. Samples: For each type of metal panel indicated.

1.04 INFORMATIONAL SUBMITTALS

- A. Product test reports.
- B. Warranties: Sample of special warranties.

1.05 CLOSEOUT SUBMITTALS

- A. Maintenance data.

1.06 QUALITY ASSURANCE

- A. Installer Qualifications: An entity that employs installers and supervisors who are trained and approved by manufacturer.
- B. UL-Certified, Portable Roll-Forming Equipment: UL-certified, portable roll-forming equipment capable of producing metal panels warranted by manufacturer to be the same as factory-formed products. Maintain UL certification of portable roll-forming equipment for duration of work.

1.07 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of metal panel systems that fail in materials or workmanship within specified warranty period.
 - 1. Warranty Period: 2 years from date of Substantial Completion.
- B. Special Warranty on Panel Finishes: Manufacturer's standard form in which manufacturer agrees to repair finish or replace metal panels that show evidence of deterioration of factory-applied finishes within specified warranty period.
 - 1. Finish Warranty Period: 20 years from date of Substantial Completion.
- C. Special Weathertightness Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace standing-seam metal roof panel assemblies that fail to remain weathertight, including leaks, within specified warranty period.
 - 1. Warranty Period: 20 years from date of Substantial Completion.

PART 2 PRODUCTS

2.01 PERFORMANCE REQUIREMENTS

- A. Energy Performance:
 - 1. Provide roof panels that are listed on the EPA/DOE's ENERGY STAR "Roof Product List" for steep-slope roof products.
 - 2. Provide roof panels according to one of the following when tested according to CRRC-1:
 - a. 3-year, aged solar reflectance of not less than 0.55 and emissivity of not less than 0.75.
 - b. 3-year, aged solar reflectance index of not less than 64 when calculated according to ASTM E1980.
- B. Structural Performance: Provide metal panel systems capable of withstanding the effects of the following loads, based on testing according to ASTM E1592:
 - 1. Wind Loads and Other Design Loads: Refer to Section 01_81_50 - Design Criteria.
 - 2. Deflection Limits: For wind loads, no greater than 1/180 of the span.
- C. Air Infiltration: Air leakage of not more than 0.06 cubic feet per minute per square foot. when tested according to ASTM E1680 at the following test-pressure difference:
 - 1. Test-Pressure Difference: 6.24 pounds-force per square foot.
- D. Water Penetration under Static Pressure: No water penetration when tested according to ASTM E1646 at the following test-pressure difference:
 - 1. Test-Pressure Difference: 6.24 pounds-force per square foot.
- E. Hydrostatic-Head Resistance: No water penetration when tested according to ASTM E2140.

- F. Wind-Uplift Resistance: Provide metal roof panel assemblies that comply with UL 580 for wind-uplift-resistance class indicated.
 - 1. Uplift Rating: UL 90.
- G. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes by preventing buckling, opening of joints, overstressing of components, failure of joint sealants, failure of connections, and other detrimental effects. Base calculations on surface temperatures of materials due to both solar heat gain and nighttime-sky heat loss.
 - 1. Temperature Change (Range): 120 degrees Fahrenheit, ambient; 180 degrees Fahrenheit, material surfaces.

2.02 STANDING-SEAM METAL ROOF PANELS

- A. Provide factory-formed metal roof panels designed to be installed by lapping and interconnecting raised side edges of adjacent panels with joint type indicated and mechanically attaching panels to supports using concealed clips in side laps. Include clips, cleats, pressure plates, and accessories required for weathertight installation.
 - 1. Steel Panel Systems: Unless more stringent requirements are indicated, comply with ASTM E1514.
- B. Vertical-Rib, Seamed-Joint, Standing-Seam Metal Roof Panels: Formed with vertical ribs at panel edges and a flat pan between ribs; designed for sequential installation by mechanically attaching panels to supports using concealed clips located under one side of panels, engaging opposite edge of adjacent panels, and mechanically seaming panels together.
 - 1. Basis-of-Design Product: Subject to compliance with requirements, provide Berridge Manufacturing Company; Berridge Zee-Lock Double Lock or a comparable product by one of the following:
 - a. AEP Span a brand of ASC Profiles LLC, a part of BlueScope.
 - b. ATAS International, Inc.
 - c. Fabral; a brand of OmniMax International.
 - d. Metal Sales Manufacturing Corporation.
 - e. PAC-CLAD; Petersen Aluminum Corporation; a Carlisle company.
 - 2. Metallic-Coated Steel Sheet: Zinc-coated (galvanized) steel sheet complying with ASTM A653/A653M, G90 coating designation, or aluminum-zinc alloy-coated steel sheet complying with ASTM A792/A792M, Class AZ50 coating designation; structural quality. Prepainted by the coil-coating process to comply with ASTM A755/A755M.
 - a. Nominal Thickness: 0.028 inch.
 - b. Exterior Finish: Two-coat fluoropolymer.
 - c. Color: As selected by Architect from manufacturer's full range.
 - 3. Clips: One-piece fixed.
 - 4. Material:
 - a. 0.028-inch- nominal thickness, zinc-coated (galvanized) or aluminum-zinc alloy-coated steel sheet.
 - 5. Joint Type: Double folded.
 - 6. Panel Coverage: 16 inches.
 - 7. Panel Height: 2.0 inches.

2.03 UNDERLAYMENT MATERIALS

- A. Self-Adhering, High-Temperature Underlayment: Provide self-adhering, cold-applied, sheet underlayment, a minimum of 40 mils thick, consisting of slip-resistant, polyethylene-film top surface laminated to a layer of butyl or SBS-modified asphalt adhesive, with release-paper backing. Provide primer when recommended by underlayment manufacturer.
 - 1. Thermal Stability: Stable after testing at 240 deg F; ASTM D1970.
 - 2. Low-Temperature Flexibility: Passes after testing at minus 20 degrees Fahrenheit; ASTM D1970.
 - 3. Basis-of-Design Product: Subject to compliance with requirements, provide Grace Ice & Watershield HT or a comparable product by one of the following:
 - a. Tamko.
 - b. Mid-States Asphalt.
 - c. Soprema.
 - d. MFM.
 - e. Polyglass.
- B. Slip Sheet: Manufacturer's recommended slip sheet, of type required for application.

2.04 MISCELLANEOUS MATERIALS

- A. Miscellaneous Metal Subframing and Furring: ASTM C645; cold-formed, metallic-coated steel sheet, ASTM A653/A653M, G90 hot-dip galvanized coating designation or ASTM A792/A792M, Class AZ50 coating designation unless otherwise indicated. Provide manufacturer's standard sections as required for support and alignment of metal panel system.
- B. Panel Accessories: Provide components required for a complete, weathertight panel system including trim, copings, fasciae, mullions, sills, corner units, clips, flashings, sealants, gaskets, fillers, closure strips, and similar items. Match material and finish of metal panels unless otherwise indicated.
 - 1. Closures: Provide closures at eaves and ridges, fabricated of same metal as metal panels.
 - 2. Backing Plates: Provide metal backing plates at panel end splices, fabricated from material recommended by manufacturer.
 - 3. Closure Strips: Closed-cell, expanded, cellular, rubber or crosslinked, polyolefin-foam or closed-cell laminated polyethylene; minimum 1-inch-thick, flexible closure strips; cut or premolded to match metal panel profile. Provide closure strips where indicated or necessary to ensure weathertight construction.
- C. Flashing and Trim: Provide flashing and trim formed from same material as metal panels as required to seal against weather and to provide finished appearance. Locations include, but are not limited to, eaves, rakes, corners, bases, framed openings, ridges, fasciae, and fillers. Finish flashing and trim with same finish system as adjacent metal panels.
- D. Gutters and Downspouts: Formed from same material as roof panels according to SMACNA's "Architectural Sheet Metal Manual." Finish to match metal roof panels, roof fascia and rake trim.

- E. Panel Fasteners: Self-tapping screws designed to withstand design loads.
- F. Panel Sealants: Provide sealant type recommended by manufacturer that are compatible with panel materials, are nonstaining, and do not damage panel finish.
 - 1. Sealant Tape: Pressure-sensitive, 100 percent solids, gray polyisobutylene compound sealant tape with release-paper backing; 1/2 inch wide and 1/8 inch thick.
 - 2. Joint Sealant: ASTM C920; as recommended in writing by metal panel manufacturer.
 - 3. Butyl-Rubber-Based, Solvent-Release Sealant: ASTM C1311.

2.05 FABRICATION

- A. Fabricate and finish metal panels and accessories at the factory, by manufacturer's standard procedures and processes, as necessary to fulfill indicated performance requirements demonstrated by laboratory testing. Comply with indicated profiles and with dimensional and structural requirements.
- B. On-Site Fabrication: Subject to compliance with requirements of this Section, metal panels may be fabricated on-site using UL-certified, portable roll-forming equipment if panels are of same profile and warranted by manufacturer to be equal to factory-formed panels. Fabricate according to equipment manufacturer's written instructions and to comply with details shown.
- C. Provide panel profile, including major ribs and intermediate stiffening ribs, if any, for full length of panel.
- D. Fabricate metal panel joints with factory-installed captive gaskets or separator strips that provide a weathertight seal and prevent metal-to-metal contact, and that minimize noise from movements.
- E. Sheet Metal Flashing and Trim: Fabricate flashing and trim to comply with manufacturer's recommendations and recommendations in SMACNA's "Architectural Sheet Metal Manual" that apply to design, dimensions, metal, and other characteristics of item indicated.

2.06 FINISHES

- A. Panels and Accessories:
 - 1. Two-Coat Fluoropolymer: AAMA 621. Fluoropolymer finish containing not less than 70 percent polyvinylidene fluoride (PVDF) resin by weight in color coat.
 - 2. Concealed Finish: White or light-colored acrylic or polyester backer finish.

PART 3 EXECUTION

3.01 PREPARATION

- A. Miscellaneous Supports: Install subframing, furring, and other miscellaneous panel support members and anchorages according to ASTM C754 and metal panel manufacturer's written recommendations.

3.02 INSTALLATION OF UNDERLAYMENT

- A. Self-Adhering Sheet Underlayment: Apply primer if required by manufacturer. Comply with temperature restrictions of underlayment manufacturer for installation. Apply at locations indicated below, wrinkle free, in shingle fashion to shed water, and with end laps of not less than 6 inches staggered 24 inches between courses. Overlap side edges not less than 3-1/2 inches. Roll laps with roller. Cover underlayment within 14 days.
 - 1. Apply over the entire roof surface.
- B. Slip Sheet: Apply slip sheet over underlayment before installing metal roof panels.
- C. Flashings: Install flashings to cover underlayment to comply with requirements specified in Section 07_60_00 - Flashing and Sheet Metal.

3.03 INSTALLATION OF STANDING-SEAM METAL ROOF PANELS

- A. Standing-Seam Metal Roof Panel Installation: Fasten metal roof panels to supports with concealed clips at each standing-seam joint at location, spacing, and with fasteners recommended in writing by manufacturer.
 - 1. Install clips to supports with self-tapping fasteners.
 - 2. Install pressure plates at locations indicated in manufacturer's written installation instructions.
 - 3. Seamed Joint: Crimp standing seams with manufacturer-approved, motorized seamer tool so clip, metal roof panel, and factory-applied sealant are completely engaged.
 - 4. Watertight Installation:
 - a. Apply a continuous ribbon of sealant or tape to seal joints of metal panels, using sealant or tape as recommend in writing by manufacturer as needed to make panels watertight.
 - b. Provide sealant or tape between panels and protruding equipment, vents, and accessories.
 - c. At panel splices, nest panels with minimum 6-inch end lap, sealed with sealant and fastened together by interlocking clamping plates.
- B. Accessory Installation: Install accessories with positive anchorage to building and weathertight mounting, and provide for thermal expansion. Coordinate installation with flashings and other components.
- C. Flashing and Trim: Comply with performance requirements, manufacturer's written installation instructions, and SMACNA's "Architectural Sheet Metal Manual." Provide concealed fasteners where possible, and set units true to line and level as indicated. Install work with laps, joints, and seams that will be permanently watertight and weather resistant.

3.04 CLEANING AND PROTECTION

- A. Remove temporary protective coverings and strippable films, if any, as metal panels are installed, unless otherwise indicated in manufacturer's written installation instructions. On completion of metal panel installation, clean finished surfaces as recommended by metal panel manufacturer. Maintain in a clean condition during construction.

END OF SECTION

SECTION 07_72_00

ROOF ACCESSORIES

PART 1 GENERAL

1.01 SUMMARY

- A. Section Includes:
 - 1. Roof curbs.
 - 2. Removable access covers.

1.02 ACTION SUBMITTALS

- A. Product Data: For each type of roof accessory.
- B. Shop Drawings: For roof accessories.
- C. Samples: For each exposed product and for each color and texture specified.

1.03 INFORMATIONAL SUBMITTALS

- A. Sample warranties.

1.04 CLOSEOUT SUBMITTALS

- A. Operation and maintenance data.

1.05 WARRANTY

- A. Special Warranty on Painted Finishes: Manufacturer's standard form in which manufacturer agrees to repair finishes or replace roof accessories that show evidence of deterioration of factory-applied finishes within 20 years from date of Substantial Completion.

PART 2 PRODUCTS

2.01 ROOF CURBS

- A. Roof Curbs: Internally reinforced roof-curb units capable of supporting superimposed live and dead loads, including other construction indicated on Drawings, bearing continuously on roof structure, and capable of meeting performance requirements; with welded or mechanically fastened and sealed corner joints, and integrally formed deck-mounting flange at perimeter bottom.
 - 1. Basis-of-Design Product: Subject to compliance with requirements, provide Roof Products, Inc.; RPC-3LW2X4 or a comparable product by one of the following:
 - a. Curbs Plus, Inc.

- b. Custom Solution Roof and Metal Products.
 - c. Greenheck Fan Corporation.
 - d. LMCurbs.
 - e. Milcor; Commercial Products Group of Hart & Cooley, Inc.
 - f. Pate Company (The).
 - g. Roof Curb Systems.
 - h. Roof Products and Systems (RPS); a division of Hart & Cooley, Inc.
- B. Size: Coordinate dimensions with roughing-in information or Shop Drawings of equipment to be supported.
- C. Material: Zinc-coated (galvanized) steel sheet, 14-gauge, 22-gauge liner:
 - 1. Finish: Factory prime coating.
- D. Construction:
 - 1. Curb Profile: Manufacturer's standard compatible with roofing system.
 - 2. Fabricate curbs to minimum height of 12 inches above roofing surface unless otherwise indicated.
 - 3. Top Surface: Level top of curb, with roof slope accommodated by sloping deck-mounting flange.
 - 4. Insulation: Factory insulated with 3-1/2-inch-thick glass-fiber board insulation.
 - 5. Liner: Same material as curb, of manufacturer's standard thickness and finish.
 - 6. Nailer: Factory-installed 2 by 4 wood nailer along top flange of curb, continuous around curb perimeter.
 - 7. Wind Restraint Straps and Base Flange Attachment: Provide wind restraint straps, welded strap connectors, and base flange attachment to roof structure at perimeter of curb, of size and spacing required to meet wind uplift requirements.
 - 8. Metal Counterflashing: Manufacturer's standard, removable, fabricated of same metal and finish as curb.

2.02 REMOVABLE ACCESS COVER

- A. Access Cover: Internally reinforced cover units capable of supporting superimposed live and dead loads, including other construction indicated on Drawings, bearing continuously on roof curb, and capable of meeting performance requirements; with welded or mechanically fastened and sealed corner joints, and integrally formed flashing at perimeter.
 - 1. Basis-of-Design Product: Subject to compliance with requirements, provide Roof Products, Inc.; RPRC-1 or a comparable product by one of the following:
 - a. Curbs Plus, Inc.
 - b. Custom Solution Roof and Metal Products.
 - c. Greenheck Fan Corporation.
 - d. LMCurbs.
 - e. Milcor; Commercial Products Group of Hart & Cooley, Inc.
 - f. Pate Company (The).
 - g. Roof Curb Systems.
 - h. Roof Products and Systems (RPS); a division of Hart & Cooley, Inc.

- B. Size:
 - 1. 72 inches by 72 inches.
 - 2. Coordinate dimensions with roughing-in information.
- C. Material: Zinc-coated (galvanized) steel sheet, 14-gauge, 18-gauge liner.
 - 1. Finish: Factory prime coating.
- D. Construction:
 - 1. Top Surface: Slope top of cover for water runoff.
 - 2. Insulation: Fully insulated with glass-fiber board insulation.
 - 3. Liner: Same material as curb, of manufacturer's standard thickness and finish.
 - 4. Internal channels for reinforcement.
 - 5. Metal Counterflashing: Manufacturer's standard, removable, fabricated of same metal and finish as curb.
 - 6. Lifting lugs.

PART 3 EXECUTION

3.01 INSTALLATION

- A. General: Verify dimensions of roof openings for roof accessories. Install roof accessories according to manufacturer's written instructions.
 - 1. Install roof accessories level; plumb; true to line and elevation; and without warping, jogs in alignment, buckling, or tool marks.
 - 2. Anchor roof accessories securely in place so they are capable of resisting indicated loads.
 - 3. Use fasteners, separators, sealants, and other miscellaneous items as required to complete installation of roof accessories and fit them to substrates.
 - 4. Install roof accessories to resist exposure to weather without failing, rattling, leaking, or loosening of fasteners and seals.
- B. Metal Protection: Protect metals against galvanic action by separating dissimilar metals from contact with each other or with corrosive substrates by painting contact surfaces with bituminous coating or by other permanent separation as recommended by manufacturer.
 - 1. Coat concealed side of uncoated aluminum roof accessories with bituminous coating where in contact with wood, ferrous metal, or cementitious construction.
 - 2. Underlayment: Where installing roof accessories directly on cementitious or wood substrates, install a course of underlayment and cover with manufacturer's recommended slip sheet.
- C. Seal joints with elastomeric sealant as required by roof accessory manufacturer.

3.02 REPAIR AND CLEANING

- A. Galvanized Surfaces: Clean field welds, bolted connections, and abraded areas and repair galvanizing according to ASTM A 780/A 780M.
- B. Clean exposed surfaces according to manufacturer's written instructions.
- C. Replace roof accessories that have been damaged or that cannot be successfully repaired by finish touchup or similar minor repair procedures.

END OF SECTION

SECTION 07_72_53

SNOW GUARDS

PART 1 GENERAL

1.01 SUMMARY

- A. Section Includes:
 - 1. Rail-type, seam-mounted snow guards.

1.02 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Shop Drawings: Include roof plans showing layouts and attachment details of snow guards.
 - 1. Include details of rail-type snow guards.
- C. Delegated-Design Submittal: For snow guards, include analysis reports signed and sealed by the qualified professional engineer responsible for their preparation.
 - 1. Include calculation of number and location of snow guards.

1.03 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For professional engineer's experience with providing delegated design engineering services of the kind indicated, including documentation that the engineer is licensed in the jurisdiction in which the Project is located.
- B. Product Test Reports: For each type of snow guard, for tests performed by a qualified testing agency, indicating load at failure of attachment to roof system identical to roof system used on this Project.

PART 2 PRODUCTS

2.01 PERFORMANCE REQUIREMENTS

- A. Delegated Design: Engage a qualified professional engineer, as defined in Section 01_45_17 - Contractor Quality Control Plan, to design snow guards, including attachment to roofing material and roof deck, applicable for attachment method, based on the following:
 - 1. Roof snow load.
 - 2. Snow drifting
 - 3. Roof slope.
 - 4. Roof type.
 - 5. Roof dimensions.
 - 6. Roofing substrate type and thickness.
 - 7. Snow guard type.
 - 8. Snow guard fastening method and strength.

9. Snow guard spacing.
 10. Coefficient of Friction Between Snow and Roof Surface: 0.
 11. Factor of Safety: 2.
- B. Performance Requirements: Provide snow guards that withstand exposure to weather and resist thermally induced movement without failure, rattling, or fastener disengagement due to defective manufacture, fabrication, installation, or other defects in construction.
1. Temperature Change: 120 degrees Fahrenheit, ambient; 180 degrees Fahrenheit, material surfaces.
- C. Structural Performance: Snow guards shall withstand the effects of gravity loads and the following loads and stresses within limits and under conditions indicated.
1. Snow Loads: Refer to Section 01_81_50 - Design Criteria.

2.02 RAIL-TYPE SNOW GUARDS

- A. Rail-Type, Seam-Mounted Snow Guards:
1. Basis-of-Design Product: Subject to compliance with requirements, provide S-5! Metal Roof Innovations, Ltd.; SnoRail/SnoFence or a comparable product by one of the following:
 - a. Alpine SnowGuards.
 - b. IceBlox Inc.
 - c. LMCurbs.
 - d. Rocky Mountain Snow Guards, Inc.
 - e. TRA Snow and Sun, Inc.
 2. Description: Snow guard rails fabricated from metal pipes, bars, or extrusions, anchored to brackets and equipped with two rails.
 3. Brackets and Baseplates: ASTM B209 aluminum, clear anodized.
 4. Bars: ASTM B221 aluminum; mill finish.
 - a. Profile: Round.
 5. Seam clamps: ASTM B221 aluminum extrusion or ASTM B85/B85M aluminum casting with stainless steel set screws incorporating round nonpenetrating point; designed for use with applicable roofing system to which clamp is attached.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Install snow guards according to manufacturer's written instructions.
1. Space rows as recommended by manufacturer.
- B. Attachment for Standing-Seam Metal Roofing:
1. Do not use fasteners that will penetrate metal roofing or fastening methods that void metal roofing finish warranty.

2. Rail-Type, Seam-Mounted Snow Guards:
 - a. Install brackets to vertical ribs in straight rows.
 - b. Secure with stainless steel set screws, incorporating round nonpenetrating point, on same side of standing seam.
 - c. Torque set screw according to manufacturer's instructions.
 - d. Install cross members to brackets.

END OF SECTION

SECTION 07_84_00

FIRESTOPPING

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes: The requirements for providing firestopping.

1.02 REFERENCES

- A. ASTM International (ASTM):
 - 1. E814 - Standard Test Methods for Fire Tests of Penetration Firestops Systems.
- B. International Conference of Building Officials (ICBO).
- C. Underwriters Laboratories, Inc. (UL).

1.03 SUBMITTALS

- A. Product data: Submit manufacturer's data and installation instructions.

PART 2 PRODUCTS

2.01 MATERIALS

- A. Firestopping:
 - 1. Intumescent material capable of expanding up to 8 to 10 times when exposed to temperatures over 250 degrees Fahrenheit.
 - 2. Product shall be UL classified and have ICBO approved fire resistance rating up to 3 hours in accordance with ASTM E814.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Fill and seal holes or voids in fire rated floors and walls including pipes penetrating between buildings with acceptable firestopping material in accordance with manufacturer's instructions:
 - 1. Penetrations shall be free of dirt and debris.
 - 2. Dam penetrations, if required, with an acceptable material.

- B. Apply firestopping material to the penetration using a caulking gun, putty knife, or other normal trade tools:
 - 1. Provide minimum 1/2-inch caulk or putty for 2-hour fire rating with metal pipe.
 - 2. Provide minimum 1-inch caulk or putty for 3-hour rating with metal or insulated metal pipe.
- C. Normal curing time is 7 days; however, seal shall be immediately functional, providing cold smoke, water, and fire seal.
- D. Remove damming materials if necessary after cure.

3.02 CLEANING

- A. Clean surrounding areas after installation in compliance with manufacturer's instructions.

END OF SECTION

SECTION 07_92_00

JOINT SEALANTS

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Acrylic-latex sealant.
 - 2. Silicone sealant.
 - 3. Synthetic rubber sealing compound.
 - 4. Synthetic sponge rubber filler.
 - 5. Related materials.

1.02 REFERENCES

- A. ASTM International (ASTM):
 - 1. C920 - Standard Specification for Elastomeric Joint Sealants.
 - 2. C1330 - Standard Specification for Cylindrical Sealant Backing for Use with Cold Liquid-Applied Sealants.
 - 3. C1521 - Standard Practice for Evaluating Adhesion of Installed Weatherproofing Sealant Joints.
 - 4. D412 - Standard Test Methods for Vulcanized Rubber and Thermoplastic Elastomers - Tension.
 - 5. D624 - Standard Test Method for Tear Strength of Conventional Vulcanized Rubber and Thermoplastic Elastomer.

1.03 SUBMITTALS

- A. Furnish Submittals as specified in Section 01_33_00 - Submittal Procedures.
- B. Product Submittals:
 - 1. As specified in Section 01_60_01 - Product Requirements.
 - 2. Product data.
 - 3. Shop Drawings.
 - 4. Samples: include color selections.
 - 5. Manufacturer's instructions.
 - 6. Calculations.
 - 7. Schedules.

1.04 QUALITY ASSURANCE

- A. Manufacturer qualifications: Manufacturer of proposed product for minimum of 5 years with satisfactory performance record.
- B. Installer qualifications: Manufacturer approved installer of products similar to specified products on minimum 5 projects of similar scope as the Project with satisfactory performance record.

1.05 PROJECT OR SITE CONDITIONS

- A. Do not apply sealant on wet or frosty surfaces or when surface temperature is higher than 100 degrees Fahrenheit or lower than recommended by the manufacturer.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. Deliver, store, and handle products in accordance with the manufacturer's recommendations.
- B. Code date packages:
 - 1. Do not use material older than the manufacturer's published shelf life.
 - 2. Store materials at temperatures lower than 80 degrees Fahrenheit.
 - 3. Condition materials in accordance with the manufacturer's instructions prior to installation.

1.07 SEQUENCING AND SCHEDULING

- A. Caulk joints prior to painting.

1.08 WARRANTY

- A. As specified in Section 01_78_36 - Warranties and Bonds.
- B. Warrant to correct defective products for a minimum of 1 year in accordance with the manufacturer's standard warranty.

PART 2 PRODUCTS

2.01 SEALANTS

- A. General:
 - 1. Provide colors matching materials being sealed.
 - 2. Where compound is not exposed to view in finished work, provide the manufacturer's color which has best performance.
 - 3. Nonsagging sealant for vertical and overhead horizontal joints.
 - 4. Sealants for horizontal joints: Self-leveling pedestrian/traffic grade.
 - 5. Joint cleaner, primer, bond breaker: As recommended by the sealant manufacturer.
 - 6. Sealant backer rod and/or compressible filler made from closed cell polyethylene, polyethylene jacketed polyurethane foam, or other flexible, nonabsorbent, non-bituminous material recommended by the sealant manufacturer to:
 - a. Control joint depth.
 - b. Break bond of sealant at bottom of joint.
 - c. Provide proper shape of sealant bead.
 - d. Serve as expansion joint filler.

2.02 ACRYLIC-LATEX SEALANT

- A. Permanently flexible, nonstaining, and nonbleeding latex modified acrylic sealant compound, colors as selected by the Engineer from the manufacturer's standard options.
 - 1. Manufacturers: One of the following or equal:
 - a. Pecora Corp., AC-20.
 - b. Sonneborn, Sonolac.
 - c. Tremco, Tremflex 834.

2.03 SILICONE SEALANT

- A. ASTM C920, Type S, Grade NS, Class 25, single component silicone sealant.
 - 1. Manufacturers: One of the following or equal:
 - a. Dow Corning, 795.
 - b. General Electric, 1200 Series.
 - c. Pecora Corp., 864.
 - d. Tremco, Proglaze.

2.04 SYNTHETIC RUBBER SEALING COMPOUND

- A. Manufacturers: One of the following or equal:
 - 1. Pacific Polymers, Elastothane 227R.
 - 2. Sika Corporation, Sikaflex 2c NS or SL.
- B. Material: In accordance with ASTM C920, Type M, Grade P (pourable), Class 25; and Type M, Grade NS (non-sag), Class 25; multi-part polyurethane; able to cure at room temperature to firm, highly resilient polymer; able to perform satisfactory when continuously submerged in water or sewage and exposed to direct sunlight in dry condition; with the following properties determined at 75 degrees Fahrenheit and 50 percent relative humidity.
 - 1. Base: Polyurethane rubber.
 - 2. Application time: Minimum 2 hours.
 - 3. Cure time: Maximum 3 days.
 - 4. Tack free time: Maximum 24 hours.
 - 5. Ultimate hardness: Non-sag 25, pourable/SL 40, within 5 Shore A.
 - 6. Tensile strength: Non-sag 95 pounds per square inch minimum and self-leveling minimum 170 pounds per square inch when tested in accordance with ASTM D412.
 - 7. Ultimate elongation: Minimum 340 percent when tested in accordance with ASTM D412.
 - 8. Tear resistance: Non-sag 45 pounds per inch minimum and self-leveling minimum 85 pounds per inch when tested in accordance with ASTM D624, Die C.
 - 9. Service temperature range: -25 degrees to 158 degrees Fahrenheit.
- C. Color: Gray to match concrete, unless indicated on the Drawings.

2.05 SYNTHETIC SPONGE RUBBER FILLER

- A. Closed-cell expanded sponge rubber manufactured from synthetic polymer neoprene base, or resilient polyethylene foam backer rod. In accordance with ASTM C1330, Type C.
 - 1. Manufacturers: The following or equal:
 - a. Presstite, No. 750.3 Ropax Rod Stock.
- B. Characteristics:
 - 1. Suitable for application intended.
 - 2. Strength: As necessary for supporting sealing compound during application.
 - 3. Resiliency: Resistance to environmental conditions of installation.
 - 4. Bonding: No bonding to the sealing compound.
 - 5. Structure: Cellular, prevents absorption of water.
 - 6. Compatibility with other materials in joint and acceptance by the manufacturer of the sealing compound.
 - 7. Size: Minimum 25 percent greater than nominal joint width.

2.06 RELATED MATERIALS

- A. Primer: Nonstaining type, recommended by the sealant manufacturer to suit application.
- B. Joint cleaner: Noncorrosive, nonstaining, compatible with joint forming materials and as recommended by the sealant manufacturer.
- C. Bond breaker tape: Pressure-sensitive tape recommended by the sealant manufacturer to suit application.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Verify acceptability of joint dimensions, physical, and environmental conditions.
- B. Verify that surfaces are dry, clean, and free of dirt, grease, curing compound, and other residue which might interfere with adhesion of sealants.

3.02 PREPARATION

- A. Allow concrete to cure thoroughly before caulking.
- B. Synthetic sponge rubber filler:
 - 1. Prepare surfaces designated to receive filler in accordance with the manufacturer's installation instructions.
 - 2. Do not stretch filler beyond its normal length during installation.

- C. Caulking:
 - 1. Verify that surfaces are dry, clean, and free of dirt, grease, curing compounds, and other residue that might interfere with adhesion of sealant.
 - 2. Concrete, masonry, wood, and steel surfaces: Clean and prime in accordance with the manufacturer's instructions prior to caulking.
- D. Synthetic rubber sealing compound:
 - 1. Ensure surfaces to which synthetic rubber must bond are dry and free of dust, dirt, and other foreign residue.
 - 2. Heavy sandblasted caulking groove to sound surface and prime with the manufacturer's recommended primer for particular surface.
- E. For sidewalks, pavements, and similar joints sealed with elastomeric sealants and subject to traffic and other abrasion and indentation exposures, fill joints to depth equal to 75 percent of joint width, but neither more than 5/8 inches deep nor less than 3/8 inches deep.
- F. For normal moving building joints sealed with elastomeric sealants not subject to traffic, fill joints to depth equal to 50 percent of joint width, but neither more than 1/2 inch deep nor less than 1/4 inch deep.
- G. For joints sealed with acrylic-latex sealants, fill joints to depth in range of 75 percent to 125 percent of joint width.
- H. Use joint filler to achieve required joint depths, to allow sealants to perform properly.
- I. Prepare surfaces and install synthetic sponge rubber filler in accordance with the manufacturer's recommendations.
- J. Do not stretch filler beyond normal length during installation.
- K. Apply bond breaker when recommended by the joint sealer manufacturer.

3.03 INSTALLATION

- A. Synthetic sponge rubber filler: Install in accordance with the manufacturer's installation instructions.
- B. Caulking, joints, and sealing:
 - 1. Construct expansion, contraction, and construction joints as indicated on the Drawings.
 - 2. Install pipe and conduit in structures as indicated on the Drawings.
 - 3. Caulk doors, windows, louvers, and other items installed in or over concrete openings inside and out.
 - 4. Use synthetic rubber sealing compound for caulking where indicated on the Drawings or as specified, except for masonry construction and where specified otherwise.
 - 5. Complete caulking prior to painting.
 - 6. Verify that concrete is thoroughly cured prior to caulking.
 - 7. When filler compressible material is used, use untreated type.
 - 8. Apply caulking with pneumatic caulking gun.

9. Use nozzles of proper shape and size for application intended.
10. Maintain continuous bond between caulking and sides of joint to eliminate gaps, bubbles, or voids and fill joint in continuous operation without layering of compound.
11. Employ experienced applicators to caulk joints and seams in neat workmanlike manner.
12. To hasten curing of compound when used on wide joints subject to movement, apply heat with infrared lamps or other convenient means.
13. Apply synthetic rubber sealing compound with pneumatic caulking tool or other acceptable method.

3.04 CLEANING

- A. Clean surfaces adjacent to sealant as work progresses.
- B. Remove excess uncured sealant by soaking and scrubbing with sealant cleaning solvent.
- C. Remove excess cured sealant by sanding with No. 80 grit sandpaper.
- D. Leave finished work in neat, clean condition.

3.05 SCHEDULE

- A. Acrylic latex:
 1. Use where indicated on the Drawings.
 2. Interior joints with movement less than 7.5 percent and not subject to wet conditions.
- B. Silicone:
 1. Use where indicated on the Drawings.
 2. Joints and recesses formed where window, door, louver and vent frames, and sill adjoin masonry, concrete, stucco, or metal surfaces.
 3. Door threshold bedding.
 4. Moist or wet locations, including joints around plumbing fixtures.
 5. Stainless steel doors and frames, including joints between applied stops and frames, and around anchor bolts.
 6. Plenum joints.
- C. Synthetic rubber sealing compound, non-sag Type II:
 1. Use where indicated on the Drawings.
 2. Water-bearing and earth-bearing concrete structures.
 3. Joints in masonry, concrete vertical surfaces, and metal-faced panels in vertical surfaces.
 4. Joints between sheet metal flashing and trim.
 5. Joints between sheet metal flashing and trim, and vertical wall surfaces.
 6. Small voids between materials requiring filling for weathertight performance in vertical surfaces.
 7. Perimeters of frames of doors, windows, louvers, and other openings where bonding is critical to airtight performance.
 8. Expansion and control joints in masonry vertical surfaces.

- D. Synthetic rubber sealing compound, self-leveling Type I:
 - 1. Use where indicated on the Drawings.
 - 2. Expansion and control joints in masonry, concrete horizontal surfaces, and metal panels in horizontal surfaces.
 - 3. Small voids between materials requiring filling for weathertight performance in horizontal surfaces.
 - 4. Pavement joints.
 - 5. Perimeters of frames of doors, windows, louvers, and other openings in horizontal surfaces where bonding is critical to airtight performance.

3.06 FIELD QUALITY CONTROL

- A. Adhesion testing:
 - 1. Perform adhesion tests in accordance with ASTM C1521 and the following criteria:
 - a. Water bearing structures: 1 test per every 1,000 linear feet of joint sealed.
 - b. Chemical containment areas: 1 test per every 1,000 linear feet of joint sealed.
 - c. Building expansion joints: 1 test per every 500 linear feet of joint sealed.
 - d. All other type of joints, except butt glazing joints: 1 test per every 3,000 linear feet of joint sealed.
 - e. Manufacturer's authorized factory representative provide written recommendations for remedial measures on failing tests.

END OF SECTION

SECTION 08_11_13

HOLLOW METAL DOORS AND FRAMES

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes: Steel Fire Resistive Rated and Non-Fire Resistive Rated:
 - 1. Doors.
 - 2. Door frames.

1.02 REFERENCES

- A. American National Standards Institute (ANSI):
 - 1. A250.6 - Hardware on Steel Doors (Reinforcement Application).
 - 2. A250.8 - Recommended Specification for Standard Steel Doors and Frames.
- B. ASTM International (ASTM):
 - 1. A653 - Standard Specification for Sheet Steel, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process.
 - 2. A924 - Standard Specification for General Requirements for Steel Sheet, Metallic-Coated by the Hot-Dip Process.
 - 3. A1008 - Standard Specification for Steel, Sheet, Cold-Rolled, Carbon, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy With Improved Formability, Solution Hardened, and Bake Hardenable.
 - 4. A1011 - Standard Specification for Steel, Sheet and Strip, Hot-Rolled, Carbon, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy With Improved Formability, and Ultra-High Strength.
 - 5. E413 - Classification for Rating Sound Insulation.
- C. National Association of Architectural Metal Manufacturers (NAAMM)/Hollow Metal Manufacturers Association (HMMA):
 - 1. HMMA 861 - Guide Specifications for Commercial Hollow Metal Doors and Frames.
- D. National Fire Protection Association (NFPA):
 - 1. 80 - Standard for Fire Doors and Other Opening Protectives.
 - 2. 252 - Standard Methods of Fire Tests of Door Assemblies.
- E. Steel Door Institute (SDI):
 - 1. SDI-111 - Recommended Details for Standard Steel Doors, Frame, Accessories and Related Components.
 - 2. SDI-117 - Manufacturing Tolerances Standard Steel Doors and Frames.
- F. Underwriters' Laboratories, Inc., (UL):
 - 1. UL 10C - Positive Pressure Fire Tests of Door Assemblies.
 - 2. UL 102 - Sustainability Assessment for Swinging Door Leafs.

1.03 SUBMITTALS

- A. Product data.
- B. Shop drawings: Show the following with references to the Engineer's door marks and hardware groups:
 - 1. Location of door and frame types.
 - 2. Details of fabrication, including core construction, glass lights, louvers, weatherstripping, and factory finish for each door.
 - 3. Cutouts and reinforcements for hardware.
 - 4. Methods of installation and anchorage to adjacent construction.
- C. Certificates documenting:
 - 1. Fire-rated units have been successfully tested as specified in this Section.
- D. Manufacturer's instructions: Submit manufacturer's installation instructions.
- E. Pre-Submittal Conference:
 - 1. Conduct conference in compliance with requirements in Section 01_31_19 - Project Meetings with attendance by representatives of Supplier, Installer.
 - 2. Contractor to review proper methods and procedures for installing hollow metal doors and frames and to verify installation of electrical knockout boxes and conduit at frames with electrified or access control hardware.

1.04 QUALITY ASSURANCE

- A. Testing agency qualifications: Approved by ultimate enforcing authority for the Project; regularly engaged in inspection of materials and workmanship at factory.

1.05 DELIVERY, STORAGE, AND HANDLING

- A. Before delivery, identify type and size of each door and frame in such a way that markings will not damage finish.
- B. Preassemble doorframes in shop and deliver to Project site with spreader bar at sill or tie them in pairs to form box.
- C. Protect doors and frames with resilient packaging sealed with heat shrunk plastic. Break seal on-site to permit ventilation.
- D. Protect doors and frames during shipment and storage to prevent warping, bending, and corrosion.

1.06 SEQUENCING AND SCHEDULING

- A. Ensure timely delivery of reviewed hardware schedule and hardware templates such that no delay occurs in the work of the Contract.

PART 2 PRODUCTS

2.01 MATERIALS

- A. Sheet steel: ASTM A1008, commercial quality, level, cold rolled steel, or ASTM A1011, hot rolled, pickled and oil rolled steel. Galvanize by hot-dip process with zinc-coating in accordance with ASTM A924 or with ASTM A653 and the coating designation A60 or G60.
- B. Clips, bolts, screws, and rivets: sized as recommended by manufacturer.
- C. Primer: Rust- inhibitive epoxy primer compatible with high-solids epoxy finish coating system as specified in Section 09_96_01 - High-Performance Coatings.
- D. Touch-up materials: Primer as recommended by manufacturer.
- E. Door hardware: As specified in Section 08_71_00 - Door Hardware.
- F. Grout: As specified in Section 04_22_00 - Concrete Unit Masonry.

2.02 DOOR AND FRAME TYPES

- A. Interior doors: ANSI 250.8, Grade III, Model 3 or NAAMM HMMA 810 Type A and NAAMM HMMA 861, flush steel rib-stiffened, minimum 18-gauge face sheets.
- B. Exterior doors: ANSI 250.8, Grade III, Model 3, or NAAMM HMMA 810 Type A and NAAMM HMMA 861, flush steel rib-stiffened, minimum 16-gauge face sheets.
- C. Interior frames: ANSI 250.8 or NAAMM HMMA 861, fully welded frames, minimum 16-gauge, sizes and shapes as indicated on the Drawings.
- D. Exterior frames: ANSI 250.8 or NAAMM HMMA 861, fully welded frames HMMA 861, except minimum 14-gauge sizes and shapes as indicated on the Drawings.

2.03 FABRICATION OF FRAMES

- A. Galvanize all frames installed in exterior openings.
- B. Frames: Sheet steel, integral type, welded continuous to full depth of frames with minimum 5/8-inch deep stops, unless otherwise indicated on the Drawings.
- C. Hardware reinforcements: Fabricate according to SDI A250.6 with reinforcing plates from same material as door face sheets.
- D. Jamb Anchors: As required for adjacent wall construction, minimum 3 per jamb, unless otherwise indicated on the Drawings.
- E. Floor anchors: Fixed type, except where adjustable anchors are indicated on the Drawings, 1 per jamb, with minimum 2 holes for anchorage. Where floor fill occurs, terminate bottom of frames at indicated finished floor level and support by adjustable extension clips resting on and anchored to structural slabs.

- F. Anchors at masonry: Adjustable strap and stirrup, minimum 16-gauge corrugated or perforated steel at maximum of 30 inches on center and extending minimum 8 inches into masonry.
- G. Anchors at previously placed concrete: Countersink machine screws through the frame into expansion devices spaced at maximum 30 inches on center.
- H. Anchors at structural steel framing: Welded or otherwise securely fastened with stainless steel screws.
- I. Anchors for fire resistive frames: Conform to requirements of labeling authority having jurisdiction.
- J. Masonry angle stiffeners: Factory welded into heads of frames for installation in openings more than 48 inches wide.
- K. Mullions, muntins, and transom bars: Minimum 18-gauge, tubular sheet steel matching, and butt-welded to head and jamb members.
- L. Removable stops: Fasten at approximately 12 to 16 inches on center.

2.04 FABRICATION OF DOORS

- A. Galvanize all doors installed in exterior openings.
- B. Reinforce face sheets with steel rib stiffeners, spaced at maximum 6 inches apart, and securely attached to face sheets by spot welds at maximum 5 inches on center.
- C. Fill voids between face sheets and stiffeners with fiberglass insulation having a minimum density of 0.8 pounds per cubic foot.
- D. Edges: Full weld without visible joints. Bevel striking edge 1/8 inch in 2 inches.
- E. Door cores:
 - 1. Stiffeners: Vertical steel ribs formed from minimum 22-gauge plain sheet steel, spaced at maximum 6 inches apart and securely attached to face sheets by spot welds at maximum 5 inches on center.
 - 2. Core fillers: Insulation, minimum 0.60 pound density noncombustible type, installed in spaces between stiffeners for full height of door; labeled door core material shall conform to requirements of labeling authority.
- F. Tops and bottoms of doors: Close with continuous recess steel channel of minimum 16-gauge, extending full width of door and spot welded to both faces.
- G. Tops and bottoms of exterior doors: Flush closing channels welded to make tops and bottoms waterproof with weep holes for escape of moisture.
- H. Hardware reinforcements: Fabricate according to SDI A250.6 with reinforcing plates from same material as door face sheets.

- I. Astragals:
 - 1. Install on active leaf of double doors in accordance with UL listing requirements for fire resistive ratings as indicated on the Drawings, and for exterior pairs of doors.
 - 2. Do not install on doors swinging in pairs with rating of 90 minutes or less in means of egress where both leaves are required to provide building code required exiting widths.
 - 3. Do not provide astragal cutouts for hardware operations.
- J. Astragal clearances for fire resistive rated doors:
 - 1. Door bottoms at doors designated to receive non-combustible threshold: Not to exceed 3/8 inch between threshold and door bottom.
 - 2. Door bottoms where there is no threshold: Maximum clearance between door and floor not to exceed 1/2 inch.
 - 3. Door bottoms at doors designated to receive combustible floor coverings: Not to exceed 1/2 inch between floor covering and door bottom.
 - 4. Clearance between door and frame and between meeting edges of pairs of doors: Not to exceed 1/8 inch.
- K. Astragal clearances for non-fire resistive rated doors: Same as fire resistive rated doors, unless otherwise indicated on the Drawings.

2.05 FABRICATION OF FIRE RATED DOORS AND FRAMES

- A. Fabricate to meet requirements of the building code as specified in Section 01_41_00 - Regulatory Requirements, UL 10C, UL 102, and NFPA 252, except hose stream test shall not be required for opposite swing double egress exit doors and for doors of fire endurance rating of less than 45 minutes with or without approved glass lites.
- B. Temperature rise requirements of doors at exit enclosures and exit passageways: Maximum transmitted temperature end point of less than 450 degrees Fahrenheit above ambient at end of 30 minutes when tested in accordance with the building code as specified in Section 01_41_00 - Regulatory Requirements.
- C. Apply approved testing agency labels on fire rated doors and frames.
- D. Fabricate oversized fire rated doors in accordance with requirements for ratings indicated on the Drawings.

2.06 ACCESSORIES

- A. Mullions and transom bars: Join to adjacent members by welding or rigid mechanical anchors.
- B. Grout guards: Formed from same material as frames, not less than 0.016 inches thick.

- C. Silencers:
 - 1. Drill single leaf doorframe jamb stops for minimum 3 silencers.
 - 2. Drill double-leaf doorframe head stops for minimum 2 silencers.
 - 3. Do not drill doorframes for silencers when weatherstripping is to be installed.

2.07 FINISHING

- A. Thoroughly clean surfaces of oil, grease, and other impurities; touch-up abraded galvanizing; and chemically etch.
- B. Fill irregularities and sand smooth finish surface. Apply 1 coat of manufacturer's standard rust inhibitive baked-on primer.
- C. Finish painting: EPU-M-1 high solids epoxy polyurethane system:
 - 1. All doors: As specified in Section 09_96_01 - High-Performance Coatings.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Examine reviewed hardware schedules and verify proper coordination of hardware and doors and frames.
- B. Examine opening locations and verify the following:
 - 1. Correctness of dimensions, backing, or support conditions.
 - 2. Absence of defects that would adversely affect frame or door installation.

3.02 INSTALLATION

- A. Install doors and frames in accordance with approved shop drawings and manufacturer's instructions.
- B. Frames:
 - 1. Set accurately in position, plumb, align, and attach securely to structure.
 - 2. Set in place before construction of adjacent masonry or framed walls.
 - 3. Anchor frames to previously placed concrete.
 - 4. Set frames before removing spreader bars.
 - 5. Fully grout frames in masonry as the Work progresses.
 - 6. Grout frames at concrete through keyways provided at head and jambs.
- C. Doors:
 - 1. Install at correct openings, ensure smooth swing and proper closure with frame.
- D. Fire resistive frames and doors:
 - 1. Install to conform to NFPA 80 for fire resistive rated class as indicated on the Drawings.

- E. Door hardware:
 - 1. Install in accordance with Section 08_71_00 - Door Hardware.
 - 2. Drill and tap doors and frames to receive non-template, mortised, and surface-mounted door hardware.
- F. Separate or isolate dissimilar metals with neoprene gaskets, sleeves, and washers, or with coatings acceptable to the Engineer.

3.03 TOLERANCES

- A. Manufacturing and installation tolerances: As indicated on the Drawings or in conformance to SDI 117 as minimum.

3.04 ADJUSTING AND CLEANING

- A. Prime coat touch-up: Immediately after installation, sand smooth and touch-up rust areas, and other areas where primer has been damaged, with prime touch-up paint.
- B. Make adjustments as required for correct, proper, and free function and smooth operation without binding of hardware or doors and frames.
- C. Protect doors and frames from damage to surface or profile.

END OF SECTION

SECTION 08_31_14
FLOOR ACCESS DOORS

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Non-fire-rated floor access doors.

1.02 REFERENCES

- A. American Association of State Highway and Transportation Officials (AASHTO):
 - 1. Standard Specifications for Highway Bridges.
- B. ASTM International (ASTM):
 - 1. C1802 - Standard Specification for Design, Testing, Manufacture, Selection, and Installation of Fabricated Metal Horizontal Access Hatches for Utility, Water, and Wastewater Structures.
- C. Occupational Safety and Health Administration (OSHA):
 - 1. 29 CFR 1910 - Occupational Safety and Health Standards.

1.03 SUBMITTALS

- A. Furnish Submittals as specified in Section 01_33_00 - Submittal Procedures.
- B. Product data.
- C. Shop Drawings that include the following:
 - 1. Floor access door installation recommendations.
 - 2. Locations of floor access doors.
 - 3. Door size and configuration.
 - 4. Live load capacity.
 - 5. Materials of construction and finishes provided.

1.04 DELIVERY, STORAGE, AND HANDLING

- A. As specified in Section 01_60_01 - Product Requirements and the manufacturer's instructions.
- B. Identify type and size of each floor access door in way not to damage finish prior to delivery.
- C. Deliver products only after proper facilities are available.
- D. Deliver and store packaged products in original containers with seals unbroken and labels intact until time of use.

- E. Handle carefully to prevent damage and store on clean concrete surface or raised platform in safe, dry area.
 - 1. Do not dump onto ground.
- F. Protect floor access doors during shipment and storage to prevent warping, bending, and corrosion.

1.05 WARRANTY

- A. Provide manufacturer's warranty against defects in material and workmanship for a period of 5 years.

1.06 MAINTENANCE

- A. Deliver 2 keys for each cylinder lock to the Owner.

PART 2 PRODUCTS

2.01 LIGHT-DUTY FLOOR ACCESS DOORS

- A. Manufacturers: One of the following or equal:
 - 1. The Bilco Co., Floor Doors Model K with FPG fall protection grating.
 - 2. Nystrom, FDFL with SGT fall protection grating.
- B. Style: Single leaf or double leaf as indicated on the Drawings, capable of withstanding minimum live load of 150 pounds per square foot and designed to open to 90 degrees and lock automatically in that position.
- C. Material: Unless otherwise specified elsewhere, aluminum.
- D. Door leaf: 1/4-inch aluminum diamond-pattern plate reinforced with aluminum stiffeners as required for specified live load.
- E. Frame: 1/4-inch extruded aluminum with built-in neoprene cushion and with strap anchors bolted to exterior.
- F. Hardware:
 - 1. Hinges: Cast steel hinges bolted to underside door leaf that pivot on torsion bars that counterbalance door for ease of operation.
 - 2. Lock: Snap lock with removable handle mounted on door leaf.
 - 3. Grip handle: Provide vinyl grip handle designed to release cover for closing.
 - 4. Operating mechanism: Automatic hold-open arm.

2.02 FALL PROTECTION GRATING SYSTEM

- A. Furnish and install on vault access doors, where indicated on the Drawings, fall protection grating system.
 - 1. Door manufacturer shall install the grating system when the door is fabricated or field installed (by others) on existing doors already in use.
 - 2. If field installation is necessary grating system shall be installed in accordance with the manufacturer's instructions.

- B. Performance characteristics:
 - 1. Grating panel(s) shall be high visibility safety yellow in color.
 - 2. Grating panel(s) shall lock automatically in the full open position.
 - 3. Grating system shall have a 25-year warranty.
 - 4. Grating panel(s) shall have a provision for locking to prevent unauthorized opening.
- C. Grating: Panels shall be aluminum with a powder coat paint finish and designed to meet OSHA 29 CFR 1910 requirements for fall protection.
- D. Hold open feature: A Type 316 stainless steel hold open device shall be provided to lock the cover in the fully open 90-degree position.
- E. Hardware: Type 316 stainless steel.

2.03 FINISHES

- A. Floor access door:
 - 1. Aluminum: Manufacturer's standard mill finish.
 - 2. Aluminum in contact with dissimilar metals and concrete: Manufacturer's standard bituminous coating.
- B. Hardware:
 - 1. Provide optional Type 316 stainless steel hardware throughout, including parts of the latch and lifting mechanism assemblies, hold-open arms, and all brackets, hinges, pins, and fasteners.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Examine construction to receive floor access door and verify correctness of dimensions and other supporting or adjoining conditions.

3.02 PREPARATION

- A. Coordinate details with other work supporting, adjoining, or requiring floor access doors.
- B. Verify dimensions and profiles for each opening.
- C. Verify that location will serve portion of work to which access is required.
 - 1. Where proposed functional location conflicts with other work, notify the Engineer before installation.
- D. Apply coating to aluminum surfaces that will be in contact with dissimilar metals or concrete when there is none.

3.03 INSTALLATION

- A. Install in accordance with the manufacturer's instructions.
- B. Ensure correct types and adequate sizes at proper locations.
- C. Securely attach frames to supporting work and ensure doors, frames, and hardware operate smoothly and are free from warp, twist, and distortion.

3.04 ADJUSTING

- A. Adjust doors, frames, and hardware to operate smoothly, freely, and properly without binding.

3.05 CLEANING

- A. Thoroughly clean surfaces of grease, oil, or other impurities; touch up abraded prime coat where applicable.

END OF SECTION

SECTION 08_33_23
OVERHEAD COILING DOORS

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes: Non-fire rated insulated overhead coiling doors.

1.02 REFERENCES

- A. National Electrical Manufacturers Association (NEMA):
1. 250 - Enclosures for Electrical Equipment (1000 V Maximum).
- B. ASTM International:
1. A123 - Standard specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
 2. A653 - Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) by the Hot-Dip Process.
 3. A666 - Standard specification for Austenitic Stainless Steel Sheet, Strip, Plate, and Flat Bar.
 4. A924 - Standard Specification for General Requirements of Steel Sheet, Metallic-Coated by the Hot-Dip Process (Referenced by ASTM A653).

1.03 SUBMITTALS

- A. Product data:
1. General: Submit data completely describing products.
- B. Shop drawings:
1. Drawings showing complete installation details, required clearances, relation to building structure, complete electrical rough-in requirements required for installation of motor operators for doors and for connection of such doors to fire alarm system, referenced to the door mark number.
 2. Show location and size of access doors required to perform maintenance on doors and auxiliary equipment.
- C. Samples: Submit samples of finishes for finish selection.
- D. Quality control submittals:
1. Manufacturer's instructions:
 - a. Installation instructions for each type and size of door, including manufacturer's data, operating instructions, and maintenance data.
 - b. Furnish installer copy of diagrams and installation instructions.

- E. Contract closeout submittals:
 - 1. Project record documents:
 - a. Operation and maintenance data: Provide manufacturer's operation and maintenance data for each different type of door specified, complete with manufacturer's list of recommended spare parts and their prices, electrical schematic diagrams, and name and address of nearest maintenance organization approved by door manufacturer.
 - b. Warranty: Provide manufacturer's standard warranty.

1.04 QUALITY ASSURANCE

- A. Regulatory requirements:
 - 1. Wind loading as specified in Section 01_81_50 - Design Criteria.
 - 2. Seismic requirements for door anchorage and support systems as specified in Section 01_81_50 - Design Criteria.

1.05 DELIVERY, STORAGE, AND HANDLING

- A. Packing, shipping, and storage: Protect doors during shipment and storage to prevent warping, bending, and corrosion.
- B. Deliver materials only after proper facilities are available: Provide clean dry surfaces or platform as required and protect from deterioration and foreign matter.

1.06 PROJECT CONDITIONS

- A. Field measurements: Field verify all opening dimensions and clearances prior to fabricating doors. Fitting doors to openings is the responsibility of the Contractor.

1.07 SEQUENCING AND SCHEDULING

- A. Inserts and anchorages: Furnish inserts and anchoring devices which must be set into concrete or built into masonry. Provide setting drawings, templates, and directions for installation of anchorage devices. Coordinate delivery with other work to avoid delay to the Contract.

PART 2 PRODUCTS

2.01 DESIGN AND PERFORMANCE CRITERIA

- A. Design requirements:
 - 1. Compatibility with space and service requirements:
 - a. Doors and equipment items provided shall be compatible with space limitations specified and indicated on the Drawings.
 - b. Make modifications to doors and equipment items necessary to conform with space limitations or with utility services specified for rough-in.
 - c. Provide items complete including all necessary ancillary equipment as may be required for complete and trouble-free operation.

2. Maintenance requirements: For ease of maintenance, provide overhead coiling doors complying with following requirements:
 - a. Provide each door assembly as complete unit produced or supplied by a single manufacturer, including frames, sections, brackets, operating mechanisms, hardware, except hardware items specified in Section 08_71_00 - Door Hardware, and all necessary accessories for installation of complete in openings indicated.
 - b. Unless otherwise specified, all doors of particular type throughout the entire project shall be as manufactured or supplied by a single manufacturer.

2.02 MANUFACTURED UNITS

- A. Manufacturers: One of the following or equal:
 1. Overhead Door Corp.
 2. Wayne-Dalton Corp.
 3. The Cookson Co., Inc.
- B. Steel overhead coiling door:
 1. Mounting: Face of wall.
 2. Operation: Manual.
 3. Curtain:
 - a. Exterior slats: Manufacturer's standard, minimum 20-gauge steel galvanized in accordance with ASTM A653, interlocking flat-faced slats with ends of alternate slats fitted with metal end locks to hold curtain in alignment.
 - b. Bottom bar: Steel galvanized in accordance with ASTM A123, fitted with 2 equal-sized steel angles minimum 1/8-inch thick, with lift handle and cylindrical lock with housing capable of receiving cylinder as specified in Section 08_71_00 - Door Hardware at either end and provided with a flexible PVC bulb type astragal to ensure a consistent seal along the floor. Extrusion designed to interlock with door curtain.
 - c. Weatherstripping:
 - 1) Bottom bar: Manufacturer's standard, provided with a flexible PVC bulb type astragal to ensure a consistent seal along the floor. Extrusion designed to interlock with door curtain.
 - 2) Door jambs: Manufacturer's standard vinyl extrusion seals, manufacturer's standard.
 - 3) Hood: Manufacturer's standard vinyl air baffle.
 4. Guides: Steel galvanized in accordance with ASTM A123, formed of roll formed steel channels and angles or structural angles of sufficient depth to provide a groove of adequate depth on each jamb to hold curtain firmly in guides under design wind pressure.
 5. Brackets: Steel galvanized in accordance with ASTM A123, steel plate with permanently sealed ball bearings designed to enclose ends of coil and provide support for counterbalance pipe at each end.

6. Barrel and counterbalance mechanism: Steel pipe of sufficient size to carry door load with maximum deflection of 0.03 inch per foot of opening width and counterbalanced by helical springs, oil tempered torsion type designed with minimum safety factor of 1.25 percent, and having cast iron barrel plugs that anchor springs to tension shaft and pipe.
 7. Hood: Manufacturer's standard, minimum 24-gauge steel galvanized in accordance with ASTM A653, designed to enclose curtain coil and counterbalance mechanism.
- C. Insulation:
1. Interior slats: Material to match exterior slats as specified in previous article, interlocking flat-faced slats, manufacturer's standard size with ends of alternate slats fitted with metal end locks to hold curtain in alignment.
 2. Insulation: CFC-free Polyethylene foam yielding a minimum R-value of 6.20.
- D. Door operators:
1. Chain operator: Unless otherwise indicated on the Drawings, use at doors 56 square feet or larger in area. Provide a continuous hand chain and gearing on coil side of door.

2.03 ACCESSORIES

- A. Fasteners: Sizes and types as recommend by reviewed door manufacturer.

2.04 FINISHES

- A. Slats, hood and bottom bar:
1. Galvanized steel: Manufacturer's standard rust inhibitive prime coat and with powder coat finish as selected by Owner from manufacturer's standard colors.
- B. Guides and bracket plates:
1. Galvanized steel: manufacturer's standard rust inhibitive prime coat in a flat black finish.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Verification of conditions: Examine openings to receive overhead coiling doors and verify:
1. Dimensions and correctness of backing or support conditions.
 2. Absence of defects that would adversely affect installation.
- B. Do not start the work until unsatisfactory conditions are corrected.

3.02 PREPARATION

- A. Verify dimensions and design for each opening.

- B. Coordinate details with other work supporting or adjoining coiling doors.
- C. Furnish fastening devices as required to mount doors properly.

3.03 INSTALLATION

- A. Install doors in strict accordance with manufacturer's installation instructions, unless specifically otherwise indicated on the Drawings.
- B. Install assemblies plumb, square, and level at their proper elevations and in their proper planes.
- C. Securely anchor assemblies to interior face of openings, in manner that provides full opening clearance, perfectly aligned and adjusted for smooth operation.
- D. Interface with other products: Separate or isolate dissimilar metals with neoprene gaskets, sleeves, or washers, or with an acceptable coating.

3.04 ADJUSTING

- A. Verify that door assemblies are securely anchored to structure, guides are perfectly aligned, and doors are adjusted for smooth operation.
- B. Upon completion of installation, ensure doors are free from warp, twist, or distortion and are lubricated and properly adjusted to operate freely.

3.05 CLEANING

- A. Thoroughly clean surfaces of grease, oil, and other impurities.
- B. Replace any damaged or otherwise disfigured doors with new prior to final acceptance.

3.06 DEMONSTRATION

- A. Provide Owner's maintenance employees with minimum of 8 hours of maintenance instruction.

3.07 PROTECTION

- A. Protect installed doors from damage until final acceptance.

END OF SECTION

SECTION 08_45_01

TRANSLUCENT WALL PANELS

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Prefabricated insulated translucent wall sandwich panel system.
 - 2. Battens and perimeter closure system.
 - 3. System accessories and flashing.

1.02 REFERENCES

- A. Architectural Aluminum Manufacturers Association (AAMA):
 - 1. 2604 - Voluntary Specification, Performance Requirements and Test Procedures for High Performing Organic Coatings on Aluminum Extrusions and Panels.
 - 2. 2605 - Voluntary Specification, Performance Requirements and Test Procedures for Superior Performing Organic Coatings on Aluminum Extrusions and Panels.
- B. ASTM International (ASTM):
 - 1. C297 - Standard Test Method for Flatwise Tensile Strength of Sandwich Constructions.
 - 2. D635 - Standard Test Method for Rate of Burning and/or Extent and Time of Burning of Plastics in a Horizontal Position.
 - 3. D1002 - Standard Test Method for Apparent Shear Strength of Single-Lap-Joint Adhesively Bonded Metal Specimens by Tension Loading (Metal-to-Metal).
 - 4. D1037 - Standard Test Methods for Evaluating Properties of Wood-Base Fiber and Particle Panel Materials.
 - 5. D2244 - Standard Practice for Calculation of Color Tolerances and Color Differences from Instrumentally Measured Color Coordinates.
 - 6. E84-00a - Standard Test Method for Surface Burning Characteristics of Building Materials.
- C. International Code Council (ICC).
- D. National Fenestration Rating Council (NFRC):
 - 1. 100 - Procedure for Determining Fenestration Product U-factors.
- E. Underwriters Laboratories (UL):
 - 1. 972 - Burglary Resisting Glazing Material.

1.03 SUBMITTALS

- A. Shop drawings: Indicate at appropriate scale to clearly delineate materials and details of fabrication and installation.
- B. Product data: Manufacturer's standard technical specifications and product literature describing materials, special handling instructions, and installation instructions.
- C. Samples: Include metal finishes and face sheet types and colors.
- D. Manufacturer's installation instructions.
- E. Warranty.
- F. Manufacturer's Certificates: Certifications that materials meet specified requirements.
 - 1. Certifications:
 - a. Test reports to be furnished by wall panel system manufacturer.
 - b. The manufacturer shall submit certified test reports made by an independent testing organization for each type and class of panel system.
 - 2. Reports shall verify that the material will meet all performance requirements of this Section.
 - a. Previously completed test reports will be acceptable if current and indicative of products used on this project.
 - 3. Test reports:
 - a. Flame spread and smoke development: ASTM E84.
 - b. Burn extent: ASTM D635.
 - c. Color difference: ASTM D2244.
 - d. Impact strength: UL 972.
 - e. Bond strength: ASTM C297 after aging by ASTM D1002.
 - f. Accelerated aging: ASTM D1037.
 - g. Insulation U-value: NFRC-100.
 - h. Design loads: As specified in Section 01_81_50 - Design Criteria.
- G. Proof of regular, independent quality control monitoring under a building code review and listing program shall be submitted.

1.04 PERFORMANCE REQUIREMENTS

- A. The manufacturer shall be responsible for the configuration and fabrication of the complete wall panel system.

1.05 QUALITY ASSURANCE

- A. Manufacturer qualifications:
 - 1. Wall panel system manufacturer shall be listed by a recognized building code authority, including the ICC, which requires quality control inspections by an approved agency for sandwich panel construction. Submit ICC report, indicating UL Class A rating.
 - 2. Quality control inspections and testing conducted at least once each year, shall include manufacturing facilities, sandwich panel components and

production sandwich panels for conformance with acceptance criteria for sandwich panels as regulated by the ICC and as specified in Section 01_41_00 - Regulatory Requirements.

3. Materials and products shall be manufactured by a company continuously and regularly engaged in the manufacture of specified materials for a period of not less than 10 consecutive years; and can show evidence of these materials being satisfactorily used on at least 6 projects of similar size, scope and type within such a period.
 - a. At least 3 of the projects shall have been in successful use for 10 years or longer.

- B. Installer qualifications: Installer shall have been in the business of erecting specified materials for at least 5 consecutive years; and can show evidence of satisfactory completion of projects of similar size, scope and type.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. Deliver, store, and handle products in accordance with manufacturer's recommendations.
- B. Store panels on the long edge, several inches above the ground, blocked and under cover to prevent warping.

1.07 WARRANTY

- A. Provide warranty as specified in Section 01_78_36 - Warranties and Bonds.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. One of the following or equal:
 1. Kalwall.
 2. Kingspan Light + Air.

2.02 DESIGN AND PERFORMANCE CRITERIA

- A. The manufacturer shall be responsible for the configuration and fabrication of the complete wall panel system.

2.03 COMPONENTS

- A. Translucent facing:
 1. Translucent fiberglass faces shall be manufactured from glass fiber reinforced thermoset resins by insulated wall panel system fabricator especially for architectural use.
 2. Flame spread:
 - a. The interior face sheets shall be UL listed and have a flame spread of Class I in accordance with ASTM E84.

- b. Face shall not deform, deflect or drip when subjected to fire or flame; or become detached when subjected to 300 degrees Fahrenheit for 1 hour.
 - 3. Weatherability:
 - a. The full thickness of the exterior face shall not change color more than 3.0 Hunter or CIE Units (DELTA E by ASTM D2244) after 5 years outdoor South Florida weathering at 7 degrees facing south.
 - b. The exterior face shall have long-term resistance to reinforcing fiber exposure.
 - 4. Appearance:
 - a. The face sheets shall be uniform in color to prevent splotchy appearance.
 - b. Faces shall be completely free of ridges and wrinkles, which prevent proper surface contact in bonding to the aluminum grid core.
 - c. Clusters of air bubbles/pinholes, which collect moisture and dirt are not acceptable.
 - d. Exterior face sheets shall be 0.070 inches thick and white in color.
 - e. Interior face sheets shall be 0.45 inches thick and white in color.
 - f. Faces shall not vary more than plus or minus 10 percent in thickness.
 - 5. Strength: The exterior face sheet shall be uniform in strength and repel an impact equal to 70-foot pounds when tested in accordance with UL 972.
- B. Non-combustible grid core:
- 1. Panel framing: 6063-T6 or 6005-T5 aluminum I-beams with mechanical interlocking muntin-mullions and perimeter framing to prevent high and low intersections, which do not allow full bonding surface to contact with face material.
 - 2. Width of I-beam shall be no less than 7/16 inch.
 - 3. Aluminum I-beam grid shall be machined to tolerances of not greater than plus or minus 0.002 inches.
 - 4. Adhesive:
 - 5. Laminate adhesive: Waterproof resin for use in laminating polyester sheet to aluminum grid core.
 - 6. Impact and thermal shock: Adhesive capable of withstanding impact and thermal shock normally encountered in exterior construction.
 - 7. Adhesive bond line: Straight, black, cover entire width of I-beam, with neat, sharp edge.
 - 8. Initial bond strength between face sheet and grid core, ASTM C297.
 - 9. After accelerated aging, ASTM D1037: No significant change in bond strength, ASTM C297.

2.04 PANEL FABRICATION

- A. Translucent panels:
- 1. Panel thickness: 2-3/4 inches.
 - 2. Translucent faces: Manufactured from glass fiber reinforced thermoset resins, formulated specifically for architectural use.
 - a. Thermoplastic (e.g. polycarbonate, acrylic) faces are not acceptable.
 - b. Face sheets shall not deform, deflect or drip when subjected to fire or flame.
 - 3. Interior face sheets:
 - a. Flame spread: Underwriters Laboratories (UL) listed, which requires periodic unannounced retesting, with flame spread rating no greater than

- 25 and smoke developed no greater than 250 when tested in accordance with UL 723.
- b. Burn extent by ASTM D 635 shall be no greater than 1 inch.
- 4. Exterior face sheets:
 - a. Color stability: Full thickness of the exterior face sheet shall not change color more than 3 CIE Units DELTA E by ASTM D 2244 after 5 years outdoor South Florida weathering at 5° facing south, determined by the average of at least three white samples with and without a protective film or coating to ensure long-term color stability. Color stability shall be unaffected by abrasion or scratching.
 - b. Strength: Exterior face sheet shall be uniform in strength, with panel meeting ASTM E1996 and ASTM E1886 or TAS 201, 202 and 203.
 - 5. Appearance:
 - a. Exterior face sheets: Smooth 0.070 inch thick and Crystal in color.
 - b. Interior face sheets: Smooth 0.045 inch thick and Crystal in color.
 - c. Face sheets shall not vary more than ±10 percent in thickness and be uniform in color.
 - 6. Thermal value:
 - a. "U" factor, flat only.
 - 1) Thermally broken: 0.10.
 - 7. Light transmission: 10 percent, and solar heat gain coefficient of 0.13.
 - a. Wall panels shall be a true sandwich panel of flat fiberglass sheets bonded to a grid core of mechanically interlocking aluminum I-beams and shall be laminated under a controlled process of heat and pressure.
- B. Panel core grid: Grid pattern shall be nominal 12 inches by 24 inches and symmetrical about the horizontal centerline of each panel, for flat panel.
 - C. Bonding: The adhesive bonding line shall be straight, cover the entire width of the I-beam and have a neat, sharp edge. In order to verify bonding strength, white spots at intersections of muntins and mullions shall not exceed 4 for each 40 square feet of panel, nor shall they be more than 3/64 inches in width.
 - D. Wall panels and aluminum perimeter frame shall be pre-assembled where practical and sealed at the factory.
 - 1. Panels should be shipped to the job site in rugged shipping units and shall be ready for erection.

2.05 BATTENS AND PERIMETER CLOSURE SYSTEM

- A. Material: Extruded 6063-T6 and 6063-T5 aluminum screw clamp-tight type closure system.
- B. Aluminum closures to be supplied with 300 series stainless steel screws excluding final fasteners to the building and shall be factory sealed to the panels.
 - 1. Aluminum battens and cap plates shall be field installed.
- C. All exposed aluminum to be architectural corrosion resistant finish, which meets the performance requirements of AAMA 2604 and 2605, color to be selected from manufacturer's standards.

2.06 FLEXIBLE SEALING TAPE

- A. Sealing tape shall be manufacturer's standard pre-applied to closure system at the factory under controlled conditions.

PART 3 EXECUTION

3.01 EXAMINATION

- A. General: Surfaces or openings to receive translucent wall panels shall be inspected by the system supplier or installer for acceptance.

3.02 PREPARATION

- A. Contractor shall prepare openings including isolating dissimilar materials from aluminum system which may cause damage by electrolysis and shall provide temporary enclosures if required.

3.03 ERECTION

- A. The erector shall erect translucent wall panel system in strict accordance with approved shop drawings as supplied by manufacturer.
- B. Fastening and sealing shall be in strict accordance with manufacturer's shop drawings.
 - 1. All aluminum shall be cleaned before sealants are applied.

3.04 CLEANING AND PROTECTION

- A. After other trades have completed work on adjacent material, carefully inspect translucent panel installation and make adjustments necessary to ensure proper installation and weathertight conditions.

END OF SECTION

SECTION 08_71_00

DOOR HARDWARE

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Hardware for aluminum and hollow metal doors.
 - 2. Hardware for fire-rated doors.
 - 3. Electrically operated and controlled hardware.
 - 4. Lock cylinders for doors with balance of hardware specified in other sections.
 - 5. Thresholds.
 - 6. Weatherstripping and gasketing.

1.02 REFERENCES

- A. Americans with Disabilities Act (ADA):
 - 1. 2010 ADA Standards for Accessible Design; 2010.
- B. ASTM International (ASTM):
 - 1. E283/E283M - Standard Test Method for Determining Rate of Air Leakage Through Exterior Windows, Skylights, Curtain Walls, and Doors Under Specified Pressure Differences Across the Specimen; 2019.
- C. Builders Hardware Manufacturers Association (BHMA):
 - 1. A156.1 - Standard for Butts and Hinges; 2021.
 - 2. A156.2 - Bored and Preassembled Locks and Latches; 2022.
 - 3. A156.3 - Exit Devices; 2020.
 - 4. A156.4 - Door Controls - Closers; 2019.
 - 5. A156.5 - Cylinders and Input Devices for Locks; 2020.
 - 6. A156.6 - Standard for Architectural Door Trim; 2021.
 - 7. A156.7 - Template Hinge Dimensions; 2016.
 - 8. A156.16 - Auxiliary Hardware; 2018.
 - 9. A156.18 - Materials and Finishes; 2020.
 - 10. A156.21 - Thresholds; 2019.
 - 11. A156.22 - Standard for Gasketing; 2021.
 - 12. A156.28 - Standard for Recommended Practices for Mechanical Keying Systems; 2018.
 - 13. A156.115 - Hardware Preparation in Steel Doors and Steel Frames; 2016.
 - 14. A156.115W - Hardware Preparation in Wood Doors with Wood or Steel Frames; 2006.
- D. Door and Hardware Institute (DHI):
 - 1. H&S - Sequence and Format for the Hardware Schedule; 2019.
 - 2. KSN - Keying Systems and Nomenclature; 2019.

3. LOCS - Recommended Locations for Architectural Hardware for Standard Steel Doors and Frames; 2004.
 4. WDHS.3 - Recommended Locations for Architectural Hardware for Flush Wood Doors; 1993; also, in WDHS-1/WDHS-5 Series, 1996.
- E. International Code Council, Inc. (ICC):
1. A117.1 - Accessible and Usable Buildings and Facilities; 2017.
- F. ITS (DIR) - Directory of Listed Products; Current Edition.
- G. MIL-STD-810 - Environmental Engineering Considerations and Laboratory Tests; 2019H.
- H. National Fire Protection Association (NFPA):
1. NFPA 70 - National Electrical Code; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
 2. NFPA 80 - Standard for Fire Doors and Other Opening Protectives; 2022.
 3. NFPA 105 - Standard for Smoke Door Assemblies and Other Opening Protectives; 2022.
 4. NFPA 252 - Standard Methods of Fire Tests of Door Assemblies; 2022.
- I. UL Solutions (UL):
1. UL (DIR) - Online Certifications Directory; Current Edition.
 2. UL 10C - Standard for Positive Pressure Fire Tests of Door Assemblies; Current Edition, Including All Revisions.
 3. UL 294 - Access Control System Units; Current Edition, Including All Revisions.
 4. UL 1784 - Standard for Air Leakage Tests of Door Assemblies; Current Edition, Including All Revisions.

1.03 ADMINISTRATIVE REQUIREMENTS

- A. Coordinate the manufacture, fabrication, and installation of products that door hardware is installed on.
- B. Sequence installation to ensure facility services connections are achieved in an orderly and expeditious manner.
- C. Preinstallation Meeting: Convene a preinstallation meeting 1 week prior to commencing work of this Section; require attendance by affected installers and the following:
 1. Engineer.
 2. Supplier's Architectural Hardware Consultant (AHC).
 3. Hardware Installer.
 4. Owner's Security Consultant.
- D. Furnish templates for door and frame preparation to manufacturers and fabricators of products requiring internal reinforcement for door hardware.

- E. Keying Requirements Meeting:
 - 1. Schedule meeting at project site prior to Contractor occupancy.
 - 2. Attendance Required:
 - a. Owner.
 - 3. Agenda:
 - a. Establish keying requirements.
 - b. Verify locksets and locking hardware are functionally correct for project requirements.
 - c. Verify that keying and programming complies with project requirements.
 - d. Establish keying submittal schedule and update requirements.
 - 4. Incorporate "Keying Requirements Meeting" decisions into keying submittal upon review of door hardware keying system including, but not limited to, the following:
 - 5. Record minutes and distribute copies within two days after meeting to participants, with two copies to Architect, Owner, participants, and those affected by decisions made.
 - 6. Deliver established keying requirements to manufacturers.

1.04 SUBMITTALS

- A. See Section 01_33_00 - Submittal Procedures for submittal procedures.
- B. Product Data: Manufacturer's catalog literature for each type of hardware, marked to clearly show products to be furnished for this project, and includes construction details, material descriptions, finishes, and dimensions and profiles of individual components.
- C. Shop Drawings - Door Hardware Schedule: A detailed listing that includes each item of hardware to be installed on each door.
 - 1. Prepared by or under supervision of AHC.
 - 2. Comply with DHI (H&S) using door numbering scheme and hardware set numbers as indicated in the Contract Documents.
 - a. Submit in vertical format.
 - 3. Include complete description for each door listed.
- D. Shop Drawings - Electrified Door Hardware: Include diagrams for power, signal, and control wiring for electrified door hardware that include details of interface with building safety and security systems. Provide elevations and diagrams for each electrified door opening as follows:
 - 1. Prepared by or under supervision of AHC and Electrified Hardware Consultant (EHC).
 - 2. Elevations: Include front and back elevations of each door opening showing electrified devices with connections installed and an operations narrative describing how opening operates from either side at any given time.
 - 3. Diagrams: Include point-to-point wiring diagrams that show each device in door opening system with related colored wire connections to each device.
- E. Manufacturer's Installation Instructions: Indicate special procedures and perimeter conditions requiring special attention.
- F. Manufacturer's qualification statement.

- G. Installer's qualification statement.
- H. Supplier's qualification statement.
- I. Maintenance Data: Include data on operating hardware, lubrication requirements, and inspection procedures related to preventative maintenance.
- J. Keying Schedule:
 - 1. Submit three (3) copies of Keying Schedule in compliance with requirements established during Keying Requirements Meeting unless otherwise indicated.
- K. Warranty: Submit manufacturer's warranty and ensure that forms have been completed in Owner's name and registered with manufacturer.
- L. Project Record Documents: Record actual locations of concealed equipment, services, and conduit.
- M. Maintenance Materials and Tools: Furnish the following for Owner's use in maintenance of project.

1.05 QUALITY ASSURANCE

- A. Standards for Fire-Rated Doors: Maintain one copy of each referenced standard on site, for use by Architect and Contractor.
- B. Manufacturer Qualifications: Company specializing in manufacturing products specified in this Section with minimum three years of documented experience.
- C. Installer Qualifications: Company specializing in performing work of the type specified for commercial door hardware with at least three years of documented experience.
- D. Supplier Qualifications: Company with certified AHC and EHC to assist in work of this Section.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. Package hardware items individually; label and identify each package with door opening code to match door hardware schedule.

1.07 WARRANTY

- A. See Section 01_78_24 - Operation and Maintenance Manuals for additional warranty requirements.
- B. Manufacturer Warranty: Provide manufacturer warranty against defects in material and workmanship for period indicated, from Date of Substantial Completion. Complete forms in Owner's name and register with manufacturer.
 - 1. Closers: 10 years, minimum.
 - 2. Exit Devices: 3 years, minimum.
 - 3. Locksets and Cylinders: Lifetime.
 - 4. Other Hardware: 2 years, minimum.

PART 2 PRODUCTS

2.01 GENERAL REQUIREMENTS

- A. Provide specified door hardware as required to make doors fully functional, compliant with applicable codes, and secure to extent indicated.
- B. Provide individual items of single type, of same model, and by same manufacturer.
- C. Locks: Provide a lock for each door, unless it's indicated that lock is not required.
 - 1. Lock Function: Provide lock and latch function numbers and descriptions of manufacturer's Series. As indicated in hardware sets.
 - 2. Trim: Provide lever handle or pull trim on outside of each lock, unless otherwise indicated.
 - 3. Strikes:
 - a. Finish: To match lock or latch.
 - b. Curved-Lip Strikes: Provide as standard, with extended lip to protect frame, unless otherwise indicated.
 - c. Center Strike at Pairs of Doors: 7/8-inch (22.2-mm) lip.
- D. Closers:
 - 1. Provide door closer on each exterior door, unless otherwise indicated.
 - 2. Provide door closer on each fire-rated and smoke-rated door.
 - 3. Spring hinges are not an acceptable self-closing device, unless otherwise indicated.
- E. Overhead Stops and Holders (Door Checks):
 - 1. Provide stop for every swinging door, unless otherwise indicated.
 - 2. Overhead Stop is not required if positive stop feature is specified for door closer; positive stop feature of door closer is not an acceptable substitute for a stop, unless otherwise indicated.
 - 3. Overhead stop is not required if a floor or wall stop has been specified for the door.
- F. Drip Guards: Provide at head of out-swinging exterior doors unless protected by roof or canopy directly overhead.
- G. Thresholds:
 - 1. Exterior Applications: Provide at each exterior door, unless otherwise indicated.
- H. Weatherstripping and Gasketing:
 - 1. Provide weatherstripping on each exterior door at head, jambs, and meeting stiles of door pairs, unless otherwise indicated.
 - 2. Provide door bottom sweep on each exterior door, unless otherwise indicated.
- I. Electrically Operated and/or Controlled Hardware: Provide necessary power supplies, power transfer hinges, relays, and interfaces as required for proper operation; provide wiring between hardware and control components and to building power connection in compliance with NFPA 70.

- J. See Section 28_10_00 - Access Control: Electronic Access Control Devices for additional access control system requirements.
- K. Fasteners:
 - 1. Provide fasteners of proper type, size, quantity, and finish that comply with commercially recognized standards for proposed applications.
 - a. Aluminum fasteners are not permitted.
 - b. Provide phillips flat-head screws with heads finished to match door surface hardware unless otherwise indicated.
 - 2. Provide machine screws for attachment to reinforced hollow metal and aluminum frames.
 - a. Self-drilling (Tek) type screws are not permitted.
 - 3. Provide stainless steel machine screws and lead expansion shields for concrete and masonry substrates.
 - 4. Provide wall grip inserts for hollow wall construction.
 - 5. Fire-Resistance-Rated Applications: Comply with NFPA 80.
 - a. Provide wood or machine screws for hinges mortised to doors or frames, strike plates to frames, and closers to doors and frames.
 - b. Provide steel through bolts for attachment of surface mounted closers, hinges, or exit devices to door panels unless proper door blocking is provided.

2.02 PERFORMANCE REQUIREMENTS

- A. Provide door hardware products that comply with the following requirements:
 - 1. Applicable provisions of federal, state, and local codes.
 - 2. Accessibility: ADA Standards and ICC A117.1.
 - 3. Fire-Resistance-Rated Doors: NFPA 80, listed and labeled by qualified testing agency for fire protection ratings indicated, based on testing at positive pressure in accordance with NFPA 252 or UL 10C.
 - 4. Hardware on Fire-Resistance-Rated Doors: Listed and classified by UL (DIR), ITS (DIR), testing firm acceptable to authorities having jurisdiction, or as suitable for application indicated.
 - 5. Hardware for Smoke and Draft Control Doors (shown as "S" and as indicated on the Drawings): Provide door hardware that complies with local codes, and requirements of assemblies tested in accordance with UL 1784.
 - 6. Hardware Preparation for Steel Doors and Steel Frames: BHMA A156.115.
 - 7. Hardware Preparation for Wood Doors with Wood or Steel Frames: BHMA A156.115W.
 - 8. Products Requiring Electrical Connection: Listed and classified by UL (DIR) as suitable for the purpose specified.

2.03 HINGES

- A. Manufacturers: Conventional butt hinges.
 - 1. BEST; Dormakaba Group: www.bestaccess.com/#sle.
 - 2. Or approved equal.

- B. Properties:
1. Butt Hinges: As applicable to each item specified.
 - a. Standard Weight Hinges: Minimum of 2 permanently lubricated non-detachable bearings.
 - b. Heavy Weight Hinges: Minimum of 4 permanently lubricated bearings on heavy weight hinges.
 - c. Template screw hole locations.
 - d. Bearing assembly installed after plating.
 - e. Bearings: Exposed fully hardened bearings.
 - f. Bearing Shells: Shapes consistent with barrels.
 - g. Pins: Easily seated, non-rising pins.
 - 1) Fully plate hinge pins.
 - 2) Non-Removable Pins: Slotted stainless steel screws.
 - h. UL 10C listed for fire-resistance-rated doors.
- C. Sizes: See Door Hardware Schedule.
1. Hinge Widths: As required to clear surrounding trim.
 2. Sufficient size to allow 180 degree swing of door.
- D. Finishes: See Door Hardware Schedule.
1. Fully polish hinges; front, back, and barrel.
- E. Grades:
1. Butt Hinges: Comply with BHMA A156.1 and BHMA A156.7 for templated hinges.
 2. Comply with BHMA A156.18 Materials and Finishes.
- F. Material: Base metal as indicated for each item by BHMA material and finish designation.
- G. Types:
1. Butt Hinges: Include full mortise hinges.
- H. Options: As applicable to each item specified.
- I. Quantities:
1. Butt Hinges: 3 hinges per leaves up to 90 inches (2,286 mm) in height. Add 1 for each additional 30 inches (762 mm) in height or fraction thereof.
 - a. Hinge weight and size unless otherwise indicated in hardware sets:
 - 1) For doors up to 36 inches (914 mm) wide and up to 1-3/4 inches (44.5 mm) thick provide hinges with a minimum thickness of 0.134 inch (3.4 mm) and a minimum of 4-1/2 inches (114 mm) in height.
 - 2) For doors from 36 inches (914 mm) wide up to 42 inches (1,067 mm) wide and up to 1-3/4 inches (44.5 mm) thick provide hinges with a minimum thickness of 0.145 inch (3.7 mm) and a minimum of 4-1/2 inches (114 mm) in height.

- 3) For doors from 42 inches (1,067 mm) wide up to 48 inches (1,219 mm) wide and up to 1-3/4 inches (44.5 mm) thick provide hinges with a minimum thickness of 0.180 inch (4.6 mm) and a minimum of 5 inches (127 mm) in height.
 - 4) For doors greater than 1-3/4 inches (44.5 mm) thick provide hinges with a minimum thickness of 0.180 inch (4.6 mm) and a minimum of 5 inches (127 mm) in height.
- J. Applications: At swinging doors.
 - 1. Provide non-removable pins at out-swinging doors with locking hardware and all exterior doors.
- K. Products:
 - 1. Butt hinges:
 - a. Ball bearing, 5-knuckle.

2.04 BOLTS

- A. Manufacturers:
 - 1. Trimco: www.trimcohardware.com/#sle.
- B. Properties:
 - 1. Flush Bolts:
 - a. Automatic Flush Bolts: Automatically latching upon closing of door leaf.
 - 1) Bolt Throw: 3/4 inch (19 mm), minimum.
 - 2. Dustproof Strikes: For bolting into floor, provide except at metal thresholds.
- C. Options:
 - 1. Lever extensions: Provide for top bolt at oversized doors.
- D. Products:
 - 1. Automatic flush bolts: 3810.

2.05 EXIT DEVICES

- A. Manufacturers:
 - 1. BEST, dormakaba Group: www.bestaccess.com/#sle.
 - 2. Substitutions: Not permitted.
- B. Properties:
 - 1. Actuation: Full-length touchpad.
 - 2. Touchpads: "T" style metal touchpads and rail assemblies with matching chassis covers end caps.
 - 3. Latch Bolts: Stainless steel deadlocking with 3/4-inch (19-mm) projection using latch bolt.
 - 4. Lever Design: Match project standard lockset trims.
 - 5. Cylinder: Include where cylinder dogging or locking trim is indicated.
 - 6. Strike as recommended by manufacturer for application indicated.
 - 7. Sound dampening on touch bar.

8. Dogging:
 - a. Non-Fire-Resistance-Rated Devices: Cylinder 1/4-inch (6-mm) hex key dogging.
 - b. Fire-Resistance-Rated Devices: Manual dogging not permitted.
 9. Touch bar assembly on wide style exit devices to have a 1/4-inch (6.3-mm) clearance to allow for vision frames.
 10. All exposed exit device components to be of architectural metals and "true" architectural finishes.
 11. Handing: Field-reversible.
 12. Fasteners on Back Side of Device Channel: Concealed - exposed fasteners not allowed.
 13. Vertical Latch Assemblies' Operation: Gravity, without the use of springs.
- C. Grades: Complying with BHMA A156.3, Grade 1.
1. Provide exit devices tested and certified by UL or by a recognized independent laboratory for mechanical operational testing to 10 million cycles minimum with inspection confirming Grade 1 Loaded Forces have been maintained.
- D. Options:
1. Electrified Devices:
 - a. Latchbolt Retraction: Motorized latchbolt retraction.
 2. Furnish less bottom rod (LBR) at scheduled locations to eliminate use of floor mounted strikes.
 3. Weatherized True Architectural Finish: Provide where indicated in Door Hardware Schedule as 626W.
 - a. Weatherized exterior components to include active case cover, touch bar, device channel, slide channel fillers, vertical rods, latch covers, and device end cap.
 - 1) Base Metal Material: Brass.
 - 2) Plated Finish: Satin nickel and chrome, using a double-dip, two-step process.
 - b. Performance Requirements:
 - 1) BHMA A156.18 Salt Spray Certified using 600 Hours of testing, 3 times longer than the Standard's requirements.
 - 2) MIL-STD-810G 509.6 Salt Fog Certified.
 - 3) MIL-STD-810G 510.6 Sand and Dust Certified.
 - 4) MIL-STD-810G 521.4 Icing or Freezing Rain Certified.
 - c. Compatible non-weatherized electrified options as specified in Door Hardware Schedule.
 4. WTS touch bar switch.
 5. WALW hardwired exit alarm.
- E. Products:
1. 2000.

2.06 LOCK CYLINDERS

- A. Manufacturers:
1. BEST, dormakaba Group: www.bestaccess.com/#sle.
 2. Substitutions: Not permitted.

- B. Properties:
 - 1. Lock Cylinders: Provide key access on outside of each lock, unless otherwise indicated.
 - a. Provide cylinders from same manufacturer as locking device.
 - b. Provide cams and/or tailpieces as required for locking devices.
 - c. Provide cylinders with appropriate format interchangeable cores where indicated.
- C. Grades:
 - 1. Standard Security Cylinders: Comply with BHMA A156.5.
- D. Types: As applicable to each item specified.
- E. Applications: At locations indicated in hardware sets, and as follows
 - 1. As required for items with locking devices provided by other Sections, including at elevator controls and cabinets.
 - a. When provisions for lock cylinders are referenced elsewhere in the Project Manual to this Section, provide compatible type of lock cylinder, keyed to building keying system, unless otherwise indicated.
- F. Products:
 - 1. Rim/mortise: 12E-72 and 1E-74.

2.07 MORTISE LOCKS

- A. Manufacturers:
 - 1. BEST, dormakaba Group: www.bestaccess.com/#sle.
 - 2. Substitutions: Not permitted.
- B. Properties:
 - 1. Mechanical Locks: Manufacturer's standard.
 - a. Fitting modified ANSI A115.1 door preparation.
 - b. Door Thickness Coordination Fitting 1-3/4 inch (44 mm) to 2-1/4 inch (57 mm) thick doors.
 - c. Latch: Solid, one-piece, anti-friction, self-lubricating stainless steel.
 - 1) Latchbolt Throw: 3/4 inch (19 mm), minimum.
 - d. Auxiliary Deadlatch: 1-piece stainless steel, permanently lubricated.
 - e. Backset: 2-3/4 inch (70 mm).
 - f. Lever Trim:
 - 1) Functionality: Allow the lever handle to move up to 45 degrees from horizontal position prior to engaging the latchbolt assembly.
 - 2) Strength: Locksets outside locked lever designed to withstand minimum 1,400 inch-lbs (158.2 Nm) of torque. In excess of that, a replaceable part will shear. Key from outside and/or inside lever will still operate lockset.
 - 3) Spindle: Designed to prevent forced entry from attacking of lever.
 - 4) Independent spring mechanism for each lever.
 - 5) Trim to be self-aligning and thru-bolted.
 - 6) Handles: Made of forged or cast brass, bronze, or stainless steel construction. Levers that contain a hollow cavity are not acceptable.
 - 7) Levers to operate a roller bearing spindle hub mechanism.

2. Electrified Locks: Same properties as standard locks, and as follows:
 - a. Voltage: 24 VAC.
 - b. Function: Electrically locked (Fail Safe) or unlocked (Fail Secure), as indicated for each lock in Door Hardware Schedule.
- C. Finishes: See Door Hardware Schedule.
 1. Core Faces: Match finish of lockset.
- D. Options:
 1. Provide locksets made in a manufacturing facility to compliant with ISO 9001-Quality Management and ISO 14001-Environmental Management.
- E. Products: Mortise locks, including standard and electrified types.
 1. 40H.

2.08 COORDINATORS

- A. Manufacturers:
 1. Trimco: www.trimcohardware.com/#sle.
- B. Properties:
 1. General: Non-handed devices, with field-selectable active door leaf.
 2. Coordinators: Devices on pairs of doors with closers and self-latching or automatic flush bolts installed.
 - a. Coordinator Operation: Only when inactive door is opened.
- C. Code Compliance: As required by authorities having jurisdiction in the State in which the Project is located.
 1. Meet UL 10C for Positive Pressure.
- D. Types:
 1. Coordinators: Bar.
- E. Installation:
 1. Mounting: Provide necessary mounting brackets and filler bars to ensure proper installation of coordinator and related hardware.
 2. Coordination: Properly sequence installation of other door hardware affected by placement of coordinators and carry bars.
- F. Products:
 1. 3090 Series.

2.09 CLOSERS

- A. Manufacturers:
 1. dormakaba; dormakaba Group: www.dormakaba.com/us-en/#sle.
 2. Substitutions: Not permitted.
- B. Properties:
 1. Surface Mounted Closers: Manufacturer's standard.
 - a. Construction: R14 high silicon aluminum alloy.

- b. Mechanism: Separate tamper-resistant adjusting valves for closing and latching speeds.
 - c. Hydraulic Fluid: All-weather type.
 - d. Arm Assembly: Standard for product specified.
 - 1) Include hold-open, integral stop, or spring-loaded stop feature, as specified in Door Hardware Schedule.
 - 2) Parallel arm to be a heavy-duty rigid arm.
 - 3) Where "IS" or "S-IS" arms are specified in hardware sets, if manufacturer does not offer this arm provide a regular arm mount closer in conjunction with a heavy-duty overhead stop equal to a dormakaba 900 Series.
 - e. Covers:
 - 1) Type: Standard for product selected.
 - a) Full.
 - 2) Material: Plastic.
 - 3) Finish: Painted.
- C. Grades:
 - 1. Closers: Comply with BHMA A156.4, Grade 1.
 - a. Underwriters Laboratories Compliance:
 - 1) Product Listing: UL (DIR) and ULC for use on fire-resistance-rated doors.
 - a) UL 228 - Door Closers-Holders, With or Without Integral Smoke Detectors.
- D. Code Compliance: As required by authorities having jurisdiction in the State in which the Project is located.
- E. Types:
 - 1. Rack-and-pinion, surface-mounted. 1-1/2 inches (38 mm) minimum bore.
- F. Options:
 - 1. Delayed action, adjustable with an independent valve.
- G. Installation:
 - 1. Mounting: Includes surface mounted installations.
 - 2. Mount closers on non-public side of door and stair side of stair doors unless otherwise noted in hardware sets.
 - 3. At out-swinging exterior doors, mount closer on interior side of door.
 - 4. Provide adapter plates, shim spacers, and blade stop spacers as required by frame and door conditions.
 - 5. Where an overlapping astragal is included on pairs of swinging doors, provide coordinator to ensure door leaves close in proper order.
- H. Products:
 - 1. Surface Mounted:
 - a. 8900.

2.10 PROTECTION PLATES

- A. Manufacturers:
 - 1. Trimco: www.trimcohardware.com/#sle.
- B. Properties:
 - 1. Plates:
 - a. Kick Plates: Provide along bottom edge of push side of every wood door with closer, except aluminum storefront and glass entry doors, unless otherwise indicated.
 - 1) Size: 10 inches (254 mm) high by 2 inches (51 mm) less door width (LDW) on push side of door.
 - b. Edges: Beveled, on 4 unless otherwise indicated.
- C. Grades: Comply with BHMA A156.6.
- D. Material: As indicated for each item by BHMA material and finish designation.
 - 1. Metal Properties: Stainless steel.
 - a. Metal, Standard Duty: Thickness 0.050 inch (1.27 mm), minimum.
- E. Installation:
 - 1. Fasteners: Countersunk screw fasteners.
- F. Products:
 - 1. Kick Plates: K0050.

2.11 STOPS AND HOLDERS

- A. Manufacturers:
 - 1. Trimco: www.trimcohardware.com/#sle.
- B. General: Provide overhead stop/holder when wall or floor stop is not feasible.
- C. Grades:
 - 1. Door Holders, Wall Bumpers, and Floor Stops: Comply with BHMA A156.16 and Resilient Material Retention Test as described in this standard.
- D. Material: Base metal as indicated for each item by BHMA material and finish designation.
- E. Types:
 - 1. Floor Stops: Provide with bumper floor stop.
- F. Products:
 - 1. Floor Stops: 1209HA.

2.12 THRESHOLDS

- A. Manufacturers:
- B. National Guard Products, Inc: www.ngpinc.com/#sle.

- C. Properties:
 - 1. Threshold Surface: Fluted horizontal grooves across full width.
- D. Grades: Thresholds: Comply with BHMA A156.21.
- E. Types: As applicable to project conditions. Provide barrier-free type at every location where specified.
 - 1. Saddle Thresholds: Without thermal break.
- F. Products: As listed in the hardware sets.

2.13 WEATHERSTRIPPING AND GASKETING

- A. Manufacturers:
 - 1. National Guard Products, Inc: www.ngpinc.com/#sle.
- B. Properties:
 - 1. Weatherstripping Air Leakage Performance: Not exceeding 0.3 cubic feet per minute per square foot of door opening at 0.3 inches of water pressure differential for single doors, and 0.5 cubic feet per minute per square foot of door area at 0.3 inches of water pressure differential for double doors for gasketing other than smoke control, as tested according to ASTM E283/E283M; with resilient or flexible seal strips that are easily replaceable and readily available from stocks maintained by manufacturer.
 - 2. Adhesive-Backed Perimeter Gasketing: Silicone gasket material applied to frame with self- adhesive.
 - 3. Rigid, Housed, Perimeter Gasketing: Sponge silicone gasket material held in place by aluminum housing; fastened to frame stop with screws.
 - 4. Overlapping Astragals for Meeting Stiles: Neoprene strip gasket material held in place by aluminum housing and overlapping when doors are closed; mounted to face of meeting stile with screws; surface mounted to door.
 - 5. Meeting Astragals for Meeting Stiles: Silicone bulb gasket material held in place by aluminum housing; mounted with screws.
 - a. Mounting: Surface mounted on face of each door.
 - 6. Door Sweeps: Neoprene gasket material held in place by flat aluminum housing or flange; surface mounted to face of door with screws.
- C. Grades: Comply with BHMA A156.22.
- D. Products:
 - 1. Meeting Stile Seals: See Door Hardware Schedule.
 - 2. Door Bottom Seals:
 - a. Door Sweeps: See Door Hardware Schedule.

2.14 MISCELLANEOUS ITEMS

- A. Manufacturers:
 - 1. Trimco: www.trimcohardware.com/#sle.

- B. Properties:
 - 1. Coat Hooks: Provide on room side of door, screw fastened.
 - a. Material: Brass.
- C. Products:
 - 1. Coat Hooks: 3071.

2.15 ELECTRIFIED HARDWARE

- A. Manufacturers:
 - 1. BEST, dormakaba Group: www.bestaccess.com/#sle.
 - 2. Substitutions: Not permitted.
- B. Properties:
 - 1. Power Supply Units: Manufacturer's standard.
 - a. Regulatory Compliance:
 - 1) United States Compliance:
 - a) UL listed for Class II Output.
 - b) Comply with UL 294 Standards incorporating enhanced Access Control. communications capabilities.
 - 2) Canada Compliance:
 - a) Comply with ULC S-319 Electronic Access Control Systems.
 - b. Enclosures: Lockable NEMA Type 1, with hinged cover and knockouts.
 - c. Power: 24 VAC, 10 Amp; field-selectable.
 - d. Emergency Release Terminals: Designed to release devices upon activation of fire alarm system.
 - e. Auxiliary contacts for remote signaling.
 - f. User-selectable time delay from 0 to 4 minutes.
 - g. Fire Alarm System Interface: Standard.
 - 1) Fire alarm terminal with green LED indicating power is available.
 - h. Output Distribution Board with indicator LEDs.
 - i. On/Off LED power indicator.
 - 2. Power Transfers: Manufacturer's standard.
 - a. Door Loops:
 - 1) Armored flex conduits 18 inches (450 mm) long.
 - 2) Capacity: Up to 1/4-inch (6.35 mm) diameter wire bundle.
 - 3. Wire Harnesses: Of sufficient length, with quick connectors.
 - a. Wire Harness End Connection to Power Supply or Junction Box: One end with bare leads.
- C. Products:
 - 1. Power Supplies:
 - a. RPSMLR2.
 - 2. Power Transfers:
 - a. EPT-12C.

2.16 KEYS AND CORES

- A. Manufacturers:
 - 1. BEST, dormakaba Group: www.bestaccess.com/#sle.
 - 2. Substitutions: Not permitted.

- B. Properties: Complying with guidelines of BHMA A156.28.
1. Provide small format interchangeable core.
 2. Provide Patented CORMAX keys and cores.
 3. Provide keying information in compliance with DHI (KSN) standards.
 4. Keying Schedule: Arrange for a keying meeting, with Architect, Owner and hardware supplier, and other involved parties to ensure locksets and locking hardware, are functionally correct and keying complies with project requirements.
 5. Keying: Master keyed.
 6. Include construction keying and control keying with removable core cylinders.
 7. Supply keys in following quantities:
 - a. Master Keys: 4 each.
 - b. Construction Master Keys: 6 each.
 - c. Construction Keys: 15 each.
 - d. Construction Control Keys: 2 each.
 - e. Control Keys if New System: 2 each.
 8. Provide key collection envelopes, receipt cards, and index cards in quantity suitable to manage number of keys.
 9. Deliver keys with identifying tags to Owner by security shipment direct from manufacturer.
 10. Permanent Keys and Cores: Stamped with applicable key marking for identification. Do not include actual key cuts within visual key control marks or codes. Stamp permanent keys "Do Not Duplicate."
 11. Include installation of permanent cores and return construction cores to hardware supplier. Construction cores and keys to remain property of hardware supplier.
- C. Products:
1. Patented:
 - a. CORMAX.

2.17 FINISHES

- A. Finishes: Identified in Hardware Sets.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Verify that doors and frames are ready to receive this work; labeled, fire-rated doors and frames are properly installed, and dimensions are as indicated on shop drawings.
- B. Correct all defects prior to proceeding with installation.
- C. Verify that electric power is available to power operated devices and of correct characteristics.

3.02 INSTALLATION

- A. Install hardware in accordance with manufacturer's instructions and applicable codes.
- B. Install hardware using the manufacturer's fasteners provided. Drill and tap all screw holes located in metallic materials. Do not use "Riv-Nuts" or similar products.
- C. Install hardware on fire-rated doors and frames in accordance with applicable codes and NFPA 80.
- D. Install hardware for smoke and draft control doors in accordance with NFPA 105.
- E. Use templates provided by hardware item manufacturer.
- F. Do not install surface mounted items until application of finishes to substrate are fully completed.
- G. Wash down masonry walls and complete painting or staining of doors and frames.
- H. Complete finish flooring prior to installation of thresholds.
- I. Door Hardware Mounting Heights: Distance from finished floor to center line of hardware item. As indicated in following list; unless noted otherwise in Door Hardware Schedule or indicated on the Drawings.
 - 1. For Steel Doors and Frames: Install in compliance with DHI (LOCS) recommendations.
 - 2. Mounting heights in compliance with ADA Standards:
 - a. Locksets: 40-5/16-inch (1,024-mm).
 - b. Push Plates/Pull Bars: 42-inch (1,067-mm).
 - c. Deadlocks (Deadbolts): 48-inch (1,219-mm).
 - d. Exit Devices: 40-5/16-inch (1,024-mm).
 - e. Door Viewer: 43-inch (1,092-mm); standard height 60-inch (1,524-mm).
- J. Set exterior door thresholds with full-width bead of elastomeric sealant at each point of contact with floor providing a continuous weather seal; anchor thresholds with stainless steel countersunk screws.
- K. Include in installation for existing doors and frames any necessary field modification and field preparation of doors and frames for new hardware. Provide necessary fillers, reinforcements, and fasteners for mounting new hardware and to cover existing door and frame preparations.

3.03 FIELD QUALITY CONTROL

- A. Provide an AHC to inspect installation and certify that hardware and installation has been furnished and installed in accordance with manufacturer's instructions and as specified.

3.04 ADJUSTING

- A. Adjust hardware for smooth operation.
- B. Adjust gasketing for complete, continuous seal; replace if unable to make complete seal.

3.05 CLEANING

- A. Clean finished hardware in accordance with manufacturer's written instructions after final adjustments have been made.
- B. Clean adjacent surfaces soiled by hardware installation activities.
- C. Replace items that cannot be cleaned to manufacturer's level of finish quality at no additional cost.

3.06 PROTECTION

- A. Do not permit adjacent work to damage hardware or finish.

3.07 HARDWARE SCHEDULE

Manufacturer List	
Code	Name
AB	ABH Manufacturing Inc.
BE	Best Access Systems
BY	By Related Section
DM	Dorma Door Controls
NA	National Guard
PR	BEST Precision Exit Devices
RC	RCI
ST	BEST Hinges and Sliding
TR	Trimco
Option List	
Code	Description
1/4-20 SSMS/EA	Stainless Machine Screws w/Expansion Anchors
B4E	Beveled 4 Edges
C	Quick Connect Wiring System
CD	Cylinder Dogging
CSK	Counter Sunk Screw Holes
FL	Fire Exit Hardware
LBR	Less Bottom Rod
MLR	Motorized Latch Retraction
RQE	Request to Exit
SIA	Abrasive Coating
TS	Touchbar Monitoring Switch

Finish List				
Code		Description		
28		Aluminum Anodized (Clear)		
32D		Satin Stainless Steel		
626		Satin Chromium Plated		
626W		Weatherized Satin Chrome		
628		Satin Aluminum, Clear Anodized		
630		Satin Stainless Steel		
689		Aluminum Painted		
AL		Aluminum		
BL		Black		
US32D		Stainless Steel, Dull		
Hardware Sets				
Set #1.0				
Door: D01				
6	Butt Hinges	CB191 4.5" x 4.5" NRP	630W	ST
1	Exit Device	C MLR TS 2202 X 1702A LD	626W	PR
1	Exit Device	C TS 2201 LD	626W	PR
2	Door Closer	8916 SPA	689	DM
2	Kick Plate	K0050 10" x 1" LDW B4E CSK	630	TR
2	Floor Stop	1209HA	630	TR
2	Power Transfer	EPT-12C	628	PR
1	Power Supply	RPSMLR2BB		PR
1	Card Reader	by Owner's Security Integrator		BY
2	Position Switch	9540	BL	RC
1	Astragal Set	115NA		NA
1	Weatherstrip	160SA Head & Jambs		NA
1	Drip Cap	16 A - 4" ODW		NA
2	Door Sweep	200NA		NA
1	Handicap Threshold	713 72" 1/4-20 SSMS/EA SIA	AL	NA
NOTE: Doors are normally closed and locked. Access is gained with valid credentials. Free egress is allowed at all times without use of keys, credentials, special knowledge or effort.				

Set #2.0				
Doors: D05				
3	Butt Hinges	CB191 4.5" x 4.5" NRP	630W	ST
1	Exit Device	C MLR TS 2103 X 1703A	626W	PR
1	Rim Cylinder	12E-72 PATD	626	BE
1	Door Closer	8916 SPA	689	DM
1	Kick Plate	K0050 10" x 2" LDW B4E CSK	630	TR
1	Floor Stop	1209HA	630	TR
1	Power Transfer	EPT-12C	628	PR
1	Power Supply	RPSMLR2BB		PR
1	Card Reader	by Owner's Security Integrator		BY
1	Position Switch	9540	BL	RC
1	Weatherstrip	160SA Head & Jambs		NA
1	Drip Cap	16 A - 4" ODW		NA
1	Door Sweep	200NA		NA
1	Handicap Threshold	713 72" 1/4-20 SSMS/EA SIA	AL	NA
NOTE: Doors are normally closed and locked. Access is gained with valid credentials. Free egress is allowed at all times without use of keys, credentials, special knowledge or effort.				
Set #2.1				
Doors: D02, D03, D04				
3	Butt Hinges	CB191 4.5" x 4.5" NRP	630W	ST
1	Exit Device	C MLR TS 2102 X 1702A	626W	PR
1	Door Closer	8916 SPA	689	DM
1	Kick Plate	K0050 10" x 2" LDW B4E CSK	630	TR
1	Floor Stop	1209HA	630	TR
1	Power Transfer	EPT-12C	628	PR
1	Power Supply	RPSMLR2BB		PR
1	Card Reader	by Owner's Security Integrator		BY
1	Position Switch	9540	BL	RC
1	Weatherstrip	160SA Head & Jambs		NA
1	Drip Cap	16 A - 4" ODW		NA
1	Door Sweep	200NA		NA
1	Handicap Threshold	713 72" 1/4-20 SSMS/EA SIA	AL	NA
NOTE: Doors are normally closed and locked. Access is gained with valid credentials. Free egress is allowed at all times without use of keys, credentials, special knowledge or effort.				
Set #3.0				
Door: D06, D07				
1	Position Switch	9540	BL	RC

Set #4.0				
Door: D08, D09				
3	Butt Hinges	CB199 4.5" x 4.5" NRP	630W	ST
1	Passage Set	45H-0N15N PATD	630	BE
1	Door Closer	8916 S-DS	689	DM
1	Kick Plate	K0050 10" x 2" LDW B4E CSK	630	TR
1	Gasketing	5050B Head & Jambs		NA
Set #5.0				
Door: D10				
3	Butt Hinges	CB199 4.5" x 4.5" NRP	630W	ST
1	Privacy Set	45H-0L15N PATD	630	BE
1	Door Closer	8916 S-DS	689	DM
1	Kick Plate	K0050 10" x 2" LDW B4E CSK	630	TR
1	Gasketing	5050B Head & Jambs		NA

END OF SECTION

SECTION 08_91_00

LOUVERS

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Stationary louvers.

1.02 REFERENCES

- A. Air Movement and Control Association International, Inc. (AMCA):
 - 1. 500-L - Laboratory Methods of Testing Louvers for Rating.
 - 2. 500-D - Laboratory Methods of Testing Dampers for Rating.
 - 3. 511 - Certified Ratings Program - Product Rating Manual for Air Control Devices.
- B. American Society of Civil Engineers (ASCE):
 - 1. 7 - Minimum Design Loads and Associated Criteria for Building and Other Structures.
- C. ASTM International (ASTM):
 - 1. E330 - Standard Test Method for Structural Performance of Exterior Windows, Doors, Skylights and Curtain Walls by Uniform Static Air Pressure Difference.
- D. Testing Application Standard (TAS):
 - 1. 100A - Standard Test Procedure for Wind and Wind Driven Rain Resistance and/or Increased Windspeed Resistance of Soffit Ventilation Strip and Continuous or Intermittent Ventilation System Installed.
 - 2. 202 - Criteria for Testing Impact and Non-impact Resistant Building Envelope Components Using Uniform Static Air Pressure.
 - 3. 203 - Criteria for Testing Products Subject to Cyclic Wind Pressure.
- E. Underwriters Laboratories, Inc. (UL).

1.03 TERMINOLOGY

- A. The words and terms listed below, are not defined terms that require initial capital letters, but, when used in this Section have the indicated meaning.
 - 1. Drainable-blade louver: Louver with blades having gutters that collect water and drain it to channels in jambs and mullions, which carry it to bottom of unit and away from opening.

1.04 SUBMITTALS

- A. As specified in Section 23_05_00 - Common Work Results for HVAC.

1.05 QUALITY ASSURANCE

- A. Provide louvers with the following, unless otherwise specified:
 - 1. AMCA certification and rating in accordance with AMCA 511 for air performance and water penetration.

PART 2 PRODUCTS

2.01 GENERAL

- A. Louver types: As indicated on the Drawings.
 - 1. Identify louvers with a letter L followed by a number referring to a louver type in this Section.
 - 2. Identify individual louver size and airflow rates.
- B. Accessories:
 - 1. Provide installation clips and flanged or jamb-mounting styles suitable for the mounting locations.
 - 2. As indicated on the Drawings.
 - 3. Provide extended sills for louvers indicated as installed recessed from the exterior wall surface.
 - 4. Provide stainless steel fasteners unless noted otherwise.
 - 5. Corrosion protection.
 - 6. Provide gravity damper for outside air intake and exhaust louvers, unless noted otherwise.
- C. Protective coatings for aluminum in contact with concrete or masonry:
 - 1. Manufacturers: One of the following or equal:
 - a. Koppers Co., Inc.
 - b. Porter Coatings.
 - c. Tarmastic 100.

2.02 DESIGN AND PERFORMANCE REQUIREMENTS

- A. Performance: In accordance with AMCA 511 when tested in accordance with AMCA 500.
- B. Wind Load: Refer to Section 01_81_50 - Design Criteria.
- C. Louvers for severe windstorm applications:
 - 1. Shall resist the cyclic pressures, static pressures, and missile impact loads in accordance with:
 - a. Applicable building codes as specified in Section 01_41_00 - Regulatory Requirements.
 - 2. Shall resist wind driven rain in accordance with:
 - a. TAS 100A:
 - 1) Louvers shall not require the use of a manual damper to meet the certification requirements.

2.03 STATIONARY ACOUSTICAL LOUVERS

- A. Manufacturers: One of the following or equal:
1. Greenheck, AFJ-801.
 2. Ruskin.
 3. Airolite Co.
- B. Requirements:
1. Type: Stationary acoustical louver with louver depth as indicated on the Drawings.
 2. Material: Minimum 0.080-inch thick extruded or formed aluminum for frame and blades.
 3. Frame: 8-inch deep formed aluminum frame with 0.100-inch nominal wall thickness.
 4. Blades: 0.080-inch formed aluminum exterior surface; blades positioned at 45 degree angle and spaced approximately 6 inches center to center.
 5. Screens: 3/4-inch mesh by 0.051-inch aluminum or stainless steel bird screen with removable frame.
 6. Pressure drop: Maximum 0.13-inch water column at 1,000 feet per minute free area velocity for intake louvers.
 7. Free area: Minimum 25 percent.
 8. Finish: Kynar.
 9. Acoustical performance: Attenuation at least as follows for the depth of louver indicated:

Frequency (hertz)	Attenuation (dB)			
	4-inch Depth	6-inch Depth	8-inch Depth	12-inch Depth
125	11	8	11	8
250	9	9	11	14
500	11	12	13	17
1,000	15	16	19	22
2,000	17	20	21	21
4,000	16	18	20	21
8,000	16	18	23	20

PART 3 EXECUTION

3.01 EXAMINATION

- A. Inspect areas to receive louvers.
1. Notify the architect of conditions that would adversely affect the installation or subsequent utilization of the louvers.
 2. Do not proceed with installation until unsatisfactory conditions are corrected.

3.02 PREPARATION

- A. Clean opening thoroughly prior to installation.
- B. Prepare surfaces using the methods recommended by the manufacturer for achieving the best result for the substrate under the project conditions.

3.03 INSTALLATION

- A. Install louvers at locations indicated on the Drawings and in accordance with manufacturer's instructions.
- B. As specified in Section 23_05_00 - Common Work Results for HVAC.

3.04 FIELD QUALITY CONTROL

- A. Test equipment performance and balance equipment as specified in Section 23_05_93 - Testing, Adjusting, and Balancing for HVAC.

END OF SECTION

SECTION 09_84_12

METAL FACED ACOUSTICAL PANELS

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes: Metal-faced acoustical panels, and associated materials and accessories.

1.02 REFERENCES

- A. ASTM International (ASTM):
 - 1. C423 - Standard Test Method for Sound Absorption and Sound Absorption Coefficients by the Reverberation Room Method.
 - 2. E84 - Standard Test Method for Surface Burning Characteristics of Building Materials.
- B. Fire ratings: Flame spread of 10, smoke developed of 5 when tested in accordance with ASTM E84.

1.03 SUBMITTALS

- A. Product data.
- B. Shop drawings: Include panel layout and mounting details.
- C. Test reports: Results of octave band sound absorption tests by independent acoustical laboratory.
- D. Manufacturer's installation instructions.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Metal-faced acoustical panels: One of the following or equal:
 - 1. Eckel Industries, Inc., Model EFP, for ceiling or wall mounting.
 - 2. Noise Barriers LLC, Quietperf NB-II.
 - 3. Kinetics Noise Control, Model KNP.

2.02 DESIGN AND PERFORMANCE CRITERIA

- A. Sound absorption: Minimum Noise Reduction Coefficient (NRC) of 0.90 for 30- by 120-inch panels with 2-inch thick minimum wrapped acoustical insulation, when tested in accordance with ASTM C423(Type A mounting). Minimum octave band sound absorption coefficients (Type A mounting) as follows:
 - 1. 125 hertz: 0.20.

2. 250 hertz: 0.65.
3. 500 hertz: 0.95.
4. 1,000 hertz: 0.95
5. 2,000 hertz: 0.75.
6. 4,000 hertz: 0.55.

2.03 MATERIALS

- A. Metal facing: Sheet steel, minimum 22-gauge, zinc coated, embossed.
- B. Framing members: Sheet steel, minimum 20-gauge, zinc coated.
- C. Fastener inserts: Blind threaded, 1/4 inch, 20 threads per inch, minimum 200-pound tensile strength.
- D. Mounting brackets: Sheet steel, minimum 18-gauge, zinc coated, for low frequency.
- E. Framing member fasteners: Bolts, Type 316 stainless steel, 1/4 inch, 20 threads per inch, 3/4-inch long.
- F. Anchors: Type 316 stainless steel, suitable for application as specified in Section 05_05_24 - Mechanical Anchoring and Fastening to Concrete and Masonry.
- G. Acoustical insulation: 2-inch thick, fine fibered, fibrous glass, or mineral wool having a density of not less than 1.5 pounds per cubic foot.
- H. Acoustical insulation wrap: Encapsulated in a 1.5 to 2 mil flame guard polyethylene.

2.04 FABRICATION

- A. Break facings to wrap around insulation on long edges.
- B. Fabricate 30-inch-wide by 96-inch-long panels. Panels shall be 2 inches thick (nominal).
- C. Break and punch holes for fastener inserts:
 1. Panel shall be attached to the framing member using set screws or rivets.
 2. Submit a detail of the method of attachment of the framing members to the panel.
- D. Wrap and secure acoustical insulation within framing members or facings.
- E. Break mounting brackets.
 1. Punch fastener holes.
 2. Furnish brackets loose for fastening in field.
 3. Furnish 2 additional brackets for ceiling hung panels.
- F. Finish: Manufacturer's standard polyurethane enamel; White.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Install acoustical panels in accordance with manufacturer's instructions.
- B. Avoid interference with doors, windows, piping, louvers, exhaust fans, control panels, light fixtures, and other electrical or mechanical equipment when locating panels.
- C. Space panels equally and symmetrically whenever possible.
- D. Install panels plumb or level.
- E. Anchor mounting brackets to substrate and fasten mounting brackets to framing members.

END OF SECTION

SECTION 09_96_01

HIGH-PERFORMANCE COATINGS

TABLE OF CONTENTS

PART 1	GENERAL.....	2
1.01	SUMMARY	2
1.02	REFERENCES	2
1.03	TERMINOLOGY	4
1.04	SUBMITTALS	5
1.05	QUALITY ASSURANCE.....	7
1.06	DELIVERY, STORAGE, AND HANDLING	9
1.07	PROJECT CONDITIONS	10
1.08	TECHNICAL REPRESENTATIVES' RESPONSIBILITIES.....	12
PART 2	PRODUCTS	13
2.01	DESIGN AND PERFORMANCE CRITERIA	13
2.02	MATERIALS	13
2.03	COATING SYSTEMS IDENTIFICATION	13
2.04	PRODUCTS FOR COATING SYSTEMS	14
PART 3	EXECUTION	14
3.01	GENERAL PROTECTION REQUIREMENTS.....	14
3.02	GENERAL SURFACE PREPARATION REQUIREMENTS	15
3.03	MECHANICAL AND ELECTRICAL EQUIPMENT PREPARATION	15
3.04	CLEANING OF NEW AND PREVIOUSLY COATED OR NEW SURFACES.....	16
3.05	BLAST CLEANING.....	16
3.06	PREPARATION REQUIREMENTS FOR CONCRETE SURFACES	17
3.07	GENERAL PREPARATION REQUIREMENTS FOR METALLIC SURFACES.....	18
3.08	PREPARATION REQUIREMENTS BY SURFACE TYPE	20
3.09	APPLICATION REQUIREMENTS.....	20
3.10	APPLICATION REQUIREMENTS FOR CONCRETE COATING SYSTEMS	24
3.11	COATING SYSTEMS	25
3.12	SURFACES NOT REQUIRING COATING.....	25
3.13	QUALITY CONTROL.....	26
3.14	CORRECTIVE MEASURES.....	27
3.15	CLEANUP.....	28
3.16	FINAL INSPECTION	28

ATTACHMENT A - SCHEDULE OF SURFACES TO BE COATED

ATTACHMENT B - COATING DETAIL SHEETS

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Coatings, including coating systems, surface preparation, application requirements, and quality control requirements.

1.02 REFERENCES

- A. Abbreviations:
 - 1. CMU - Concrete masonry units.
 - 2. CSA - Coating system applicator. Specialty subcontractor retained by the Contractor to perform surface repairs, surface preparations, and apply coating systems as specified in this Section.
 - 3. CSM - Coating system manufacturer.
 - 4. CTR - Coating system manufacturer's technical representative.
 - 5. DFT - Dry-film thickness. Thickness of cured film, usually expressed in mils (0.001 inch).
 - 6. VOC - Volatile organic compound. The portion of the coating that is a compound of carbon, is photochemically reactive, and evaporates during drying or curing; expressed in grams per liter (g/l) or pounds per gallon (lb/gal). VOC is determined by EPA Method 24.
 - 7. WFT - Wet film thickness. Coating thickness as measured immediately after application. Usually expressed in mils (0.001 inch).
- B. Standards:
 - 1. ASTM International (ASTM):
 - a. A380 - Standard Practice for Cleaning, Descaling, and Passivation of Stainless Steel Parts, Equipment, and Systems.
 - b. A780 - Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings.
 - c. D16 - Standard Terminology for Paint, Related Coatings, Materials, and Applications.
 - d. D2200 - Standard Practice for Use of Pictorial Surface Preparation Standards and Guides for Painting Steel Surfaces.
 - e. D3359 - Standard Test Methods for Rating Adhesion by Tape Test.
 - f. D3960 - Standard Practice for Determining Volatile Organic Compound (VOC) Content of Paints and Related Coatings.
 - g. D4262 - Standard Test Method for pH of Chemically Cleaned or Etched Concrete Surfaces.
 - h. D4263 - Standard Test Method for Indicating Moisture in Concrete by the Plastic Sheet Method.
 - i. D4285 - Standard Test Method for Indicating Oil or Water in Compressed Air.
 - j. D4414 - Standard Practice for Measurement of Wet Film Thickness by Notch Gages.
 - k. D4417 - Standard Test Methods for Field Measurement of Surface Profile of Blast-Cleaned Steel.
 - l. D4787 - Standard Practice for Continuity Verification of Liquid or Sheet Linings Applied to Concrete Substrates.

- m. D5162 - Standard Practice for Discontinuity (Holiday) Testing of Nonconductive Protective Coating on Metallic Substrates.
 - n. D7234 - Standard Test Method for Pull-Off Adhesion Strength of Coatings on Concrete Using Portable Pull-Off Adhesion Testers.
 - o. E337 - Standard Test Method for Measuring Humidity with a Psychrometer (the Measurement of Wet- and Dry-Bulb Temperatures).
 - p. F1869 - Standard Test Method for Measuring Moisture Vapor Emission Rate of Concrete Subfloor Using Anhydrous Calcium Chloride.
 - q. F2170 - Standard Test Method for Determining Relative Humidity in Concrete Floor Slabs Using In-situ Probes.
2. International Concrete Repair Institute (ICRI):
 - a. 310.2 - Guideline for Selecting and Specifying Concrete Surface Preparation for Sealers, Coatings, Polymer Overlays, and Concrete Repair.
 3. NACE International (NACE):
 - a. SP0178 - Design, Fabrication, and Surface Finish Practices for Tanks and Vessels to Be Lined for Immersion Service.
 - b. SP0188 - Discontinuity (Holiday) Testing of New Protective Coatings on Conductive Substrates.
 4. National Association of Pipe Fabricators (NAPF):
 - a. 500-03 - Surface Preparation Standard for Ductile Iron Pipe and Fittings in Exposed Locations Receiving Special External Coatings and/or Special Internal Linings.
 5. NSF International (NSF):
 - a. 61 - Drinking Water System Components - Health Effects.
 - b. 600 - Health Effects Evaluation and Criteria For Chemicals In Drinking Water.
 6. Occupational Safety and Health Administration (OSHA).
 7. Society for Protective Coatings (SSPC):
 - a. Glossary - SSPC Protective Coatings Glossary.
 - b. Guide 6 - Guide for Containing Surface Preparation Debris Generated during Paint Removal Operations.
 - c. PA 1 - Shop, Field, and Maintenance Painting of Steel.
 - d. PA 2 - Procedure for Determining Conformance to Dry Coating Thickness Requirements.
 - e. PA 9 - Measurement of Dry Coating Thickness Using Ultrasonic Gages.
 - f. QP 1 - Field Application of Coatings to Complex Industrial and Marine Structures.
 - g. QP 3 - Shop Application of Complex Protective Coating Systems.
 - h. SP 1 - Solvent Cleaning.
 - i. SP 2 - Hand Tool Cleaning.
 - j. SP 3 - Power Tool Cleaning.
 - k. SP 5 - White Metal Blast Cleaning.
 - l. SP 7 - Brush-Off Blast Cleaning.
 - m. SP 10 - Near-White Metal Blast Cleaning.
 - n. SP 11 - Power Tools Cleaning to Bare Metal.
 - o. SP 13 - Surface Preparation of Concrete.
 - p. SP 16 - Brush-Off Blast Cleaning of Coated and Uncoated Galvanized Steel, Stainless Steels, and Non-Ferrous Metals.
 - q. SP VIS 1 - Guide and Reference Photographs for Steel Surfaces Prepared by Dry Abrasive Blast Cleaning.

1.03 TERMINOLOGY

- A. Definitions used in this Section are in accordance with definitions referenced in ASTM D16, ASTM D3960, and SSPC Glossary of Definitions.
- B. The words and terms listed below are not defined terms that require initial capital letters, but, when used in this Section, have the indicated meaning.
1. Abrasive: Material used for blast cleaning, such as sand, grit, or shot.
 2. Abrasive blast cleaning: Cleaning/surface preparation by abrasive propelled at high speed.
 3. Anchor pattern: Profile or texture of prepared surface(s).
 4. Biogenic sulfide corrosion: Corrosion caused by sulfuric acid formed when *Thiobacillus* bacteria metabolizes hydrogen sulfide.
 5. Bug holes: Small cavities resulting when air bubbles are entrapped in the surface of formed concrete during placement and consolidation.
 6. Dew point: Temperature a given air/water vapor mixture starts to condense.
 7. Dry to recoat: Time interval between material application and its ability to receive the next coat.
 8. Dry to touch: Time interval between material application and its ability to tolerate a light touch without coating damage.
 9. Drying time: Time interval between application and material curing.
 10. Exposed surface: Any indoor or outdoor surface not buried or encased.
 11. Feather edging: Reducing coating thickness at its edge to blend with existing surrounding coating.
 12. Ferrous: Cast iron, ductile iron, wrought iron, and all steel alloys, except stainless steel.
 13. Field coat: Application of a surface coating system at the work site.
 14. Finish coat: Final coat in a paint system, including texture, color, smoothness of surface, and other properties affecting appearance.
 15. Hold point: A defined point, specified in this Section, at which Work shall be halted for inspection.
 16. Holiday: A discontinuity, skip, void, or pinhole in coating or coating system film that exposes the substrate.
 17. Honeycomb: Segregated and porous surface of hardened concrete due to insufficient consolidation.
 18. Hydroblast: High or ultra-high-pressure water jet surface preparation.
 19. Immersed/Immersion: A service condition in which substrate is submerged, is immediately above liquids, or is subject to frequent wetting, splashing, or washdown.
 20. Incompatibility: One coating's inability to overlay another coating or surface as evidenced by bleeding, poor bonding, or lifting of old coating; inability of a coating to bond to a substrate.
 21. Laitance: A thin, weak, brittle layer of cement and aggregate fines on a concrete surface.
 22. Mil: 0.001 inch.
 23. Overspray: Dry spray, particularly paint bonded to an unintended surface.
 24. Pinhole: A small diameter discontinuity in a coating or coating system film, created by off gassing from a void in a concrete or masonry substrate causing a void between coats or exposing the substrate. Usually caused by coating application while temperature is rising.

25. Pot life: Time interval after components are mixed and coating can be satisfactorily applied.
26. Prime coat: First full paint coat applied to a surface when using a multicoat system. Primers adhere to a new substrate, protect the substrate, and promote adhesion of subsequent coats of paint. The prime coat on metal surfaces is the first full coat and does not include solvent wash, grease emulsifiers, or other pretreatment applications.
27. Resurfacer/Resurfacing material: A layer of cementitious and/or resin-based material used to fill or otherwise restore surface continuity to worn or damaged concrete surfaces.
28. Shop coat: One or more coats applied in an off-site shop or plant before shipment to work site where field or finishing coat(s) are applied.
29. Stripe coat: A separate brush coat of paint applied to all weld seams, pits, nuts/bolts/washers, and edges. This coat shall not be applied until the previous coats have cured. Once applied, the coat shall be allowed to cure before subsequent coats are applied.
30. System: Protective film with one or more coats applied in a predetermined order, including surface preparation and quality control requirements.
31. Thick film coating system: A coating system applied with a minimum dry film thickness of 25 mils.
32. Touch-up painting: Application of paint on previously painted surfaces to repair marks, scratches, and deteriorated or damaged areas to restore the appearance and performance of the coating.
33. Water blast: An alternative to air abrasive blast cleaning that can be used with or without abrasive injection. Water cleaning at pressures up to 5,000 pounds per square inch is called low-pressure water cleaning or power washing. High-pressure water cleaning uses water pressures between 5,000 and 10,000 pounds per square inch. Water jetting is water blasting with added abrasive at pressures between 10,000 and 25,000 pounds per square inch. Ultra-high-pressure water jetting is water blasting at pressures above 25,000 pounds per square inch.
34. Weld splatter: Beads of non-structural weld metal that adhere to the surrounding surface, removed as part of surface preparation.

1.04 SUBMITTALS

- A. As specified in Section 01_33_00 - Submittal Procedures, submit the following:
 1. Schedule of proposed coating materials.
 2. Schedule of surfaces to be coated with each coating material.
 3. Dehumidification and heating plan.
 4. Methods for tenting blasting areas and methods to protect existing equipment from dust and debris.
 5. Abrasives and abrasive blast cleaning disposal.
 6. Product data, application, and safety data sheets.
 7. NSF certification of coatings for potable water supply systems, including NSF 600 and/or NSF 61.
 8. Compliance with regulatory requirements:
 - a. VOC limitations.
 - b. Hazardous lead compounds and polychlorinated biphenyls (removal and disposal methods).
 9. Manufacturer's standard color samples.

10. Include 8-inch square drawdowns or brushouts of topcoat finish when requested. Identify each sample as to finish, formula, color name and number, sheen name, and gloss units.
11. Affidavits signed by an officer of the CSM's corporation attesting to full compliance of each coating system component with current federal, state, and local air pollution control regulations and requirements.
12. Thick film coating systems (greater than 25 mils):
 - a. CSM's detailed written instructions for coating system treatment and graphic details for coating system terminations in coated structures, including pipe penetrations, metal embedments, gate frames, and other terminations encountered.
 - b. Include detailed treatment for coating system at concrete joints.
13. Quality assurance Submittals:
 - a. Quality assurance plan.
 - b. Qualifications:
 - 1) Field coating applicator includes:
 - a) Provide a minimum of 5 project references where similar coating work has been performed by the company in the past 5 years:
 - (1) Name and address of project.
 - (2) Year of installation.
 - (3) Year placed in operation.
 - (4) Point of contact: Name and phone number.
 - b) SSPC-QP 1 certified as required.
 - 2) Shop coating applicator includes:
 - a) Provide a minimum of 5 project references where similar coating work has been performed by the company in the past 5 years:
 - (1) Name and address of project.
 - (2) Year of installation.
 - (3) Year placed in operation.
 - (4) Point of contact: Name and phone number.
 - b) SSPC-QP 3 certified as required.
 - c. Field Quality Control:
 - 1) Provide certification letters from NACE Certified Level 3 Coating Inspector for surface preparation and coating application conformance with these specifications for any field-applied procedures performed as may be applicable to the Project.
 - 2) Indicate results of applicators furnished tests and inspections, including, but not limited to, ambient environmental conditions, surface cleanliness, surface profile, DFT measurements, holiday testing, etc.
 - d. CSA reports:
 - a) Written daily quality control inspection reports.
 - b) Reports to observe and approve surface preparation of structures to be coated.
 - c) Reports to observe and approve coating application procedures.
 - d) Reports on visits to plants to observe and approve surface preparation and coating application on shop-coated items.

14. For each substituted coating material "equal" to specified product in the coating tabulation:
 - a. List of not less than 5 similar successful material applications:
 - 1) Project name, location, type of structure, and application dates.
 - 2) Owner's name, address, and telephone number.
 - b. Certification that material meets or exceeds specified requirements:
 - 1) Manufacturer's certification, including technical representative's signature and date of signature.
 - 2) Independent laboratory's certified test reports.

1.05 QUALITY ASSURANCE

- A. Coating inspector:
 1. CSA inspector and/or third-party inspector shall be trained and knowledgeable in the specified coating's application.
 2. Provide calibrated inspection instruments and demonstrate use as required.
 3. Applicator's quality assurance inspector foreman shall oversee all aspects of coating work and shall be NACE Level III certified or an SSPC Protective Coatings Inspector (PCI).
 - a. Oversees lesser qualified inspectors and provides them training and guidance for testing and report preparations, provides documentation for all inspection equipment showing calibrations, and verifies the equipment is free from damage and is in proper working condition.
- B. Regulatory requirements: Comply with governing agencies' regulations by using coatings in accordance with their VOC limits.
 1. Lead-based coatings are not permitted.
 2. Do not use coal-tar epoxy in contact with drinking water or exposed to ultraviolet radiation.
- C. Pre-installation conference: Conduct as specified in Section 01_31_19 - Project Meetings.
 1. Coordinate Hold Point schedule.
- D. Field samples:
 1. Prepare and coat a minimum 100-square-foot area of each system between corners or limits such as control or construction joints.
 2. Approved field sample may be part of the Work.
- E. Obtain approval before coating other surfaces. Use products by the same manufacturer for prime coats, intermediate coats, and finish coats on same surface, unless specified otherwise. Coatings must be compatible with one another and complete a cohesive coating system.
- F. CSM services:
 1. CSA shall arrange for CTR to attend pre-installation conferences.
 2. Visit the Project Site periodically to consult on and inspect specified surface preparation and application Hold Points.
 3. Visit coating plants to observe and approve surface preparation procedures and coating application of items to be shop primed and coated.
 4. CTR shall provide written inspection reports.

- G. Quality control requirements:
1. Applicator shall be responsible for the workmanship and quality of the coating system installation.
 - a. Inspections by the Owner, Engineer, or CTR will not relieve or limit the CSA's responsibilities.
 2. In accordance with this Specification's requirements and the standards referenced in this Section. Changes in the coating system application requirements will be allowed only with the Engineer's written acceptance.
 3. Specially trained crews with experience applying the specified coating system coating are required for:
 - a. Coating application using plural component spray equipment or other specialty equipment.
 - b. Coating with specialty linings for severe service conditions, including floor coatings, and with linings for corrosive headspaces or secondary containment areas.
 4. CTR shall specially train personnel for coating systems as specified in Attachment B - Coating Detail Sheets.
 - a. CSM shall approve personnel in writing applying the coating system.
 5. Do not use contaminated, outdated, diluted materials, and/or materials from previously opened containers.
 6. Identify inspection access points used by the Owner's or Engineer's personnel.
 7. Provide ventilation, ingress, egress, or other means as necessary for the Owner's or Engineer's personnel to safely access the work areas.
 8. Conduct and continually inspect Work so the coating system is installed as specified. CSM shall provide written directions to correct coating work not in accordance with the specifications or is otherwise unacceptable.
 9. Provide written daily reports summarizing test data, work progress, surfaces covered, ambient conditions, quality control inspection test findings, and other information pertinent to the coating system application.
 - a. Determine relative humidity in accordance with ASTM E337. Confirm other conditions, such as proper protective measures for surfaces not to be coated and safety requirements for personnel.
 - 1) Measure daily at the shift's beginning and end and at intervals not to exceed 4 hours during the shift.
 - 2) Determine the acceptability of weather and/or environmental conditions within the structure in accordance with the CSM's requirements.
 - b. Monitoring surface preparation: Spot check cleanliness, surface profile, and surface pH testing at least 3 times daily. Check each surface at least once. In accordance with:
 - 1) ASTM D4262.
 - 2) ASTM D4263.
 - 3) ASTM D4417.
 - 4) ICRI 310.2 requirements.
 - 5) SSPC surface preparation standards.
 - c. Confirm that compressed air used for surface preparation or blow-down cleaning is free of oil and moisture.
 - d. Monitor surface preparation daily at the shift's beginning and end and at intervals not to exceed 4 hours during the shift.
 - e. Do not apply coatings when environmental conditions are outside of the CSM's published limits.

- f. Monitoring coatings application: Continuously inspect, measure, and record the wet film thickness and general film quality (visual inspection) for runs, sags, pinholes, holidays, etc., during coating.
 - 1) Perform WFT measurements in accordance with ASTM D4414.
 - g. Post cure evaluation: Measure and inspect the overall dry film thickness on all surfaces.
 - 1) Conduct a DFT survey and perform adhesion testing, holiday detection, or cure testing as specified in this Section and/or the CSM's written instructions.
 - 2) Perform applicable tests in accordance with ASTM D4541, ASTM D4787, ASTM D5162, ASTM D7234, SSPC-PA 1, SSPC-PA 2, SSPC-PA 9, and other pertinent standards and recommended practices.
- H. Inspection at Hold Points:
- 1. Conduct inspections at Hold Points during the coating system application and record the results.
 - 2. Coordinate Hold Points with the Engineer so the Engineer can observe the Contractor's inspections on a scheduled basis.
 - 3. Provide the Engineer with a minimum of 24 hours of notice before conducting Hold Point inspections.
 - 4. Hold Points shall be as follows:
 - a. Conditions before surface preparation: Before starting surface preparation, observe, record, and confirm that oil, grease, and/or soluble salts are gone from the surface.
 - b. Post surface preparation: After completing surface preparation, measure and inspect for cleanliness and proper surface profile as specified in this Section and in the CSM's written instructions.
 - c. Coatings application: At the beginning of any coating system application, measure, record, and confirm acceptability of surface and ambient air temperature and humidity. Inspect applicator's equipment for serviceability and suitability for coatings application.
 - d. Post application inspection: Identify defects in application work on all surfaces, including pinholes, holidays, excessive runs, or sags, inadequate or excessive film thickness, and other problems.
 - e. Follow-up corrective actions and final inspection: Measure and re-inspect corrective coating work performed to repair defects at prior Hold Points and repeat until the surface condition is acceptable. Conduct final visual inspection with follow-up tests, such as holiday detection, adhesion tests, and DFT surveys.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. As specified in Section 01_60_01 - Product Requirements.
- B. Immediately remove unspecified and unapproved coatings from the Project Site.
- C. Deliver new, labeled, unopened containers:
 - 1. Do not deliver materials after the manufacturer's expiration date or over 12 months from manufacturing date, whichever is more stringent. Store

- materials in well-ventilated enclosed structures and protect from weather and excessive heat or cold in accordance with the CSM's recommendations:
- a. Store flammable materials in accordance with federal, state, and local requirements.
 - b. Store rags and cleanup materials appropriately to prevent fire and spontaneous combustion.
2. Store and dispose of hazardous waste in accordance with federal, state, and local requirements. This requirement specifically applies to waste solvents and coatings.
 3. Container labels shall show the following:
 - a. Brand name or product title.
 - b. CSM's batch number.
 - c. CSM's manufacture date.
 - d. CSM's name.
 - e. Generic material type.
 - f. Application and mixing instructions.
 - g. Hazardous material identification label.
 - h. Shelf-life expiration date.
 - i. Color.
 - j. Mixing and reducing instructions.
 4. Clearly mark containers to indicate safety hazards associated with the use of or exposure to materials.

1.07 PROJECT CONDITIONS

- A. Apply coatings to dry surfaces.
 1. Surface moisture: In accordance with the manufacturer's requirements or as specified in this Section.
 - a. Plaster and gypsum wallboard: 12 percent.
 - b. Masonry and concrete blocks: 12 percent.
 - c. Interior located wood: 15 percent.
 - d. Concrete floors: Moisture vapor transmission rate of no more than 3.0 pounds per 1,000 square feet per 24 hours in accordance with ASTM F1869 or relative humidity no greater than 80 percent if tested in accordance with ASTM F2170, unless the CSM's recommendations are more restrictive.
 - e. Concrete structures: Negative results from plastic sheet test in accordance with ASTM D4263, and maximum of 80 percent relative humidity in accordance with ASTM F2170.
- B. Do not apply coatings when the following conditions exist. If such conditions exist, provide containment, covers, environmental controls, and other necessary measures.
 1. During rainy, misty, or damp weather, or to surfaces with frost or condensation.
 2. When the surface temperature is below 10 degrees Fahrenheit above the dew point.
 3. When ambient or surface temperature:
 - a. Is less than 55 degrees Fahrenheit unless the manufacturer allows a lower temperature.
 - b. Is less than 65 degrees Fahrenheit for clear finishes unless the manufacturer allows a lower temperature.

- c. Exceeds 90 degrees Fahrenheit unless the manufacturer allows a higher temperature.
 - d. Exceeds the manufacturer's recommendation.
 - 4. When relative humidity is higher than 85 percent.
 - 5. Under dusty or adverse environmental conditions.
 - 6. When light on surfaces measures less than 15-foot candles.
 - 7. When wind speed exceeds 15 miles per hour.
- C. Apply coating only under evaporation conditions rather than condensation.
 - 1. Use dehumidification equipment, fans, and/or heaters inside enclosed areas to maintain required atmospheric and surface temperature requirements for proper coating application and cure.
 - 2. Measure and record relative humidity and air and surface temperatures at the start and end of each shift to confirm proper humidity and temperature levels inside the work area.
 - a. Submit test results.
- D. Continuously ventilate, dehumidify, and heat enclosed spaces with high humidity during surface preparation, coating application, and curing.
 - 1. Maintain minimum air temperature of 55 degrees Fahrenheit and 10 degrees Fahrenheit above the dew point.
 - 2. Maintain dew point of at least 10 degrees Fahrenheit less than the temperature of the coldest part of the structure where work is performed.
 - 3. Reduce dew point temperature in conditioned space by at least 10 degrees Fahrenheit within 20 minutes.
 - 4. Seal work areas and maintain positive pressure in accordance with the dehumidification equipment supplier's recommendations.
 - 5. Maintain these conditions before, during, and after application to ensure proper adhesion and cure of coatings for no less than:
 - a. Entire curing period.
 - b. 8 hours after coating.
- E. Systems:
 - 1. Site electrical power availability as specified in Section 01_50_00 - Temporary Facilities and Controls.
 - 2. Internal combustion engine generators may be used.
 - a. Obtain required permits and provide air pollution and noise control devices on equipment as required by permitting agencies require.
 - b. Comply with state, federal, and local fire and explosion protection measures when locating and operating generators.
 - c. Locate engine generator outside hazardous classified areas in accordance with NFPA 820.
 - d. Provide daily fuel service for generators for duration of use.
 - 3. Dehumidification:
 - a. Provide desiccant or refrigeration drying.
 - b. Use only desiccant types with a rotary desiccant wheel capable of continuous operation.
 - c. Liquid, granular, or loose lithium chloride drying systems are not acceptable.

4. Heating:
 - a. Use electric, indirect combustion, or steam coil.
 - b. Direct-fired combustion heaters are not acceptable heat sources during abrasive blasting, coating application, or coating cure.
 5. Filters:
 - a. Use a filtration system for dust removal designed to not interfere with the dehumidification equipment's ability to control dew point and relative humidity inside the reservoir.
 - b. Do not allow air from the working area or dust filtration equipment to recirculate through their dehumidifier during coating application or when solvent vapors are present.
 6. Design and Submittals:
 - a. Prepare and submit dehumidification and heating plan, including all equipment, and operating procedures.
 - b. Suppliers of services and equipment shall have at least 3 years of experience in similar applications.
- F. Provide containment and ventilation system components in accordance with SSPC-Guide 6, Level 3, and as required for hazardous materials.

1.08 TECHNICAL REPRESENTATIVES' RESPONSIBILITIES

- A. General:
 1. Attend pre-installation conference.
 2. Perform on-site application training.
- B. Coating system installation training:
 1. Provide a minimum of 8 hours of classroom and off-site training for application personnel and supervisory personnel in one of the following ways:
 - a. Train a minimum of 2 supervisory personnel and 2 application personnel.
 - b. Submit a letter from the CSM stating that CSM approves the supervisory and application personnel, listed by name and responsibility, and no additional training is required.
 2. CTR can train up to 14 application personnel and 3 supervisory personnel at a time.
 3. Minimum training requirements:
 - a. Explain in detail the mixing, application, curing, and termination requirements.
 - b. Provide hands-on demonstration of coating system mixing.
 - c. Explain in detail the ambient condition requirements for temperature and humidity.
 - d. Explain in detail the surface preparation requirements.
 - e. Explain in detail the re-coat times, cure times, and related ambient condition requirements.
 - f. Write a letter stating that training was satisfactorily completed by the personnel, listed by name and responsibility.
 4. Provide special training as specified in the coating detail sheets.
 5. Visit the Site at the following intervals:
 - a. On the first day of application of any coating system.

- b. As necessary during surface preparation and application to ensure installations are made in accordance with the manufacturer's recommendations.
 - c. As required to resolve field problems attributed to or associated with the manufacturer's products.
- 6. Routinely inspect and verify in writing that application personnel have successfully performed surface preparation, filler/surfacer application, coating system application, and quality control inspection in accordance with this Section and to warrantable quality.
 - a. Be on site to periodically observe and oversee:
 - 1) Coating application.
 - 2) End of surface preparation.
 - 3) During coating application.
 - 4) Post-cure inspection.
- 7. Conduct final review of completed coating system installation and submit detailed report to the Owner.

PART 2 PRODUCTS

2.01 DESIGN AND PERFORMANCE CRITERIA

- A. Coating materials shall be formulated for environments encountered in water and wastewater treatment processes.
- B. Coating materials that encounter water distributed as potable water shall be certified in accordance with NSF 61.

2.02 MATERIALS

- A. General:
 - 1. As specified in Section 01_60_01 - Product Requirements.

2.03 COATING SYSTEMS IDENTIFICATION

- A. Naming conventions: Coating systems identifications contain the elements defined in Table 1.

Table 1. Coating System Identification Elements					
First Element	-	Second Element	-	Third Element	- Fourth Element (optional)
3 or 4 alpha characters		1-3 alpha characters		1 number	3 or 4 alpha characters
Coating Type		Substrate		System Number	Additional Substrate or Special Condition
Example: EPX	-	C	-	6	- BSC

- 1. First element identifies the coating type using the following abbreviations:
 - a. ACR: Acrylic.
 - b. CTE: Coal tar epoxy.
 - c. ELA: Elastomeric acrylic.

- d. EPU: Epoxy-polyurethane.
 - e. EPX: Epoxy.
 - f. POL: Polyurethane.
 - g. SIL: Silicone.
 - h. SILX: Siloxane or silane.
 - i. VE: Vinyl ester.
2. Second element identifies the substrate using the following abbreviations:
 - a. C: Concrete or masonry.
 - b. F: Concrete flooring.
 - c. FRP: Fiber-reinforced plastic.
 - d. GM: Galvanized metal.
 - e. M: Metal.
 - f. PVC: Polyvinyl chloride, chlorinated polyvinyl chloride.
 3. Third element identifies the sequential system number.
 - a. For example, EPX-C-2 is the second standard epoxy coating system for concrete substrates.
 4. Fourth element is optional and identifies the additional substrate or special condition with the following abbreviations:
 - a. BG: Below grade or buried.
 - b. BSC: Biogenic sulfide corrosion-resistant applications in wastewater.
 - c. OZ: Organic zinc primer, epoxy polyurethane system.
 - d. PWS: Potable water service applications (NSF-61 approved).
 - e. SC: Secondary containment.

2.04 PRODUCTS FOR COATING SYSTEMS

- A. Products: As specified in Attachment B - Coating Detail Sheets.
- B. Cleaning solvents:
 1. Requirements for solvent wash, solvent wipe, or cleaner used, including, but not limited to, those used for surface preparation in accordance with SSPC-SP 1.
 2. Use clean white cloths and clean fluids in solvent cleaning.

PART 3 EXECUTION

3.01 GENERAL PROTECTION REQUIREMENTS

- A. Protect adjacent surfaces from coatings and damage associated with coating work and repair any damage that occurs.
- B. Place coating waste, cloths, and material that may pose a fire hazard in closed metal containers and remove daily from the Site.
- C. Remove electrical plates, surface hardware, fittings, and fasteners before coating application.
 1. Carefully store, clean, and replace items after completing coating in each area.
 2. Do not use solvent or degreasers to clean hardware that may remove permanent lacquer finishes.

- D. Erect and maintain protective enclosures in accordance with SSPC-Guide 6.
- E. Protect the following surfaces from abrasive blasting by masking or by other means:
 - 1. Threaded portions of valve and gate stems, grease fittings, and identification plates.
 - 2. Machined surfaces for sliding contact.
 - 3. Surfaces to be assembled against gaskets.
 - 4. Surfaces of shafting where sprockets will be fit.
 - 5. Surfaces of shafting where bearings will be fit.
 - 6. Machined bronze surfaces, including slide gates.
 - 7. Cadmium-plated items, except cadmium-plated, zinc-plated, or sherardized fasteners used to assemble equipment requiring abrasive blasting.
 - 8. Galvanized items, unless scheduled to be coated.

3.02 GENERAL SURFACE PREPARATION REQUIREMENTS

- A. Prepare surfaces in accordance with coating detail sheets in Attachment B - Coating Detail Sheets.
 - 1. Include coating and surface preparation requirements.
 - 2. CSM's instructions will also have surface preparation requirements but follow the more stringent if information conflicts.
- B. Where required by the Owner's representative, a NACE International certified coatings inspector, provided by the Contractor, will inspect and approve surfaces to be coated before applying a coating.
 - 1. Applicator shall coordinate coating inspections.
 - a. Identify coating inspection Hold Points during the pre-installation conference.
 - b. Provide at least 2 days' notice before inspection.
 - 2. Correct surface defects identified by the inspector at no additional cost to the Owner.

3.03 MECHANICAL AND ELECTRICAL EQUIPMENT PREPARATION

- A. Remove grilles, covers, and access panels for mechanical and electrical system and coat separately.
- B. Prepare and finish coat equipment primed by the manufacturer using specified intermediate and topcoats, as applicable, and color selected by the Owner.
- C. Prepare, prime, and coat both insulated and bare pipes, conduits, boxes, insulated and bare ducts, hangers, brackets, collars, and supports, except where items are covered with material not requiring coating, or with a prefinished coating.
- D. Replace identification markings on mechanical or electrical equipment when coated over or spattered.
- E. Prepare and coat interior surfaces of air ducts and convectors and baseboard heating cabinets visible through grilles and louvers with 1 coat of flat black paint to limit of sight line.

- F. Prepare and coat dampers exposed immediately behind louvers, grilles, and convector and baseboard heating cabinets to match face panels.
- G. Prepare and coat exposed conduit and appurtenances occurring in finished areas with color and texture to match adjacent surfaces.
- H. Prepare and coat sides, front, back, and edges of plywood backboards for electrical equipment before installing backboards and mounting equipment on them.
- I. Color code equipment, piping, conduit, and exposed ductwork and apply color banding and identification, such as flow arrows, naming, and numbering, in accordance with the Contract Documents.

3.04 CLEANING OF NEW AND PREVIOUSLY COATED OR NEW SURFACES

- A. Utilize cleaning agent to remove soluble salts, such as chlorides, from concrete and metal surfaces:
 - 1. Cleaning agent: Biodegradable non-flammable and containing no VOC.
 - 2. Manufacturers: The following or equal:
 - a. CHLOR*RID International, Inc.
 - 1) Complete soluble salt removal with steam or warm water cleaning.
 - 3. Clean surfaces with decontamination agent in conjunction with abrasive blast cleaning, steam cleaning, high-pressure washing, or hand washing, as approved by the CTR and the Engineer.
 - 4. Test cleaned surfaces to ensure removal of soluble salts. Carry out additional cleaning as needed.
 - 5. Complete final surface preparation before applying the new coating system in accordance with the manufacturers printed instructions.

3.05 BLAST CLEANING

- A. Surface preparation requirements:
 - 1. Do not reuse spent blast abrasive.
 - 2. Ensure that filter compressed air used for blast cleaning is free of condensed water and oil.
 - a. Clean moisture traps at least once every 4 hours or more frequently, as required, to prevent moisture from entering the abrasive blasting equipment air supply.
 - b. Check blast air for moisture and oil after each cleaning in accordance with ASTM D4285.
 - 3. Install oil separators just downstream of compressor discharge valves and at the discharge point of blast pot discharges. Check separators on the same frequency as the moisture traps.
 - 4. Keep regulators, gauges, filters, and separators on compressor air lines connected always when blasting nozzles operational.
 - 5. Install an air dryer or desiccant filter drying unit to dry the compressed air before blast pot connections. Use and maintain the dryer throughout surface preparation work.

6. Use a venturi-type, or other high velocity-type, abrasive blast nozzles supplied with at least 100 pounds per square inch gauge air pressure at the nozzle and enough volume to obtain appropriate blast cleaning production rates and surface cleanliness.
7. Provide airborne particulate evacuation and filtering that meets OSHA safety standards. Maintain optimal visibility both to clean and provide the specified surface profile and to allow inspection of the substrate during surface preparation work.
8. Surfaces blasted and prepared and not coated/painted the same day shall be re-prepared prior to coating/painting. Any rust-back occurring before coating shall be removed.
9. Prepared blasted surfaces may be open longer if dehumidification (DH) is used to reduce moisture vapor and eliminate the potential for rust-back.

3.06 PREPARATION REQUIREMENTS FOR CONCRETE SURFACES

- A. Cure for at least 28 days before coating.
- B. Remove degraded concrete using abrasive blast cleaning or high or ultra-high-pressure water jetting, chipping, or other abrading tools until achieving a sound, clean substrate. Remove bruised or cracked concrete.
- C. Prepare substrate cracks and areas requiring resurfacing; perform detailed treatment, including, but not limited to, terminating edges in accordance with the CSM's recommendations, and as indicated on the Drawings.
 1. Prepare concrete surfaces in accordance with SSPC-SP 13.
- D. Prepare concrete surfaces in accordance with SSPC-SP 13.
 1. Inspect concrete surfaces to select appropriate surface preparation method to provide a suitable substrate for the specified coating system.
 2. Use blast cleaning or other means to expose the complete perimeter of air voids or bug holes. Do not leave shelled over, hidden air voids beneath the exposed concrete surface.
 3. Repair concrete defects and physical damage.
 4. Clean concrete surfaces of dust, mortar, formwork, fins, loose concrete particles, form release materials, oil, and grease.
 5. Fill voids to provide surface as specified in Section 03_35_29 - Concrete Finishes.
- E. Provide clean substrate visually free of calcium sulfate, loose, coarse, or fine aggregate, laitance, loose hydrated cement paste, and otherwise harmful substances.
 1. Confirm concrete surface minimum pH of 9.0 with surface pH testing.
 2. If after surface preparation the surface pH remains below 9.0, perform additional water blasting, cleaning, or abrasive blast cleaning until additional pH testing indicates an acceptable pH level.
- F. Prepare concrete surface for coating in accordance with SSPC-SP 13.
 1. Provide ICRI 310.2 minimum No. 3 concrete surface profile (CSP) or as specified on the coating detail sheets.
 2. Evaluate profile of the prepared concrete using ICRI 310.2 surface profile replicas.

- G. Blast clean cementitious repair mortars or grouts to the same profile and degree of cleanliness requirements required for concrete substrates.
- H. Blast clean polymer-based surfacers or waterborne modified cementitious surfaces only if they have exceeded the CSM's recommended recoat time.
- I. Vacuum or blow down concrete surfaces before coating application, leaving a dust free, sound concrete substrate.
 - 1. Thoroughly clean concrete surfaces to be coated to remove loose dirt and spent abrasive.
 - 2. Remove debris produced by blast cleaning from the structures to be coated, and legally dispose of it off site.
- J. Test moisture content of concrete to be coated:
 - 1. Conduct ASTM D4263 plastic sheet test at least once for every 500 square feet of surface area to be coated.
 - a. Any moisture on plastic sheet after test period constitutes a non-acceptable test, and the concrete must be dried further.
 - 2. Conduct ASTM F1869 test at least once for every 1,000 square feet of concrete floor surface area to be coated.
 - 3. Conduct ASTM F2170 one relative humidity moisture test at least once for each 500 square feet of non-floor concrete surface area where the opposite side is exposed to soil or water.
 - a. Waterproof surfaces exposed to soil or water where specified in Section 07_11_00 - Dampproofing.
 - 4. Comply with specified minimum moisture content and the CSM's written recommendations for moisture vapor transmission rates or relative humidity values.
- K. Masonry surfaces:
 - 1. Cure for at least 28 days before coating.
 - 2. Prepare masonry surfaces to remove chalk, laitance, loose dirt, dried mortar splatter, dust, peeling, or loose existing coatings, or otherwise deleterious substances to leave a clean, sound substrate.
 - 3. Wash and scrub masonry surfaces with clear water. Do not use muriatic acid.
 - 4. Seal or fill masonry surfaces with a sealer or block filler compatible with the specified primer after cleaning.
 - 5. Confirm that masonry surfaces are dry before coating application.
 - a. When using pressure washing or low-pressure water blast cleaning for preparation, allow the masonry to dry for at least 5 days under dry weather conditions or until the minimum ambient temperature is 70 degrees Fahrenheit before coating.

3.07 GENERAL PREPARATION REQUIREMENTS FOR METALLIC SURFACES

- A. Remove rust, scale, and welding slag and spatter.
 - 1. Remove and grind smooth excessive weld material and weld spatter on metal surfaces before blast cleaning in accordance with NACE SP0178.
 - 2. Grind sharp edges on metal substrate to approximately 1/16-inch radius before abrasive blast cleaning.

- B. Prepare metallic surfaces in accordance with applicable portions of surface preparation specifications of the SSPC specified for each coating system.
 - 1. Remove grease and oil in accordance with SSPC-SP 1.
 - 2. Measure profile depth of the surface to be coated in accordance with Method C of ASTM D4417. Select blast particle size and gradation to produce the specified surface profile.
 - 3. Constantly monitor and maintain ambient environmental conditions to ensure cleanliness and that no “rust back” occurs before coating material application.
 - 4. Surfaces not coated the same day they are prepared shall be re-prepared prior to coating unless approved moisture control equipment is used and approved by the Owners representative.
- C. Prepare metallic surfaces by blast cleaning in accordance with SSPC-VIS 1 (ASTM D2200). Prepare abrasive blast representative areas for the Owner’s representative to inspect on the first day of cleaning.
- D. Unless otherwise specified, the requirements for blast cleaning steel, ductile iron, and stainless-steel substrates are as follows:
 - 1. Ferrous metal surfaces not to be submerged: Abrasive blast in accordance with SSPC-SP 10 unless blasting may damage adjacent surfaces, is prohibited, or is specified otherwise. Where abrasive blasting is not possible, clean surfaces to bare metal with power tools in accordance with SSPC-SP 11.
 - 2. Ferrous metal surfaces to be submerged: Abrasive blast in accordance with SSPC-SP 5, unless specified otherwise, to clean and provide roughened surface profile with a depth between 2 and 4 mils.
 - 3. Remove traces of grit, dust, dirt, rust scale, friable material, loose corrosion products, or embedded abrasive from substrate before coating application.
 - 4. When abrasive blasted surfaces rust or discolor before coating, abrasive blast clean surfaces again.
- E. Field preparation of shop-primed surfaces:
 - 1. Smooth welds and prominences with power tools before applying field-applied coatings.
 - 2. Clean and dry shop-primed ferrous metal surfaces and fabricated assemblies before applying field coats.
 - 3. Prepare shop epoxy primed surfaces with light abrasive blasting or abrading and then vacuum before applying finish coats.
 - a. Follow CSM instructions for surface preparation when the primer recoat limit has been exceeded.
 - 4. Non-immersion service: Clean in accordance with SSPC-SP 2 or SSPC-SP 3 and uniformly roughen.
 - 5. Immersion, BSC, and SC service: Remove shop primer in accordance with SSPC-SP 5.
- F. Damaged shop primer or rust bleeding:
 - 1. Ferrous metals: Clean in accordance with SSPC-SP 1 and spot blast in accordance with SSPC-SP 10 to achieve a uniform surface profile between 2.0 and 2.5 mils before recoating.
 - 2. Reject galvanized steel with rust bleeding.

- G. Damaged coating: Repair by abrasive blast cleaning surfaces as specified for the coating system; feather to a smooth transition before touching up.

3.08 PREPARATION REQUIREMENTS BY SURFACE TYPE

- A. Steel and ferrous metal surfaces that require coating:
 - 1. Degrease or solvent clean (SSPC-SP 1).
 - 2. Abrasive blast surfaces to a SSPC-SP 10 for non-immersion and a SSPC-SP 5 for immersion.
 - a. If abrasive blast cannot be performed, abrade in accordance with SSPC-SP 7.
- B. Galvanized steel and non-ferrous metal surfaces:
 - 1. Degrease or solvent clean (SSPC-SP 1) to remove oily residue.
 - 2. Abrasive blast clean in accordance with SSPC-SP 16.
 - a. If abrasive blast cannot be performed, abrade in accordance with SSPC-SP 3.
 - 3. Apply metal pretreatment within 24 hours before coating galvanized surfaces that cannot be thoroughly abraded, such as bolts, nuts, or preformed channels.
 - 4. Test surface for contaminants using copper sulfate solution.
- C. Stainless-steel surfaces:
 - 1. Abrasive blast clean in accordance with SSPC-SP 16 to leave a clean, uniform appearance with surface profile between 1.5 and 2.5 mils.
- D. Ductile iron pipe and fittings to be lined or coated: Abrasive blast clean in accordance with NAPF 500-03.
- E. Sherardized, aluminum, copper, and bronze surfaces:
 - 1. Abrasive blast clean in accordance with SSPC-SP 16.
 - 2. Prepare in accordance with the CSM's instructions.
- F. Cadmium-plated, zinc-plated, or sherardized fasteners:
 - 1. Abrasive blast in the same manner as uncoated metal when assembling equipment designated for abrasive blasting.
- G. PVC and FRP surfaces:
 - 1. Lightly sand surfaces to be coated.
 - a. Sand to remove gloss and establish uniform surface profile.
 - 2. Vacuum to remove loose dust, dirt, and other materials.
 - 3. Solvent clean with clean white rags and allow solvent to evaporate completely before applying coating materials.

3.09 APPLICATION REQUIREMENTS

- A. Apply coatings in accordance with the manufacturer's instructions.
- B. Empty aboveground piping to be coated of contents when applying coatings.

- C. Items to be coated: Commercial or manufactured items with a factory or shop-applied coating system.
 - 1. Factory or shop-applied permanent coating system:
 - a. Commercial components shall be coated with the manufacturer's standard surface preparation and applied permanent coating system:
 - 1) Pumps and valves: Shop coat with the manufacturer's highest quality coating system in accordance with the Project Specifications.
 - 2) Non-immersed equipment: Touch up shop primer, and coat in the field with specified coating system after installation.
 - 3) Immersed equipment with shop primer: Touch up shop primer and coat in the field with specified coating system after installation.
 - 2. Items subject to sunlight shall be topcoated with ultraviolet (UV) stable materials.
 - 3. Permanent coating system shall have a 10-year corrosion-free protection without significant defects stored in atmospheric exposure.
 - 4. Color and gloss: Manufacturer's standard color unless a specific color is otherwise specified in the color schedule or indicated on the Drawings.
 - 5. Unless otherwise specified, unexposed surfaces that require coatings, such as interior of cabinets, enclosures, and equipment, shall be given the manufacturer's standard permanent coated finish.
 - 6. Field repair: Repair damaged areas of coated surfaces with compatible materials to equal thickness and color match of undamaged areas.
- D. Repair damaged galvanized surfaces in accordance with ASTM A780. Repair materials containing cadmium and lead are not permitted.
- E. Stainless steel surfaces to receive uniform passivation. Clean and restore uniform passivation layer on damaged, contaminated, or depassivated stainless steel surfaces in accordance with ASTM A380.
- F. Wash coat and prime sherardized, aluminum, copper, and bronze surfaces, or prime with the manufacturer's recommended special primer.
- G. Use equipment designed to apply materials specified.
 - 1. Use compressors with moisture traps and filters that remove water and oils from the air.
 - a. Perform a paper blotter test at the Engineer's request to verify air is sufficiently free of oil and moisture. Do not allow the amount of oil and moisture to exceed the CSM-recommended amount.
 - 2. Equip spray equipment with properly sized mechanical agitators, pressure gauges, pressure regulators, and spray nozzles.
- H. Where 2 or more coats are required, tint prime coat intermediate coats as necessary to distinguish each coating and to help indicate coverage.
- I. Apply coating by brush, roller, trowel, or spray, unless a specific application method is required by the coating manufacturer's instructions or these Specifications.
 - 1. With a brush, stripe coat edges, welds, corners, nuts, bolts, and difficult-to-reach areas, as necessary, before spray application to ensure specified coating thickness along edges.
 - 2. After the prime coat dries, mark, repair, and retest pinholes and holidays before intermediate or topcoats are applied.

- J. Spray application:
1. With a brush, stripe coat edges, welds, corners, nuts, bolts, and difficult-to-reach areas, as necessary, before spray application to ensure specified coating thickness along edges.
 2. When using spray application, apply each coat to a thickness no greater than recommended in the coating manufacturer's instructions.
 3. Use airless spray method unless air spray method is required by the CSM's instruction or these Specifications.
 4. Conduct spray coating under controlled conditions. Protect adjacent construction and property from coating mist, fumes, or overspray.
- K. Shop and field coats:
1. Prime coat: Shop-apply or field-apply prime coats as specified. Use shop-applied primer compatible with the specified field coating system and apply at the minimum dry film thickness recommended by the finish coat CSM.
 - a. Provide datasheets identifying the shop primer to on-site coating application personnel.
 - b. Perform adhesion tests on the shop primer.
 - c. Remove and recoat damaged, deteriorated, and poorly applied shop coatings.
 - d. If the shop primer coat meets this Section's requirements, spot prime exposed metal of shop-primed surfaces before spray applying primer over the entire surface.
 2. Field coats: Apply field coats with one or more prime coats and finish coats to build up coating to dry film thickness specified for the coating system.
 - a. Do not apply finish coats until other work in the area is complete and previous coats are inspected.
 3. Adhesion confirmation: Perform adhesion tests after proper coating cure in accordance with ASTM D3359. Demonstrate that:
 - a. Primer coat adheres to the substrate.
 - b. Coatings adhere to the primer and intermediate coats.
 - 1) Coating 5 mils or more DFT: Achieve adhesion test result of 5A on immersed surfaces and 4A or better on other surfaces.
 - 2) Coating less than 5 mils DFT: Achieve adhesion test results of 5B on immersed surfaces and 4B or better on other surfaces.
- L. Brush, roll, trowel, or spray and back roll coats for concrete and masonry.
- M. Plural component coating application:
1. Premix contents of component drums if required by the CSM each day.
 2. Before starting application:
 - a. Verify gauges are working properly.
 - b. Complete ratio checks.
 - c. Sample the mix on plastic sheeting to ensure set time is appropriate and complete.
 - d. Label and retain spray samples. Submit to the Engineer when requested.
- N. Drying and recoating:
1. Provide means to prevent condensate or dew on substrate surface or between coats and during curing after applying the last coat.

2. Allow each coat to cure or dry thoroughly, in accordance with, if required, the CSM's printed instructions before recoating.
 3. Use the CSM's printed instructions and the requirements specified in this Section to determine the minimum required drying time.
 - a. Recoat coatings within time limits recommended by CSM.
 - b. If time limits are exceeded, abrasive blast clean and de-gloss clean before applying another coat.
 4. Ensure primer and intermediate coats of coating are unscarred and completely integral when applying each succeeding coat.
 5. Touch up suction spots between coats and apply additional coats where required to produce finished surface of solid, even color, free of defects.
 6. Repair holidays in accordance with the requirements on pertinent Coating Detail Sheets or as recommended by the CSM.
 7. Sand and feather to a smooth transition and recoat scratched, contaminated, or otherwise damaged coating surfaces so repairs are invisible to the naked eye.
- O. Workmanship:
1. Ensure that coated surfaces are free from runs, drips, ridges, waves, laps, dry spray, and brush marks. Coats shall be applied to produce a smooth, even film of uniform thickness completely coating corners and crevices.
 2. Evenly apply each coat of material and sharply cut to a line created with masking tape or other suitable materials.
 3. When coating complex steel shapes, stripe coat welds, edges of structural steel shapes, metal cut-outs, pits in steel surfaces, or rough surfaces with the primer before overall coating system application.
 - a. Brush apply stripe coat to ensure proper coverage.
 - b. Do not stripe coat with spray or roller.
 4. Ensure that the finish coat, including repairs, has a uniform color and gloss.
- P. Coating properties, mixing, and thinning:
1. If maximum recoat time is exceeded, prepare surface with solvent washing, light abrasive blasting, sanding, or other procedures in accordance with the CSM's instructions.
 2. Allow adequate drying time between coats as instructed by the CSM, adjusted as necessary for the Site conditions.
 3. Ensure that coatings, when applied, provide a satisfactory film and a smooth even surface. Lightly sand glossy undercoats to provide a surface suitable for proper application and adhesion of subsequent coats. Thoroughly stir and strain coating materials during application and maintain uniform consistency.
 4. Mix coatings with 2 or more components in accordance with the CSM's instructions.
 5. Where necessary to suit conditions of the surface, temperature, weather, and method of application, thin the coating in accordance with the CSM's recommendations.
 - a. Ensure that volatile organic content (VOC) of the thinned coating complies with prevailing air pollution control regulations.
 - b. Thin coatings to only what is necessary to obtain proper application characteristics.
 - c. Use a thinner recommended by the CSM.

- Q. Film thickness and continuity:
1. Apply coating to the specified thicknesses.
 - a. Apply additional coats when necessary to achieve specified thicknesses, especially at edges and corners.
 2. Verify WFT of the coating system first coat and after applying each subsequent coat.
 3. Do not allow the minimum thickness at any point to deviate more than 20 percent on the low end and 120 percent on the high end from the required average.
 4. Do not allow the surface area covered per gallon of coating for various types of surfaces to exceed those recommended by the CSM.
 - a. Provide coating coverage worksheets listing the maximum and minimum coverage for each unit volume of coating for concrete surfaces.
 5. Apply additional coats to achieve the specified dry film thickness if brush or roller application methods cannot achieve the specified film thickness per coat.
- R. Protecting coated surfaces:
1. Do not handle, work on, or otherwise disturb coated items until the coating is completely dry and hard.
 2. After installation, recoat shop-coated surfaces with specified coating system as necessary to match surrounding surfaces, and to coordinate with the specified color identification requirements.
- S. Special requirements:
1. Before erection, apply all but the final finish coat to interior surfaces of roof plates, roof rafters and supports, pipe hangers, piping in contact with hangers, and contact surfaces inaccessible after assembly. Apply final coat after erection.
 2. Coat structural slip-critical connections and high strength bolts and nuts after erection.
 3. Areas damaged during erection:
 - a. Prepare surface for spot repairs as specified for the coating system.
 - b. Recoat with prime coat before applying subsequent coats.
 - c. Touch up surfaces after installation.
 - d. Clean and dry surfaces to be coated at time of application.
 4. Coat underside of equipment bases and supports not galvanized with at least 2 coats of primer specified before setting the equipment in place.
 5. Coat aluminum surfaces in contact with concrete.

3.10 APPLICATION REQUIREMENTS FOR CONCRETE COATING SYSTEMS

- A. Apply filler/surfacer as recommended by CSM to fill bug holes and air voids in concrete or block texture in CMU, leaving a uniformly filled surface that does not produce blowholes or outgassing causing the coating system to pinhole.
1. Allow filler/surfacers to cure sufficiently before applying prime coat as required by the CSM. Use the CSM-recommended drying time between coats.
- B. Apply surfacer or filler and let dry before coating application.
1. Use the drying time between filler/surfacer and coating system specified by the CSM for the Site conditions.
 - a. Let concrete substrate dry before applying filler/surfacers or coating system materials.

2. If the maximum recoat time is exceeded, prepare surfaces by solvent washing, light abrasive blasting, and other procedures in accordance with the CSM's instructions.
 3. Apply a complete parge coat of the specified filler/surfacer material over the entire substrate before applying the coating system.
 - a. Scrub filler/surfacer into the substrate to completely fill open air voids and bug holes.
 - b. Completely cover the substrate, unless otherwise specified, above such filled voids by 1/8 inch of thickness.
 - c. Provide relatively flat, uniformly even surface before coating application.
 4. Secondary containment: Place surfacer or filler 1/16 inch thick above concrete plane to create a monolithic surface free of pinholes.
 - a. Floor surfaces: Broadcast with aggregate to create a non-slip surface texture.
 - b. Remove excess aggregates and apply base coat to encapsulate embedded non-slip aggregate.
- C. Concrete substrate temperatures:
1. Apply filler/surfacers and the coating system when temperatures are falling, typically late afternoon or evening.
 - a. Do not coat concrete with rising concrete substrate surface temperatures or substrates in direct sunlight, to minimize outgassing from the substrate and formation of pinholes, and/or blistering.
 2. Should bubbles, pinholes, or other discontinuities form in the applied coating system material, they shall be repaired.
 - a. Should discontinuities develop in the filler/surfacer material or in the first coat of the coating material, repair them before the next coat.
 - b. When discontinuities occur, open the air void behind or beneath the discontinuities and completely fill with specified coating material. Then, abrade the coated area around the discontinuities repair reapply coating over that area.
- D. Perform application detail work in accordance with these Specifications, the CSM's current written recommendations, and Drawings, whichever is stricter.
- E. Concrete coating systems application requirements:
1. Concrete coating minimum dry film thickness excludes parge coat, block filler, and sealer.

3.11 COATING SYSTEMS

- A. Attachment A - Schedule of Surfaces to be Coated specifies surfaces to be coated in the field with the coating systems required.

3.12 SURFACES NOT REQUIRING COATING

- A. Stainless steel piping, valves, pipe supports, instrument sunshades.
1. Clean and restore uniform passivation layer on damaged, contaminated, or de-passivated stainless-steel surfaces in accordance with ASTM A380.

- B. Sliding surfaces on expansion joints, motor and pump shafts, machined surfaces at bearings and seals, grease fittings, etc.
- C. Galvanized structural steel framing, galvanized roof decking, galvanized pipe supports.
- D. Copper and brass pipe, fittings, valves, etc.
- E. Bronze valves, bearings, bushings, and fasteners.
- F. Corrosion resistant special alloys: Inconel, Alloy 20, Hastelloy, etc.
- G. Exterior concrete.
- H. Plastic surfaces, except coat PVC, CPVC, and other plastic piping system exposed to sunlight.
- I. Exception - Piping that is encased in concrete or cement mortar:
 - 1. Coat the first 6 inches of pipe to be encased.
 - 2. Caulk gaps and seams after encasement.

3.13 QUALITY CONTROL

- A. CSA to perform, or contract with an inspection agency to perform, quality control inspection and testing of the coating work covered by this Section. These inspections shall include the following:
 - 1. Prepare reports, after daily coating work ends, summarizing each day's test data, observations, drawings, and photographs.
 - 2. Perform the following activities to confirm conformance with the specifications:
 - a. Inspect ambient conditions during coating system installation at Hold Points for conformance with the specified requirements.
 - b. Inspect each coated surface type and coating system applied to verify the following:
 - 1) Inspect materials upon receipt to ensure that the CSM supplied them.
 - 2) Verify that specified storage conditions for the coating system materials, solvents, and abrasives are provided.
 - 3) Inspect and record findings for substrate cleanliness.
 - 4) Inspect and record pH of concrete and metal substrates.
 - 5) Inspect and record substrate profile (anchor pattern).
 - 6) Measure and record ambient air and substrate temperature.
 - 7) Measure and record relative humidity.
 - 8) Check for substrate moisture in concrete.
 - 9) Verify that mixing of coating system materials is in accordance with the CSM's instructions.
 - 10) Inspect, confirm, and record that the coating system materials' "pot life" is not exceeded during installation. Inspect to verify that recoat limitations for coating materials are not exceeded.
 - 11) Perform adhesion testing.
 - 12) Measure and record the coating system's thickness.
 - 13) Verify proper curing of the coating system in accordance with the CSM's instructions.

- 14) Holiday or continuity testing in accordance with NACE SP0188 for coatings that will be immersed or exposed to aggressively corrosive conditions.
 - 15) Prepare and submit written reports directly to the Owner's representative at the shift's end:
 - a) Reports shall identify observations and testing relative to the quality of the surface preparation and painting/coatings work.
 - b) Reports shall address any conditions observed which have the potential to adversely impact the finished painting/coating system integrity and performance.
 - c) Any such findings shall be immediately repaired.
 - c. Verify surface profile of substrates by completing the following:
 - 1) Inspect preparation and application of coating detail treatment at terminations, transitions, metal embedment's in concrete, and joints and cracks in substrates.
 - 2) Inspect application of filler/surfacer materials for concrete and masonry substrates.
- B. Damaged factory finishes shall be repaired and, if directed by the Owner's representative, refinished the entire surfaces of the factory-finish equipment at the applicators' expense.
- C. Owner-provided inspection or inspection by others does not limit the required Contractor's or CSA's responsibilities for quality workmanship or quality control. Owners' inspection is in addition to any inspection performed by the applicator.

3.14 CORRECTIVE MEASURES

- A. Repair pinholes or holidays identified by holiday testing as follows:
1. Remove coating system at pinholes and holidays at least 2-inches diameter around the defect back to expose substrate.
 2. Concrete voids: Chip back to expose entire cavity in all directions.
 - a. Completely fill void with approved filler/surfacer material using a putty knife or other suitable tool and strike off. Cure in accordance with the CSM's recommendations.
 3. Aggressively abrade or sand the intact coating system surfaces at least 3 inches beyond the removal area in all directions to produce a uniform 6- to 8-mil profile in the intact coating system.
 4. Remove dust, dirt, etc., leaving clean, sound surfaces.
 5. Tape to mask the periphery of the prepared intact coating area to prevent coating repair application onto the prepared area.
 6. Apply the coating system with enough coats to achieve the specified finish coat thickness over the defect and coating removal area. Feather the coating onto the abraded coated surfaces around the removal area to avoid a lip and to achieve a neat repair outline.
 7. Follow curing time between coats as specified by the CSM for the Site conditions. Solvent wash and abrasive blast in accordance with the CSM's instructions if the maximum recoat time is exceeded.
 8. Apply coating at specified dry film thickness.

3.15 CLEANUP

- A. Remove surplus materials, protective coverings, and accumulated rubbish after completing coating. Thoroughly clean surfaces and repair overspray or other coating-related damage.

3.16 FINAL INSPECTION

- A. Conduct final inspection of coating system work to determine whether it meets specifications requirements.
- B. Conduct subsequent final inspection with the Engineer to ensure Work is in accordance with Contract Documents requirements.
- C. Mark any rework required.
 - 1. Re-clean and repair, as specified, at no additional cost to the Owner.

END OF SECTION

ATTACHMENT A - SCHEDULE OF SURFACES TO BE COATED

ATTACHMENT A
Schedule of Surfaces to be Coated

- A. The following schedule is incomplete. Coat unlisted surfaces with same coating system as similar listed surfaces. Contact Engineer for clarification.

EPU-M-1	Metals, exterior, non-immersed
EPX-M-1	Metals, interior, non-immersed
EPX-M-3	Metals, immersed, and buried (except for 42-inch and 54-inch steel pipelines. See Specification 09_99_97 for coatings on these pipes)
EPX-M-5	Aluminum surfaces in contact with concrete or masonry. Locations where Alkali-resistant bitumastic is specified.
EPX-C-2	Immersed concrete
Notes:	
1: Non-immersed ferrous metal surfaces include: a. Doors, doorframes, ventilators, louvers, grilles, exposed sheet metal, and flashing. b. Pipe, valves, pipe hangers, supports and saddles, conduit, cable tray hangers, and supports. c. Motors and motor accessory equipment. d. Drive gear, drive housing, coupling housings, and miscellaneous gear drive equipment. e. Valve and gate operators and stands. f. Structural steel. g. Crane and hoist rails. h. Exterior of tanks and other containment vessels. i. Mechanical equipment supports, drive units, and accessories. j. Bare electrical equipment: boxes, exposed conduit, and accessories. k. Pumps not submerged. l. Other miscellaneous metals. 2: Immersed ferrous metal surfaces include: a. Interior surfaces of ferrous metal tanks. b. Field priming of ferrous metal surfaces with defective shop-prime coat; including non-submerged service. c. Bell rings, underside of manhole covers and frames. d. Sump pumps, including underside of base plates and submerged suction and discharge piping. e. Exterior of submerged piping and valves other than stainless steel or PVC piping. f. Submerged pipe supports and hangers. g. Stem guides. h. Other submerged iron and steel metal unless specified otherwise.	

ATTACHMENT B - COATING DETAIL SHEETS

Attachment B			
Coating Detail Sheet			
Coating System	EPU-M-1		
Coating Material	Two coats epoxy with polyurethane finish coat		
Substrate	Metal		
Products: One of the following or equal:	Primer	Intermediate Coat	Finish Coat
Carboline	Carboguard 890	Carboguard 890	Carbothane 134 VOC
International Paint	Devran 224V	Devran 224V	Devthane 379
PPG	Amercoat 385	Amercoat 385	Amercoat 450H
Sherwin Williams	Macropoxy 646	Macropoxy 646	Hi Solids Polyurethane
Tnemec	Series 69	Series 69	Series 1095
Service Condition	Interior or Exterior, subject to direct sunlight. Non-immersion.		
Surface Preparation			
General	Prepare surfaces as specified in this Section and as follows.		
Ferrous Metal	Bare surfaces: SSPC-SP10, Near-White Blast Cleaning. Shop primed surfaces: SSPC-SP2, Hand Tool Cleaning or SSPC-SP3, Power Tool Cleaning. Damaged primer or rust: SSPC-SP10, Near White Blast Cleaning and spot prime.		
Nonferrous Metal	SSPC-SP16, Brush Blast Cleaning.		
Galvanized Metal	SSPC-SP16, Brush Blast Cleaning. Test for surface contaminants.		
Surface Profile			
Ferrous Metal	2.5 to 3.0 mils		
Nonferrous Metal	1.5 to 2.0 mils		
Galvanized Metal	1.5 to 2.0 mils		
System Thickness (Dry Film)			
Total	10 to 13 mils		
Primer	4 to 5 mils		
Intermediate Coat	4 to 5 mils		
Finish Coat	2 to 3 mils		
Application			
Special CTR Training	Not required.		

Attachment B			
Coating Detail Sheet			
Coating System	EPX-M-1		
Coating Material	Epoxy		
Substrate	Metal		
Products: One of the following or equal:	Primer	Intermediate Coat	Finish Coat
Carboline	Carboguard 890	None Applied	Carboguard 890
International Paint	Bar-Rust 236	None Applied	Bar-Rust 236
PPG	Amerlock 2/400 Series	None Applied	Amerlock 2/400 Series
Sherwin Williams	Macropoxy 646	None Applied	Macropoxy 646
Tnemec	Series 69	None Applied	Series 69
Service Condition	Interior, non-corrosive.		
Surface Preparation			
General	Prepare surfaces as specified in this Section and as follows.		
Ferrous Metal	Bare surfaces: SSPC-SP10, Near-White Blast Cleaning. Shop primed surfaces: SSPC-SP2, Hand Tool Cleaning or SSPC-SP3, Power Tool Cleaning. Damaged primer or rust: SSPC-SP10, Near White Blast Cleaning and spot prime.		
Nonferrous Metal	SSPC-SP16, Brush Blast Cleaning.		
Galvanized Metal	SSPC-SP16, Brush Blast Cleaning. Test for surface contaminants.		
Surface Profile			
Ferrous Metal	2.5 to 3.0 mils		
Nonferrous Metal	1.5 to 2.0 mils		
Galvanized Metal	1.5 to 2.0 mils		
System Thickness (Dry Film)			
Total	10 to 12 mils		
Primer	4 to 6 mils		
Finish Coat	4 to 6 mils		
Application			
Special CTR Training	Not required.		

Attachment B			
Coating Detail Sheet			
Coating System	EPX-M-3		
Coating Material	Epoxy		
Substrate	Metal		
Products: One of the following or equal:	Primer	Intermediate Coat	Finish Coat
Carboline	Carboguard 891	Carboguard 891	Carboguard 891
International Paint	Bar-Rust 236	Bar-Rust 236	Bar-Rust 236
PPG	Amercoat 240	Amercoat 240	Amercoat 240
Sherwin Williams	Tank Clad HS	Tank Clad HS	Tank Clad HS
Tnemec	Series 104	Series 104	Series 104
Service Condition	Immersed; non-immersed, corrosive environment. Not for Biogenic Sulfide Corrosion areas in wastewater.		
Surface Preparation			
General	Prepare surfaces as specified in this Section and as follows.		
Ferrous Metal	Bare surfaces: SSPC-SP5, White Metal Blast Cleaning. Shop primed surfaces: SSPC-SP7, Brush-Off Blast Cleaning. Damaged primer or rust: SSPC-SP5, White Metal Blast Cleaning and spot prime.		
Nonferrous Metal	SSPC-SP16, Brush-Off Blast Cleaning.		
Galvanized Metal	SSPC-SP16, Brush-Off Blast Cleaning.		
Surface Profile			
Ferrous Metal	2.5 to 3.0 mils		
Nonferrous Metal	1.5 to 2.0 mils		
Galvanized Metal	1.5 to 2.0 mils		
System Thickness (Dry Film)			
Total	16 to 20 mils		
Primer	4 to 8 mils		
Intermediate Coat	4 to 8 mils		
Finish Coat	4 to 8 mils		
Application			
Special CTR Training	Not required.		

Attachment B			
Coating Detail Sheet			
Coating System	EPX-M-5		
Coating Material	Epoxy mastic		
Substrate	Metal		
Products: One of the following or equal:	Primer	Intermediate Coat	Finish Coat
Carboline	CSM recommended	None applied	Carbomastic 15
International Paint	CSM recommended	Bar-Rust 231	Bar-Rust 231
PPG	CSM recommended	None applied	Amerlock 2 AL
Sherwin Williams	CSM recommended	None applied	Epoxy Mastic Aluminum II
Tnemec	CSM recommended	Series 135	Series 135
Service Condition	Interior, corrosive environment, confined enclosures, where minimal surface preparation is possible.		
Surface Preparation			
General	Prepare surfaces as specified in this Section and as follows.		
Ferrous Metal	Bare surfaces: SSPC-SP11, Power to Cleaning to Bare Metal. Shop primed surfaces: SSPC-SP3, Power Tool Cleaning. Damaged primer or rust: SSPC-SP11, Power to Cleaning to Bare Metal.		
Nonferrous Metal	SSPC-SP16, Brush-Off Blast Cleaning.		
Surface Profile			
Ferrous Metal	2.0 to 2.5 mils		
Nonferrous Metal	1.0 to 1.5 mils		
System Thickness (Dry Film)			
Total	15 to 19 mils		
Primer	2 to 4 mils		
Finish Coat	15 mils		
Application			
Special CTR Training	Not required.		

Attachment B			
Coating Detail Sheet			
Coating System	EPX-C-2		
Coating Material	Epoxy		
Substrate	Concrete or masonry		
Products: One of the following or equal:	Primer	Intermediate Coat	Finish Coat
Carboline	Carboguard 890	Carboguard 890	Carboguard 890
International Paint	Bar-Rust 236	Bar-Rust 236	Bar-Rust 236
PPG	Amerlock 2/400 Series	Amerlock 2/400 Series	Amerlock 2/400 Series
Sherwin Williams	Macropoxy 646	Macropoxy 646	Macropoxy 646
Tnemec	Series 69	Series 69	Series 69
Service Condition	Immersion, Interior, Non-Immersion, Moderately Corrosive.		
Surface Preparation			
General	Prepare surfaces as specified in this Section and as follows.		
Concrete	Cure at least 28 days and dry to the CSM's recommended moisture content. Remove loose concrete and laitance from surfaces, and repair voids and cracks as specified in this Section.		
Existing Coated Concrete	Remove all existing coating to a sound substrate or intact, well-adhered coating. Abrade all surfaces to achieve required surface profile and vacuum to remove all loose dirt, paint chips, and dirt.		
Masonry	Cure at least 28 days and dry to CSM's recommended moisture content. Fill holes or other joint defects with mortar and repoint. Scrape or chip to remove loose or splattered mortar. Wash and scrub masonry surfaces with clear water to remove foreign and deleterious substances. Do not use muriatic acid. Fill surfaces with block filler compatible with the specified primer after cleaning.		
Surface Profile			
Concrete	0.5 to 1.5 mils		
Existing Coated Concrete	0.5 to 1.5 mils		
Masonry	0.5 to 1.5 mils		
System Thickness (Dry Film)			
Total	10 mils, excluding block filler and sealer.		
Application			
General	Let sealer or filler dry at least 48 hours before primer application. Use CSM's recommended drying time between coats.		
Special CTR Training	Not required.		

SECTION 09_99_97
STEEL PIPELINE COATINGS

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes: Pipeline coatings for buried steel pipe.

1.02 REFERENCES

- A. ASTM International (ASTM):
1. B1000 - Standard Practices for Casting Preparation and Test Procedure of Porcelain Enamel-lined Pipe, Fittings, and Valves for Use in the Municipal Wastewater, Sewage, and Water Treatment Industry.
 2. C283 - Standard Test Methods for Resistance of Porcelain Enameled Utensils to Boiling Acid.
 3. D792 - Standard Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement.
 4. D4541 - Standard Test Method for Pull-Off Strength of Coatings Using Portable Adhesion Testers.
- B. American Water Works Association (AWWA):
1. C216 - Heat-Shrinkable Cross-Linked Polyolefin Coatings for Steel Water Pipe and Fittings.
 2. C222 - Polyurethane Coatings and Linings for Steel Water Pipe and Fittings.
- C. NSF International (NSF):
1. 61 - Drinking Water System Components - Health Effects.
- D. Society for Protective Coatings (SSPC):
1. PA 2 - Procedure for Determining Conformance to Dry Coating Thickness Requirements.
 2. QP 1 - Standard Procedure for Evaluating the Qualifications of Industrial/Marine Painting Contractors (Field application to Complex industrial and Marine Steel Structures.
 3. SP 1 - Solvent Cleaning.
 4. SP 3 - Power Tool Cleaning.
 5. SP 5 - White Metal Blast Cleaning.
 6. SP 6 - Commercial Blast Cleaning.
 7. SP 10 - Near-White Metal Blast Cleaning.
 8. SP 11 - Power Tool Cleaning to Bare Metal.
 9. SP 13 - Surface Prep of Concrete.

1.03 SUBMITTALS

- A. Submit as specified in Section 01_33_00 - Submittal Procedures.

- B. Product Data: As specified in Section 40_05_00.01 - Common Work Results for General Piping.
- C. Certificate of Source Testing as specified in Section 01_60_01 - Product Requirements.
- D. Manufacturer's qualifications.
 - 1. Manufacturer qualifications and list of projects using the specified material: 5 years minimum.
 - 2. Polyurethane field repair: SSPC-QP 1 certification required.
- E. Manufacturer's Quality Assurance Manual.
 - 1. Submit manufacturer's coating application quality assurance manual to Engineer prior to beginning coating application.
 - a. Strict conformance to the requirements of the manual will be required.
 - b. Deviation from the requirements of the manual will be grounds for the Engineer to reject the applied coating.

1.04 DELIVERY, STORAGE, AND HANDLING

- A. Block piping and associated fittings for shipment to prevent damage to coatings and linings.
- B. Carefully handle piping and associated fittings during loading, unloading, and installation:
 - 1. Do not drop piping material from cars or trucks.
 - 2. Lower piping by mechanical means.
 - 3. Do not drop or pound pipe to fit grade.
- C. Store piping, fittings, and other accessories such that they do not accumulate and hold rainwater, dirt, and debris.

PART 2 PRODUCTS

2.01 COATING MATERIALS

- A. As specified in Section 01_60_01 - Product Requirements.
- B. Prepare, install, and repair in accordance with manufacturer's requirements.
- C. Contractor is responsible for:
 - 1. That coating selected is suitable for the application conditions anticipated, such as temperature, humidity, etc.
 - 2. Managing the project schedule to allow adequate cure time before backfill or immersion based on surface temperatures at the time of application.

2.02 PLURAL COMPONENT POLYURETHANE

- A. Coat pipe with minimum 25-mil DFT plural component, polyurethane coating system (referred to as a polyurethane system) applied in accordance with AWWA C222 and as specified in this Section.
 - a. Surface preparation:
 - 1) In accordance with AWWA C222 and as specified in this Section.
 - 2) Steel pipe: SSPC-SP 5, 3.00 mil profile, minimum, or in accordance with manufacturer's requirements, whichever is greater.
- B. Manufacturers: One of the following or equal:
 - 1. Chemline, Chemthane 2265.
 - 2. Lifelast, Equivalent product.
- C. Adhesion test procedures:
 - 1. Use self-aligning pneumatic pull off equipment and test procedures in accordance with ASTM D4541, Method E, using Delfesko Positest AT-A except as modified in this Section.
 - a. Perform at an applied load rate of 100 pounds per square inch per second, plus or minus 10 pounds per square inch.
 - b. Use automatic adhesion test equipment.
 - c. Perform tests to coating or glue failure or maximum test load, whichever happens first.
 - d. In accordance with ASTM D4541 using standard 20-millimeter dollies.
 - e. Base adhesion testing on 3 tests.
 - 1) Conduct the tests by the same person, test equipment, and test procedure.
 - 2) Complete the tests within a 30-minute period.
 - f. Conduct adhesion tests within an area not to exceed 6 inches by 6 inches.
 - g. Score coatings with more than 10 percent elongation or 25 mils thick around dolly to metal substrate using manual methods and tools, normal to the pipe surface, and in a manner that does not stress or overheat the coating.
 - 2. Attach dollies for adhesion testing to the coating surface using a 2-part epoxy or cyanoacrylate glue and cured for a minimum of 12 hours before testing or until full cure, whichever is greater.
 - a. Pipe fabricator and coating manufacturer determine glue type for the pipe diameter, temperatures, and environmental conditions.
 - 3. Perform adhesion testing at temperatures between 55 and 90 degrees Fahrenheit or at temperatures in accordance with coating manufacturer's requirements.
 - a. Testing up to 115 degrees Fahrenheit or below 55 degrees Fahrenheit will be permitted if tests can demonstrate no statistically detectable effect on test results and in accordance with coating manufacturer's requirements and Engineer's approval.
 - 4. Epoxy coating and lining adhesion criteria:
 - a. Coating is acceptable if first dolly pull test exceeds 1,750 pounds per square inch, minimum.
 - b. If first dolly pull is less than 1,750 pounds per square inch, perform 2 additional tests with acceptance based on "Best of 3" evaluation method as defined in this Section.

5. Pipe lot performance criteria:
 - a. Minimum median value for coating or lining adhesion tests: 2,000 pounds per square inch.
 - b. Classify failing pipe lots as rejected until 100 percent of the pipe within the pipe lot has been tested for adhesion.
 - 1) Reject each pipe that fails the coating adhesion criteria.
6. Adhesion test evaluation and records:
 - a. Definition: "Best of 3" evaluation method is when 2 of 3 test values meet the adhesion criteria.
 - b. Consider adhesion tests as valid and suitable for acceptance or rejection of the coating, except where retesting is required.
 - c. Adhesion test failure:
 - 1) Adhesive or substrate failure.
 - a) Definition: A percentage of separation of the coating from the steel substrate or between distinct coating layers.
 - 2) Cohesive test failure.
 - a) Definition: A percentage of failure within the coating, resulting in coating remaining both on the steel substrate and test dolly.
 - d. Retest coating adhesion tests:
 - 1) When any test is glue failure at 25 percent or more of dolly surface area and the test value is less than the Acceptance Criteria or the Minimum Criteria.
 - 2) Within the same 6-inch by 6-inch test area as the original adhesion testing.
 - 3) Retest disputed adhesion tests.
 - a) Owner's representative will witness dolly attachment and adhesion retesting.
 - e. Adhesion tests will be conducted on pipe coating and lining independently and will be accepted or rejected independently.
 - f. Maintain adhesion test records in an electronic spreadsheet that includes the following information:
 - 1) Pipe identification.
 - 2) Pipe coating date.
 - 3) Adhesion test date.
 - 4) Surface tested (interior or exterior).
 - 5) Surface temperature at time of test.
 - 6) Coating thickness.
 - 7) Tensile force applied.
 - 8) Applied load rate per second.
 - 9) Mode of failure.
 - 10) Percentage of failure types, previously defined, relative to dolly surface area.
 - 11) Dolly size and attachment glue used.
 - 12) If different coatings are tested, include coating manufacturer and product number.
7. Adhesion test repairs:
 - a. Fabricator or contractor to complete adhesion repairs as specified this Section.
 - b. Randomly select repair patches on epoxy or polyurethane coating for adhesion testing in a manner as described in this Section and at the discretion of the coating inspector.

- D. Long term adhesion test:
1. Acceptance criteria:
 - a. Not more than 10 percent loss of adhesion over duration of test.
 - b. Differential based on the highest average adhesion result to the lowest average adhesion result.
 2. Test durations, cumulative:
 - a. 1 day.
 - b. 7 days.
 - c. 3 weeks.
 - d. 2 months.
 3. Sample preparation:
 - a. SSPC-SP 5, 3.00 mils profile, minimum.
 - b. Test area minimum: 18 inches by 18 inches.
 - c. Curved steel plate.
 - 1) Minimum radius of 15 inches.
 - 2) Inclined between 30 and 45 degrees.
 4. Test procedure:
 - a. Expose samples to ambient, outdoor conditions, and facing in a southern direction for maximum UV exposure for the full duration of the test.
 5. Adhesion test results:
 - a. Based on 8 pulls per test period with the 3 lowest pulls discarded.
 - b. Based an average of the 5 highest pulls and identify the values used.
 6. Record adhesion pulls and their failure mode.
 7. Repair sample after adhesion tests to prevent water from causing any effects on subsequent adhesion tests.

2.03 HEAT SHRINK SLEEVES

- A. Apply heat shrink sleeves in accordance with AWWA C216 and as specified in this Section.
- a. Heat shrink sleeves are restricted to buried pipeline joints and couplings. Application inside vaults or where exposed to the weather will not be allowed.
 - b. Store, handle, and apply field heat shrink sleeve coatings in accordance with AWWA C216 and as specified in this Section.
 - 1) Store sleeves in shipping box until use is required.
 - 2) Keep dry and sheltered from exposure to direct sunlight.
 - 3) Store off the ground or concrete floors.
 - 4) Maintain at a temperature between 60 and 100 degrees Fahrenheit in accordance with sleeve manufacturer's requirements.
 - 5) Acceptable types of heat shrink sleeves: Type I or II.
 - c. Shop prepare pipe joints for heat shrink sleeves with holdback primer as specified this Section.
2. Manufacturers: One of the following or equal:
- a. Canusa.
 - b. Covalence.
3. Engineer may approve use of "Weld After Backfill".
4. Sleeve width:
- a. Contractor to consider sleeve shrinkage and joint profile in determining sleeve width required.

- b. Overlapping of 2 or more heat shrink sleeves to achieve the necessary width on pipe joints will not be permitted without Engineer approval.
- 5. Sleeve overlap:
 - a. Minimum of 3 inches or as indicated on the Drawings.
- 6. Heat shrink sleeve material:
 - a. Cross-linked polyolefin wrap with a mastic sealant.
 - b. Nominal thickness: 85-mil.
 - c. Suitable for pipeline operating temperature.
 - d. Sleeve material recovery in accordance with sleeve manufacturer's requirements.
- 7. Filler mastic:
 - a. Adhere filler material to the pipe and heat shrink sleeve.
 - b. Size and type in accordance with sleeve manufacturer's requirements.
 - c. Provide filler material at step changes greater than 1/4-inch.
- 8. Apply filler material in a manner and of sufficient thickness that no tenting or voids remain under the heat shrink sleeve.
- 9. Joints subject to weld after backfill: Filler mastic melt temperature minimum of 500 degrees Fahrenheit.

PART 3 EXECUTION

3.01 GENERAL

- A. Apply coating and repair in accordance with manufacturer's requirements and as specified in this Section.
- B. Notify Engineer at least 3 days prior to application of coating products.
- C. Inspect coating prior to backfilling of pipe and associated items.
- D. Holdback of and coating from field-welded shall be as determined by designer for coating system specified.
- E. Unless otherwise indicated, coat exterior surfaces of pipe and fittings passing through structure walls from center of wall or from wall flange to end of underground portion.

3.02 DEFECTS IN COATINGS

- A. Engineer will identify defective coating to be field repaired in accordance with the applicable AWWA standard.
 - 1. Pipe joints exceeding the following defect maximum will be rejected.
 - a. Minor defects:
 - 1) No more than 1.5 per 100 square feet of surface area.
 - 2) 2 or more minor repairs within an 8-inches diameter circle will be considered a single repair.
 - 3) Repairs for adhesion testing will not be included in the total number of repairs.
 - 4) Repair in accordance with manufacturer's requirements.

- b. Major defects:
 - 1) No more than 3 major repairs on each pipe joint.
 - 2) No more than 30 percent repairs on the pipe surface area with defects.
- 2. Minor repairs:
 - a. Repairs less than 8 inches in the greatest dimension.
 - b. Repair in accordance with manufacturer's requirements.
- 3. Major repairs:
 - a. Repairs that exceed 8 inches in the greatest dimension.
 - b. Repair in accordance with manufacturer's requirements.

3.03 PLURAL COMPONENT POLYURETHANE

- A. Joints:
 - 1. Field applied coating or lining shall be of the same density, smoothness, and thickness as shop applied coating or lining.
 - 2. Comply with same application requirements as shop applied coating or lining.
 - a. Provide heating and/or dehumidification equipment as required to meet the environmental conditions necessary for proper coating application.

3.04 HEAT SHRINK SLEEVES

- A. Apply heat shrink sleeve joint coating system as indicated on the Drawings.
 - 1. No cement mortar coating is required.
 - 2. Do not use heat shrink sleeves on complex shapes like couplings, valves, flanges, and other similar shapes.
 - 3. Field prepare pipe joints in accordance with SSPC-SP 1 and SSPC-SP 3 to remove dirt, mud, oil, and grease prior to application of heat shrink sleeve.
 - 4. Temperature requirements:
 - a. Preheat pipe uniformly in accordance with sleeve manufacturer's requirements.
 - 1) Monitor pipe temperature using a surface temperature gauge, infrared thermometer, or color changing crayons.
 - 2) Protect preheated pipe from rain, snow, frost, or moisture with tenting or shields and do not permit the joint to cool.
 - 5. Fill cracks, crevices, gaps, and step-downs greater than 1/8 inch with filler mastic.
 - a. Apply filler material in accordance with the manufacturer's requirements.
 - 6. Overlap on a 1-inch-wide step from outer wrap to middle wrap to inner wrap.
 - 7. Completed joint sleeve fully adhered to the pipe and existing coating surface without voids.
 - a. Provide visible mastic beading along the full circumference of the sleeve.
 - b. Wrinkling or excessive burns on the sleeves are not acceptable.
 - c. Reject sleeves that do not meet requirements.
 - d. Make minor repairs using heat applied patch material specified for minor coating repairs.
 - 8. Allow the sleeve to cool before backfilling.
 - a. In hot climates, provide shading from direct sunlight.
 - b. Use water quenching only when permitted by the sleeve manufacturer.
 - 9. Bury heat shrink sleeves as soon as practical after installation. Limit exposure to direct sunlight in accordance with manufacturer's requirements.

10. Reject heat shrink joint coatings which have become wrinkled or disbanded because of prolonged exposure to UV light or thermal cycling.
11. Double coating of defective heat shrink coatings will be permitted if the second sleeve is wider to adhere directly to the pipe.

END OF SECTION

SECTION 10_14_00

SIGNAGE

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Plastic and metal signs for building and Site use.
 - 2. Room signage.
 - 3. Dimensional characteristics.
 - 4. Interior and exterior panel signs.
 - 5. Allowable floor load signs.
- B. All signage provided shall comply with City of Thornton standards.

1.02 REFERENCES

- A. American National Standards Institute (ANSI):
 - 1. Z535.1 - Safety Colors.
 - 2. Z535.2 - Environmental and Facility Safety Signs.
- B. National Fire Protection Association (NFPA):
 - 1. 704 - Standard System for the Identification of the Hazards of Materials for Emergency Response.

1.03 SUBMITTALS

- A. Furnish Submittals as specified in Section 01_33_00 - Submittal Procedures.
- B. Product data:
 - 1. Manufacturer's data indicating sign type, style, and color.
- C. Shop Drawings:
 - 1. Include lists of sign types, sizes, text, colors, and locations.
- D. Samples: Include actual materials.
- E. Manufacturer's installation instructions.

1.04 QUALITY ASSURANCE

- A. Obtain each sign type indicated from one source from a single manufacturer.
- B. Regulatory requirements: Provide signage in accordance with Americans with Disabilities Act as published in the Federal Register, Volume 56, No. 144, Friday, July 26, 1991.

PART 2 PRODUCTS

2.01 SAFETY SIGNS

- A. General:
 - 1. Colors: In accordance with ANSI Z535.1.
 - 2. Design: In accordance with ANSI Z535.2.
 - 3. 40-mil thick aluminum with baked enamel finish.
 - 4. Fasteners: Round head stainless steel bolts or screws.
- B. Manufacturers: One of the following or equal:
 - 1. Emedco.
 - 2. Seton Name Plate Co., Special Wording.
- C. Danger signs:
 - 1. Background: White.
 - 2. Heading: White lettering on red oval with white border in black rectangular panel.
 - 3. Message: Black lettering on white.
 - 4. Size: As scheduled.
- D. Caution signs:
 - 1. Background: Yellow.
 - 2. Heading: Yellow lettering on black rectangular panel.
 - 3. Message: Black lettering on yellow.
 - 4. Size: As scheduled.
- E. Safety instruction signs:
 - 1. Background: White.
 - 2. Heading: White lettering on green rectangular panel.
 - 3. Message: Black lettering.
 - 4. Size: As scheduled.
- F. Warning signs:
 - 1. Background: Orange.
 - 2. Heading: Black lettering on orange diamond in black rectangular panel.
 - 3. Message: Black lettering on orange.
 - 4. Size: As scheduled.
- G. Notice information signs:
 - 1. Background: White.
 - 2. Heading: White lettering on blue rectangular panel.
 - 3. Message: Black lettering.
 - 4. Size: As scheduled.
- H. See Attachment A - Safety Signage Schedule for specific sign size, location, text, and quantity.

PART 3 EXECUTION

3.01 PREPARATION

- A. Protect adjacent surfaces which may be damaged by installation of signs.
- B. Prepare substrates in accordance with the sign manufacturer's instructions.
- C. Remove scale, dirt, grease, and other contaminants from substrates.

3.02 INSTALLATION

- A. Install signs in accordance with the sign manufacturer's instructions.
- B. Fasten signs securely in level, plumb, and true to plane positions.
- C. Install signs where indicated on the Drawings or as indicated in the Attachment.

END OF SECTION

ATTACHMENT A - SAFETY SIGNAGE SCHEDULE

Signage

10_14_00-4

203505

CO/Thornton/203505-100000/04 Design/04 Specs/Carollo/SWPS/10_14_00 (IFB2)

Thornton Water Project (12-777XP)

Source Water Pump Station

May 2026

SAFETY SIGNAGE SCHEDULE

A. NON-POTABLE WATER:

1. Location: At non-potable water hose valves inside the pump station.
2. Height: To be coordinated with Owner.
3. Size: 10 inches wide by 7 inches high.
4. Heading: DANGER
5. Wording: NON-POTABLE WATER
DO NOT DRINK

B. ROOM NAMES:

1. Location: On wall outside room adjacent to latch side of doors or when not enough space on latch side, on nearest adjacent wall.
2. Height: 60 inches above floor to center of sign.
3. Size: 6 inches square.
4. Colors: As selected by the City of Thornton.
5. Text: Sign per door describing room function.

C. REMOTELY CONTROLLED AUTOMATIC EQUIPMENT:

1. Location: On front and back of equipment that starts automatically by remote control.
2. Height: 60 inches above floor to center of sign.
3. Size: 6 inches square.
4. Heading: DANGER
5. Wording: THIS EQUIPMENT STARTS AUTOMATICALLY
BY REMOTE CONTROL

D. HIGH VOLTAGE WARNING:

1. Location: On front and back of equipment, adjacent to doors to rooms containing devices that operate at 600 volts or greater.
2. Height: 60 inches above floor to center of sign.
3. Size: Rectangular with 3-inch letters.
4. Heading: DANGER
5. Wording: HIGH VOLTAGE
KEEP OUT

E. Eye Wash Station:

1. Location: Next to the portable eye wash station.
2. Height: 54 inches above floor to center of sign.
3. Size: Rectangular with 3-inch letters.
4. Colors: White letters on green background.
5. Text: EMERGENCY EYE WASH
6. Arrow: Provide arrow pointing to the shower and eye wash.

SECTION 10_28_00

TOILET, BATH, AND LAUNDRY ACCESSORIES

PART 1 GENERAL

1.01 SUMMARY

- A. Section Includes:
 - 1. Public-use washroom accessories.
 - 2. Custodial accessories.

1.02 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Samples: For each exposed product and for each finish specified, full size:
 - 1. Approved full-size samples will be returned and may be used in the Work.
- C. Delegated Design Submittal: For grab bars:
 - 1. Include structural design calculations indicating compliance with specified structural-performance requirements.

1.03 INFORMATIONAL SUBMITTALS

- A. Sample warranties.

1.04 CLOSEOUT SUBMITTALS

- A. Maintenance data.

1.05 WARRANTY

- A. Manufacturer's Special Warranty for Mirrors: Manufacturer agrees to repair or replace mirrors that fail in materials or workmanship within specified warranty period.
 - 1. Warranty Period: 10 years from date of substantial completion.

PART 2 PRODUCTS

2.01 PERFORMANCE REQUIREMENTS

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

- B. Structural Performance: Design accessories and fasteners to comply with the following requirements:
 - 1. Grab Bars: Installed units are able to resist 250 pounds-force concentrated load applied in any direction and at any point.
- C. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - 1. ASI-American Specialties, Inc.
 - 2. Bobrick Washroom Equipment, Inc.
 - 3. Bradley Corporation.

2.02 PUBLIC-USE WASHROOM ACCESSORIES

- A. Toilet Tissue (Roll) Dispenser:
 - 1. Description: Double-roll dispenser.
 - 2. Mounting: Surface mounted.
 - 3. Operation: Noncontrol delivery with standard spindle.
 - 4. Capacity: Designed for 4-1/2- or 5-inch-diameter tissue rolls.
 - 5. Material and Finish: Stainless steel, ASTM A480/A480M No. 4 finish (satin).
- B. Grab Bar:
 - 1. Mounting: Flanges with concealed fasteners.
 - 2. Material: Stainless steel, 0.05 inch thick.
 - a. Finish: Smooth, ASTM A480/A480M No. 4 finish (satin).
 - 3. Outside Diameter: 1-1/2 inches.
 - 4. Configuration and Length: As indicated on Drawings.
- C. Mirror Unit:
 - 1. Frame: Stainless steel angle, 0.05 inch thick.
 - a. Corners: Welded and ground smooth.
 - 2. Size: As indicated on Drawings.
 - 3. Shelf:
 - a. Type: Integral, welded.
 - b. Depth: 5 inches.
 - 4. Hangers: Manufacturer's standard rigid, tamper and theft resistant.
- D. Hook:
 - 1. Description: Double-prong unit.
 - 2. Mounting: Exposed.
 - 3. Material and Finish: Stainless steel, ASTM A480/A480M No. 4 finish (satin).

2.03 CUSTODIAL ACCESSORIES

- A. Custodial Mop and Broom Holder:
 - 1. Description: Unit with shelf, hooks, holders, and rod suspended beneath shelf.
 - 2. Length: 36 inches.
 - 3. Hooks: Four.
 - 4. Mop/Broom Holders: Three, spring-loaded, rubber hat, cam type.

5. Material and Finish: Stainless steel, ASTM A480/A480M No. 4 finish (satin).
 - a. Shelf: Not less than nominal 0.05-inch-thick stainless steel.
 - b. Rod: Approximately 1/4-inch-diameter stainless steel.

2.04 FABRICATION

- A. Keys: Provide universal keys for internal access to accessories for servicing and resupplying. Provide minimum of six keys to Owner's representative.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Install accessories in accordance with manufacturers' written instructions, using fasteners appropriate to substrate indicated and recommended by unit manufacturer. Install units level, plumb, and firmly anchored in locations and at heights indicated.
 1. Remove temporary labels and protective coatings.
- B. Grab Bars: Install to comply with specified structural-performance requirements.

END OF SECTION

SECTION 10_44_00
FIRE PROTECTION SPECIALTIES

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes: Fire extinguishers.

1.02 REFERENCES

- A. ASTM International (ASTM):
1. E814-11a - Standard Test Method for Fire Tests of Penetration Firestop Systems.
- B. National Fire Protection Association (NFPA):
1. 10 - Standard for Portable Fire Extinguishers.
- C. Underwriters Laboratories, Inc. (UL):
1. 711 - Rating and Fire Testing of Fire Extinguishers.

1.03 SUBMITTALS

- A. Product data.
1. Extinguishers: Materials description for fire extinguishers; include ratings and classifications.
 2. Installation instructions for each product specified.

1.04 QUALITY ASSURANCE

- A. Manufacturer qualifications: Minimum 5 years with satisfactory performance record.

1.05 WARRANTY

- A. As specified in Section 01_78_36 - Warranties and Bonds.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. The following or equal:
1. Activar Construction Products Group - JL Industries.

2.02 FIRE EXTINGUISHERS

- A. Multi-purpose chemical type:
1. Extinguisher unit containing a fluidized and siliconized mono ammonium phosphate powder; nonconductive and nontoxic.

2. Construction: Heavy duty steel cylinder with metal valve and siphon tube, O-ring seal, replaceable valve stem seal, visual pressure gage, pull pin and upright squeeze grip.
3. Finish: Factory powder-coated: Red.
4. UL Effectiveness Rating in accordance with UL 711: Class A, B, and C fires.
5. UL Rating in accordance with UL 711: 4A-80BC.
6. Drawing will use the symbol FE for "Fire Extinguisher".

2.03 WALL BRACKETS

- A. Type: Standard as manufactured by fire extinguisher manufacturer.

2.04 ADDITIONAL OPTIONS

- A. Wall signs and cabinet lettering:
 1. Mounting direction: Vertical.
 2. Type: Decal lettering.
 3. Text: FIRE EXTINGUISHER.
 4. Color: Red.

2.05 FABRICATION

- A. Form cabinet enclosure with right angle inside corners and seams. Form perimeter trim.
- B. Pre-drill for anchors.
- C. Hinge doors for 180 degree opening.
- D. Weld, fill, and grind components smooth.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Install in accordance NFPA 10, Standard for Portable Fire Extinguishers.

3.02 LOCATIONS

- A. Install fire extinguisher mounting in wall brackets as indicated on the Drawings.

END OF SECTION

SECTION 23_05_00

COMMON WORK RESULTS FOR HVAC

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. General prescriptive, design, and performance requirements for products and mechanical equipment used to heat, ventilate, cool, or otherwise condition or distribute indoor air.
 - 2. Specific requirements for ductwork accessories:
 - a. Dampers and damper operators.
 - 3. Specific requirements for refrigerant piping.

1.02 REFERENCES

- A. Air-Conditioning, Heating, and Refrigeration Institute (AHRI):
 - 1. 210/240 - Performance Rating of Unitary Air-Conditioning and Air-Source Heat Pump Equipment.
 - 2. 270 - Sound Rating of Outdoor Unitary Equipment.
 - 3. 340/360 - Performance Rating of Commercial and Industrial Unitary Air Conditioning and Heat Pump Equipment.
 - 4. 430 - Performance Rating of Central Station Air-handling Unit Supply Fans.
- B. Air Movement and Control Association International, Inc. (AMCA):
 - 1. 11 - Certified Ratings Program Operating Manual.
 - 2. 210 - Laboratory Methods for Testing Fans for Certified Aerodynamic Performance Rating.
 - 3. 211 - Certified Ratings Program — Product Rating Manual for Fan Air Performance.
 - 4. 301 - Methods for Calculating Fan Sound Ratings from Laboratory Test Data.
 - 5. 311 - Certified Ratings Program — Product Rating Manual for Fan Sound Performance.
 - 6. 500 - Laboratory Methods of Testing Dampers for Rating.
 - 7. 511 - Certified Ratings Program Product Rating Manual for Air Control Devices.
- C. American Bearing Manufacturers Association (ABMA):
 - 1. 9 - Load Ratings and Fatigue Life for Ball Bearings.
 - 2. 11 - Load Ratings and Fatigue Life for Roller Bearings.
- D. American National Standards Institute (ANSI):
 - 1. Z21.47 - Gas Fired Central Furnaces (except Direct Vent Central Furnaces).

- E. American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE):
 - 1. Standard 15 - Safety Standard for Refrigeration System.
 - 2. Standard 52.2 - Methods of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size.
- F. American Society of Mechanical Engineers (ASME):
 - 1. RTP-1 - Reinforced Thermoset Plastic Corrosion-Resistant Equipment.
- G. ASTM International (ASTM):
 - 1. B32 - Standard Specification for Solder Metal.
 - 2. B75 - Standard Specification for Seamless Copper Tube.
 - 3. B280 - Standard Specification for Seamless Copper Tube for Air Conditioning and Refrigeration Field Service.
 - 4. B813 - Standard Specification for Liquid and Paste Fluxes for Soldering of Copper and Copper Alloy Tube.
 - 5. B828 - Standard Practice for Making Capillary Joints by Soldering of Copper and Copper Alloy Tube and Fitting.
 - 6. C1136 - Standard Specification for Flexible, Low Permeance Vapor Retarders for Thermal Insulation.
 - 7. D1784 - Standard Classification System and Basis for Specification for Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds.
 - 8. D1785 - Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120.
 - 9. D2466 - Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 40.
 - 10. D2467 - Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80.
 - 11. D2564 - Standard Specification for Solvent Cements for Poly(Vinyl Chloride) (PVC) Plastic Piping Systems.
 - 12. D2665 - Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Drain, Waste, and Vent Pipe and Fittings.
- H. National Bureau of Standards: NBS PS15-69 - Custom Contact-Molded Reinforced-Polyester Chemical-Resistant Process Equipment.
- I. National Electrical Manufacturers Association (NEMA):
 - 1. 250 - Enclosures for Electrical Equipment (1,000 V Maximum).
- J. National Fire Protection Association (NFPA):
 - 1. 70 - National Electrical Code (NEC).
 - 2. 90A - Standard for the Installation of Air Conditioning and Ventilating Systems.
- K. National Roofing Contractors Association (NRCA).
- L. International Association of Plumbing and Mechanical Officials (IAPMO):
 - 1. IS 3 - Installation Standard for Copper Plumbing Tube, Pipe, and Fittings.
- M. Sheet Metal and Air Conditioning Contractors National Association (SMACNA).

- N. Underwriters Laboratories, Inc. (UL):
1. 555 - Standard for Fire Dampers.
 2. 555C - Standard for Safety Ceiling Dampers.
 3. 555S - Standard for Smoke Dampers.
 4. 900 - Standard for Air Filter Units.
 5. 60335-2-40 - Safety Standard for Household and Similar Electrical Appliances.

1.03 SUBMITTALS

- A. Where items in this Section are components of equipment or systems specified in other sections, include data for this Section's components with the equipment or system Submittal.
- B. When products are specified in this Section but are not referenced in other Technical Sections, submit:
1. As specified in Section 01_33_00 - Submittal Procedures.
 2. Product data:
 - a. Sufficient to substantiate specified requirements.
 3. Description of coating system and instructions for field touch up and re-coating.

PART 2 PRODUCTS

2.01 GENERAL

- A. Technical Sections product requirements supersede conflicting requirements in this Section.
- B. As specified in Section 01_60_01 - Product Requirements.
- C. Electrical:
1. Components and assemblies.
 2. Carry UL listing marking.
 3. In accordance with NEC requirements.
- D. Fans:
1. Rated and labeled in accordance with AMCA 210 and AMCA 211.
 2. Belt drive systems:
 - a. Adjustable for minimum within 5 percent speed change.
 - b. Rated for 150 percent of maximum motor horsepower.
- E. Unitary air conditioners and heat pumps:
1. Rated in accordance with AHRI 210/240 or 340/360, AHRI 270, and AHRI 430.
 2. In accordance with ASHRAE Standard 15.
 3. Heating: Certified in accordance with ANSI Z21-47.
 4. Refrigerant:
 - a. Fully charged with R-454B.
 - b. Compliant with ASHRAE 15.
 - c. HFO refrigerant with global warming potential (GWP) of 700 or less.
 - d. Must have a refrigerant monitoring system and be rated in accordance with UL 60335-2-40.

- F. Filters:
 - 1. Media: UL 900 listed.
- G. Insulation and adhesives: In accordance with NFPA 90A requirements for flame spread and smoke generation.
- H. Factory coating: For equipment with factory coatings, manufacturer to supply 2 containers (each about a pint) of the paint for Contractor/Owner touch up.

2.02 DESIGN AND PERFORMANCE CRITERIA

- A. General:
 - 1. Environmental conditions as specified in Section 01_81_50 - Design Criteria.
 - 2. Provide instrumentation and controls to meet the equipment operating requirements as specified in Section 23_09_13 - Instrumentation and Control Devices for HVAC.
- B. Fans:
 - 1. Sharply rising pressure characteristics throughout the operating range and beyond the efficiency peak.
 - 2. Peak operating points to be as close as possible to the maximum efficiency and whose operating range is within the normal fan selection range.
 - 3. Bearings rated in accordance with ABMA 9 or 11 for a L10 life rating of not less than 50,000 hours.
 - 4. Total sound power levels in the 8 octave band range in accordance with AMCA 301, not to exceed the lesser of the following or the sones level indicated on the Drawings.

Sound Power Level, decibels levels referenced to 10 to 12 watts								
Frequency, Hz	63	125	250	500	1,000	2,000	4,000	8,000
General	100	98	94	88	84	84	78	75

- 5. Shall be in accordance with AMCA 11 and bear the AMCA Certified Ratings Program seal for air performance and sound performance according to AMCA 211 and AMCA 311.

- C. Unitary air conditioners and heat pumps:
 - 1. Outdoor noise levels in the 8 octave band ranges, as measured in accordance with AHRI 270 shall not exceed the following:

Octave Bands								
Unit Nominal Capacity (Tons)	63	125	250	500	1,000	2,000	4,000	8,000
0 to 5	64	70	71	74	74	71	67	67
12 and larger	84	88	84	83	84	78	72	68

- 2. Capable of starting and cooling from 45 to 125 degrees Fahrenheit ambient outdoor air temperature and exceeding the maximum load criteria of AHRI 210/240 or 340/360.

3. Heat pumps capable of starting and heating at or above 0 degrees Fahrenheit outdoor ambient air temperature.
4. Minimum cooling, Energy Efficiency Ratio (EER) and Integrated Energy Efficiency Ratio (IEER), as rated in accordance with AHRI 210/240 or 340/360 for split systems and packaged units is as follows:

Equipment Type	Net Cooling Cap (Btu per hour)	EER ⁽¹⁾	IEER ⁽²⁾
Air Cooled	<65,000	13.4	N/A
Air Cooled	>240,000 and <760,000	10.0	13.2
Notes: (1) Deduct 0.2 degrees from the required EER for units with a heating section other than electric resistance heat. (2) IEER is only applicable to equipment with capacity control in accordance with AHRI 340/360.			

5. Units with heating capabilities: Meet or exceed the following:
 - a. Annual fuel utilization efficiency: 80 percent.
 - b. Steady state efficiency: 80 percent.

D. Filters:

1. Efficiency: 45 to 50 percent dust spot efficiency when rated in accordance with ASHRAE Test Standard 52.2.

2.03 DAMPERS

A. General:

1. Type, style, and size as indicated on the Drawings.
2. Components: Include with each damper:
 - a. Type, frame, actuators, clips, connectors, and other accessories necessary for mounting.
 - 1) Manual actuators: Factory supplied locking quadrant on factory mounted stand-off bracket.
 - a) Bracket finish to match frame.
3. Leakage class, when specified, to be in accordance with AMCA 511 and product to bear AMCA Rating Seal for Air Leakage.
 - a. Blade seals to be mechanically attached.

B. Backdraft dampers (BDD):

1. BDD-1, Style 1; counterbalanced backdraft damper:
 - a. Manufacturers: One of the following or equal:
 - 1) Ruskin, Model CBD6.
 - 2) Greenheck.
 - b. Frame:
 - 1) Minimum depth: 2.25 inches.
 - 2) Minimum thickness: 0.125 inches.
 - 3) Material: 6063T5 aluminum.
 - 4) With insect screen and water stop.
 - c. Blades:
 - 1) Minimum thickness: 0.070 inches.
 - 2) Material: 6063T5 aluminum.
 - 3) High strength nylon bearings.

- 4) Elastomer edge seals.
- 5) Aluminum tie-bar.
- 6) Blades require no more than 4.25 inches clearance beyond frame when fully open.
- d. Counterbalance:
 - 1) Zinc plated bar on blades.
 - 2) Adjustable down to 0.01-inch wg opening.
- e. Finish:
 - 1) Mill.

2.04 DAMPER OPERATORS

- A. General: Provide manual damper operator for each damper furnished as indicated on the Drawings.
- B. Manual operators by damper manufacturer:
 - 1. Operate damper manually with a force not exceeding 20 pounds.
 - 2. Provide with locking quadrant.
 - 3. Provide 3/8 inch, or larger, square double-ended drive shaft adequate for required damper torque, with machined keyways allowing for mounting in 2 positions, 90 degrees apart.
 - 4. Provide sufficient number of operators for torque required to operate damper.

2.05 SCREENS

- A. Required on all fans and louvers unless otherwise indicated on the Drawings.
- B. Characteristics and features:
 - 1. Bird screen: 1/2-inch mesh by 14 gauge.
 - a. For exhaust applications.
 - 2. Insect screens: 18 by 14 mesh.
 - a. For intake applications.
 - 3. Screens and frames, same material as ductwork, hood, louver, fan, or equipment connected to screen.
 - 4. Screens secured in frames.

2.06 FLEXIBLE CONNECTORS

- A. Provide flexible duct connectors at connections to fans and other air movement equipment as indicated on the Drawings.
- B. FL-1, Duct to Duct Flexible Connection:
 - 1. Fabric shall be fire resistant, waterproof, mildew-resistant, and airtight.
 - a. At least 4 inches of fabric shall be exposed.
 - b. Flexible connections shall be in accordance with the requirements of UL and NFPA.

2. Interior locations:
 - a. Manufacturers: One of the following or equal:
 - 1) Flextech Engineering.
 - 2) Ventfabrics, Ventglas.
 - b. Fabric for flexible connections installed inside office areas shall be Neoprene coated glass fabric suitable for a temperature range of 20 to 180 degrees Fahrenheit and shall have a weight of at least 27 ounces per square yard and a thickness of 0.024 inches.

2.07 REFRIGERANT PIPING

- A. Seamless copper tube:
 1. Type:
 - a. Straight lengths: ASTM B75, USN Alloy C12200, H55 Temper.
 - b. Coiled lengths: ASTM B280, USN Alloy C12200, O60.
 - c. Outside diameter sized, minimum wall thickness in accordance with ASTM B280 and ASTM B75.
 2. Non-VRF system:
 - a. Solder: ASTM B32, Alloy Grade Sb5.
 - b. Flux: ASTM B813.

2.08 CONDENSATE DRAIN PIPING

- A. PVC:
 1. PVC pipe: Designation PVC 1120 in accordance with ASTM D1785 and appendices:
 - a. Pipe and fittings: Extruded from Type I, Grade 1, Class 12454 B material in accordance with ASTM D1784.
 - b. PVC pipe: Schedule 80 unless otherwise indicated on the Drawings.
 2. Fittings:
 - a. Supplied by the pipe manufacturer.
 - b. Pressure fittings: In accordance with ASTM D2466 or ASTM D2467.
 - c. DWV fittings: In accordance with ASTM D2665.
 3. Solvent cement: In accordance with ASTM D2564:
 - a. Manufacturers: The following or equal:
 - 1) Primer: IPS Corp Type P-70™.
 - 2) Cement: IPS Corp Type 724™ cement or cement certified by the manufacturer for chemical service.

2.09 PIPE INSULATION

- A. General:
 1. As specified in Section 01_60_01 - Product Requirements.
 2. Insulation thicknesses: In inches as specified in the following table.
 - a. Thickness shown is nominal.
 - b. Manufacturing tolerance of 15 percent variation is permissible.

Table 1. Required Insulation Thicknesses (Inches)		
Service Temperature Range⁽¹⁾	Nominal Pipe Diameters	
	1 Inch and Less	1.25 to 2 Inches
100 to 200 degrees Fahrenheit	1.5	1.5
40 to 100 degrees Fahrenheit	0.5	1.0
Notes: (1) As specified in Table 2. Insulation Schedule, at the end of this Section.		

B. Insulation, Type 1:

1. Manufacturers: One of the following or equal:
 - a. Aeroflex USA Inc., Aerocel® AC.
 - b. Armacell®, AP Armaflex.
2. Insulation material: Closed cell elastomeric insulation.
3. Minimum temperature range: -40 degrees Fahrenheit to 220 degrees Fahrenheit.
4. K-factor at 75 degrees Fahrenheit: Not more than 0.27 Btu-inch/hour-square feet-degrees Fahrenheit.
5. Fire ratings:
 - a. Flame spread: 25 or less.
 - b. Smoke density: 50 or less for insulation thicknesses up to 1.5 inches.
6. Joints: Seal with the manufacturer's recommended contact adhesive to form a continuous water barrier.

C. Insulation jackets:

1. Type 1:
 - a. Manufacturers: One of the following or equal:
 - 1) Johns Manville, Zeston® 2000 PVC.
 - 2) Proto Corp., LoSMOKE PVC.
 - 3) Speedline® Corp., Smoke-Safe™ PVC.
 - b. Material: Ultraviolet-resistant polyvinyl chloride jacketing, 20-mil minimum thickness.
 - c. Fire rating: 25 maximum flame spread, smoke developed 50 or less.
 - d. Color: White.
 - e. Overlap: 1 inch minimum at joints and fittings.
 - f. Joint seal: PVC solvent welded or adhesive as recommended by the manufacturer.
 - g. Fittings: Factory made with full thickness insulation.

D. Vapor barriers:

1. Type 1:
 - a. Material: White Kraft paper bound to aluminum foil in accordance with ASTM C1136, Type 1.
 - b. Permeability: 0.02 perms or lower.
 - c. Maximum flame spread rating: 25.
 - d. Edge seal: Pressure-sensitive tape lap seal.
 - e. Circumferential joints: 4-inch wide tape or 4-inch overlap with adhesive seal.
2. Type 2:
 - a. Manufacturers: One of the following or equal:
 - 1) Benjamin Foster, No. 30-76.

- 2) Childers Products, CP10/11 Vi-Acryn.
 - 3) Foster Products, 36-10/46-10 Weatherite.
 - 4) Insul-Coustic, No. I.C.-580.
- b. Material: Mastic.

E. Insulation schedule:

Table 2. Insulation Schedule					
Service Designation⁽¹⁾	Location⁽²⁾	Insulation Type	Jacket Type	Service Temp. °F⁽³⁾	Vapor Barrier
HVAC Refrigerant	Interior or Exterior	1	1	40 to 200	Required
HVAC Condensate	Interior or Exterior	1	1	Below 60	Required
Notes: (1) Refer to the Pipe Schedule in Section 40_05_00.01 - Common Work Results for General Piping for service designations. (2) Insulation jackets are not required for interior installations that are concealed. See definitions for description of concealed locations. (3) Unless noted otherwise, use service temperature range provided in this table to establish insulation thickness as required by Table 1.					

2.10 EQUIPMENT NAMEPLATES

- A. Provide a nameplate with the following markings, plainly visible after installation:
1. Manufacturer's name, trademark, or other descriptive marking to identify specific equipment.
 2. Where equipment is electrically powered:
 - a. Supply voltage, phase, frequency, and full-load current.
 - b. Power source or circuit ID.
 - c. Short-circuit current rating based on one of the following:
 - 1) Rating of a listed and labeled assembly.
 - 2) Rating established utilizing an approved method.

2.11 SHIPPING, SPARE PARTS, MAINTENANCE PRODUCTS, AND SPECIAL TOOLS

- A. As specified in Section 01_60_01 - Product Requirements.
- B. Inspect fasteners for proper tightness.
- C. Ship units in one piece (or modular, if required), factory assembled, piped, internally wired, and factory tested.
- D. Provide:
1. Filters: 2 extra (3 total) sets per each unit with filters.
 2. Sheaves and belts: 1 set for change-out for final balance per unit installed.
 3. Belts: 1 extra set for each unit installed as determined by final balance.
- E. Provide a 2-year supply of maintenance products as specified in the manufacturer's maintenance literature.

PART 3 EXECUTION

3.01 GENERAL

- A. Technical Sections execution requirements supersede conflicting requirements in this Section.
- B. As specified in Section 01_60_01 - Product Requirements.
- C. Inspect fasteners for proper tightness.
- D. Provide temporary closures for openings designed for airflow.

3.02 INSTALLATION

- A. Examine and verify details and sections as indicated on the Drawings, ascertain adequacy, and determine conflicts in dimensions and clearances.
 - 1. Take measurements and verify dimensions to ascertain fit of installation.
 - 2. Ascertain structural sufficiency to support installation.
 - 3. Ascertain that supports and openings are correctly located; otherwise cut new openings where required.
 - 4. Confirm specified thermostat or other controls are compatible with specified equipment.
- B. Install in accordance with the manufacturer's instructions.
 - 1. Electrical products installation in accordance with NFPA 70 NEC.
 - 2. If there are conflicts, the NEC supersedes the manufacturer's instruction.
 - a. Notify the Engineer of conflicts.
- C. Equipment supports and anchoring:
 - 1. General:
 - a. Set equipment so that connecting flanges, screwed connections, or flexible connections will meet without strain or distortion.
 - b. Equipment may not be grouted, nor equipment anchors finally tightened, until all service connections to equipment are complete and in satisfactory alignment with no strain transmitted to the equipment.
 - 2. Equipment supported on concrete slab:
 - a. Install equipment and secure in place as recommended by the manufacturer, as indicated on the Drawings, and as shown in approved anchoring details for that equipment.
 - b. Examine pads or supports and make required repairs, using means acceptable to the Engineer, prior to installation of equipment. Confirm:
 - 1) Correctly sized, regular, and even pads.
 - 2) Correct anchor bolt sizes and locations.
 - c. Accurately align and level equipment over stainless steel shims and wedges placed near anchor bolts.
 - d. Tighten anchor bolts against shims and wedges and re-check for level and alignment before placing grout.

- e. Place grout under equipment frame or base:
 - 1) Install non-shrink grout as specified in Section 03_60_00 - Grouting, unless otherwise required by the equipment manufacturer or indicated on the Drawings.
 - 2) Before grouting, install block outs around anchor bolts and shims to prevent grouting in those areas.
 - 3) Finish grout and cure for not less than 3 days.
 - 4) After initial curing, loosen anchor bolts and fill block outs with non-shrink cement grout.
 - 5) Finish and cure grout at block outs for not less than 3 days.
 - f. Tighten anchors against grout.
 - 3. Equipment supported on roof curb:
 - a. Install in accordance with the NRCA manual.
- D. Equipment and ducts:
- 1. Remove dust and debris before installation.
 - 2. Protect from dust and debris by covering openings with tape or plastic during installation and until equipment is operated.
 - 3. Adjust alignment of ducts to resolve conflicts with the work of other trades.
 - 4. Install and wire unitary air conditioners, controls, and thermostats in accordance with the manufacturer's recommendations.
 - 5. Provide flexible duct and flexible piping connections at connections to unitary air conditioners.
 - a. FL-1 Flexible Connections:
 - 1) Install at building expansion joints and as indicated on the Drawings.
 - 2) Install with collar and metal band to form airtight joints.
 - 3) Install with minimum 4 inches of slack in fabric.
 - 4) Install with minimum 3 inches of specified material on each side of fabric.
 - 5) Exterior locations: Install sheet metal weather cover over fabric.
 - 6) Duct alignment shall be a maximum of 1/2-inch offset.
 - 7) Minimum/maximum gap shall be 2 inches and 6 inches.
 - 8) Lap longitudinal joints and glue in accordance with the manufacturer's recommendations.
 - 6. Lubrication lines and fittings:
 - a. Support and protect lines from source to point of use.
 - b. Fittings:
 - 1) Bring to outside of equipment in manner such that fittings are readily accessible from outside without necessity of removing covers, plates, housings, or guards.
 - 2) Mount together wherever possible using factory-mounted multiple fitting assemblies securely mounted, parallel with equipment lines, and protected from damage.
 - 7. Remove dust and debris from ductwork and equipment at completion of installation.
 - 8. Set grilles, dampers, and diffusers to achieve flows and flow patterns indicated on the Drawings.
- E. Refrigerant piping:
- 1. Support copper tubing as specified in Section 40_05_07.01 - Pipe Supports and Section 40_05_07.03 - Preformed Channel Pipe Support System.

2. Clean copper lines with high-pressure air after first disconnecting piping at instruments, filters, pressure reducers, valve operators, and other special devices.
 3. Installation of copper tubing:
 - a. In accordance with ASTM B828 and IAPMO IS 3.
 - b. In straight runs, supported at intervals close enough to avoid sagging.
 - c. Make cuts square with a tubing cutter or with a 32-tooth hacksaw.
 - 1) Provide a sizing tool to correct distortions.
 4. Ream the inside of the tubing and remove burrs from the outside, holding the end of the tubing downward and preventing chips and fillings from entering the tubing.
 5. Perform flaring with a flare block and yoke type screw feed flaring tool:
 - a. After removing the tubing from the flare block, inspect both surfaces of the flare for splits, cracks, or other imperfections.
 - b. Where there are imperfections, cut off the imperfect flare and prepare a new flare.
 6. Insulate piping as specified in this Section.
- F. Gas, water piping, drains, and venting in accordance with the authority having jurisdiction and applicable codes.
- G. Completed equipment installations must have confirmation that:
1. Equipment is properly assembled.
 2. Equipment moves or rotates in the proper direction.
 3. Shafting, drive elements, and bearings are installed and lubricated in accordance with proper tolerances.
 4. No unusual power consumption, lubrication temperatures, bearing temperatures, or other conditions are observed.
 5. Installation meets the requirements for intended use as well as the specified vibration and noise tolerances.

END OF SECTION

SECTION 23_05_93

TESTING, ADJUSTING, AND BALANCING FOR HVAC

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Testing air systems installed as part of this Contract.

1.02 REFERENCES

- A. Associated Air Balance Council (AABC):
 - 1. National Standards Total System Balance.
- B. National Environmental Balancing Bureau (NEBB):
 - 1. Procedural Standards for Testing, Adjusting, and Balancing Environmental Systems.
- C. Sheet Metal and Air Conditioning Contractors' National Association (SMACNA):
 - 1. HVAC Systems - Testing, Adjusting, and Balancing.
- D. Testing, Adjusting, and Balancing Bureau (TABB):
 - 1. TAB Procedural Guide.

1.03 SUBMITTALS

- A. Resumes of proposed supervisor and personnel showing training and qualifications.
 - 1. Include courses, exams, or tests relating to HVAC testing - taken and passed.
- B. Testing plan:
 - 1. At least 30 days prior to starting field work.
 - 2. Set of report forms completed with design flow values and installed equipment pressure drops and required cubic feet per minute for air terminals.
 - 3. Heating, ventilating, and air conditioning system schematic similar to Figure 6-1 in SMACNA HVAC Testing, Adjusting, and Balancing.
 - 4. Complete list of instruments proposed to be used, organized in appropriate categories, with data sheets for each showing:
 - a. Manufacturer and model number.
 - b. Description and use when needed to further identify instrument.
 - c. Size or capacity range.
 - d. Latest calibration date.
 - 5. Proposed schedule for testing and balancing.
- C. Report:
 - 1. Not more than 45 days prior to the Contractor's request for final inspection, submit the draft report on applicable reporting forms.

2. At least 15 days prior to the Contractor's request for final inspection, submit 3 copies of final reports incorporating the Engineer's comments on the draft report.
3. List of instruments used and last date of calibration of each.
4. Procedures followed for testing, adjusting, and balancing.
5. Identification and succinct description of systems included in report.
6. Initial balance test results made with dampers and air control devices in full open positions.
7. Description of final locations and sizes, including opening area and dimensioned configuration of orifices and other restrictions used to achieve final balanced flows.
8. Description of final location and opening positions of dampers, registers, louvers, and valves.
9. Schematics of systems included in report; use schematics as part of testing, adjusting, and balancing report to summarize design and final balanced flows.
10. Testing, adjusting, and balancing report forms.
11. Final field results established for system balancing, including airflow, fan speeds, and fan static pressures at the fan inlet and outlet.
12. Appendices.
 - a. Raw field data taken during testing.
 - b. Sample calculation sheet for each type of calculation made to convert raw field data to final results.
 - c. Initial air balance results with dampers and registers in full open position; include airflow at all inlets and outlet, initial fan speed, and fan suction and discharge pressures.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION

- A. Work of testing, adjusting, and balancing of heating, ventilation, and air conditioning systems to be by an independent testing agency and a certified member in good standing with AABC, NEBB, or TABB.
- B. Field testing to be performed or directly supervised by personal who have passed a test and balance course or exam and is an AABC, NEBB, or TABB certified supervisor.

3.02 PREPARATION

- A. Prior to start of testing, adjusting, and balancing, verify that:
 1. System installation is complete in accordance with the requirements for completed equipment installations specified in Section 23_05_00 - Common Work Results for HVAC and capable of full operation.
 2. Outside conditions are within reasonable range relative to design conditions.
 3. Lighting fixtures are energized.

4. Special equipment such as computers, laboratory equipment, and electronic equipment are in full operation.
5. Requirements for preparation for testing and balancing have been met for elements of each system which require testing.

3.03 FIELD QUALITY CONTROL

- A. Test, adjust, and balance each separate complete heating, ventilating, and air conditioning systems.
 1. Include existing heating, ventilating, and air conditioning components when affected by the Work.
- B. Perform testing, adjusting, and balancing cycles until airflows meet acceptance criteria.
 1. Ascertain airflow balance between overall requirements and flow in individual supply and exhaust grilles.
- C. Initial testing, adjusting, and balancing:
 1. Test each system with dampers, grilles, orifices, and other variable airflow devices in their full open position; measure and report initial airflows, fan speed, and fan static pressures at fan inlet and outlet.
 2. Adjust total system flow downward or upward by adjusting fan speed until one inlet or outlet is at indicated flow and all other flows exceed indicated flows.
 3. Adjust fan speed by changing fan drives or sheaves as necessary.
- D. Subsequent testing, adjusting, and balancing:
 1. Perform adjustments by adjusting dampers, louvers, or size of orifices or plates.
 2. Measure and record air volume discharged at each inlet and outlet and adjust air inlets and outlets to design air volumes within 0 to 5 percent over design rates.
 3. Adjust fan speeds and motor drives within drive limitations, for required air volume.
 4. Measure air flow and static pressures and adjust air supply and exhaust fan units to deliver at least 100 to 105 percent of the design air volume.
 5. Measure and record static air pressure conditions on fans, including filter and coil pressure drops and total pressure across the fan.
 6. Evaluate building and room pressure conditions to determine adequate supply and return air conditions.
 7. Evaluate space and zone temperature of conditions to determine adequate performance of the systems to maintain temperatures without draft.
 8. Permanently mark final balance positions of balancing dampers.
- E. Develop heating, ventilating, and air conditioning system schematics similar to Figure 6-1 in SMACNA Testing, Adjusting, and Balancing.
- F. Accurately record the required data on AABC, NEBB, or TABB test and balance report forms.
- G. Measure amperage draw of fan and pump motors at final balance.

- H. Test primary source equipment in accordance with AABC, NEBB, or TABB procedures.
 - 1. Primary source equipment includes items listed in this Section not previously tested as part of this testing, adjusting, and balancing work.
 - 2. Complete appropriate AABC, NEBB, or TABB equipment test forms for each piece of equipment.
 - 3. Calculate cooling and heating capacities to show conformance with specified capacities.
 - 4. Adjust equipment as needed to deliver specified cooling and heating loads.
 - 5. Record final equipment performing characteristics and adjustment settings in the final design report.
- I. Testing, adjusting, and balancing acceptance criteria:
 - 1. Procedures successful and complete when heating, ventilating, and air conditioning systems and components are functioning properly and system air flows are within specified tolerances of design flows.

END OF SECTION

SECTION 23_07_13
DUCTWORK INSULATION

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Internal acoustical insulation for metal air ductwork systems.

1.02 REFERENCES

- A. ASTM International (ASTM):
 - 1. E84 - Standard Test Method for Surface Burning Characteristics of Building Materials.
 - 2. G21 - Standard Practice for Determining Resistance of Synthetic Polymeric Materials to Fungi.
- B. Sheet Metal and Air Conditioning Contractors National Association (SMACNA).

1.03 SUBMITTALS

- A. Furnish Submittals as specified in Section 01_33_00 - Submittal Procedures.
- B. Product data: As specified in Section 40_05_00.01 - Common Work Results for General Piping.

1.04 QUALITY ASSURANCE

- A. Comply with SMACNA ducting construction standards and the specified requirement, whichever is more stringent.

1.05 WARRANTY

- A. As specified in Section 01_78_36 - Warranties and Bonds.

PART 2 PRODUCTS

2.01 INTERNAL DUCTWORK INSULATION

- A. Insulation installed on the inside of ductwork.
- B. Manufacturers: One of the following or equal:
 - 1. Johns Manville, Linacoustic RC flexible duct liner or Permacoat Linacoustic R-300 rigid duct liner.
 - 2. Owens Corning, QuietR flexible duct liner or Fiberglass rigid duct liner.

- C. Type: Flexible or board type duct liner with 1 coated surface meeting the following:
 - 1. Thickness: As required to achieve the following R-values:
 - a. For exterior ducting, provide 2 inches minimum thickness to meet an installed value of R-8. Provide additional weatherproof exterior barrier covering.
 - b. For interior ducting in ceiling plenums, attics, or other unconditioned spaces, provide 2 inches minimum thickness to meet an installed value of R-6.
 - 2. Temperature range: 40 to 250 degrees Fahrenheit.
 - 3. Density: 1.5 pounds per cubic foot.
 - 4. Thermal conductivity: 0.25 Btu-inch per hour per square foot per degree Fahrenheit at 75 degrees Fahrenheit.
 - 5. Fire hazard classification in accordance with ASTM E84:
 - a. Flame spread: 25.
 - b. Smoke developed: 50.
 - 6. Service conditions: Velocities to 2,500 feet per minute.
 - 7. Acoustical performance: NRC of 0.55 minimum.
 - 8. Bacterial growth: None, in accordance with ASTM G21.
- D. Edge treatment: Provide leading edges with galvanized metal nosing; seal other edges with the manufacturer's recommended edge treatment.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Internal ductwork insulation:
 - 1. Provide rigid insulation on rectangular ducts carrying conditioned air that pass through outdoor or unconditioned spaces as indicated on the Drawings.
 - 2. Install with coated surface facing inside of duct; attach with adhesive to duct and provide fasteners spaced at not to exceed 12 inches transverse (perpendicular) to flow and 18 inches parallel (longitudinal) to flow; provide fasteners within 3 inches of transverse edges and 4 inches of longitudinal edges.
 - 3. Follow the manufacturer's published installation instructions.
 - 4. Install metal nosing on leading edges and seal other exposed edges with the manufacturer's edge treatment.

END OF SECTION

SECTION 23_09_13

INSTRUMENTATION AND CONTROL DEVICES FOR HVAC

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes: Controls for Heating, Ventilating, and Air Conditioning (HVAC) Systems.
- B. The Building Management System Contractor (BMSC) shall furnish and install a fully integrated system, incorporating direct digital control (DDC) for energy management and equipment monitoring. For any DDC controlled items, the Building Management System (BMS) shall be a distributed system of fully intelligent, standalone controllers operating in a multi-tasking, multi-user environment true peer-to-peer local operating network. The BAS shall include all software and hardware, Primary Field Controllers (PFC), Application Specific Controllers (ASC), sensors, control devices, actuators, installation, calibration, supervision, adjustments, and fine tuning necessary for a complete and fully operational system. Installation shall comply with local, state, and federal code requirements as applicable.
- C. BASC is responsible for all configuration and programming to provide monitoring and control points for each node identified on the control diagrams. The control sequences are described in the sequence of operation on the drawings and/or in the equipment specifications. Refer to the other Division 23 sections for manufacturer supplied equipment controllers.
- D. The BAS shall be configured to provide all control, sequences of operation, and systems monitoring as required by these specifications and by the drawings. Provide all required devices, sensors, hardware, software, wiring, controllers, etc. Including any required and not specifically addressed in this specification but required for system functionality. It shall be the responsibility of the BASC to provide a complete and functioning system.
- E. The new controls installed as part of the project shall be web accessible through a unique IP address. Full read-only access shall be provided to the owner prior to the start of functional testing.
- F. All control wiring shall be provided for a complete and operable system. All wiring shall be installed in accordance with nec and all local codes. Run control wiring parallel and Perpendicular to building lines; avoid diagonal runs. Electrical contractor shall provide 120-volt power source to junction boxes. BMSC shall furnish and install all additional 120-volt power to system as required. BMSC shall provide 24-volt step down control transformers and wiring for control devices as required.

1.02 REFERENCES

- A. CSA international (CSA).
- B. National electrical code (NEC).
- C. Restriction of certain hazardous substances (ROHS).
- D. National electrical manufacturers association (NEMA):
- E. 250 - Enclosures for Electrical Equipment (1,000 Volts Maximum).
- F. National fire protection association (NFPA):
- G. 90a - Standard for the Installation of Air-Conditioning and Ventilating Systems.
- H. Underwriters' laboratories, inc. (UL):
 - 1. 13 - Standard for Safety Power-Limited Circuit Cables.
 - 2. 268a - Standard For Smoke Detectors for Duct Application.
 - 3. 508 - Standard For Industrial Control Equipment.
 - 4. 1479 - Fire Tests of Through-Penetration Firestops.
 - 5. 1685 - Standard For Safety Vertical-Tray Fire-Propagation and Smoke-Release Test for Electrical and Optical-Fiber Cables.

1.03 DEFINITIONS

- A. Abbreviations:
 - 1. ASC: Application Specific Controller.
 - 2. BMS: Building Management System.
 - 3. BMSC: Building Management System Contractor.
 - 4. DDC: Direct Digital Control.
 - 5. GUI: Graphical User Interface.
 - 6. I/O: Input/Output.
 - 7. LAN: Local Area Network.
 - 8. LNS: Lonworks Network Services.
 - 9. MS/TP: Master-Slave/Token-Passing.
 - 10. PC: Personal Computer.
 - 11. PFC: Primary Field Controller.
 - 12. PID: Proportional Plus Integral Plus Derivative.
 - 13. POT: Portable Operator's Terminal.
 - 14. RTD: Resistance Temperature Detector.
 - 15. RF: Radio Frequency.
 - 16. SCT: Software Configuration Tool.
 - 17. SNVT: Standard Network Variable Type.
 - 18. TCP/IP: Transport Control Protocol/Internet Protocol.
 - 19. UPS: Uninterruptible Power Supply.
 - 20. USB: Universal Serial Bus.
- B. NEMA:
 - 1. Type 1 enclosure in accordance with NEMA 250.
 - 2. Type 3 enclosure in accordance with NEMA 250.

3. Type 3R enclosure in accordance with NEMA 250.
4. Type 4 enclosure in accordance with NEMA 250.
5. Type 4X enclosure in accordance with NEMA 250.

1.04 SUBMITTALS

- A. Submit as specified in Section 01_33_00 - Submittal Procedures.
- B. Product data: As specified in Section 23_05_00 - Common Work Results for HVAC.
- C. Shop drawings: Include but not limited to the following in the project's control system drawing set:
 1. Control system drawings title sheet.
 2. List of I/O points.
 3. Control system components list.
 4. Valve and damper schedules.
 5. Control system schematics.
 6. HVAC equipment electrical ladder diagrams.
 7. Component wiring diagrams.
 8. Terminal strip diagrams.
 9. Communication architecture schematic.
 10. Sequence of Operation.
 11. Equipment data cut sheets.
 12. Sample color graphics for each equipment type.
 13. All icons and legend of graphic symbols.
- D. Product data: include manufacturer's technical literature for each control device. Indicate dimensions, capacities, performance characteristics, electrical characteristics, finishes for materials, and installation and startup instructions for each type of product indicated.
 1. DDC system hardware: bill of materials of equipment indicating quantity, manufacturer, and model number. Include technical data for operator workstation equipment, interface equipment, control units, transducers/transmitters, sensors, actuators, valves, relays/switches, control panels, and operator interface equipment.
 2. Control system software: include technical data for operating system software, operator interface, color graphics, and other third-party applications.
 3. Controlled systems: instrumentation list with element name, type of device, manufacturer, model number, and product data. Include written description of sequence of operation including schematic diagram. Control system software: list of color graphics indicating monitored systems, data (connected and calculated) point addresses, output schedule, and operator notations.
 4. Controlled systems:
 - a. Schematic diagrams of each controlled system with control points labeled and control elements graphically shown, with wiring.
 - b. Scaled drawings showing mounting, routing, and wiring of elements including bases and special construction.
 - c. Written description of sequence of operation including schematic diagram.
 - d. Points list.

- E. Operation and maintenance data: for HVAC instrumentation and control system to include in emergency, operation, and maintenance manuals. In addition to items specified in division 01 section "operation and maintenance data," include the following:
1. Index sheet, listing contents in alphabetical order.
 2. Maintenance instructions and lists of spare parts for each type of control device and compressed-air station.
 3. Manufacturer's equipment parts list of all functional components of the system, auto-cad compatible disk of system schematics, including wiring diagrams.
 4. Auto-cad compatible as-built interconnection wiring diagrams. Interconnection wiring diagrams shall have identified and numbered system components and devices.
 5. Keyboard illustrations and step-by-step procedures indexed for each operator function.
 6. Inspection period, cleaning methods, cleaning materials recommended, and calibration tolerances.
 7. Calibration records and list of set points.
 8. Description of sequence of operations.
 9. Operator's manual.
 10. Trunk cable schematic showing remote electronic panel locations, and all trunk data.
 11. List of connected data points, including panels to which they are connected and input device.
 12. Conduit routing diagrams.
 13. Software configuration tool.
 14. Custom programming tool on CD.

1.05 INFORMATIONAL SUBMITTALS

- A. Product Certificates:
1. Data communications protocol certificates: certifying that each proposed DDC system component complies with ASHRAE 135.
- B. Software and firmware operational documentation: include the following:
1. Software operating and upgrade manuals.
 2. Program software backup: on a magnetic media or compact disc, complete with data files.
 3. Device address list.
 4. Printout of software application and graphic screens.
 5. Software license required by and installed for DDC workstations and control systems.
- C. Software upgrade kit: For Owner to use in modifying software to suit future systems revisions or monitoring and control revisions.
- D. Source quality-control reports.
- E. Field quality-control reports.
- F. Sample Warranty: For manufacturer's warranty.

1.06 QUALITY ASSURANCE

- A. The control system shall be designed in accordance with UL and CSA standards.
- B. Installer qualifications: automatic control system manufacturer's authorized representative who is trained and approved for installation of system components required for this project.
 - 1. Submit documentation certifying the controls contractor performing the work has completed at least three DDC systems installations of a similar design to this project and programmed similar sequences of operation for at least two years.
 - 2. The project shall be supervised by a controls specialist who has completed BACnet network design, installation, and training.
- C. Electrical components, devices, and accessories: listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- D. Materials and equipment shall be the catalogued products of manufacturers regularly engaged in production and installation of building automation systems, shall be manufacturer's latest standard design that complies with the specification requirements, and shall be supported by a local service organization.
- E. All electronic equipment shall conform to the requirements of FCC Regulation, Part 15, Section 15, Governing Radio Frequency Electromagnetic Interference and be so labeled.
- F. Delivery, storage, and handling:
 - 1. Handle, store, and protect equipment and materials to prevent damage before and during installation according to manufacturer's recommendations.
 - 2. Replace damaged or defective items.
 - 3. System software: update to latest version of software at project completion.
- G. The contractor shall verify all dimensions in the field and advise the Construction Manager of any discrepancy before performing work.

1.07 COORDINATION

- A. Coordinate location of thermostats, humidistats, and other exposed control sensors with plans and room details before installation.
- B. Coordinate supply of conditioned electrical branch circuits for control units and operator workstation.
- C. DDC system provider shall furnish and install:
 - 1. A fully integrated BACnet building automation system, UL listed, incorporating direct digital control (DDC) for energy management, equipment monitoring and control.
 - 2. Necessary conduit, wiring, enclosures, and panels, for all DDC temperature control equipment and devices. Installation shall comply with applicable local and national codes (see Section 01_41_00 - Regulatory Requirements).

3. All components and control devices necessary to provide a complete and operable DDC system as specified herein.
 4. All conduit and wiring for power to all DDC system devices, including but not limited to 120-volt, 24 volts AC, 24 volts DC, etc.
 5. DDC system provider shall be responsible for all electrical work associated with the DDC system and as called for on the drawings. This DDC system control wiring shall be furnished and installed in accordance with the Electrical requirements as specified in Division 16, the National Electric Code, and all applicable local codes.
 6. DDC System Provider shall furnish and install all LAN, WAN and Modbus Communication cables as required.
 7. DDC System Provider shall provide programming modifications necessary to fine tune sequences during commissioning and through warranty period of systems at no additional cost.
- D. Mechanical contractor provides:
1. All wells and openings for water and air monitoring devices, temperature sensors, flow switches and alarms furnished by DDC System Provider.
 2. Installation of all control valves furnished by DDC System Provider.
 3. Installation of control dampers external to air handling units furnished by DDC System Provider, and adjacent access doors for smoke; outdoor air, return air, exhaust air.
- E. Electrical contractor provides:
1. Electrical Contractor shall provide dedicated 120-volt, 20-ampere circuits and circuit breakers from normal and/or emergency power panel for each Direct Digital Controller. Run power circuit within 5 feet of equipment installed and connected by DDC System Provider.
 2. Wall mounted junction box and conduit to ceiling space for all room temperature sensors, relative humidity sensors and carbon dioxide sensors.

1.08 DELIVERY, STORAGE, AND HANDLING

- A. The system control products shall be stored and handled per manufacturer's recommendations.

1.09 SITE CONDITIONS

- A. Elevation and ambient conditions as specified in Section 01_81_50 - Design Criteria.

1.10 WARRANTY

- A. Special warranties: Warranty period begins at date of Project Acceptance or first date of Beneficial Use by the Owner:
1. One year: Parts and on-site labor for components, systems, and programming.
- B. Provide all services, materials, and equipment necessary for the successful operation of the entire control system for a period of one year after the date of Certificate of Contract Completion and Owner Operating Personnel training or Acceptance of Installation.

- C. The adjustment, required testing, and repair of the system includes all computer equipment, software, transmission, equipment and all sensors and control devices.
- D. The contractor shall have the ability to provide on-line support services. On-line support services shall allow the local subcontractor to monitor and control the Building's Automation System via an internet connection. This remote connection to the Building shall be within 2 hours of the time that the problem is reported. This coverage shall be extended to include normal business hours, after business hours, weekends, and holidays.
- E. If the problem cannot be resolved on-line by the local office, the national office of the building automation system manufacturer shall have the same capabilities for remote connection to the Building. If the problem cannot be resolved with on-line support services, the BASC shall dispatch the appropriate personnel to the job site to resolve the problem within 4 hours of the time that the problem is reported.

1.11 OPERATOR WORKSTATION REQUIREMENTS

- A. The operator workstation portion of the BAS shall consist of one or more full-powered configuration and programming workstations, and one or more web-based operator workstations. For this project provide a minimum of 10 concurrent operator users and 2 concurrent engineering users within the system.
- B. The programming and configuration workstation software shall allow any user with adequate permission to create and/or modify any or all parts of the BMS.
- C. Web-based workstations (webstations) shall have a minimum of 10 concurrent operator users.
- D. All configuration workstations shall be personal computers operating under the Microsoft Windows operating system. The application software shall be capable of communication to all network server controllers and shall feature high-resolution color graphics, alarming, trend charting. It shall be user configurable for all data collection and data presentation functions.
- E. A minimum of 1 physical workstation shall be allowed on the ethernet network. In this client/server configuration, any changes or additions made from one workstation will automatically appear on all other workstations since the changes are accomplished to the databases within the NSC. Systems with a central database will not be acceptable.

PART 2 PRODUCTS

2.01 CONTROL SYSTEM

- A. Manufacturers:
 - 1. Honeywell International Inc.: Tridium, as supplied by Control Solutions, Inc.

- B. A fully integrated and fully programmable BACnet Building Automation System (BAS), UL listed (UL916 and UL864 if applicable), incorporating Direct Digital Control (DDC) and pneumatic control for energy management, equipment monitoring and control.
- C. Control system shall consist of sensors, indicators, actuators, final control elements, interface equipment, other apparatus, accessories, and software connected to distributed controllers operating in Multiuser, multitasking environment on token-passing network and programmed to control mechanical systems. An operator workstation permits interface with the network via dynamic color graphics with each mechanical system, building floor plan, and control device depicted by point-and-click graphics.
- D. Local control units: modular, comprising processor board with electronically programmable, nonvolatile, read-only memory; and backup power source.
 - 1. Units monitor or control each i/o point, process information, and download from or upload to operator workstation or diagnostic terminal unit.
 - 2. Stand-alone mode control functions operate regardless of network status. Functions include the following:
 - a. Global communications.
 - b. Discrete/digital, analog, and pulse I/O.
 - c. Monitoring, controlling, or addressing data points.
 - 3. Local operator interface provides for download from or upload to operator workstation or diagnostic terminal unit.
 - 4. ASHRAE 135 compliance: control units shall use ASHRAE 135 protocol and communicate using ISO 8802-3 (Ethernet) datalink/physical layer protocol.
- E. I/O interface: Hardwired inputs and outputs may tie into system through controllers. Protect points so that shorting will cause no damage to controllers.
 - 1. Binary Inputs: Allow monitoring of on-off signals without external power.
 - 2. Pulse Accumulation Inputs: Accept up to 10 pulses per second.
 - 3. Analog Inputs: Allow monitoring of low-voltage (0 to 10 volts DC), current (4 to 20 mA), or resistance signals.
 - 4. Binary Outputs: Provide on-off or pulsed low-voltage signal, selectable for normally open or normally closed operation with three-position (on-off-auto) override switches and status lights.
 - 5. Analog Outputs: Provide modulating signal, either low voltage (0 to 10 volts DC) or current (4 to 20 mA) with status lights, two-position (auto-manual) switch, and manually adjustable potentiometer.
 - 6. Tri-State Outputs: Provide two coordinated binary outputs for control of three-point, floating-type electronic actuators.
 - 7. Universal I/O's: Provide software selectable binary or analog outputs.
- F. Power supplies: transformers with class 2 current-limiting type or overcurrent protection; limit connected loads to 80 percent of rated capacity. Dc power supply shall match output current and voltage requirements and be full-wave rectifier type with the following:
 - 1. Output ripple of 5.0 mV maximum peak to peak.

2. Combined 1 percent line and load regulation with 100-mic.sec. Response time for 50 percent load changes.
 3. Built-in overvoltage and overcurrent protection and be able to withstand 150 percent overload for at least 3 seconds without failure.
- G. Power Line Filtering: Internal or external transient voltage and surge suppression for workstations or controllers with the following:
1. Minimum dielectric strength of 1,000 volts.
 2. Maximum response time of 10 nanoseconds.
 3. Minimum transverse-mode noise attenuation of 65 dB.
 4. Minimum common-mode noise attenuation of 150 dB at 40 to 100 Hz.

2.02 WEB ACCESS

- A. DDC system shall be web compatible.
1. Web-compatible access to DDC system:
 - a. Operator workstation shall perform overall system supervision and configuration, graphical user interface, management report generation, and alarm annunciation.
 - b. DDC system shall support web browser access to building data. Operator using a standard web browser shall be able to access control graphics and change adjustable set points.
 - c. Any computer loaded with Microsoft Edge, either a district computer residing on the districts network or an off-site computer over the internet, will have the ability to access all functions of the BAS. Use of additional software is not acceptable.
 - d. An unlimited number of simultaneous users shall be able to access the server software.
 - e. Web access shall be password protected.

2.03 SYSTEM PERFORMANCE

- A. Comply with the following performance requirements:
1. Graphic Display: Display graphic with minimum 20 dynamic points with current data within ten seconds.
 2. Graphic Refresh: Update graphic with minimum 20 dynamic points with current data within eight seconds.
 3. Object Command: Reaction time of less than two seconds between operator command of a binary object and device reaction.
 4. Object Scan: Transmit change of state and change of analog values to control units or workstation within six seconds.
 5. Alarm Response Time: Annunciate alarm at workstation within 45 seconds. Multiple workstations must receive alarms within five seconds of each other.
 6. Program Execution Frequency: Run capability of applications as often as five seconds, but selected consistent with mechanical process under control.
 7. Performance: Programmable controllers shall execute DDC PID control loops, and scan and update process values and outputs at least once per second.

8. Reporting Accuracy and Stability of Control: Report values and maintain measured variables within tolerances as follows:
 - a. Temperature Differential: Plus or minus 0.25 degrees Fahrenheit (0.15 degrees Celsius).
 - b. Electrical: Plus or minus 5 percent of reading.
- B. Future expandability:
 1. DDC system size shall be expandable to an ultimate capacity of at least 2.0 times total I/O points indicated.
 2. Additional DDC controllers, I/O and associated wiring shall be all that is needed to achieve ultimate capacity. Initial network infrastructure shall be designed and installed to support ultimate capacity.
 3. Operator interfaces installed initially shall not require hardware and software additions and revisions for ultimate capacity.
- C. Environmental Conditions for Controllers, Gateways, Routers, Instruments and Actuators:
 1. Products shall operate without performance degradation under ambient environmental temperature, pressure and humidity conditions encountered for installed location.
 - a. Pressure: Pressure conditions normally encountered in the installed location.
 - b. Vibration: Vibration conditions normally encountered in the installed location.
 - c. Temperature:
 - 1) Products installed indoors in conditioned spaces: Ambient temperatures in the range of 32 degrees Fahrenheit to 131 degrees Fahrenheit.
 - 2) Products installed outdoors or in unconditioned indoor spaces: Ambient temperatures in the range of -20 degrees Fahrenheit to 150 degrees Fahrenheit.
 2. Products shall be protected with enclosures satisfying the following minimum requirements unless more stringent requirements are indicated. Products not available with integral enclosures complying with requirements indicated shall be housed in protective secondary enclosures. Installed location shall dictate the following NEMA 250 enclosure requirements:
 - a. Outdoors: Enclosures installed outdoors shall meet NEMA 250 Type 4X requirements.
 - b. Mechanical and electrical rooms: Enclosures located in mechanical or electrical rooms shall meet NEMA 250 Type 2 requirements.
 - c. Other locations: Enclosures in other locations including but not limited to occupied spaces, above ceilings and plenum returns shall meet NEMA 250 Type 4X requirements.
 3. Weathershields for sensors located outdoors shall prevent the sun from directly striking the sensor. The weathershield shall be provided with adequate ventilation so that the sensing element responds to the ambient conditions of the surroundings. The weathershield shall prevent rain from directly striking or dripping onto the sensor. Weathershields installed near or in outside air intake ducts shall be installed such that normal outside air flow does not cause rainwater to strike the sensor. Weathershields shall be constructed of unpainted aluminum or white PVC.

- D. Electric power quality:
 - 1. Power-Line Surges: Protect susceptible DDC system products connected to AC power circuits from power-line surges to comply with requirements of IEEE C62.41.
 - 2. Power conditioning: Protect susceptible DDC system products connected to AC power circuits from irregularities and noise rejection.
 - 3. Ground fault: Protect products from ground fault by providing suitable grounding. Products shall not fail due to ground fault condition.
- E. Backup power source:
 - 1. HVAC systems and equipment served by a backup power source shall have associated DDC system products that control such systems and equipment also served from a backup power source.
- F. Continuity of operation after electric power interruption:
 - 1. Equipment and associated factory-installed controls, field-installed controls, electrical equipment, and power supply connected to building normal and backup power systems shall automatically return equipment and associated controls to operating state occurring immediately before loss of normal power, without need for manual intervention by operator when power is restored either through backup power source or through normal power if restored before backup power is brought online.

2.04 UNITARY CONTROLLERS

- A. Unitized, capable of stand-alone operation with sufficient memory to support its operating system, database, and programming requirements, and with sufficient i/o capacity for the application.
 - 1. Configuration: Local keypad and display; diagnostic LEDs for power, communication, and processor; wiring termination to terminal strip or card connected with ribbon cable; memory with bios; and 72-hour battery backup.
 - 2. Operating system: Manage I/O communication to allow distributed controllers to share real and virtual object information and allow central monitoring and alarms. Perform scheduling with real-time clock. Perform automatic system diagnostics; monitor system and report failures.
 - 3. ASHRAE 135 compliance: Communicate using read (execute and initiate) and write (execute and initiate) property services defined in ASHRAE 135. Reside on network using MS/TP datalink/physical layer protocol and have service communication port for connection to diagnostic terminal unit.
 - 4. Enclosure: Waterproof rated for operation at 40 to 150 degrees Fahrenheit (5 to 65 degrees Celsius).

2.05 ANALOG CONTROLLERS

- A. Step Controllers: 6- or 10-stage type, with heavy-duty switching rated to handle loads and operated by electric motor.
- B. Electric, Outdoor-Reset Controllers: Remote-bulb or bimetal rod-and-tube type, proportioning action with adjustable throttling range, adjustable set point, scale range minus 10 to plus 70 degrees Fahrenheit (minus 23 to plus 21 degrees Celsius), and single- or double-pole contacts.

- C. Electronic Controllers: Wheatstone-bridge-amplifier type, in steel enclosure with provision for remote-resistance readjustment. Identify adjustments on controllers, including proportional band and authority.
 - 1. Single controllers can be integral with control motor if provided with accessible control readjustment potentiometer.
- D. Fan-Speed Controllers: Solid-state model providing field-adjustable proportional control of motor speed from maximum to minimum of 55 percent and on-off action below minimum fan speed. Controller shall briefly apply full voltage, when motor is started, to rapidly bring motor up to minimum speed. Equip with filtered circuit to eliminate radio interference.
- E. Receiver Controllers: Single- or multiple-input models with control-point adjustment, direct or reverse acting with mechanical set-point adjustment with locking device, proportional band adjustment, authority adjustment, and proportional control mode.
 - 1. Remote-control-point adjustment shall be plus or minus 20 percent of sensor span, input signal of 3 to 13 psig (21 to 90 kPa).
 - 2. Proportional band shall extend from 2 to 20 percent for 5 psig (35 kPa).
 - 3. Authority shall be 20 to 200 percent.
 - 4. Air-supply pressure of 18 psig (124 kPa), input signal of 3 to 15 psig (21 to 103 kPa), and output signal of zero to supply pressure.
 - 5. Gages: 2-1/2 inches (64 mm) in diameter, 2.5 percent wide-scale accuracy, and range to match transmitter input or output pressure.

2.06 FIELD DEVICES

- A. Furnish and install following field devices, all devices shall be approved for installation by all local, city and state authorities having jurisdiction.
- B. Space thermostats/temperature sensors:
 - 1. Space thermostats/temperature sensors shall be wall plate type with afterhours override button. All wall space thermostats/temperature sensors will be located as shown on the plans and will be mounted 48 inches above finished floor unless otherwise directed by the Authorized Owner's Representative. Provide a metal flush mount temperature sensor for single gang box mounting in public and unsupervised areas, such as corridors, vestibules, restrooms, and stairways. Protruding thermostats and temperature sensors are not acceptable.
 - 2. Communication and power wiring of all micro-controller-based thermostats will consist of only 2 conductors between the thermostat and the controller.
 - 3. The space temperature set point shall be operator adjustable at the thermostat within minimum and maximum limits. These limits shall be programmable and adjustable from the BAS both globally per building and individually per space thermostat.
- C. Temperature sensors - with accuracy of + 0.5 degrees Fahrenheit at 77 degrees Fahrenheit.
 - 1. Duct temperature sensors - precision platinum RTD element or thermister type. All duct cross sections greater than 10 sq. ft shall have serpentine averaging element to adequately average stratified air temperatures.

2. Low temperature detection thermostat - provide low-temperature protection thermostats of manual-reset type, with sensing elements 20 feet-0 inches in length downstream of hot water coil and upstream of chilled water coil. Provide thermostat designed to operate in response to coldest 1 foot-0 inches length of sensing element, regardless of temperature at other parts of element. Support element properly to cover entire duct width. Provide separate thermostats for each 25 sq. ft of coil face area or fraction thereof.
 3. Pipe immersion type - provide minimum three-inch immersion. Provide each sensor with a corresponding pipe-mounted sensor well, unless indicated otherwise. Sensor wells shall be stainless steel when used in steel piping, and brass when used in copper piping. Provide the sensor well with a heat-sensitive transfer agent between the sensor and the well interior.
- D. Humidity sensors: fully interchangeable calibration free element. Sensors shall be temperature compensated and have a minimum long-term stability of 1 percent per year.
1. Accuracy: + 2 percent rh at 77 degrees Fahrenheit from 0 to 90 percent rh and ± 3 percent from 90 to 100 percent rh, including hysteresis, non-linearity and repeatability.
 2. Range: 0 percent to 100 percent rh.
- E. Air differential pressure transmitter.
1. Range: Field selectable, suitable for application.
 2. Accuracy plus or minus 1 percent full scale combined linearity, hysteresis and repeatability.
 3. Output: Field selectable from 0 to 5 volts, 0 to 10 volts and 4-20mA.
- F. Current Sensing Switches - Variable Frequency Drive (VFD): Monitors positive status of variable speed motors with self-adjusting trip set point. Current sensing switches shall automatically compensate for effects of frequency and amperage changes associated with VFDs.
1. Amperage range: 3.5-135 amps at all frequency levels.
 2. Sensor Power: Induced.
 3. Output: Digital switch.
 4. Frequency range: 34 to 75 Hz belt loss indication and 5 to 34 Hz on/off status.
 5. Temperature range: 5 degrees Fahrenheit to 140 degrees Fahrenheit.
 6. Humidity range: 0 percent to 95 percent non-condensing.
 7. Trip set point: Self-calibrating.
- G. Current Sensing Switches - Constant Volume (CV): Monitors positive status of constant speed motors with adjustable trip set point.
1. Sensor power: Induced.
 2. Output: Digital switch.
 3. Temperature range: 5 degrees Fahrenheit to 140 degrees Fahrenheit.
 4. Humidity range: 0 percent to 95 percent non-condensing.
 5. Trip set point: Adjustable from 1 to 135 amperes.
 6. Hysteresis: 10 percent.
- H. 24-volt Manual Switches: Provide 24-volt switches indicated on the mechanical plans. 24-volt switches shall be rocker type and shall be wall mounted in a steel outlet box with metal wall plate.

- I. Power Monitor: 3-phase type with disconnect/shorting switch assembly, listed voltage and current transformers, with pulse kilowatt hour output and 4- to 20-mA kW output, with maximum 2 percent error at 1.0 power factor and 2.5 percent error at 0.5 power factor.
- J. Pressure Transmitters: Direct acting for gas, liquid, or steam service; range suitable for system; proportional output 4 to 20 mA.
- K. Smoke detectors: Refer to Section 28_46_13 - Fire Alarm Systems for requirements.

2.07 ELECTRICAL POWER DEVICES

- A. Current transformers:
 - 1. The current transformers shall be designed to be installed or removed without dismantling the primary bus or cables. The transformer shall be of a split core design.
 - 2. The core and windings shall be completely encased in a UL approved thermoplastic rated 94VA. No metal parts shall be exposed other than the terminals.
 - 3. The current transformers shall meet the following specifications:
 - a. Frequency limits: 50 to 400 Hz.
 - b. Insulation: 0.6 KV class, 10 KV BIL.
 - c. Accuracy: ± 1 percent at 5.0 to 25.0 VA accuracy class with U.P.F. burden.
 - d. Provide a disconnect switch for each current transformer.
- B. Relays:
 - 1. Relays other than those associated with digital output cards shall be general purpose, enclosed plug-in type with 8-pin octal plug and protected by a heat and shock resistant duct cover. Number of contacts and operational function shall be as required.
- C. Solid state relays (SSR): Input/Output isolation shall be greater than IOE9 ohms with a breakdown voltage of 1500V root mean square or greater at 60 Hz. The contact life shall be 10 by 10 e6 operations or greater. The ambient temperature range of SSRs shall be -20 to +140 degrees Fahrenheit. Input impedance shall not be less than 500 ohms. Relays shall be rated for the application. Operating and release time shall be for 100 milliseconds or less. Transient suppression shall be provided as an integral part of the relay.
- D. Contactors: Contactors shall be of the single coil, electrically operated, mechanically held type. Positive locking shall be obtained without the use of hooks, latches, or semi-permanent magnets. Contractor shall be double-break-silver-to-silver type protected by arcing contacts. The number of contacts and rating shall be selected for the application. Operating and release times shall be 100 milliseconds or less. Contactors shall be equipped with coil transient suppression devices.
- E. Surge and transient protection:
 - 1. Provide each digital controller with surge and transient power protection. Surge and transient protection shall consist of the following devices, installed externally to the controllers.

- F. Power line surge protection:
1. Provide surge suppressors on the incoming power at each controller or grouped terminal controllers.
 2. Surge suppressors shall be rated in accordance with UL 1449, have a fault indicating light, and conform to the following:
 - a. The device shall be a transient voltage surge suppressor, hard-wire type individual equipment protector for 120 VAC/1 phase/2 wire plus ground.
 - b. The device shall react within 5 nanoseconds and automatically reset.
 - c. The type and level of protection shall be selected by the controls contractor, unless noted otherwise.
 - d. The device shall have an indication light to indicate the protection components are functioning.
 - e. All system functions of the transient suppression system shall be individually fused and not short circuit the AC power line at any time.
 - f. Surge protection for Direct Digital Control Panels serving the boiler and chiller plants shall be a combination surge protector and noise filter such as Leviton 51020-0WM or approved equal, and located within the Direct Digital Control panel enclosure.
- G. Telephone and Communication Line Surge Protection:
1. Provide surge and transient protection for DDC controllers and DDC network related devices connected to phone and network communication lines, in accordance with the following:
 - a. The device shall provide continuous, non-interrupting protection, and shall automatically reset after safely eliminating transient surges.
 - b. The protection shall react within 5 nanoseconds using only solid-state silicon avalanche technology.
 - c. The device shall be installed at the distance recommended by its manufacturer.
- H. Controller Input/Output Protection:
1. Provide controller inputs and outputs with surge protection via optical isolation, metal oxide varistors (MOV), or silicon avalanche devices. Fuses are not permitted for surge protection.
- I. Wiring:
1. Provide complete less than 100 volts electrical wiring for the DDC system.
- J. Power Wiring:
1. All electrical wiring 100 volts and greater is furnished and installed by the electrical contractor. DDC system contractor to coordinate with electrical contractor.
 2. The following requirements are for field-installed wiring:
 - a. Wiring for 24 V circuits shall be insulated copper 18 AWG minimum and rated for 300 VAC service.

- K. Analog signal wiring:
 - 1. Field-installed analog signal wiring shall be 18 AWG single or multiple twisted pair.
 - a. Each cable shall be 100 percent shielded and have a 20 AWG drain wire.
 - 2. Each wire shall have insulation rated for 300 VAC service. Cables shall have an overall aluminum-polyester or tinned-copper cable-shield tape.

2.08 ENCLOSURES AND WEATHERSHIELDS

- A. Enclosures shall meet the following minimum requirements:
 - 1. Outdoors: enclosures installed outdoors shall meet NEMA 250 Type 4X requirements.
 - 2. Mechanical and Electrical Rooms: enclosures located in mechanical or electrical rooms shall meet NEMA 250 Type 2 requirements.
 - 3. Other locations: enclosures in other locations including but not limited to occupied spaces, above ceilings and plenum returns shall meet NEMA 250 Type 4X requirements.
- B. Weathershields for sensors located outdoors shall prevent the sun from directly striking the sensor. The weathershield shall be provided with adequate ventilation so that the sensing element responds to the ambient conditions of the surroundings. The weathershield shall prevent rain from directly striking or dripping onto the sensor. Weathershields installed near or in outside air intake ducts shall be installed such that normal outside air flow does not cause rainwater to strike the sensor. Weathershields shall be constructed of unpainted aluminum or white PVC.

2.09 IDENTIFICATION

- A. Component Identification Labeling:
 - 1. Using an electronic hand-held label maker with white tape and bold black block lettering, provide an identification label on the exterior of each new control panel, control device, actuator, and sensor.
 - a. Also provide labels on the exterior of each new control actuator indicating the (full) open and (full) closed positions. For labels located outdoors, use exterior grade label tape, and provide labels on both the inside and outside of the panel door or device cover.
 - 2. Acceptable alternatives are white plastic labels with engraved bold black block lettering permanently attached to the control panel, control device, actuator, and sensor. Have the labels and wording approved by the DDC system Owner prior to installation.

PART 3 EXECUTION

3.01 PREPARATION

- A. Before installation remove dust and debris from equipment and accessories.
- B. During installation and until equipment is operated, protect equipment and accessories from dust and debris.

3.02 SEQUENCE OF OPERATION

- A. See drawings for sequence of operation, points list and control diagrams.

3.03 FIELD QUALITY CONTROL:

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust field-assembled components and equipment installation, including connections, and to assist in field testing. Report results in writing.
- B. Perform the following field tests and inspections and prepare test reports:
 - 1. Operational Test: After electrical circuitry has been energized, start units to confirm proper unit operation. Remove and replace malfunctioning units and retest.
 - 2. Test and adjust controls and safeties.
- C. DDC Verification:
 - 1. Verify that instruments are installed before calibration, testing, and loop or leak checks.
 - 2. Check instruments for proper location and accessibility.
 - 3. Check instrument installation for direction of flow, elevation, orientation, insertion depth, and other applicable considerations.
 - 4. Check instrument tubing for proper fittings, slope, material, and support.
 - 5. Check installation of air supply for each instrument.
 - 6. Check flow instruments. Inspect tag number and line and bore size, and verify that inlet side is identified and that meters are installed correctly.
 - 7. Check pressure instruments, piping slope, installation of valve manifold, and self-contained pressure regulators.
 - 8. Check temperature instruments and material and length of sensing elements.
 - 9. Check control valves. Verify that they are in correct direction.
 - 10. Check air-operated dampers. Verify that pressure gages are provided and that proper blade alignment, either parallel or opposed, has been provided.
 - 11. Check DDC system as follows:
 - a. Verify that DDC controller power supply is from emergency power supply, if applicable.
 - b. Verify that wires at control panels are tagged with their service designation and approved tagging system.
 - c. Verify that spare I/O capacity has been provided.
 - d. Verify that DDC controllers are protected from power supply surges.
- D. Replace damaged or malfunctioning controls and equipment and repeat testing procedures.

3.04 DDC SYSTEM INTERFACE WITH EXISTING SYSTEMS

- A. Interface with Existing Systems:
 - 1. DDC systems shall interface existing systems to achieve integration

3.05 INSTALLATION

- A. Install as indicated on the Drawings, in accordance with NFPA 90A, and per the manufacturer's written instructions.
- B. Coordinate installation of HVAC control systems with other trades.
 - 1. Prior to installation, coordinate wiring and conduit requirements with electrical subcontractor.
- C. Mount remote annunciator and test station on wall near smoke detector.
 - 1. Devices shall be easily accessible from floor level.
 - 2. Label annunciator and test station.
- D. Provide all electrical work to support smoke detector.
 - 1. Coordinate with electrical subcontractor.
- E. Thermostat cable conduit installation:
 - 1. As specified in Electrical Sections 26_05_10 - General Requirements for Electrical, 26_05_00 - Common Work Results for Electrical, 26_05_18 - 600-Volt or Less Wires and Cables, and 26_05_33 - Conduits.
- F. Sensor and control station mounting:
 - 1. Where not otherwise indicated, mount 5 feet above floor or walking level.
 - 2. Provide insulating back plates when mounting is on an exterior wall or a wall adjoining an unconditioned space.
 - 3. Shield outside thermostats or sensors from the sun; provide thermostats with remote bulb and compensated capillary.
 - 4. Install locking covers where indicated on the Drawings.

3.06 TESTING

- A. Test witnessing: Witnessed.
- B. Test each control component and system as part of HVAC system testing, adjusting, and balancing as specified in section 23_05_93 - Testing, Adjusting, and Balancing for HVAC.

END OF SECTION

SECTION 23_31_13

METAL DUCTWORK

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Metal ductwork.

1.02 REFERENCES

- A. ASTM International (ASTM):
 - 1. B209 - Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate.
- B. Sheet Metal and Air Conditioning Contractors' National Association (SMACNA):
 - 1. HVAC Systems-Duct Design.
 - 2. HVAC Duct Construction Standards, Metal and Flexible.
- C. Underwriters Laboratories, Inc. (UL):
 - 1. 181A - Closure Systems for Use with Rigid Air Ducts.

1.03 SUBMITTALS

- A. Furnish Submittals as specified in Section 01_33_00 - Submittal Procedures.
- B. Product data:
 - 1. Duct and component material and details of construction.
 - 2. System layout, including floor and wall penetrations.
 - 3. Supports and anchoring details.
 - 4. Components used in the duct system, including turning vanes, dampers, flexible connections, and access doors.
- C. Shop Drawings.

1.04 WARRANTY

- A. As specified in Section 01_78_36 - Warranties and Bonds.

PART 2 PRODUCTS

2.01 GENERAL

- A. Materials:
 - 1. As specified in Section 01_60_01 - Product Requirements.
 - 2. Ducts:
 - a. Aluminum: Aluminum alloy 3003 H14 in accordance with ASTM B209.
 - 3. Reinforcing: Formed or extruded angles matching ductwork material.
- B. Changes in duct size:
 - 1. Use uniformly tapering sections.
 - 2. Taper not more than 1 inch in 5 inches of run unless otherwise indicated on the Drawings.
- C. Bends: With the exception of miter bends, inside radii of bends to be equal to or greater than the largest duct dimension.

2.02 DESIGN AND PERFORMANCE CRITERIA

- A. Pressure allowance:
 - 1. Sheet metal construction shall conform to a minimum pressure classification of 2 inches of water gauge, negative and positive pressure, unless otherwise indicated on the Drawings or specified.
 - 2. In accordance with the SMACNA HVAC Systems-Duct Design manual.
 - a. Sheet metal thicknesses: The greater of the SMACNA design or:

Minimum Gauge (B&S) for 2-inch Water Gauge Static Pressure			
Diameter or Largest Dimension of Rectangular Duct (Inches)	Galvanized Steel	Stainless Steel	Aluminum
Up to 12	24	24	21
13, 14	22	22	20
15 to 18	20	20	18
19, 20	18	18	16
21 to 26	16	16	15
Larger than 27	14	14	13

- b. Spacing of hangers and supports:
 - 1) In accordance with SMACNA but no greater than that indicated on the Drawings.
 - 2) 8 feet on center for ducts 18 inches and smaller in the largest dimension.
 - 3) 4 feet on center to ducts over 18 inches in the largest dimension.
 - c. Support connections:
 - 1) In accordance with SMACNA unless indicated on the Drawings.
 - 2) As a minimum, all support connections to metal or wood roofs at roof framing members only.
 - 3) No penetrations through roof deck, roof membrane, or connections to roof membrane.

2.03 COMPONENTS

- A. Duct sleeves:
 - 1. Install where ducts pass through concrete or masonry walls and slabs.
 - 2. Size: 2 inches larger than the duct or duct with external insulation.
 - 3. Flanges: 4-inches wide.
- B. Access openings:
 - 1. Install in locations for access to dampers, fusible links, controllers, and similar devices.
 - 2. Size: 2 inches less than duct size.
 - 3. Doors:
 - a. Gauge not less than duct sheet.
 - b. Provide continuous hinge and latch on outside.
 - 4. Gasket: Along door periphery.
 - 5. Visual panel: 1/8-inch thick, clear Plexiglas.
- C. Turning vanes:
 - 1. Install at 90-degree bends.
 - a. Square-turn elbows, smooth radius elbows, and splitters.
 - 2. Material: Same as ductwork.
 - 3. Type:
 - a. Single-blade vanes for duct widths less than 36 inches.
 - b. Airfoil type vanes for duct widths of 36 inches and greater:
 - 1) No trailing edge.
 - 4. Mounted in side rails.
 - 5. Size: 2-inch blades for ducts up to 18 inches, 4-1/2-inch blades for larger ducts.
- D. Flexible connectors:
 - 1. Install at connections to air handling equipment and at other locations indicated on the Drawings.
 - 2. As specified in Section 23_05_00 - Common Work Results for HVAC.

2.04 FABRICATION

- A. Fabricate ductwork to the configuration and outer dimensions indicated on the Drawings.
- B. Ductwork specified with insulation to be sized as indicated on the Drawings. Do not increase duct dimensions by thickness of insulation when internal insulation is specified.
- C. Do not utilize S clips, duct tape, or externally applied mastic on medium pressure duct systems.
- D. Do not use snap lock seams.

2.05 SHIPPING

- A. As specified in Section 01_60_01 - Product Requirements and Section 23_05_00 - Common Work Results for HVAC.

PART 3 EXECUTION

3.01 GENERAL

- A. As specified in Section 01_60_01 - Product Requirements and Section 23_05_00 - Common Work Results for HVAC.

3.02 INSTALLATION

- A. Hangers:
 - 1. Install as indicated on the Drawings.
 - 2. When hangers are not detailed, conform to SMACNA HVAC Systems - Duct Design Manual standards and the following requirements:
 - a. Rectangular ducts concealed in ceiling spaces:
 - 1) Use metal strap hangers.
 - 2) Fasten to sides of duct with 2 screws.
 - 3) Fasten to bottom of duct with 1 screw.
 - b. Rectangular ducts in exposed areas:
 - 1) Install shelf angle trapeze hangers or Unistrut type hangers.
 - c. Round ducts in exposed areas:
 - 1) Install 2 half-round bands with rods bolted to panels.
- B. Provide closed-cell neoprene gaskets at flanged joints.
- C. Tapes and mastics used to seal ductwork shall be listed and labeled in accordance with UL 181A and shall be marked.

3.03 FIELD QUALITY CONTROL

- A. Inspect ductwork under operating conditions.
 - 1. Correct audible leaks and leaks that can be felt with the hand.

END OF SECTION

SECTION 23_34_01

FANS

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Fans, motors, and accessories.

1.02 REFERENCES

- A. Abbreviations:
 - 1. As used in this Section and on the Drawings, abbreviations and Fan Schedule headings have the following meaning:
 - a. EF or EXF: Exhaust fan.
 - b. Hp: Fan motor horsepower.
 - c. SF or SPF: Supply fan.
 - d. Size: Nominal fan blade or wheel diameter in inches.
 - e. SP or ESP: Fan external static pressure in inches water column.
 - f. Type: Fan type as specified in this Section.
 - g. V/Ph: Fan motor voltage and power phases.
- B. Standards:
 - 1. Air Movement and Control Association International, Inc. (AMCA).
 - 2. American Bearing Manufacturers Association (ABMA):
 - a. 9 - Load Ratings and Fatigue Life for Ball Bearings.
 - b. 11 - Load Ratings and Fatigue Life for Roller Bearings.
 - 3. ASTM International (ASTM):
 - a. A108 - Standard Specification for Steel Bar, Carbon and Alloy, Cold-Finished.
 - b. D4167 - Standard Specification for Fiber Reinforced Plastic Fans and Blowers.
 - c. E84 - Standard Test Method for Surface Burning Characteristics of Building Materials.
 - 4. National Fire Protection Association (NFPA):
 - a. 820 - Standard for Fire Protection in Wastewater Treatment and Collection Facilities.
 - 5. National Roofing Contractors Association (NRCA).
 - 6. Occupational Safety and Health Administration (OSHA).

1.03 DELEGATED DESIGN

- A. As specified in Section 01_35_73 - Delegated Design Procedures.
- B. Anchoring and bracing.

1.04 SUBMITTALS

- A. Furnish Submittals as specified in Section 01_33_00 - Submittal Procedures.
- B. Product data:
 - 1. Materials.
 - 2. Primary and ancillary equipment.
 - 3. Sound power level in each of 8 octave bands and overall sones.
 - 4. Fan system layout, mechanical, electrical power, and control diagrams.
 - 5. Supports, vibration isolators, and seismic bracing calculations and details.
 - 6. Calculated fan vibration levels and field-testing method.
 - 7. Bearing life.
 - 8. Fan performance curves showing specified operating condition.
- C. Drawings:
 - 1. Component layout and identification.
 - 2. Views:
 - a. Front, side, rear elevations, and top and bottom views, with dimensions.
 - b. Connection locations, including electrical, mechanical, and other.
 - 3. Cut away drawings.
 - a. Parts list.
 - b. Material specification lists.
 - 4. Wiring, control schematics, control logic diagrams and ladder logic or similar for computer-based controls.
 - 5. Details for supports, isolators, and bracing.
- D. Delegated Design Submittals:
 - 1. Anchoring and bracing: Provide project-specific calculations based on support conditions and requirements to resist loads specified in Section 01_81_50 - Design Criteria.
 - a. To structures for equipment installed in structures designated as seismic design category C, D, E, or F.
 - b. For equipment installed outdoors.
 - c. For wall mounted equipment weighing 125 pounds or more.
- E. Manufacturer's recommendations for handling, storage, and installation.
- F. Nameplate data.
- G. Vendor operation and maintenance manuals: Manufacturer's standard instruction manual for operation and maintenance.
- H. Provide manufacturers reports on factory testing.

PART 2 PRODUCTS

2.01 GENERAL

- A. As specified in Section 23_05_00 - Common Work Results for HVAC.

2.02 DESIGN AND PERFORMANCE CRITERIA

- A. Provide instrumentation and controls to meet the equipment operating requirements as specified in Section 23_09_13 - Instrumentation and Control Devices for HVAC.

2.03 TYPE 4, SIDEWALL PROPELLER FANS

- A. Manufacturers: One of the following or equal:
 - 1. Greenheck, Model BAER.
 - 2. Loren Cook, similar series.
 - 3. Penn Ventilator, similar model.
- B. Characteristics:
 - 1. Wall-mounted, low noise propeller type, packaged unit.
 - 2. Statically and dynamically balanced propeller with aluminum blades, unless noted otherwise.
 - 3. Motor: Permanently lubricated; selected to avoid running in the service factor.
 - 4. Finishes: Provide 2.0 to 3.0-mils thick polyester powder coat or approved equal finish on fan and accessories.
- C. Accessories:
 - 1. Mounting brackets: Necessary for installation.
 - 2. Motor and fan side OSHA guards.
 - 3. Wall mount collar when necessary for.
 - 4. Dampers with damper guards when damper scheduled.
 - 5. Weather hood when scheduled.
 - 6. Provide other accessories as scheduled.

2.04 TYPE 5, CENTRIFUGAL CEILING EXHAUST FANS

- A. Manufacturers: One of the following or equal:
 - 1. Greenheck, Model SP.
 - 2. Loren Cook, similar series.
 - 3. Penn, similar series.
- B. Characteristics:
 - 1. Cabinet type centrifugal fan.
 - 2. Steel, forward-curved, squirrel-cage type wheel.
 - 3. Housing: Heavy gauge carbon steel housing.
 - 4. Access: Removable access panel.
 - 5. Finish: Galvanized fan, housing, and damper.
- C. Accessories:
 - 1. Exhaust grille, egg-crate pattern, aluminum, or PVC construction.
 - 2. Factory installed backdraft damper on discharge of fan.
 - 3. Provide other accessories as scheduled.

2.05 SOURCE QUALITY CONTROL

- A. Factory test fans listed on the Fan Schedule for proper operation, performance, and electrical controls.

2.06 SHIPPING, SPARE PARTS, MAINTENANCE PRODUCTS, AND SPECIAL TOOLS

- A. As specified in Section 01_60_01 - Product Requirements with additional requirements in Section 23_05_00 - Common Work Results for HVAC.
- B. Deliver units in 1 piece, factory assembled, internally wired, and lubricated.

PART 3 EXECUTION

3.01 GENERAL

- A. As specified in Section 01_60_01 - Product Requirements with additional requirements in Section 23_05_00 - Common Work Results for HVAC.

3.02 PREPARATION

- A. Anchoring and bracing to structures:
 - 1. Prepare equipment anchor setting template(s) and use to position anchors during construction of supporting structure(s).
 - 2. Install anchors of type and material indicated on approved anchoring designs.
 - 3. Install anchors with embedment indicated on approved anchoring designs.

3.03 INSTALLATION

- A. Install the equipment in accordance with the accepted installation instructions and anchorage details.

3.04 TESTING

- A. Test equipment performance and balance equipment as specified in Section 23_05_93 - Testing, Adjusting, and Balancing for HVAC.

3.05 FIELD QUALITY CONTROL

- A. Verify equipment operation and unit vibration is within the manufacturer's submitted maximum.

3.06 SCHEDULES

- A. As indicated on the Drawings.

END OF SECTION

SECTION 23_81_14
AIR CONDITIONING UNITS

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Split system units.
 - 2. Accessories.

1.02 REFERENCES

- A. Abbreviations:
 - 1. MERV - Minimum Efficiency Reporting Values.
- B. Standards:
 - 1. American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE):
 - a. Standard 15 - Safety Standard for Refrigeration Systems.
 - b. Standard 62.1 - Ventilation for Acceptable Indoor Air Quality.
 - 2. ASTM International (ASTM):
 - a. B117 - Standard Practice for Operating Salt Spray (Fog) Apparatus.
 - 3. Federal Specification (FS):
 - a. Standard 141 - Paint, Varnish, Lacquer and Related Materials: Methods of Inspection, Sampling and Testing.
 - 4. National Electrical Manufacturers Association (NEMA):
 - a. 250 - Enclosures for Electrical Equipment (1,000 V Maximum).
 - 5. Underwriters Laboratories, Inc. (UL):
 - a. 60335-2-40 - Safety Standard for Household and Similar Electrical Appliances.

1.03 DELEGATED DESIGN

- A. As specified in Section 01_35_73 - Delegated Design Procedures.
- B. Anchoring and bracing.

1.04 SUBMITTALS

- A. Furnish Submittals as specified in Section 01_33_00 - Submittal Procedures.
- B. Catalog cuts, bulletins, and brochures.
 - 1. Design features.
 - 2. Load capacities.
 - 3. Efficiency ratings.
 - 4. Dimensions.
 - 5. Weight: Shipping and operating.

- C. Shop Drawings:
 - 1. Component layout and identification.
 - 2. Views:
 - a. Front, side, rear elevations, and top and bottom views, with dimensions.
 - b. Connection locations, including electrical, mechanical, and other.
 - 3. Cut away drawings.
 - a. Parts list.
 - b. Material specification lists.
 - 4. Wiring, control schematics, control logic diagrams and ladder logic or similar for computer-based controls.
 - 5. Details for supports, isolators, and bracing.
- D. Delegated Design Submittals:
 - 1. Anchoring and bracing: Provide project-specific calculations based on support conditions and requirements to resist loads specified in Section 01_81_50 - Design Criteria.
 - a. To structures for equipment installed in structures designated as seismic design category C, D, E, or F.
 - b. For equipment installed outdoors.
- E. Engineering data:
 - 1. Manufacturer's published data for compressor, evaporator coil, condenser, evaporator fan, refrigerant, filter, etc.
 - 2. Maximum equipment vibration levels and field-testing method.
 - 3. Sound power level in each of 8 octave bands and overall sones.
 - 4. Fan performance curves showing specified operating condition.
 - 5. Bearing life.
- F. Manufacturer's recommendations for handling, storage, and installation.
- G. Nameplate data.
- H. Seismic certification.
- I. Vendor operation and maintenance manuals: Manufacturer's standard instruction manual for operation and maintenance.

1.05 WARRANTY

- A. As specified in Section 01_78_36 - Warranties and Bonds.
- B. Special warranty:
 - 1. Refrigerant compressors and closed or sealed refrigerant systems warranty duration: Provide 5-year warranty.
 - 2. Electric heaters warranty duration: Provide 5-year warranty.
 - 3. Gas fired heat exchangers warranty duration: Provide 10-year warranty.
 - 4. Evaporator and condensing coils warranty duration: Provide 5-year warranty.

PART 2 PRODUCTS

2.01 GENERAL

- A. As specified in Section 01_60_01 - Product Requirements with additional requirements in Section 23_05_00 - Common Work Results for HVAC.
- B. Supplied components of the unit shall be furnished and fully integrated by the unit system supplier:
 - 1. Provide piping, valves, dampers, sensors and wiring within the unit package.
 - 2. Provide a unit mounted control panel prewired on the unit to dampers and sensors within the unit.
- C. Motors:
 - 1. Totally enclosed.
 - 2. Voltage and phases as scheduled.
 - 3. Compressor motors:
 - a. Cooled by refrigerant gas passing through windings.
 - b. Provided with line break thermal and current overload protection.
 - 4. Fan and blower motors:
 - a. Permanently lubricated ball bearings.
 - b. Integral automatic reset thermal overload protection.
 - 5. Other requirements as specified.
- D. Electrical:
 - 1. Provide a single conduit connection in the unit for both power and control wiring.
- E. Refrigerant:
 - 1. Fully charged with R-454B.
 - 2. Compliant with ASHRAE 15.
 - 3. HFO refrigerant with global warming potential (GWP) of 700 or less.
 - 4. Must have a refrigerant monitoring system and be rated in accordance with UL 60335-2-40.

2.02 DESIGN AND PERFORMANCE CRITERIA

- A. As specified in Section 23_05_00 - Common Work Results for HVAC.
- B. Provide instrumentation and controls to meet the equipment operating requirements as specified in Section 23_09_13 - Instrumentation and Control Devices for HVAC.

2.03 SPLIT SYSTEM AIR CONDITIONING UNITS

- A. Manufacturers: One of the following or equal:
 - 1. Trane, TWE/TTA.
 - 2. Johnson Controls, similar series.
 - 3. Carrier, similar series.
- B. Basis of design, model, and series: As indicated on the Drawings.

- C. Refrigerant components:
 - 1. Refrigerant circuit, including:
 - a. Accumulator and filter/drier.
 - b. Compressor.
 - c. Thermostatic expansion valve.
 - d. Gauge ports.
 - e. Flow control valves.
 - f. Circuit feed system.
 - g. Service gauge connections with gauges on suction, discharge, and liquid lines to charge, evacuate, and contain refrigerant.
 - 2. Insulate refrigerant piping as specified in Section 23_05_00 - Common Work Results for HVAC.
- D. Compressors:
 - 1. Reciprocating or scroll type.
 - 2. Fully hermetically sealed, high efficiency, with internal and external vibration isolation.
 - 3. Equipped with high-pressure relief.
 - 4. Equipped with crankcase heater.
- E. Condenser fan:
 - 1. Propeller type, direct drive, aluminum blades, dynamically balanced, and vertical discharge.
 - 2. Permanently sealed ball bearings and permanently lubricated.
- F. Condenser coil:
 - 1. Seamless copper tubes with mechanically bonded aluminum plate fins.
 - 2. Coils, internal piping, and appurtenances:
 - a. Provide factory applied phenol-formaldehyde thermosetting resinous coating suitable for marine and corrosive environments.
 - 1) Coating shall meet, at a minimum, 1,000-hour salt spray exposure test in accordance with ASTM B117.
- G. Condenser unit casing:
 - 1. Manufactured of minimum 22-gauge galvanized steel, bonderized, corrosion protected, and exterior coated with a baked enamel finish interior primer coated.
 - a. Coating shall withstand FS Test Method Standard 141 (Method 6061) 500-hour salt spray test.
 - 2. Weatherproof design, reinforced, and braced for maximum rigidity.
 - 3. Provide gasketed removable panels or access doors to service equipment components and connections.
 - 4. Provide with:
 - a. Non-corrosive drain pan in accordance with ASHRAE Standard 62.1.
 - b. Minimum 3/4-inch horizontal drain connection.
 - c. Knockouts for utility and control connections.
 - d. Minimum 14-gauge steel roll formed base rail with lifting holes; provide support feet for roof mounting on units under 6 tons size.

- H. Controls and equipment safety features:
1. Provide unit controls for a complete and properly functioning system. As a minimum, provide the following:
 - a. Condenser fan controls.
 - b. Evaporator fan controls with time delay after compressor shutdown.
 - c. Code compliant economizer controls when required.
 - d. Motor contactors.
 - e. 24-volt control circuit and transformer unless otherwise indicated on the Drawings.
 - f. Manually reset circuit breakers.
 - g. 5-minute compressor cycle delay.
 - h. Check filter switch suitable for field connection remote alarm.
 - i. Provide with a low ambient cooling option.
 2. Equipment safety features, include:
 - a. High-pressure switch.
 - b. Compressor over-temperature and overcurrent.
 - c. Loss of charge/low pressure switch.
 - d. Freeze thermostat on evaporator.
 - e. Lock out protection.
 3. Provide dry-contacts for the following status and alarms:
 - a. Failed.
 - b. Running.
 - c. Dirty Filter.
 4. Provide the following input connection:
 - a. Smoke alarm shutdown.
 - b. HVAC supervisory control/enable.
 5. Interface to building HVAC controls:
 - a. Provide contacts and signals to operate unit with the HVAC control system as specified in Section 23_09_13 - Instrumentation and Control Devices for HVAC.
- I. Electrical:
1. Provide 15-amp, 120-volt, single-phase, ground fault interrupter convenience outlet at condenser unit; provide factory installed transformer, and independent fuse or breaker protection for outlet.
 2. Provide power disconnect switch at each piece of unit; mount disconnect in NEMA Type 4X enclosure if exterior to unit.
- J. Indoor air handling unit:
1. Indoor air section compartment: Insulated with minimum 1/2-inch thick, permanent, fireproof, odorless glass fiber material, and coated on the air side.
 2. Evaporator fan:
 - a. Belt driven, forward curved, double inlet, centrifugal type, steel with corrosion resistant finish, statically and dynamically balanced.
 - b. Permanently sealed ball bearings and permanently lubricated.
 - c. Adjustable pitch motor pulley.
 - d. Where the condenser fan is 7.5 horsepower or larger, provide a variable speed or 2-speed fan.
 3. Provide with ducted discharge as indicated on the Drawings.
 4. Provide with direct expansion coil aluminum drip pan and polyvinyl chloride drainpipe.

5. Filter section:
 - a. Provide with at least MERV 13 rating.
 - b. Provide low velocity, 2-inch thick, pleated filters of commercially available sizes accessible through front of unit.
 - c. Provide an expanded metal return air grill to cover filter section.
 - d. Filter face velocity shall be in accordance with the manufacturer's recommendations.
 - e. Filters for any one unit shall be the same size.
 - f. Manufacturers: One of the following or equal:
 - 1) American Air Filter.
 - 2) Camfil.
6. Provide manufactured fabricated equipment stand when scheduled.
7. Evaporator coil:
 - a. Seamless copper tubes with mechanically bonded aluminum plate fins.
 - b. Coils, internal piping, and appurtenances:
 - 1) Provide factory applied phenol-formaldehyde thermosetting resinous coating suitable for marine and corrosive environments.
 - a) Coating shall meet, at a minimum, 1,000-hour salt spray exposure test in accordance with ASTM B117.

2.04 ACCESSORIES

- A. Sensors: As specified in Section 23_09_13 - Instrumentation and Control Devices for HVAC.
- B. Hail guard.
- C. Coil guard.

PART 3 EXECUTION

3.01 GENERAL

- A. As specified in Section 23_05_00 - Common Work Results for HVAC.

3.02 PREPARATION

- A. Anchoring and bracing to structures:
 1. Prepare equipment anchor setting template(s) and use to position anchors during construction of supporting structure(s).
 2. Install anchors of type and material indicated on approved anchoring designs.
 3. Install anchors with embedment indicated on approved anchoring designs.

3.03 INSTALLATION

- A. Install the equipment in accordance with the accepted installation instructions and anchorage details.
- B. Insulate refrigerant and condensate piping as specified in Section 23_05_00 - Common Work Results for HVAC.

3.04 TESTING

- A. Test equipment performance and balance equipment as specified in Section 23_05_93 - Testing, Adjusting, and Balancing for HVAC.

3.05 SCHEDULES

- A. As indicated on the Drawings.

END OF SECTION

SECTION 23_81_44

HEAT PUMPS

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Mini-split system units.
 - 2. Accessories.

1.02 REFERENCES

- A. Abbreviations:
 - 1. MERV - Minimum Efficiency Reporting Values.
- B. Standards:
 - 1. American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE):
 - a. Standard 15 - Safety Standard for Refrigeration Systems.
 - b. Standard 62.1 - Ventilation for Acceptable Indoor Air Quality.
 - 2. ASTM International (ASTM):
 - a. B117 - Standard Practice for Operating Salt Spray (Fog) Apparatus.
 - 3. Federal Specification (FS):
 - a. Standard 141 - Paint, Varnish, Lacquer and Related Materials: Methods of Inspection, Sampling and Testing.
 - 4. National Electrical Manufacturers Association (NEMA):
 - a. 250 - Enclosures for Electrical Equipment (1,000 V Maximum).
 - 5. Underwriters Laboratories, Inc. (UL):
 - a. 60335-2-40 - Safety Standard for Household and Similar Electrical Appliances.

1.03 DELEGATED DESIGN

- A. As specified in Section 01_35_73 - Delegated Design Procedures.
- B. Anchoring and bracing.

1.04 SUBMITTALS

- A. Furnish Submittals as specified in Section 01_33_00 - Submittal Procedures.
- B. Catalog cuts, bulletins, and brochures:
 - 1. Design features.
 - 2. Load capacities.
 - 3. Efficiency ratings.
 - 4. Dimensions.
 - 5. Weight: Shipping and operating.

- C. Shop Drawings:
 - 1. Component layout and identification.
 - 2. Views:
 - a. Front, side, rear elevations, and top and bottom views, with dimensions.
 - b. Connection locations, including electrical, mechanical, and other.
 - 3. Cut away drawings.
 - a. Parts list.
 - b. Material specification lists.
 - 4. Wiring, control schematics, control logic diagrams and ladder logic or similar for computer-based controls.
 - 5. Details for supports, isolators, and bracing.
- D. Delegated Design Submittals:
 - 1. Anchoring and bracing: Provide project-specific calculations based on support conditions and requirements to resist loads specified in Section 01_81_50 - Design Criteria.
 - a. To structures for equipment installed in structures designated as seismic design category C, D, E, or F.
 - b. For equipment installed outdoors.
- E. Engineering data:
 - 1. Manufacturer's published data for compressor, evaporator coil, condenser, evaporator fan, refrigerant, and filter.
 - 2. Maximum equipment vibration levels and field-testing method.
 - 3. Sound power level in each of 8 octave bands and overall sones.
 - 4. Fan performance curves showing specified operating condition.
 - 5. Bearing life.
- F. Manufacturer's recommendations for handling, storage, and installation.
- G. Nameplate data.
- H. Seismic certification.
- I. Vendor operation and maintenance manuals: Manufacturer's standard instruction manual for operation and maintenance.

1.05 WARRANTY

- A. As specified in Section 01_78_36 - Warranties and Bonds.
- B. Special warranties:
 - 1. Refrigerant compressors and closed or sealed refrigerant systems: Provide 5-year warranty.
 - 2. Electric heaters: Provide 5-year warranty.
 - 3. Gas fired heat exchangers: Provide 10-year warranty.
 - 4. Evaporator and condensing coils: Provide 5-year warranty.

PART 2 PRODUCTS

2.01 GENERAL

- A. As specified in Section 01_60_01 - Product Requirements with additional requirements in Section 23_05_00 - Common Work Results for HVAC.
- B. Supplied components of the unit shall be furnished and fully integrated by the unit system supplier:
 - 1. Provide piping, valves, dampers, sensors and wiring within the unit package.
 - 2. Provide a unit mounted control panel prewired on the unit to dampers and sensors within the unit.
- C. Motors:
 - 1. Totally enclosed.
 - 2. Voltage and number of phases as scheduled.
 - 3. Compressor motors:
 - a. Cooled by refrigerant gas passing through windings.
 - b. Provided with line break thermal and current overload protection.
 - 4. Fan and blower motors:
 - a. Permanently lubricated ball bearings.
 - b. Integral automatic reset thermal overload protection.
 - 5. Other requirements as specified.
- D. Electrical:
 - 1. Provide a single conduit connection in the unit for both power and control wiring.
- E. Refrigerant:
 - 1. Fully charged with R-454B.
 - 2. Compliant with ASHRAE 15.
 - 3. HFO refrigerant with global warming potential (GWP) of 700 or less.
 - 4. Must have a refrigerant monitoring system and be rated in accordance with UL 60335-2-40.

2.02 DESIGN AND PERFORMANCE CRITERIA

- A. As specified in Section 23_05_00 - Common Work Results for HVAC.
- B. Provide instrumentation and controls to meet the equipment operating requirements as specified in Section 23_09_13 - Instrumentation and Control Devices for HVAC.

2.03 MINI-SPLIT SYSTEM HEAT PUMPS

- A. Manufacturers: One of the following or equal:
 - 1. Mitsubishi, PLA/PUZ.
 - 2. Daikin, similar series.
 - 3. LG, similar series.
 - 4. Lennox, similar series.
- B. Basis of design, model, and series: As indicated on the Drawings.

- C. Compressors:
 - 1. Fully hermetically sealed, high-efficiency, reciprocating or rotary or scroll-type, with rubber grommet vibration isolation.
- D. Fans:
 - 1. Indoor air fan:
 - a. Direct driven with capacitor start motor; double inlet, forward curve sirocco fan.
 - 1) Turbo fan propeller for ceiling cassette models.
 - b. Steel with corrosion resistant finish.
 - c. Statically and dynamically balanced.
 - d. Permanently sealed ball bearing type and permanently lubricated.
 - 2. Outdoor condenser fan:
 - a. Propeller type, direct drive.
 - b. Aluminum blades.
 - c. Dynamically balanced.
 - d. Permanently sealed ball bearing type and permanently lubricated.
 - 3. Evaporator and condenser coils: Seamless copper tubes with mechanically bonded aluminum plate fins.
 - 4. Provide corrosion resistant finish, suitable for marine environment.
- E. Refrigerant components:
 - 1. Refrigerant circuit, including:
 - a. Accumulator and filter/drier.
 - b. Expansion device.
 - c. Reversing valve.
 - d. Flow control valves.
 - e. Service and gauge connections on compressor suction and discharge, and liquid lines to charge, evacuate, and contain refrigerant.
- F. Controls and equipment safety features:
 - 1. Provide system controls for a complete functioning system:
 - a. High and low evaporator fan speed control for cooling and heating modes.
 - b. Fan only operation.
 - c. Space temperature condition setting.
 - 2. Equipment safety features:
 - a. Thermostatic base pan drain to prevent freeze up of the fan in collected condensate.
 - 3. Provide with a low ambient cooling option.
- G. Unit casing:
 - 1. Slide out design unit casing manufactured of high strength molded plastic with smooth finish.
 - a. Ceiling recessed cassette units:
 - 1) Space-saving ceiling-recessed cassette formed of galvanized steel.
 - 2. Outdoor casing shall be constructed from galvanized steel plate, finished with an electrostatically applied, polyester powder coating for corrosion protection.
 - 3. Weatherproof design, reinforced and braced for maximum rigidity.
 - 4. Provided with:
 - a. Accessible filter rack for filters.
 - b. Non-corrosive drain pan in accordance with ASHRAE Standard 62.1.

- c. Horizontal drain connection.
- d. Mini condensate pump suitable to be powered from indoor/outdoor unit when not internal to the unit or as indicated on the Drawings.
- e. Knockouts for power connections.

2.04 ACCESSORIES

- A. Sensors: As specified in Section 23_09_13 - Instrumentation and Control Devices for HVAC.
- B. Hail guard.
- C. Coil guard.

2.05 SHIPPING, SPARE PARTS, MAINTENANCE PRODUCTS, AND SPECIAL TOOLS

- A. As specified in Section 23_05_00 - Common Work Results for HVAC.

PART 3 EXECUTION

3.01 GENERAL

- A. As specified in Section 01_60_01 - Product Requirements with additional requirements in Section 23_05_00 - Common Work Results for HVAC.

3.02 PREPARATION

- A. Anchoring and bracing to structures:
 - 1. Prepare equipment anchor setting template(s) and use to position anchors during construction of supporting structure(s).
 - 2. Install anchors of type and material indicated on approved anchoring designs.
 - 3. Install anchors with embedment indicated on approved anchoring designs.

3.03 INSTALLATION

- A. Install the equipment in accordance with the accepted installation instructions and anchorage details.
- B. Insulate refrigerant and condensate piping as specified in Section 23_05_00 - Common Work Results for HVAC.

3.04 TESTING

- A. Test equipment performance and balance equipment as specified in Section 23_05_93 - Testing, Adjusting, and Balancing for HVAC.
 - 1. Test for outdoor sound power at levels.

3.05 FIELD QUALITY CONTROL

- A. Verify equipment installation operation and vibration is within the manufacturer's submitted maximum.

3.06 SCHEDULES

- A. As indicated on the Drawings.

END OF SECTION

SECTION 23_83_01

HEATING UNITS

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Requirements for electric unit heaters and thermostats for heaters.

1.02 REFERENCES

- A. American Gas Association (AGA).
- B. National Electrical Manufacturers Association (NEMA):
 - 1. 250 - Enclosures for Electrical Equipment (1,000 V Maximum).
- C. Underwriters' Laboratories, Inc. (UL).

1.03 DELEGATED DESIGN

- A. As specified in Section 01_35_73 - Delegated Design Procedures.
- B. Anchoring and bracing.

1.04 SUBMITTALS

- A. Submit as specified in Section 01_33_00 - Submittal Procedures.
- B. Catalog cuts, bulletins, and brochures:
 - 1. Design features.
 - 2. Load capacities.
 - 3. Efficiency ratings.
 - 4. Dimensions.
 - 5. Weight: Shipping and operating.
- C. Drawings:
 - 1. Component layout and identification.
 - 2. Views:
 - a. Front, side, rear elevations, and top and bottom views, with dimensions.
 - b. Connection locations including electrical, mechanical, and other.
 - 3. Cut away drawings:
 - a. Parts list.
 - b. Material specification lists.
 - 4. Wiring, control schematics, control logic diagrams and ladder logic or similar for computer-based controls.
 - 5. Details for supports, isolators, and bracing.

- D. Delegated Design Submittals:
 - 1. Anchoring and bracing: Provide project-specific calculations based on support conditions and requirements to resist loads specified in Section 01_81_50 - Design Criteria.
 - a. To structures for equipment installed in structures designated as seismic design category C, D, E, or F.
 - b. For wall mounted equipment weighing 125 pounds or more.
- E. Engineering data:
 - 1. Manufacturer's published data for fan, burner, and filter.
 - 2. Maximum equipment vibration levels and field-testing method.
 - 3. Sound power level in each of 8 octave bands and overall Sones.
 - 4. Fan performance curves showing specified operating condition.
 - 5. Bearing life.
- F. Manufacturer's recommendations for handling, storage, and installation.
- G. Nameplate data.
- H. Seismic certification.
- I. Vendor operation and maintenance manuals: Manufacturer's standard instruction manual for operation and maintenance.

1.05 WARRANTY

- A. As specified in Section 01_78_36 - Warranties and Bonds.

PART 2 PRODUCTS

2.01 GENERAL

- A. As specified in Section 01_60_01 - Product Requirements with additional requirements in Section 23_05_00 - Common Work Results for HVAC.

2.02 DESIGN AND PERFORMANCE CRITERIA

- A. As specified in Section 23_05_00 - Common Work Results for HVAC.
- B. Provide instrumentation and controls to meet the equipment operating requirements as specified in Section 23_09_13 - Instrumentation and Control Devices for HVAC.

2.03 ELECTRIC UNIT HEATER (EUH)

- A. Manufacturers: One of the following or equal:
 - 1. Indeeco, Type TRIAD.
 - 2. Trane.
 - 3. Markel.
 - 4. Chromalox.

- B. Fan type: Aluminum axial flow:
 - 1. Provide fan guards.
 - 2. Dynamically balance.
 - 3. Fan designed for quiet operation.
 - 4. Permanently lubricated ball bearings.
 - 5. Automatic reset thermal overload protection.
- C. Heating element characteristics:
 - 1. Rated capacity at entering air temperature of 65 degrees Fahrenheit.
 - 2. Fin type, Type 316 stainless steel plated heater elements, with elements brazed to common fins, designed for maximum strength and maximum heat transfer.
 - 3. 3-phase designed for balanced phases.
 - 4. Over temperature cutout with automatic reset.
- D. Features:
 - 1. Built-in magnetic contactors.
 - 2. Control transformer for 24-volt or 120-volt control as indicated in the Heating Unit Schedules.
 - 3. Required mounting brackets.
 - 4. Individually adjustable outlet louvers.
 - 5. Heavy 16 gauge stainless steel louvered outlet grille and plated rear grille.
 - 6. Cabinet formed of minimum thickness 18-gauge steel with steel stiffeners. Listed for corrosive areas and NEMA 4X hose down requirements.
 - 7. Controls:
 - a. Provide thermostat as specified in this Section.
 - b. Provide control transformer suitable for 24-volt or 120-volt control as indicated in the Heating Unit Schedules.
- E. Finishes:
 - 1. Casing finish backed enamel in manufacturer's standard color.

2.04 THERMOSTATS FOR UNIT HEATERS

- A. Type: Wall mounted, heat only with fan AUTO-ON selector switch when fan part of unit and separate system ON-OFF selector switch.
- B. Dial or lever temperature setpoint adjustment with 45 to 90 degrees Fahrenheit setpoint range.
- C. Setpoint and temperature indication.
- D. Control voltage as indicated in the Heating Unit Schedules.
- E. The use of mercury within the thermostat is not acceptable.
- F. Bi-metallic contacts suitable for 1- or 2-stage unit heater control as specified for the heater size or as scheduled.

2.05 SHIPPING, SPARE PARTS, MAINTENANCE PRODUCTS, AND SPECIAL TOOLS

- A. As specified in Section 01_60_01 - Product Requirements with additional requirements in Section 23_05_00 - Common Work Results for HVAC.

PART 3 EXECUTION

3.01 GENERAL

- A. As specified in Section 01_60_01 - Product Requirements with additional requirements in Section 23_05_00 - Common Work Results for HVAC.

3.02 PREPARATION

- A. Anchoring and bracing to structures:
 - 1. Prepare equipment anchor setting template(s) and use to position anchors during construction of supporting structure(s).
 - 2. Install anchors of type and material indicated on approved anchoring designs.
 - 3. Install anchors with embedment indicated on approved anchoring designs.

3.03 INSTALLATION

- A. Install the equipment in accordance with the accepted installation instructions and anchorage details.

3.04 TESTING

- A. Test equipment performance and balance equipment as specified in Section 23_05_93 - Testing, Adjusting, and Balancing for HVAC.

3.05 FIELD QUALITY CONTROL

- A. Verify equipment operation is within manufacturer's standards and that noise levels do not exceed levels specified.

3.06 SCHEDULES

- A. As indicated on the Drawings.

END OF SECTION

SECTION 26_05_00

COMMON WORK RESULTS FOR ELECTRICAL

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Requirements for electrical:
 - a. Basic design and performance criteria.
 - b. Prescriptive requirements for common components.
 - c. Installation.
- B. Contract Drawings:
 - 1. Schematic diagrams:
 - a. Controls are shown as de-energized.
 - b. Add relays, where required, to provide necessary contacts for the control system or where needed to function as interposing relays for control voltage coordination, equipment coordination, or control system voltage drop considerations.
 - c. Mount devices shown on motor controller schematic diagrams in the controller compartment enclosure, unless otherwise noted.
 - 2. Plan drawings:
 - a. Electrical drawings show desired locations, arrangements, and components of the electrical Work in a diagrammatic manner.
 - b. Locations and sizes of equipment are approximate only.
 - 3. Installation details:
 - a. Contract Drawings include typical installation details the Contractor is to use to complete the electrical Work. For cases where a typical detail does not apply, develop installation details that may be necessary for completing the Work, and submit these details for review by the Engineer.
 - b. Not all typical installation details are referenced within the drawing set. Apply and use typical details where appropriate.

1.02 REFERENCES

- A. Abbreviations:
 - 1. FAT: Factory acceptance test that is also referred to as source test.
 - 2. ICSC: Instrumentation and controls subcontractor.
 - 3. PCIS: Process control and instrumentation system.
- B. Standards:
 - 1. American National Standards Institute (ANSI).
 - 2. National Electrical Manufacturers Association (NEMA):
 - a. 250 - Enclosures for Electrical Equipment (1,000 V Maximum).
 - 3. National Fire Protection Association (NFPA):
 - a. 70 - National Electrical Code (NEC).
 - 4. Underwriters Laboratories, Inc. (UL).

1.03 TERMINOLOGY

- A. The words and terms listed below are not defined terms that require initial capital letters, but, when used in this Section, have the indicated meaning.
1. LCP: Local control panel: Operator interface panel that may contain pilot type control devices, operator interface devices, control relays, etc., and does not contain a PLC or RIO.
 2. PCM: Process control module: An enclosure containing any of the following devices: PLC, RTU, or RIO.
 3. Space: Portion of a switchgear, motor control center, panelboard, switchboard, or control panel that does not physically contain a device but is capable of accepting a device with no modifications to the equipment.
 - a. Furnish hardware to accommodate installation of future circuit breakers, instruments, relays, and controls.
 - b. Wire relay and circuit breaker control power and network connections to the compartment and provide terminations.
 - c. Space for future devices shall include:
 - 1) All necessary bus.
 - 2) Device supports and mounting equipment.
 - 3) Device connections to bus work.
 - 4) Wire troughs or raceway space.
 4. Spare: Portion of a switchgear, motor control center, panelboard, switchboard, or control panel that physically contains a device with no load connections to be made.
 5. Unequipped space: Portion of a switchgear, motor control center, panelboard, switchboard, or control panel that does not physically contain a device, standoff, bus, hardware, or other equipment.
 6. Vendor control panel (VCP): Control panels that are furnished with particular equipment by a vendor other than the ICSC. These panels may contain PLCs, RIO, OIT, HMI, etc.

1.04 DELEGATED DESIGN

- A. Requirements for Delegated Design are specified in the Technical Sections.

1.05 SUBMITTALS (NOT USED)

1.06 QUALITY ASSURANCE

- A. General:
1. Furnish equipment listed by and bearing the label of UL or of an independent testing laboratory acceptable to the Engineer and the Authority Having Jurisdiction.

1.07 DELIVERY, STORAGE, AND HANDLING

- A. Shipping precautions:
1. After completion of shop assembly and successful factory testing, pack equipment in protective crates, and enclose in heavy duty polyethylene envelopes or secured sheeting to provide complete protection from damage, dust, and moisture.

2. Place dehumidifiers, when required, inside the polyethylene coverings.
3. Skid-mount the equipment for final transport.
4. Provide lifting rings for moving without removing protective covering.
5. Display boxed weight on shipping tags together with instructions for unloading, transporting, storing, and handling at the job site.

1.08 PROJECT OR SITE CONDITIONS

- A. As specified in Section 01_81_50 - Design Criteria.

1.09 ADMINISTRATIVE REQUIREMENTS

- A. Coordination:

1. Loop drawings:
 - a. Provide electrical information required in the preparation of loop drawings, including, but not limited to:
 - 1) Conduit numbers and associated signal(s) contained within each conduit.
 - 2) Wire numbers.
 - 3) Equipment terminal numbers.
 - 4) Junction boxes and signal(s) contained within each junction box.
 - 5) Equipment power sources, and associated circuit numbers.
 - 6) As-built drawings detailing wiring.
2. Roof penetrations:
 - a. Show roof penetrations for electrical equipment and conduit on the roof drawing Submittal and include equipment information:
 - 1) Type.
 - 2) Size.
 - 3) Location.
 - 4) Configuration of individual penetrations or large penetrations for multiple conduits.
 - 5) Weight.
 - 6) Anchoring and support details.

- B. Meetings:

1. As specified in Section 01_31_19 - Project Meetings.

- C. Sequencing and scheduling:

1. Equipment anchoring: Project construction schedule must include an event for obtaining the anchor layout drawings from equipment manufacturers in adequate time for templates to be constructed and anchors to be cast-in-place.

PART 2 PRODUCTS

2.01 GENERAL (NOT USED)

2.02 DESIGN AND PERFORMANCE CRITERIA

- A. Provide field wiring and terminations.
- B. Equipment mounting and anchoring:
 - 1. Design equipment anchorage, supports, and connections for dead load, running loads, loads during start-up, seismic load specified in Section 01_81_50 - Design Criteria, and other loads as required for proper operation of equipment.
 - a. For equipment with an operating weight of 400 pounds or greater and equipment that is supported higher than 4 feet above the floor, provide calculations for:
 - 1) Operating weight and location of the centroid of mass for the equipment.
 - 2) Forces and overturning moments.
 - 3) Shear and tension forces in equipment anchorages, supports, and connections.
 - 4) Design of equipment anchorage, supports, and connections based on calculated shear and tension forces.
 - 2. Anchorage of equipment to concrete or masonry:
 - a. Perform calculations and determine number, size, type, strength, and location of anchor bolts or other connections.
 - b. Unless otherwise indicated on the Drawings, select and provide anchors from the types specified in Section 05_05_24 - Mechanical Anchoring and Fastening to Concrete and Masonry.
 - c. Provide bolt sleeves around cast-in anchor bolts for 400 pounds or greater equipment.
 - 1) Adjust bolts to final location and secure the sleeve.
 - 3. Anchorage of equipment to metal supports:
 - a. Perform calculations and determine number, size, type, strength, and location of bolts used to connect equipment to metal supports.

2.03 MANUFACTURERS (NOT USED)

2.04 MATERIALS

- A. Enclosures:
 - 1. Provide enclosures for electrical, instrumentation, and control equipment, regardless of Supplier or Subcontractor furnishing the equipment, that meet the requirements of NEMA Standard 250.
 - a. Provide metallic enclosures unless specifically indicated otherwise.
- B. Stainless steel:
 - 1. Where stainless steel is indicated or used for any portion of the electrical Work, provide a non-magnetic, corrosion-resistant alloy, ANSI Type 316, satin finish.
 - 2. Provide exposed screws of the same alloys.

3. Use stainless steel hardware, when chemically compatible, in all chemical areas or areas requiring NEMA Type 4X construction.
 4. Do not use stainless steel in any area containing chlorine, gas or solution, chlorine products or ferric chloride.
- C. Plant area electrical work requirements:
1. Provide electrical materials in accordance with the following table, unless otherwise specifically indicated on the Drawings:
 - a. Conduit installation requirements: As specified in Section 26_05_33 - Conduits.

Table 1. Electrical Material Requirements				
Plant Area	Environment: W = Wet D = Damp C = Clean/dry X = Corrosive H = Hazardous	NEMA Enclosure Type	Exposed Conduit Type (as specified in Section 26_05_33 - Conduits)	Support Materials
Electrical and Control Room	C	1	GRC	GALVANIZED STEEL
Pump Room	W	4X SST	PCS	STAINLESS STEEL
Outdoor	W, X	4X SST	PCS	STAINLESS STEEL

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

- A. Equipment:
 1. Where the Drawings do not show dimensions for locating equipment, install equipment in the approximate locations indicated on the Drawings.
- B. Provide NEC required working space in front of electrical equipment as if it could be worked on energized.
- C. Circuits of different service voltage:
 1. Voltage and service levels:
 - a. Medium voltage: Greater than 1.0 kV.
 - b. Low voltage:
 - 1) Power and controls: 120 V to 480 V.
 - c. Instrumentation: Less than 50 VDC.
 2. Install different service voltage circuits in separate raceways, boxes, manholes, and hand holes.

3. Low voltage and instrumentation circuits may be installed in a common metallic box, wireway, or cable tray with a grounded divider as indicated on the Drawings.
- D. Conductors shall not pass through equipment they are not terminating in unless indicated on the Drawings or approved by the Engineer.

3.04 FIELD QUALITY CONTROL

- A. Workmanship:
 1. Leave wiring in panels, manholes, boxes, and other locations neat, clean, and organized:
 - a. Neatly coil and label spare wiring lengths.
 - b. Shorten, re-terminate, and re-label excessively long used, as well as spare, wire and cable lengths, as directed by the Engineer.
- B. Inspection activities conducted during construction do not satisfy the inspection or testing requirements specified in Section 26_08_50 - Field Electrical Acceptance Tests.
- C. Provide on-site assistance for troubleshooting and correcting electrical issues discovered during installation and testing for the Project.

3.05 OWNER TRAINING (NOT USED)

3.06 ADJUSTING (NOT USED)

3.07 CLEANING

- A. General:
 1. Clean and vacuum enclosures to remove metal filings, surplus insulation and any visible dirt, dust, or other matter before energization of the equipment or system start-up:
 - a. Use of compressors or air blowers for cleaning is not acceptable.
 2. Clean luminaries in the areas affected by the construction.

END OF SECTION

SECTION 26_05_03
UTILITY COORDINATION

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Coordination with the utility companies to provide service.
 - 2. Contractor's responsibilities for connecting to utilities and providing utility service to the facilities.
 - 3. Descriptions of utility services required.
- B. Utility contacts:
 - 1. Electric utility:
 - a. Name: Cooper Fargen.
 - b. Utility: Poudre Valley Rural Electric Association, Inc.
 - c. Phone number: 800.432.1012.
 - d. Fax number: N/A.
 - e. E-mail: cfargen@pvrea.coop.

1.02 REFERENCES

- A. Underwriters Laboratories, Inc. (UL).

1.03 DELEGATED DESIGN (NOT USED)

1.04 SUBMITTALS

- A. Furnish Submittals as specified in Section 01_33_00 - Submittal Procedures.
- B. Certification:
 - 1. Submit certification that the intended installation has been coordinated with the utility companies.
 - 2. Include a narrative description of the utility's requirements and points of connection, names and telephone numbers for contacts at the utilities.

1.05 QUALITY ASSURANCE

- A. Materials and equipment used in performance of Electrical Work shall be listed or labeled by UL, or other equivalent recognized independent testing laboratory, for the class of service intended.

1.06 DELIVERY, STORAGE, AND HANDLING (NOT USED)

1.07 PROJECT OR SITE CONDITIONS

- A. As specified in Section 01_81_50 - Design Criteria.

1.08 ADMINISTRATIVE REQUIREMENTS

- A. Scheduling:
 - 1. General:
 - a. Before the start of Site Work, make arrangements for temporary telephone and electrical service as required.
 - 2. Electrical systems:
 - a. Before bidding, contact the utilities to determine the Work and materials that will be required from the Contractor for inclusion in the bid.
 - b. Before commencing Work, coordinate electric service entrance requirements with local electric utility to ensure that the installation will be complete:
 - 1) Confirm the utility distribution circuit, electrical characteristics, and location are consistent with the design and service voltage provided by the electric utility.
 - 2) Arrange for utility revenue meter.
 - 3) Coordinate installation of metering CTs and PTs furnished by the electric utility.

1.09 WARRANTY

- A. As specified in Section 01_78_36 - Warranties and Bonds.

PART 2 PRODUCTS

2.01 GENERAL (NOT USED)

2.02 DESIGN AND PERFORMANCE CRITERIA

- A. Electrical service:
 - 1. Temporary construction power:
 - a. As specified in Section 01_50_00 - Temporary Facilities and Controls.
 - b. Provide all Work and materials not provided by the electric utility.
 - c. Pay fees and costs for temporary construction power.
 - 2. Provide all Work and materials for providing the permanent electrical service, including, but not limited to:
 - a. Work and materials not provided by the electric utility.
 - b. Provide electrical ducts, raceways, conductors, and connections indicated on the Drawings, and all other Work and materials required for a complete electrical service, including, but not limited to:
 - c. Metering conduits from the instrument transformers to the meter.
- B. General:
 - 1. Coordinate and obtain inspections and final installation approval from the serving utilities and authorities having jurisdiction.

2.03 MANUFACTURERS (NOT USED)

2.04 MATERIALS

- A. Provide materials in accordance with the applicable requirements of the utilities and as specified in these Specifications.

2.05 MANUFACTURED UNITS (NOT USED)

2.06 EQUIPMENT

- A. Provide equipment in accordance with the applicable requirements of the utilities and as specified in these Specifications.

PART 3 EXECUTION (NOT USED)

END OF SECTION

SECTION 26_05_10

MEDIUM VOLTAGE MOTORS

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Three-phase, form-wound, squirrel cage induction, medium voltage motors.
 - 2. Requirements for installation and testing of medium voltage motors for pump tag numbers PMP-302, PMP-303, PMP-305, and PMP-306 that were previously procured by the Owner.

1.02 REFERENCES

- A. American Petroleum Institute (API):
 - 1. 541 - Form-Wound Squirrel Cage Induction Motors - 500 Horsepower and Larger.
 - 2. 547 - General Purpose Form-Wound Squirrel Cage Induction Motors - 250 Horsepower and Larger.
- B. Institute of Electrical and Electronics Engineers (IEEE):
 - 1. 85 - IEEE Test Procedure for Airborne Sound Measurements on Rotating Electric Machinery.
 - 2. 112 - IEEE Test Procedures for Polyphase Induction Motors and Generators.
- C. National Electrical Manufacturers Association (NEMA):
 - 1. MG 1 - Motors and Generators.

1.03 DELEGATED DESIGN (NOT USED)

1.04 SUBMITTALS

- A. Furnish Submittals as specified in Section 01_33_00 - Submittal Procedures.
- B. Owner Training Submittals:
 - 1. As specified in Section 01_75_17 - Commissioning.

1.05 QUALITY ASSURANCE (NOT USED)

1.06 DELIVERY, STORAGE, AND HANDLING

- A. Store the motor in accordance with the manufacturer's instructions.
- B. Energize space heaters upon receipt of the motor at the jobsite using construction power source, and keep heaters energized from this source until motors are ready for service, and heater power is available from the starter or drive.

1.07 ADMINISTRATIVE REQUIREMENTS (NOT USED)

1.08 WARRANTY

- A. As specified in Section 01_78_36 - Warranties and Bonds.

1.09 SYSTEM START-UP (NOT USED)

1.10 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 GENERAL (NOT USED)

2.02 DESIGN AND PERFORMANCE CRITERIA

- A. Coordinate characteristics and requirements of driven equipment, reduced voltage solid state starters, variable frequency drives, and accessories, to ensure a complete, fully functional, coordinated installation.
- B. Coordinate motor characteristics the short-circuit and coordination study as specified in Section 26_05_74 - Electrical System Studies:
 - 1. Provide design data as specified for the preliminary studies.
 - 2. Provide test data for the final studies.
 - 3. Coordinate recommended motor protection settings for motor protection relays.

2.03 MANUFACTURERS (NOT USED)

2.04 MATERIALS (NOT USED)

2.05 MANUFACTURED UNITS (NOT USED)

2.06 EQUIPMENT (NOT USED)

2.07 COMPONENTS (NOT USED)

2.08 ACCESSORIES (NOT USED)

2.09 SOURCE QUALITY CONTROL (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION (NOT USED)

3.04 FIELD QUALITY CONTROL

A. Field electrical acceptance testing:

1. As specified in Section 26_08_50 - Field Electrical Acceptance Tests.

3.05 OWNER TRAINING (NOT USED)

END OF SECTION

SECTION 26_05_13
MEDIUM VOLTAGE CABLES

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Medium voltage cables rated 5,000 through 35,000 volts.

1.02 REFERENCES

- A. Association of Edison Illuminating Companies (AEIC):
 - 1. CS8 - Specification for Extruded Dielectric, Shielded Power Cables Rated 5 through 46 kV.
- B. ASTM International (ASTM):
 - 1. B3 - Standard Specification for Soft or Annealed Copper Wire.
 - 2. B8 - Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft.
 - 3. B496 - Standard Specification for Compact Round Concentric-Lay-Stranded Copper Conductors.
- C. Insulated Cable Engineers Association (ICEA):
 - 1. S-93-639 - 5-46 kV Shielded Power Cable for Use in the Distribution of Electrical Energy.
 - 2. S-94-649 - Standard for Concentric Neutral Cables Rated 5 Through 46 kV.
 - 3. S-97-682 - Standard for Utility Shielded Power Cables Rated 5 Through 46 kV.
- D. National Fire Protection Association (NFPA):
 - 1. 70 - National Electrical Code (NEC).
- E. National Electrical Manufacturers Association (NEMA):
 - 1. 250 - Enclosures for Electrical Equipment (1,000 V Maximum).
- F. Underwriters Laboratories (UL):
 - 1. 1072 - Standard for Safety for Medium-Voltage Power Cables.

1.03 DELEGATED DESIGN (NOT USED)

1.04 SUBMITTALS

- A. Furnish Submittals as specified in Section 01_33_00 - Submittal Procedures.
- B. Product data:
 - 1. Manufacturer.
 - 2. Voltage class.

3. Conductor:
 - a. Size.
 - b. Material.
 - c. Stranding.
 4. Insulation:
 - a. Type.
 - b. Level.
 5. Shielding.
 6. Temperature rating.
 7. Jacket material.
- C. Shop Drawings:
1. Show splice locations.
 2. Provide details on the pull plan:
 - a. Splice locations, if applicable.
 - b. Cable layout locations, if applicable.
 - c. Actions for installing and protecting cables at each phase of the installation.
 - d. PDF annotations on pull plans corresponding to the cable pull segments included with cable pulling calculations (e.g., slope, slope direction, segment length, bend type, bend direction, bend radius, etc.).
- D. Calculations:
1. Submit cable pulling calculations to the Engineer for review and comment showing that the maximum cable tension and sidewall pressure will not exceed the manufacturer recommended values:
 - a. Provide a table showing the manufacturer's recommended maximum cable tension and sidewall pressure for each cable type and size included in the calculations.
 - 1) Increase the coefficient of friction for the calculation until either maximum cable tension or maximum sidewall pressure is reached.
 - a) If maximum sidewall pressure is reached before maximum tension, the tension at which the maximum sidewall pressure is reached will be the maximum pull tension for the pull.
 2. Submit calculations to the Engineer a minimum of 2 weeks before conduit installation.
- E. Qualifications:
1. Submit qualifications for the individual(s) that will be performing medium voltage cable splices and terminations at least 30 calendar days before splicing or terminating.
 2. Documentation that the individual has received training by the splice/termination manufacturer or an independent testing laboratory.
 3. A statement of the number of years in which the individual has been splicing and terminating medium voltage cable.
- F. Test reports:
1. Submit AC withstand partial discharge (corona) test x-y plots after manufacture and prior to shipment.
 2. Submit field test reports as specified in Section 26_08_50 - Field Electrical Acceptance Tests.

- G. Cable lengths:
 - 1. Submit installed cable lengths using a conduit measuring tape for medium voltage circuits.
- H. Record documents:
 - 1. Submit with any field modification.

1.05 QUALITY ASSURANCE

- A. Manufacturer qualifications: Minimum of 10 years of experience in manufacturing medium voltage power cables.
- B. Installer qualifications: Minimum of 5 years of experience in installation of medium voltage power cables.
- C. Medium voltage cables shall be UL listed and labeled.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. Cables stored and/or cut onsite shall have the ends turned down and sealed with cable manufacturer's standard cable end seals, or field installed heat-shrink cable end seals.

1.07 PROJECT OR SITE CONDITIONS

- A. As specified in Section 01_81_50 - Design Criteria.

1.08 ADMINISTRATIVE REQUIREMENTS

- A. Sequencing:
 - 1. Do not install cables until the Engineer reviews the Contractor-prepared cable pulling calculations.

1.09 WARRANTY

- A. As specified in Section 01_78_36 - Warranties and Bonds.

PART 2 PRODUCTS

2.01 GENERAL (NOT USED)

2.02 DESIGN AND PERFORMANCE CRITERIA

- A. Furnish and install the complete medium voltage cable system.

2.03 MANUFACTURERS

- A. One of the following or equal:
 - 1. Okonite Co.
 - 2. Prysmian General Cable.
 - 3. Southwire Co.

2.04 MATERIALS

- A. Conductors:
 - 1. Annealed uncoated copper in accordance with ASTM B3.
 - 2. Compact stranded in accordance with ASTM B496.
- B. Insulation:
 - 1. Ethylene propylene rubber (EPR).
- C. Jacket:
 - 1. Chlorinated polyethylene (CPE).

2.05 MANUFACTURED UNITS

- A. General:
 - 1. Permanently mark each cable with the following at 24-inch intervals:
 - a. American wire gauge (AWG) size or circular mill area.
 - b. Voltage rating.
 - c. Grade of insulation.
 - d. UL symbol.
 - e. Manufacturer's name.
 - 2. Medium voltage single conductor or multi-conductor cable as indicated on the Drawings or on the conduit schedule.
- B. Medium voltage single conductor cable:
 - 1. Provide cables manufactured in the last 12 months.
 - 2. Voltage ratings as indicated on the Drawings or on the conduit schedule.
 - 3. Type MV-105:
 - a. Rated for 105 degrees Celsius.
 - 4. Single conductor:
 - a. Stranding:
 - 1) In accordance with ASTM B3 and ASTM B8, Class B.
 - 5. Conductor screen:
 - a. Extruded semiconducting thermosetting compound.
 - b. Applied directly over the conductor.
 - c. In accordance with:
 - 1) AEIC CS8.
 - 2) UL 1072.
 - 6. Insulation level:
 - a. 133 percent.
 - b. Insulation screen:
 - 1) Extruded semiconducting thermosetting compound.
 - 2) Applied directly over the insulation.
 - 3) In accordance with:
 - a) ICEA S-93-639 and ICEA S-97-682.
 - b) Free-stripping.
 - 4) Provide color differentiation between semi-conducting layers and insulation.
 - 7. Shield:
 - a. 5-mil annealed copper tape with an overlap of 25 percent.

8. Applications:
 - a. Suitable for use in wet and dry locations in conduit and underground duct systems.
 - b. Cables larger than AWG 1/0 suitable for CT use in cable tray.

2.06 EQUIPMENT (NOT USED)

2.07 COMPONENTS (NOT USED)

2.08 ACCESSORIES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL

- A. Manufacturer cable in accordance with the latest standards of the ASTM and ICEA and test full cable length by these standards:
 1. AC withstand partial discharge (corona) test in accordance with AEIC CS8 and ICEA S-94-649.
 - a. Results not to exceed 5 picocoulombs.
- B. Provide cable reels with both ends of cables available for high-potential testing before installation.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

- A. Install and terminate cable in accordance with the manufacturer's recommendations:
 1. Use proper stripping and terminating tools to ensure integrity of insulation.
 2. Ground shield at terminations and splices.
 3. Maintain the manufacturer's or NEC minimum bending radius, whichever is larger.
 4. Do not bend, kink, or nick cable jacket or insulation.
 5. Properly coat wires and cables with pulling compound recommended by the cable manufacturer before pulling into conduits and prevent mechanical damage to conductors during installation:
 - a. One of the following or equal, as recommended by the cable manufacturer:
 - 1) 3M Products.
 - 2) Greenlee Products.
 - 3) Ideal Products.
 - 4) Polywater Products.

- b. Do not use oil, grease, or similar substances.
 - c. Other lubricants substituted must be accompanied by a statement from the cable manufacturer as to its acceptable use with cables being installed.
 - 6. Do not exceed the maximum pulling tension and/or sidewall pressures recommended by the cable manufacturer. Install additional pull boxes as required to meet the cable manufacturer's recommendations.
 - 7. Electrical identification: As specified in Section 26_05_53 - Identification for Electrical Systems.
 - 8. Use only tools that are recommended by the termination or splice manufacturer.
 - 9. Use a dynamometer during cable pulling operations to monitor cable pulling tensions.
- B. Cable pulling requirements:
- 1. Crew shall have "in hand" cable pulling calculations and cable pulling limitations.
 - 2. Pull cable directly from reels into the ducts.
 - 3. Cable may not be laid on the ground or otherwise handled for cutting or sorting without protection from debris or physical damage.
 - a. Utilize combination of rubber blankets and plastic sheeting to protect cables from physical damage and debris. Keep surfaces clear of debris.
 - 4. Follow cable manufacturer installation instructions for proper handling.
 - 5. Do not pull cables through more than 1 intermediate manhole on 1 pull.
 - 6. Seal cable ends against moisture or lubricant prior to pulling.
 - 7. Use non-metallic pull ropes to prevent cutting of duct materials.
 - 8. Pull cables from conductor, do not use cable pulling socks that attach to the insulation.
 - 9. Cables cut in the field shall have the cut ends immediately sealed to prevent entrance of moisture and debris.
- C. Installation of cables in manholes and handholes:
- 1. Install cables not utilizing the shortest route but routed along those walls providing the longest route and the maximum spare cable lengths.
 - 2. Run cables closely parallel to the walls, not interfering with duct entrances.
 - 3. Support cables on brackets and cable insulators spaced at a maximum of 4 feet.
 - 4. In existing manholes and handholes where new ducts are to be terminated or where new cables are to be installed, modify the existing installation of cables, cable supports, and grounding as required for a neat and workmanlike installation with cables properly arranged and supported.
- D. Splices:
- 1. Provide continuous circuits from origin to termination:
 - a. Provide, where necessary, when cable pulling tension or sidewall pressure exceeds manufacturer recommendation for the cable.
 - b. Obtain the Engineer's approval prior to making any splices.
 - 2. Make splices in manholes or pull boxes only:
 - a. Leave sufficient slack to make proper connections.
 - b. Do not pull splices into conduit.

3.04 FIELD QUALITY CONTROL

- A. Field electrical acceptance tests:
 - 1. As specified in Section 26_08_50 - Field Electrical Acceptance Tests.
- B. After cable installation, test in accordance with ICEA/NEMA, including voltage tests, hi-potential tests and partial-discharge tests, before energizing the circuits.
 - 1. Verify that no equipment is connected to the cables during tests.

END OF SECTION

SECTION 26_05_18

600-VOLT OR LESS WIRES AND CABLES

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. 600-volt class or less wire and cable.

1.02 REFERENCES

- A. Abbreviations:
 - 1. AWG: American wire gauge.
 - 2. BCCS: Bare copper-covered steel.
 - 3. CPE: Chlorinated polyethylene.
 - 4. FHDPE: Foam high-density polyethylene.
 - 5. FPE: Foam polyethylene.
 - 6. OD: Outside diameter.
 - 7. PVC: Polyvinyl chloride.
 - 8. XHHW: Cross-linked high heat water resistant insulated wire.
- B. Standards:
 - 1. ASTM International (ASTM):
 - a. B3 - Standard Specification for Soft or Annealed Copper Wire.
 - b. B8 - Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft.
 - 2. CSA International (CSA).
 - 3. Insulated Cable Engineers Association (ICEA):
 - a. S-90-661 - Individually Unshielded Twisted Pair Indoor Cables for Use in Communication Wiring Systems.
 - 4. National Electrical Manufacturers Association/Insulated Cable Engineers Association (NEMA/ICEA):
 - a. NEMA WC 57/ICEA S-73-532 - Standard for Control, Thermocouple Extension, and Instrumentation Cables.
 - b. NEMA WC 66/ICEA S-116-732 - Standard for Category 6 and 6A, 100 Ohm, Individually Unshielded Twisted Pairs, Indoor Cables (With or Without an Overall Shield) for Use in LAN Communication Wiring Systems.
 - c. NEMA WC 70/ICEA S-95-658-1999 - Standard for Power Cables Rated 2,000 Volts or Less for the Distribution of Electrical Energy.
 - 5. National Fire Protection Association (NFPA):
 - a. 70 - National Electrical Code (NEC).
 - b. 262 - Standard Method of Test for Flame Travel and Smoke of Wires and Cables for Use in Air-Handling Spaces.

6. Telecommunications Industry Association (TIA):
 - a. 568.2-D - Balanced Twisted-Pair Telecommunications Cabling and Components Standard.
 - b. 569-B - Commercial Building Standards for Telecommunications Pathways and Spaces.
7. Underwriters Laboratories Inc. (UL):
 - a. 44 - Standard for Thermoset-Insulated Wires and Cables.
 - b. 1666 - Standard for Test for Flame Propagation Height of Electrical and Optical-Fiber Cables Installed Vertically in Shafts.

1.03 DELEGATED DESIGN (NOT USED)

1.04 SUBMITTALS

- A. Furnish Submittals as specified in Section 01_33_00 - Submittal Procedures.
- B. Product data:
 1. Manufacturer of wire and cable.
 2. Insulation:
 - a. Type.
 - b. Voltage class.
 3. AWG size.
 4. Conductor material.
 5. Pulling compounds.
- C. Shop Drawings:
 1. Show splice locations.
 - a. For each proposed splice location provide written justification describing why the splice is necessary.
 2. Wire and cable pulling plan:
 - a. Provide a pull plan sketch identifying each segment of the pulling calculations, mechanical pulling equipment, and wire/cable spool locations.
- D. Test reports:
 1. Submit test reports for meg-ohm tests.
- E. Calculations:
 1. Submit cable pulling calculations to the Engineer for review and comment for cables that will be installed using mechanical pulling equipment. Show that the maximum cable tension and sidewall pressure will not exceed manufacturer recommended values:
 - a. Provide a table showing the manufacturer's recommended maximum cable tension and sidewall pressure for each cable type and size included in the calculations.
 - b. Submit the calculations to the Engineer a minimum of 2 weeks before conduit installation.
 - c. Provide the wire and cable pulling plan identified under Shop Drawings with the cable pulling calculations Submittal.

- F. Cable lengths:
 - 1. Submit installed cable lengths using a conduit measuring tape for 3-phase circuits.
 - 2. Submit installed lengths of cable for the following single-phase circuits:
 - a. Circuits feeding single-phase transformers.
 - b. Circuits feeding single-phase panelboards.

1.05 QUALITY ASSURANCE

- A. Wires and cables shall be UL listed and labeled.

1.06 DELIVERY, STORAGE, AND HANDLING (NOT USED)

1.07 PROJECT OR SITE CONDITIONS

- A. General Site and Project conditions:
 - 1. As specified in Section 01_81_50 - Design Criteria.

1.08 ADMINISTRATIVE REQUIREMENTS (NOT USED)

1.09 WARRANTY

- A. As specified in Section 01_78_36 - Warranties and Bonds.

PART 2 PRODUCTS

2.01 GENERAL

- A. Color-coding:
 - 1. Color-coding shall be consistent throughout the facility.
 - 2. The following color code shall be followed for 240/120-volt and 208/120-volt systems:
 - a. Phase A: Black.
 - b. Phase B: Red.
 - c. Phase C: Blue.
 - d. Single phase system: Black for 1 hot leg, red for the other.
 - e. Neutral: White.
 - f. High phase or wild leg: Orange.
 - g. Equipment ground: Green.
 - 3. The following color code shall be followed for 480/277-volt systems:
 - a. Phase A: Brown.
 - b. Phase B: Orange.
 - c. Phase C: Yellow.
 - d. Neutral: Gray.
 - e. Equipment ground: Green.
 - 4. The following color code shall be followed for 120 VAC control wiring:
 - a. Power: Red.
 - b. Neutral: White.

5. The following color code shall be followed for general purpose DC control circuits:
 - a. Grounded conductors: White with blue stripe.
 - b. Ungrounded conductors: Blue.
6. Switch legs shall be violet. 3-way switch runners shall be pink.
7. Wires in intrinsically safe circuits shall be light blue.
8. Wire colors shall be implemented in the following methods:
 - a. Wires manufactured of the desired color.
 - b. Continuously spiral wrap the first 6 inches of the wire from the termination point with colored tape:
 - 1) Colored tape shall be wrapped to overlap half of the width of the tape.

2.02 DESIGN AND PERFORMANCE CRITERIA

- A. Furnish and install the complete wire and cable system.

2.03 MANUFACTURERS

- A. One of the following, or equal:
 1. 600-volt class wire and cable:
 - a. Okonite Co.
 - b. Prysmian General Cable.
 - c. Service Wire.
 - d. Southwire Co.
 2. 600-volt VFD cable:
 - a. Prysmian General Cable.
 - b. Service Wire.
 - c. Southwire Co.
 3. Instrumentation class wire and cable:
 - a. Alpha Wire Co.
 - b. Belden CDT.
 - c. Okonite Co.
 - d. Prysmian General Cable.
 - e. Rockbestos Surprenant Cable Corp.
 4. Network cables:
 - a. Belden.
 - b. CommScope.
 - c. General Cable.

2.04 MATERIALS

- A. Conductors:
 1. Copper in accordance with ASTM B3.

2.05 MANUFACTURED UNITS

- A. General:
 1. Provide new wires and cables manufactured within 1 year of the date of delivery to the Site.
 2. Permanently mark each wire and cable with the following at 24-inch intervals:
 - a. AWG size.

- b. Voltage rating.
 - c. Insulation type.
 - d. UL symbol.
 - e. Month and year of manufacture.
 - f. Manufacturer's name.
 - 3. Identify and mark wire and cable as specified in Section 26_05_53 - Identification for Electrical Systems:
 - a. Use integral color insulation for #2 AWG and smaller wire.
 - b. Wrap colored tape around cable larger than #2 AWG.
- B. 600-volt class wire and cable:
- 1. Provide AWG or kcmil sizes as indicated on the Drawings or in the Conduit Schedules:
 - a. When not indicated on the Drawings, size wire as follows:
 - 1) In accordance with the NEC:
 - a) Use 75-degree Celsius ampacity ratings.
 - b) Ampacity rating after derating factors, equal to or greater than rating of the overcurrent device.
 - 2) Provide #12 AWG minimum for power conductors.
 - 3) Provide #14 AWG minimum for control conductors.
 - 2. Provide Class B stranding in accordance with ASTM B8:
 - a. Provide Class C stranding where extra flexibility is required.
 - 3. Insulation:
 - a. XHHW-2.
 - b. 90-degree Celsius rating.
- C. 600-volt VFD cables:
- 1. Conductor:
 - a. Provide Class B stranding in accordance with ASTM B3 and ASTM B8.
 - b. Copper conductor.
 - 2. Insulation:
 - a. Cross-linked Polyethylene, XLPE.
 - b. 90-degree Celsius rating.
 - c. UL 44 type RHH/RHW-2 or XHHW-2.
 - d. 2,000 volts.
 - 3. Ground:
 - a. Provide Class B compressed stranded bare copper in accordance with ASTM B3 and ASTM B8.
 - b. 3 symmetrically placed bare copper conductors in direct contact with shield.
 - c. Equivalent ground size 50 percent of the phase conductor size.
 - 4. Filler:
 - a. Cable sizes 8 and 6 use polypropylene filler.
 - b. Other cable sizes use paper filler.
 - 5. Metallic shield:
 - a. Overall 5 mil bare copper tape shield with 50 percent overlap.
 - 6. Outer jacket:
 - a. UL 1277 Type PVC.
 - 7. Cable tray rated, UL Type TC-ER.

- D. Instrumentation class cable:
1. Type TC.
 2. Suitable for use in wet locations.
 3. Voltage rating: 600 volts.
 4. Temperature rating:
 - a. 90-degree Celsius rating in dry locations.
 - b. 75-degree Celsius rating in wet locations.
 5. Conductors:
 - a. Insulation:
 - 1) Flame-retardant PVC, 15 mils nominal thickness, with nylon jacket 4 mils nominal thickness.
 - b. #16 AWG stranded and tinned.
 - c. Color code: ICEA Method 1:
 - 1) Pair: Black and white.
 - 2) Triad: Black, white and red.
 - 3) Multiple pairs or triads:
 - a) Color-coded and numbered.
 6. Drain wire:
 - a. #18 AWG.
 - b. Stranded, tinned.
 7. Jacket:
 - a. Flame retardant, moisture and sunlight resistant PVC.
 - b. Ripcord laid longitudinally under jacket to facilitate removal.
 8. Shielding:
 - a. Individual pair/triad:
 - 1) Minimum 1.35-mil double-faced aluminum foil-polyester tape overlapped to provide 100 percent coverage.
 - b. Multiple pair or triad shielding:
 - 1) Group shield: Minimum 1.35-mil double-faced aluminum foil-polyester tape overlapped to provide 100 percent coverage.
 - 2) Completely isolate group shields from each other.
 - 3) Cable shield: 2.35-mil double-faced aluminum and synthetic polymer backed tape overlapped to provide 100 percent coverage.
 - c. Shielding to be in contact with the drain wire.
- E. Network cables:
1. Copper Ethernet cable:
 - a. Provide copper Ethernet cable types as indicated on the Drawings and Specifications.
 - b. General requirements:
 - 1) Cables shall meet the standards set by TIA-568.2-D and verified by third-party testing laboratory.
 - 2) Conductors:
 - a) 4 balanced twisted pairs.
 - (1) #22 to #24 AWG thermoplastic insulated solid copper conducts enclosed by a thermoplastic jacket. Copper clad aluminum is not allowed.
 - 3) Insulation:
 - a) Non-Plenum: Polyolefin.
 - b) Plenum: Fluoropolymer.
 - 4) Color coded per T568B.

- 5) Outer jacket with ripcord.
- 6) Shielding:
 - a) Provide F/UTP cables with drain wire for cables inside any equipment or enclosure with 480 VAC and above, outdoor installations, and where indicated on the Drawings.
- 7) Voltage rating:
 - a) At a minimum provide 300 VAC rated jacket.
 - b) 600 VAC rated jacket when cables are inside equipment or enclosures that contain 480 VAC power.
- 8) Approvals and listings:
 - a) Meets NEC requirements for each application.
 - b) Riser applications: Type CMR.
 - c) Plenum applications: Type CMP.
 - d) Limited-use applications: Type CMX.
- 9) Certification:
 - a) Provide Category 5e cables with ICEA S-90-661 certification.
 - b) Provide Category 6 cables with NEMA WC 66/ICEA S-116-732 certification.
 - c) Provide Category 6A cables with NEMA WC 66/ICEA S-116-732 certification.

2.06 EQUIPMENT (NOT USED)

2.07 COMPONENTS (NOT USED)

2.08 ACCESSORIES

- A. Wire ties:
 - 1. One of the following, or equal:
 - a. Panduit, cable ties.
 - b. T&B, "Ty-Rap" cable ties.
- B. Wire markers:
 - 1. As specified in Section 26_05_53 - Identification for Electrical Systems.

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL

- A. Assembly and testing of cable shall be in accordance with the applicable requirements of NEMA WC 70/ICEA S-95-658-1999.
- B. Test type XHHW-2 in accordance with the requirements of UL 44.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

- A. Install conductors only after the conduit installation is complete, and enclosures have been vacuumed clean, and the affected conduits have been swabbed clean and dry:
 - 1. Install wires only in approved raceways.
 - 2. Do not install wire:
 - a. In incomplete conduit runs.
 - b. Until after the concrete work and plastering is completed.
- B. Properly coat wires and cables with pulling compound before pulling into conduits:
 - 1. For #4 AWG and larger, use an approved wire-pulling lubricant while cable is being installed in conduit:
 - a. Ideal Products.
 - b. Polywater Products.
 - c. 3M Products.
 - d. Greenlee Products.
 - e. Or equal, as recommended by cable manufacturer.
 - f. Do not use oil, grease, or similar substances.
- C. Cable pulling:
 - 1. Prevent mechanical damage to conductors during installation.
 - 2. For cables #1 AWG and smaller, install cables by hand.
 - 3. For cables larger than #1 AWG, power pulling winches may be used if they have cable tension monitoring equipment.
 - 4. Provide documentation that maximum cable pulling tension was no more than 75 percent of the maximum recommended level as published by the cable manufacturer. If exceeded, the Engineer may, at his discretion, require replacement of the cable.
 - 5. Ensure cable pulling crews have calculations and cable pulling limitations while pulling cable.
 - 6. Make splices or add a junction box or pullbox where required to prevent cable pulling tension or sidewall pressure from exceeding 75 percent of the manufacturer's recommendation for the specified cable size:
 - a. Make splices in manholes or pull boxes only.
 - b. Leave sufficient slack to make proper connections.
- D. Use smooth-rolling sheaves and rollers when pulling cable into cable tray to keep pulling tension and bending radius within the manufacturer's recommendations.
- E. Install and terminate wire in accordance with the manufacturer's recommendations.

- F. Neatly arrange and lace conductors in switchboards, panelboards, pull boxes, and terminal cabinets by means of wire ties:
 - 1. Do not lace wires in gutter or panel channel.
 - 2. Install wire ties with a flush cutting wire tie installation tool:
 - a. Use a tool with an adjustable tension setting.
 - 3. Do not leave sharp edges on wire ties.
- G. Terminate stranded conductors on equipment box lugs such that conductor strands are confined within the lug:
 - 1. Use ring type lugs if box lugs are not available on the equipment.
- H. Lighting circuits:
 - 1. Each circuit shall have a dedicated neutral.
- I. Splices:
 - 1. Provide continuous circuits from origin to termination whenever possible:
 - a. Obtain the Engineer's approval prior to making any splices.
 - 2. Lighting and receptacle circuit conductors may be spliced without prior approval from the Engineer.
 - 3. Where splices are necessary because of extremely long wire or cable lengths that exceed standard manufactured lengths:
 - a. Splice box NEMA rating requirements as specified in Section 26_05_00 - Common Work Results for Electrical.
 - b. Make splices in labeled junction boxes for power conductors.
 - c. Make splices for control and instrument conductors in terminal boxes:
 - 1) Provide terminal boards with setscrew pressure connectors, with spade or ring lug connectors.
 - 4. Power and control conductors routed in common raceways may be spliced in common junction boxes.
 - 5. Clearly label junction and terminal boxes containing splices with the words "SPICE LOCATED WITHIN."
 - 6. Leave sufficient slack at junction boxes and termination boxes to make proper splices and connections. Do not pull splices into conduits.
 - 7. Install splices with compression type butt splices and insulate using a heat-shrink sleeve:
 - a. In NEMA Type 4 or NEMA Type 4X areas, provide heat-shrink sleeves that are listed for submersible applications.
 - 8. Splices in below grade pull boxes, in any box subject to flooding, and in wet areas shall be made waterproof using:
 - a. A heat shrink insulating system listed for submersible applications.
 - b. Or an epoxy resin splicing kit.
- J. Apply wire markers to wires at each end after being installed in the conduit and before meg-ohm testing and termination.

- K. Instrumentation class cable:
1. Install instrumentation class cables in separate raceway systems from power cables:
 - a. Install instrument cable in metallic conduit within non-dedicated manholes or pull boxes.
 - b. Install cable without splices between instruments or between field devices and instrument enclosures or panels.
 2. Do not make intermediate terminations, except in designated terminal boxes as indicated on the Drawings.
 3. Shield grounding requirements as specified in Section 26_05_26 - Grounding and Bonding.
- L. Copper Ethernet cables:
1. In accordance with TIA-568.2-D.
 2. Pathways:
 - a. For initial installation, the maximum fill capacity for pathways (i.e., conduit, raceways, trays, baskets) is 40 percent. The maximum fill capacity of 60 percent is allowed to accommodate future additions after initial installation.
 - b. Conduit should be run in the most direct route possible with no more than two 90-degree bends between pull boxes and serve no more than 3 outlet boxes.
 3. Cable bend radius:
 - a. Proper cable bend radius control must be maintained throughout the pathways. Bend radius needs to be at a minimum 10 times the cable diameter.
 4. Cable pulling:
 - a. Provide cable pulling swivel system to prevent winding and tangling of rope and cables during pull.
 - b. Maximum pulling tension is not to exceed the manufacturer's recommendations. Cable installation should not in any way deform the cable jacket.
 - c. Do not install bruised, kinked, scored, deformed, or abraded cable. Do not splice cable between termination, tap, or junction points. Remove and discard cable if damaged during installation and replace it with new cable.
 5. Cable management:
 - a. Organize and manage cables for quick and easy moves, adds and changes.
 6. Cable termination:
 - a. Install equipment outlet connector hardware (e.g., RJ45, M12, etc.), and connect to field equipment outlet (e.g., instrument, VFD, actuator, etc.).
 - b. Use shielded connectors as required by the installation.
 - c. Coordinate cable termination at copper patch panels with ICSC and General Contractor.
 7. Testing:
 - a. Copper Ethernet cable testing requirements as specified in Section 26_08_50 - Field Electrical Acceptance Tests.
 8. Separation from EMI sources:
 - a. In accordance with TIA-569-B recommendations for separating unshielded copper voice and data communication cable from potential EMI sources, including electrical power lines and equipment.

- b. Separation between open communications cables or cables in nonmetallic raceways and unshielded power conductors and electrical equipment shall be as follows:
 - 1) Electrical equipment rating less than 2 kVA: A minimum of 5 inches.
 - 2) Electrical equipment rating between 2 and 5 kVA: A minimum of 12 inches.
 - 3) Electrical equipment rating more than 5 kVA: A minimum of 24 inches.
 - c. Separation between communications cables in grounded metallic raceways and unshielded power lines or electrical equipment shall be as follows:
 - 1) Electrical equipment rating less than 2 kVA: A minimum of 2-1/2 inches.
 - 2) Electrical equipment rating between 2 and 5 kVA: A minimum of 6 inches.
 - 3) Electrical equipment rating more than 5 kVA: A minimum of 12 inches.
 - d. Separation between communications cables in grounded metallic raceways and power lines and electrical equipment located in grounded metallic conduits or enclosures shall be as follows:
 - 1) Electrical equipment rating less than 2 kVA: No requirement.
 - 2) Electrical equipment rating between 2 and 5 kVA: A minimum of 3 inches.
 - 3) Electrical equipment rating more than 5 kVA: A minimum of 6 inches.
 - e. Separation between communications cables and electrical motors and transformers, 5 kVA or HP and larger: A minimum of 48 inches.
- M. Signal cable:
- 1. Separate and isolate electrical signal cables from sources of electrical noise and power cables by a minimum of 12 inches.
- N. Submersible cable wells and cables for floating equipment:
- 1. Provide Kellems grip or stainless steel wire mesh to support cable weight and avoid stress on insulation.
- O. Wiring allowances:
- 1. Equipment locations may vary slightly from the Drawings. Include an allowance for necessary conductors and terminations for motorized equipment, electrical outlets, fixtures, communication outlets, instruments, and devices within 10 linear feet of locations indicated on the Drawings.
 - 2. Locations for pull boxes, manholes, and duct banks may vary slightly from the Drawings. Include an allowance for necessary conductors and related materials to provide conductors to pull boxes, manholes and duct banks within 20-linear feet of locations indicated on the Drawings.

3.04 FIELD QUALITY CONTROL

- A. Field electrical acceptance testing:
 - 1. As specified in Section 26_08_50 - Field Electrical Acceptance Tests.

END OF SECTION

SECTION 26_05_20

FIBER OPTIC CABLE AND APPURTENANCES

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Fiber optic cable.
 - 2. Fiber splices and terminations.
 - 3. Accessories.

1.02 REFERENCES

- A. Abbreviations:
 - 1. N/Cm: Newtons per centimeter.
 - 2. OLTS: Optical Loss Test Set (Tier 1 test).
 - 3. OTDR: Optical Time Domain Reflectometer (Tier 2 test).
- B. Standards:
 - 1. Bellcore Standards:
 - a. GR-409 - Generic Requirements for Indoor Fiber.
 - 2. Electronic Industry Association (EIA):
 - a. FOTP-25 - Impact testing of Fiber Optic Cables and Cable Assemblies.
 - b. FOTP-33 - Fiber Optic Cable Tensile Loading and Bending Test.
 - c. FOTP-41 - Compressive Loading Resistance of Fiber Optic Cables.
 - d. FOTP-81 - Compound Flow (Drip) Test for Filled Fiber Optic Cable.
 - e. FOTP-104 - Fiber Optic Cable Cyclic Flexing Test.
 - f. FOTP-181 - Lightning Damage Susceptibility Test for Fiber Optic Cables with Metallic Components.
 - 3. Insulated Cable Engineer's Association (ICEA):
 - a. S-83-596 - Optic Fiber Premises Distribution Cables.
 - b. S-87-640 - Optic Fiber Outside Plant Communications Cable.
 - c. S-104-696 - Indoor-Outdoor Optic Fiber Cable.
 - 4. TIA/EIA Standards:
 - a. 598 - Optical Fiber Cable Color Coding.
 - b. 11801 - Information technology - Generic cabling for customer premises.
 - 5. Underwriters Laboratories, Inc. (UL):
 - a. 1666 - Test for Flame Propagation Height of Electrical and Optical-Fiber Cables Installed Vertically in Shafts.
 - b. 1685 - Vertical-Tray Fire-Propagation and Smoke-Release Test for Electrical and Optical-Fiber Cables.

1.03 TERMINOLOGY

- A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.

1.04 DELEGATED DESIGN (NOT USED)

1.05 SUBMITTALS

- A. Furnish Submittals as specified in Section 01_33_00 - Submittal Procedures.
- B. Product data:
 - 1. Complete manufacturer's brochures that identify materials and options.
 - 2. Completed datasheets, including catalog number and source for determining catalog number.
 - 3. Manufacturer's installation instructions.
 - 4. Include the following:
 - a. Manufacturer's data on testing equipment used on this Project.
 - b. Manufacturer's specifications and datasheets for all fiber types.
 - c. Manufacturer's specifications and datasheets for all connectors, bulkheads, splicing kits, breakout devices, and appurtenances used in connecting and terminating fiber spans.
 - 5. Catalog data on testing devices proposed for use plus certifications of accuracy, calibration, and traceability to standards of the NIST.
 - 6. Manufacturer's test procedures and quality assurance procedures:
 - a. After review, the Engineer may require that additional tests be performed before installation.
- C. Shop Drawings:
 - 1. Interconnection cabling diagrams for the complete system, including every fiber in each cable.
 - 2. Drawings indicating locations of all pull boxes, including pull box identifiers and lengths.
 - 3. Submit optical power budget calculations for fiber segments. Include the following:
 - a. Minimum transmit power of active devices.
 - b. Minimum receive sensitivity.
 - c. Available power, in dBm.
 - d. Loss for each segment in dBm, including cable attenuation and connector losses. Use manufacturer's data for cable attenuation at the wavelength to be used. Assume 0.5 dB per connector.
 - e. Demonstrate that remaining power budget at each receiver is equal to or greater than 3.0 dBm.
- D. Calculations:
 - 1. Cable pulling calculations for conduit runs:
 - a. Indicate on the Submittal any additional pull boxes that are required, including pull box identifiers and a written description of the location.
- E. Installation instructions:
 - 1. Submit a cable pulling and splicing work plan that includes the following:
 - a. Pull tension calculations.
 - b. Detailed description of pull operation methods for conduit runs.
 - c. Tools and equipment to be used for cable installation and testing.
 - d. Physical location of equipment setup and type.
 - e. Exact locations of splice points.

- f. Safety and manual assist cable-pulling operations.
 - g. Detailed schedule for pulling and testing cables.
 - h. Name and qualifications of the supervisory personnel directly responsible for installation of the conduit system.
 - i. Sample fiber optic cable test sheets.
 - j. Signed test sheet results.
- F. Quality Control Submittals:
 - 1. Manufacturer's representative qualifications.
 - 2. Manufacturer's Certificate of Source Testing as specified in Section 01_75_17 - Commissioning.
 - 3. Manufacturer's Certificate of Installation as specified in Section 01_75_17 - Commissioning.
- G. Test reports:
 - 1. Submit results of specified tests to the Engineer.
 - 2. Submit 3 copies of test reports showing results of tests specified in this Section or in Section 26_08_50 - Field Electrical Acceptance Tests:
 - a. Test forms shall include the following information at a minimum:
 - 1) Test type.
 - 2) Test location.
 - 3) Test date.
 - 4) Wavelength.
 - 5) Index of refraction.
 - 6) Cable identification.
 - 7) Fiber type.
 - 8) Fiber number.
 - 9) Fiber color.
 - 10) Result of the value of the tested parameter.
 - 3. Furnish hard copy and electronic copy for OTDR traces.
 - 4. Submit certification that the fiber optic cable has passed each testing stage:
 - a. Submit separate documentation for each testing stage result.
- H. Operation and maintenance manuals:
 - 1. As specified in Section 01_78_24 - Operation and Maintenance Manuals.
- I. Record documents:
 - 1. Furnish updated electrical drawings, network diagrams, and fiber cable block diagrams at the end of construction and submit as record drawings.

1.06 QUALITY ASSURANCE

- A. Furnish cable and appurtenances manufactured within 1 year of installation.
- B. Proof test optical fibers by the fiber manufacturer at a minimum load of 50 kpsi.

- C. Provide 100 percent attenuation testing for optical fibers:
 - 1. Include with each cable reel the attenuation of each fiber.
- D. Provide information on at least 5 successful fiber optic cable installations of comparable size and complexity in the past 3 years with name, address, and telephone number of facility owner, name of project with completion date, and type of conduit system and length of cable pulled.

1.07 DELIVERY, STORAGE, AND HANDLING

- A. Package cable for shipment on wooden reels:
 - 1. Seal both ends of cable to prevent ingress of moisture.
 - 2. Place fiber cable assemblies on reels such that both cable ends are available for testing.
 - 3. Weatherproof cable reel markings shall include the following:
 - a. Manufacturer.
 - b. Date of manufacture.
 - c. Shipping date.
 - d. Cable identification.
 - e. Cable configuration/fiber count.
 - f. Cable length.
 - g. Gross weight.
 - h. Cable test date.
 - i. Handling instructions.
 - j. Direction to unreel.

1.08 PROJECT OR SITE CONDITIONS

- A. As specified in Section 01_81_50 - Design Criteria.

1.09 ADMINISTRATIVE REQUIREMENTS

- A. Sequencing:
 - 1. Submit a cable pulling and splicing work plan a minimum of 45 days before the planned initiation of cable pulling. Cable pulling and splicing work plan must be approved a minimum of 15 days before pulling cable.
 - 2. Testing sequence:
 - a. Perform testing of each fiber in each cable as follows:
 - 1) At factory before shipment.
 - 2) At Project Site upon delivery.
 - 3) Submit copies of test results to the Engineer within 5 days after the delivery to the Site.
 - 4) After installation, before breakout and terminations.
 - 5) After installation is complete.
 - b. Submit test reports following each set of tests as specified in this Section.
- B. Scheduling:
 - 1. Schedule Engineer, 5 days before installation, to witness cable installations.
 - 2. Notify the Engineer and Owner a minimum of 15 days before post-installation testing.

1.10 WARRANTY

- A. As specified in Section 01_78_36 - Warranties and Bonds.

PART 2 PRODUCTS

2.01 GENERAL

- A. Furnish a complete fiber optic network as indicated on the Drawings.

2.02 DESIGN AND PERFORMANCE CRITERIA

- A. Install fiber optic system components in accordance with the recommendations of the manufacturer.

2.03 MANUFACTURERS

- A. Acceptable manufacturers are indicated with each component type as listed in the remainder of this Specification.

2.04 MATERIALS (NOT USED)

2.05 MANUFACTURED UNITS

- A. General fiber cable requirements:
 - 1. Suitable for the installed environment.
 - 2. Color-coded fibers according to TIA/EIA-598.
 - 3. Color-coded buffer tubes according to TIA/EIA-598.
 - 4. Furnish buffer tubes of a single layer nylon construction or of a material with similar mechanical performance.
 - 5. Fillers may be included in the cable core to lend symmetry to the cable cross-section where needed.
 - 6. Apply binders with sufficient tension to secure buffer tubes to the central member without crushing the buffer tubes:
 - a. Provide binders that are:
 - 1) Non-hygroscopic.
 - 2) Non-wicking (or rendered so by the flooding compound).
 - 3) Dielectric with low shrinkage.
 - 7. Provide a minimum of 1 ripcord under the cable sheath.
 - 8. Provide high tensile strength Aramid yarns, Kevlar, and/or fiberglass helically stranded evenly around the cable core:
 - a. No metallic elements whatsoever are allowed in non-armored cable.
 - 9. Jacket or sheath shall be free of holes, splits, and blisters.
 - 10. Mark jacket or sheath with:
 - a. Manufacturer's name.
 - b. "Optical Cable."
 - c. Year of manufacture.
 - d. Sequential meter marks.
 - e. Repeat markings every 1-meter.
 - f. Actual length of the cable to be within 1 percent of the length marking.

- g. Marking must be in a contrasting color to the cable jacket.
- h. Height of the marking:
 - 1) Approximately 2.5 millimeters.
- 11. Shipping, storage, and operating temperature range of the cable shall be -40 degrees Celsius to 70 degrees Celsius.
- 12. General performance characteristics:
 - a. Rated tensile load of the cables:
 - 1) Indoor/outdoor:
 - a) Short term: 1,330 N.
 - b) Long term: 400 N.
 - 2) Outdoor:
 - a) Short term: 2,600 N.
 - b) Long term: 800 N.
 - b. Non-armored fiber optic cables: Compressive load withstand of 220 N/cm applied uniformly over the length of the cable.
 - c. Armored fiber optic cables: Compressive load withstand of 440 N/cm applied uniformly over the length of the cable.
 - d. Average increase in attenuation for the fibers: Less than or equal to 0.10 dB at 1,550 nm for a cable subjected to this load:
 - 1) With no measurable increase in attenuation after load removal.
 - e. Test in accordance with EIA FOTP-41, except that the load must be applied at the rate of 3 millimeters to 20 millimeters per minute and maintained for 10 minutes.
 - f. Capable of withstanding 25 cycles of mechanical flexing at a rate of 30 within 1 cycles/minute.
 - g. Average increase in attenuation for the fibers: Less than or equal to 0.10 dB at 1,550 nm at the completion of the test.
 - h. For armored cables, any visible cracks causing separation of the armor and propagating more than 5 millimeters constitutes failure.
 - i. Outer cable jacket cracking or splitting observed under 10X times magnification, constitutes failure.

B. Indoor/outdoor cable:

- 1. Cable construction:
 - a. General:
 - 1) Cable type: Indoor/Outdoor - Flame retardant, low smoke, zero halogen, UV resistant.
 - 2) Fiber count: As indicated on the Drawings.
 - 3) Fiber type: As indicated on the Drawings.
 - 4) Buffer tube: Loose tube.
 - 5) Armoring: None.
 - 6) Waterproofing: Water blocking layer.
 - 7) Strength member:
 - a) Tight buffer: For cables with more than 12 fiber strands, utilize a central, nonmetallic strength member with a coefficient of thermal expansion similar to the fibers.
 - 8) Approvals and listings: UL 1666 and UL 1685.
 - 9) Design and test criteria: In accordance with ICEA S-104-696.
 - b. Testing:
 - 1) Fibers in the cable:
 - a) Proof test of 100 kpsi.

- b) Each optical fiber: Bellcore GR-409 strip force testing.
 - c) No gaps are allowed between the coating material and the buffer material visible under a 50-power microscope.
- c. Outer jacket material:
 - 1) Linear low-density polyethylene.
 - 2) Meet requirements of the NEC for use in indoor/outdoor areas (excluding plenums) without being enclosed in conduit.
 - 3) Flame retardant OFNR riser rated conforming to UL 1666.
 - 4) Printed with necessary UL marks and manufacturer identification.
 - 5) Sequential printing of footage in 2-foot increments.
 - 6) With a ripcord incorporated under the cable jacket.
- C. Single mode fibers:
 - 1. Fibers in the cable must be usable fibers and meet required specifications.
 - 2. Each optical fiber shall consist of a doped silica core surrounded by a concentric silica cladding.
 - 3. Single mode fiber characteristics:
 - a. Category: OS2 compliant with ITU-G.657.A1.
 - b. Jacket color: Yellow.
- D. Indoor/outdoor:
 - 1. Loose tube:
 - a. Corning Cable Systems, Freedm®.
 - b. CommScope, LazrSPEED/TerraSPEED.

2.06 EQUIPMENT (NOT USED)

2.07 COMPONENTS (NOT USED)

2.08 ACCESSORIES

- A. Patch cords:
 - 1. General:
 - a. Connector types to match supplied equipment and patch panel terminations.
 - b. Maximum length of patch cords: 25 feet.
 - c. Provide 2 spare patch cords (or 1 duplex patch cord) of each type used at each PLC or network cabinet.
 - d. Factory assembled and optically tested.
 - e. Provide mode-conditioning cords for multimode fibers operating at 1,310 nm.
 - 2. Manufacturers: One of the following or equal:
 - a. CommScope.
 - b. Corning Cable Systems.
- B. Fiber connectors:
 - 1. As specified in Section 40_66_01 - Control Systems: Network Materials and Equipment.

- C. Fiber optic identification/warning tags:
 - 1. Black letters on orange or yellow background.
 - 2. UV resistant polyethylene or other suitable material:
 - a. Manufacturers: The following or equal:
 - 1) Almetek.

2.09 SOURCE QUALITY CONTROL

- A. Source Testing:
 - 1. Before shipment and while on the shipping reel, test 100 percent of fibers for attenuation:
 - a. Copies of the results shall be:
 - 1) Maintained on file.
 - 2) Attached to the cable reel in a waterproof pouch.
 - 3) Submitted before the delivery of the cable to the jobsite to the Engineer for approval.
 - 2. Conduct the flex test in accordance with EIA FOTP-104 test condition I and III with a maximum sheave diameter of 20 times the cable OD.
 - 3. Verify that the cable withstands 25 impact cycles with:
 - a. Average increase in attenuation for fibers less than 0.20 dB at 1,550 nm.
 - b. No evidence of cracking or splitting.
 - c. Conduct test in accordance with EIA FOTP-25.
 - 4. Certify that the cable withstands a tensile load of 2,700 N (600 pounds):
 - a. Without exhibiting an average increase in attenuation of greater than 0.10 dB.
 - b. Test in accordance with EIA FOTP-33 using a maximum mandrel and sheave diameter of 560 millimeters.
 - c. Apply the load for 1 hour in test condition II.
 - 5. Certify that the cable withstands a simulated lightning strike:
 - a. Peak value of the current pulse greater than 105 kA.
 - b. Use a test current with a damped oscillatory maximum time-to-peak value of 15 μ s (which corresponds to a minimum frequency of 16.7 kHz) and a maximum frequency of 30 kHz.
 - c. Time to half-value of the waveform envelope 40 to 70 μ s.
 - d. Conduct the test in accordance with the EIA FOTP-181.
 - e. In addition to the analysis criterion set forth in EIA FOTP-181, the integrity of the buffer tubes (or analogous loose tube, i.e., core tube) and strength members must be intact after removal of the cable specimens from the test box.
 - 6. Furnish test reports and Manufacturer's Certificate of Source Testing.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Verify the condition of the conduit system before installation of the fiber optic cable or inner duct.
- B. Pass a test mandrel through fiber optic conduits prior to pulling fiber or installing inner duct.
 - 1. Run the mandrel in both directions.
- C. Examine materials and equipment before installation and verify they are free from physical damage and defects.

3.02 PREPARATION

- A. Equipment support and anchoring to structures:
 - 1. Prepare anchor setting template(s) and use to position anchors during construction of supporting structures.
 - 2. Install anchors of type and material indicated on approved anchoring designs.
 - 3. Install anchors with embedment indicated on approved anchoring designs.
- B. Before fiber splicing terminating or testing activities, verify sufficient workspace is available to perform the activity without interferences from other trades.
- C. Pre-installation test:
 - 1. Upon arrival at the Site:
 - a. Inspect the cable and reel for damage.
 - b. Test fibers with an optical time domain reflectometer (OTDR) for fiber integrity.
 - c. Verify that the fiber lengths are consistent with the cable manufacture.
 - d. Verify that traces yield no point discontinuities.
 - 2. Complete test sequence and obtain approval from the Engineer of submitted test results before cable installation.

3.03 INSTALLATION

- A. Install fiber optic patch cords in open network trays or in dedicated conduits no longer than 25 feet in length.
- B. Install fiber optic cable in continuous lengths without intermediate splices, except where approved by the Engineer.
- C. Cable installation:
 - 1. Properly attach the fiber optic cable's strength elements to a 600-pound breakaway swivel containing tension or shear pins using Kellums pulling grips that are a minimum of 18 inches long.
 - 2. Certify that cable tensile limits do not exceed cable pull tension and bend limits using tension monitoring devices.
 - 3. Leave an extra loop of fiber optic cable in each pull box.

4. Conform with the cable manufacturer's specifications, practices, and the following requirements:
 - a. When power equipment is used to install fiber optic cables, use low speeds, and do not exceed a rate of 30 meters per minute.
 - b. Do not exceed the tensile and bending limitation for fiber optic cables under any circumstances.
 - c. Use large diameter wheels, pulling sheaves, and cable guides to maintain the specified bending radius.
 - d. Use commercial dynamometers or load cells to monitor pulling tension.
 - e. A nonfreezing type of swivel inserted between the pulling line and cable pulling grip to prevent twisting under strain.
 - f. Cable to be installed using a breakaway swivel.
5. Apply to conduits a lubricant at each conduit ingress and egress location during the pull operation:
 - a. Pour or pump lubricant into the end of the conduit at the feed location at a nominal application rate of 3 gallons per 1,000 feet of cable.
 - b. If the conduit is open at intermediate locations, then apply the appropriate proportion of lubricant at each opening.
 - c. Continuously lubricate the cable as it is being pulled by pouring or pumping the lubricant into the conduit at the feed location and at each intermediate location.
 - d. Station workers at each intermediate location as required.
 - e. Remove excess lubricant that has collected.
 - f. Remove and clean the surrounding area after cable installation.
6. Install using a hydraulic capstan or winch equipped with a recording running line dynamometer graph which measures and records pulling tensions:
 - a. Use pulling equipment with slip-load capability to allow the winch to maintain a constant pulling force without taking up the winch line.
 - b. Use pulling equipment equipped with a hydraulic bypass set so that a maximum tension of 600 pounds is not exceeded.
 - c. Use only equipment designed to prevent a preset pulling tension from being exceeded.
 - d. Fiber optic cable manufacturer to provide the pulling tension setpoint.
 - e. If during the pulling operation excessive tension is detected, cease operations and notify the Engineer.
7. Position the cable reel at the feed point in alignment with the raceway and in such a position that the cable can be passed from the top of the reel in a long, smooth bend into the raceway system:
 - a. Use of a cable feeder is required unless the cable is hand-pulled.
8. Supply bull wheels, blocks, split wheels, cable feeders, and necessary equipment required to provide a clean and safe operation:
 - a. Cable shall not be allowed to travel over any wheel or block that has a radius less than the minimum radius allowed by the cable manufacturer.
9. Minimize the use of snatch blocks and rollers to guide the cable into the conduit at the feed point:
 - a. Slack feed by hand the cable into the feed point and raceway without the use of rollers.
10. Tend the cable reel at all times and turn by hand to provide the required cable slack:
 - a. Under no circumstances shall the cable tension be allowed to turn the cable reel.

11. Use a rim roller, with a wheel radius greater than the minimum cable bending radius placed at the manhole or vault opening to prevent the cable from dragging on the manhole rim or steps.
 12. Perform a continuous, thorough visual inspection for flaws, breaks, and abrasions in the cable sheath as the cable leaves the reel and maintain a slow pulling speed to permit this inspection.
 13. Damage to the sheath or finish of the cable is cause for rejecting the cable:
 - a. Replace any cable damaged in any way during installation.
 14. If the cable becomes damaged during installation, stop operations and notify the Engineer immediately:
 - a. Engineer to determine whether to replace the entire reel of cable or to install a termination panel to eliminate the damaged section.
 15. Document pulls by a graph which is annotated with the following information:
 - a. Reel number.
 - b. Pull point ID.
 - c. Date and time.
 - d. Explanations for abnormalities in readings or interruptions.
 - e. Sign-off by the Contractor and Engineer.
 16. Under no conditions shall the fiber optic cable be left exposed or unattended.
- D. After the cables are installed and spliced:
1. Rack the cables:
 - a. Loosely secure in racked position with wire ties.
 - b. Attach imprinted plastic-coated cloth identification/warning tags to each cable in at least 2 locations in each handhole/manhole.
- E. Ground armored fiber optic cables containing metallic members in accordance with NEC.
- F. Splices:
1. Provide field splices in a splice tray located in a waterproof splice enclosure:
 - a. Manufacturers: The following or equal:
 - 1) Tyco/Raychem, FOSC style splice enclosure.
 2. Loop the individual fibers a minimum of 1 full turn within the splice tray to avoid macro/micro bending.
 3. After completion of cable terminations, neatly dress cables.
 4. Protect splices with a thermal shrink sleeve.
 5. Provide fusion type fiber optic cable splicing meeting the following requirements:
 - a. Joins multimode or single mode fibers.
 - b. Establishes a permanent fusion splice.
 - c. Waterproof.
 - d. Re-enterable, rearrangeable, and reusable.
 - e. Splice loss less than 0.10 dB.
 - f. Protected by a splice enclosure.
 6. Requirement for outdoor fiber splice enclosures:
 - a. Seal.
 - b. Bond.
 - c. Anchor.
 - d. Protect fiber optic cable splices.
 - e. Stand-alone unit that does not require an outer enclosure.

- f. Provide for a maximum of 6 cable entries in a butt-end configuration.
 - g. Used in aerial, underground, and direct buried applications.
 - 7. Requirement for indoor fiber splice enclosures:
 - a. Anchor.
 - b. Protect fiber optic cable splices.
 - c. Stand-alone unit that does not require an outer enclosure.
 - d. Suitable for the minimum number of splices at that location plus additional capacity for reconfigurations.
 - 8. Re-splice any splice that has a loss greater than 0.10 dB.
 - 9. Leave a minimum of 20 feet of fiber optic cable at each end of splice.
- G. Terminations:
- 1. Terminate fiber inside a patch panel:
 - a. Direct landing to a switch, router hub, or PLC will not be allowed.
 - 2. Terminate outdoor cables using a breakout kit that seals the cable and provides physical protection for the fiber strands.
 - 3. Terminate indoor cables using breakout kits with field installed terminators.
 - 4. Labeling:
 - a. Permanently label cable terminations. Use labels produced by a wire printer using pressure sensitive polyester labels.
 - b. Label patch panels as specified in Section 26_05_53 - Identification for Electrical Systems.
- H. Installation Verification:
- 1. Furnish Manufacturer's Certificate of Installation Verification.

3.04 FIELD QUALITY CONTROL

- A. Field electrical acceptance testing:
 - 1. As specified in Section 26_08_50 - Field Electrical Acceptance Tests.
- B. Utilize personnel certified by the manufacturer with specific knowledge of the cable manufacturer's recommended installation procedures.
- C. General:
 - 1. Test results shall meet or exceed manufacturer specifications:
 - a. Test each fiber of each cable for breaks, abnormalities, and overall attenuation characteristics.
 - 2. Pre-installation tests and post-installation tests to be witnessed and signed off by the Engineer and Owner.
 - 3. Perform OLTS test with equipment capable and calibrated to show anomalies of 0.1 dB as a minimum:
 - a. Test multimode fibers at 850 nm and 1,300 nm.
 - b. Test single mode fibers at 1,310 nm and 1,550 nm.
 - 4. Perform OTDR tests on fiber cables less than 100 meters with the aid of a launch cable:
 - a. Adjust OTDR pulse width settings to a maximum setting of 1/1,000th of the cable length or 10 nanoseconds.

- D. Manufacturer's field service:
1. Provide the services of a certified manufacturer's engineering representative for the equipment specified in this Section at the jobsite for the frequency and minimum duration (travel time excluded) as specified below to perform the following services:
 - a. Three 8-hour days for inspection, assistance during installation and alignment, and certification of proper installation:
 - 1) Submit a certificate of installation.
 - b. Three 8-hour-days for assistance and witnessing of system testing and any required troubleshooting.
 - c. Three individual 8-hour sessions for operation and maintenance training of City of Thornton's personnel:
 - 1) Conduct each individual training session on a separate workday.
 2. The manufacturer's engineering representative is required at the Construction Manager's direction to provide 5 separate trips to the jobsite to fulfill the above requirements.

3.05 OWNER TRAINING (NOT USED)

3.06 ADJUSTING (NOT USED)

3.07 CLEANING

- A. Clean fiber optic connectors after termination and before testing. After cleaning, cover unterminated connectors with a protective boot.
- B. At the completion of construction, touch up the finish on fiber patch panels and enclosures.

3.08 PROTECTION

- A. Protect the fiber system from physical damage and the encroachment of dust, before, during, and after installation.

END OF SECTION

SECTION 26_05_21

LOW VOLTAGE WIRE CONNECTIONS

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Wire connecting devices.
 - 2. Terminations.
 - 3. Splices.
 - 4. Power distribution blocks.

1.02 REFERENCES

- A. ASTM International (ASTM):
 - 1. D3005 - Standard Specification for Low-Temperature Resistant Vinyl Chloride Plastic Pressure-Sensitive Electrical Insulating Tape.
- B. CSA International (CSA):
 - 1. C22.2 - No. 197-M1983 (R2208) - PVC Insulating Tape.
- C. Underwriters Laboratories, Inc. (UL):
 - 1. 486A-B - Standard of Safety for Wire Connectors.
 - 2. 510 - Standard for Polyvinyl Chloride, Polyethylene, and Rubber Insulating Tape.
 - 3. 1953 - Outline of Investigation for Power Distribution Blocks.

1.03 DELEGATED DESIGN (NOT USED)

1.04 SUBMITTALS

- A. Furnish Submittals as specified in Section 01_33_00 - Submittal Procedures.
- B. Product data:
 - 1. Catalog cutsheets.
 - 2. Installation instructions.

1.05 QUALITY ASSURANCE

- A. Materials shall be UL listed.

1.06 DELIVERY, STORAGE, AND HANDLING (NOT USED)

1.07 PROJECT OR SITE CONDITIONS

- A. As specified in Section 01_81_50 - Design Criteria.

1.08 ADMINISTRATIVE REQUIREMENTS (NOT USED)

1.09 WARRANTY

- A. As specified in Section 01_78_36 - Warranties and Bonds.

PART 2 PRODUCTS

2.01 GENERAL (NOT USED)

2.02 DESIGN AND PERFORMANCE CRITERIA

- A. Provide a complete system of wiring connectors, terminators, fittings, etc., for a complete wiring system suitable for the cables and conductors used.

2.03 MANUFACTURERS

- A. Manufacturers for each type of technology are specified with the equipment in this Section.

2.04 MATERIALS (NOT USED)

2.05 MANUFACTURED UNITS (NOT USED)

2.06 EQUIPMENT

- A. Control connections:
 - 1. Use insulated ring type wire terminators for connections to screw terminals:
 - a. With chamfered/funneled terminal barrel entry.
 - b. Deep internal serrations.
 - c. Long barrel design to reduce electrical resistance and increased insulator-barrel surface area to ensure that the insulator remains in contact with the barrel.
 - d. Electroplated-tin copper conductor.
 - e. Manufacturers: The following or equal:
 - 1) ABB, Sta-Kon.
 - 2. For process equipment connections, work from the manufacturer's drawings.
- B. Joints, splices, taps, connections, and terminations:
 - 1. 600-volt conductors:
 - a. Use solderless connectors.
 - b. Copper pigtail adaptors.
 - 1) For use on select applications as approved by the Engineer.
 - 2) 600 volt, 90 degrees Celsius rated.
 - 3) UL 486A/B listed.
 - 4) Manufacturers: One of the following or equal:
 - a) Burndy APY series.
 - b) ILSCO CPM series.

- c. Use only plated copper alloy connectors or lugs:
 - 1) Aluminum connectors or lugs are not acceptable for copper conductors.
 - d. Under those specific conditions where aluminum conductors have been allowed or are specified then the connectors for aluminum conductors shall be specifically designed for that purpose.
 - e. For wire #10 AWG and smaller, use compression splice caps, with insulating caps:
 - 1) Manufacturers: The following or equal:
 - a) Buchanan, 2006S or 2011S, with 2007 or 2014 insulating caps.
 - f. For wire #8 AWG and larger, use heavy duty copper compression connectors:
 - 1) Manufacturers: One of the following or equal:
 - a) ABB.
 - b) Burndy.
 - g. Heat shrink tubing:
 - 1) Suitable for indoors, outdoors, overhead, direct burial or submerged applications.
 - 2) Minimum shrink ratio: 4 to 1.
 - 3) Continuous operating temperature: -55 degrees Celsius to 110 degrees Celsius.
 - 4) Internally applied adhesive sealant.
 - 5) Cross-linked polyolefin:
 - a) Manufacturers: One of the following or equal:
 - (1) 3M, ITCSN.
 - (2) ABB, Shrink-Kon.
 - 2. Instrumentation class cable splices:
 - a. Suitable for indoor, outdoors, weather exposed, direct buried, or submersed applications.
 - b. Utilizing an epoxy, polyurethane, and re-enterable compounds.
 - c. For use with shielded or unshielded plastic- and rubber-jacketed, signal, control, and power cables rated up to 1 kilovolt.
 - d. Two-part mold body with tongue and groove seams and built-in spacer webbing.
 - e. Manufacturers: The following or equal:
 - 1) 3M, Scotchcast 72-N.
- C. Insulating tape:
- 1. General purpose insulating tape:
 - a. Minimum 7 mil vinyl tape.
 - b. Suitable for application in an ambient of -18 degrees Celsius (0 degrees Fahrenheit).
 - c. Operating range up to 105 degrees Celsius (220 degrees Fahrenheit).
 - d. Flame retardant, hot- and cold-weather resistant, UV resistant.
 - e. For use as a primary insulation for wire cable splices up to 600 VAC.
 - f. Meeting and complying with:
 - 1) ASTM D3005, Type I.
 - 2) UL 510.
 - 3) CSA C22.2.

- g. Manufacturers: The following or equal:
 - 1) 3M, Scotch Number Super 33+.
 - 2. General purpose color-coding tape:
 - a. Minimum 7 mil vinyl tape.
 - b. Suitable for application on PVC and polyethylene jacketed cables.
 - c. For use indoors and outdoors in weather protected enclosures.
 - d. Available with the following colors:
 - 1) Red.
 - 2) Yellow.
 - 3) Blue.
 - 4) Brown.
 - 5) Gray.
 - 6) White.
 - 7) Green.
 - 8) Orange.
 - 9) Violet.
 - e. For use as phase identification, marking, insulating, and harnessing.
 - f. Meeting and complying with:
 - 1) UL 510.
 - 2) CSA C22.2.
 - g. Manufacturers: The following or equal:
 - 1) 3M, Scotch Number 35.
- D. Power distribution blocks:
 - 1. UL 1953 listed.
 - 2. Short circuit rating: Not less than the system maximum available fault current at the point of application.
 - 3. Provide fuses or circuit breakers in enclosure as required to meet the fault current requirements.
 - 4. Voltage rating: 600 VAC.
 - 5. IP 20 finger safe enclosure.
 - 6. Tin-plated aluminum or copper terminals suitable for copper conductors.
 - 7. Manufacturers: One of the following or equal:
 - a. Eaton CHDB series.
 - b. Rockwell Automation 1492 PD series.
 - c. Schneider Electric LB series.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

- A. Load connections:
 - 1. Connect loads to the circuits as indicated. Color-code branch circuits as specified in Section 26_05_18 - 600-Volt or Less Wires and Cables.
- B. Zero to 600-volt systems:
 - 1. Make connections with the proper tool and die as specified by the device manufacturer.
 - 2. Use only tooling and dies manufactured by the device manufacturer.
 - 3. Insulate connections and splices with Scotch 33+ tape and Scotchfill, or pre-molded plastic covers, or heat shrink tubing and caps.
 - 4. Number power and control wires before termination.
- C. Motor connections (600 volts and below):
 - 1. Terminations on motor leads, including leads that are connected to accommodate the motor current, and the wires entering the motor terminal box from the power source, shall have ring type compression lugs or mechanical torqued insulated lugs.
 - 2. Cover bolted connectors with a heat shrinkable, cross-linked polyolefin material formed as a single opening boot:
 - a. In damp and wet locations, use a complete kit containing mastic that shall seal out moisture and contamination.
 - b. Shrink cap with low heat as recommended by the manufacturer.
 - 3. Wire markers shall be readable after boot installation.
 - 4. Manufacturers: One of the following or equal:
 - a. ABB, Blackburn Insulated multi-taps connectors.
 - b. NSI Industries, Polaris insul-tap connectors.
 - c. Raychem, MCK.
- D. Power distribution terminal blocks:
 - 1. Connect fuses or circuit breakers on the line side of power distribution terminal blocks as required to meet short circuit requirements.

END OF SECTION

SECTION 26_05_22

MEDIUM VOLTAGE CABLE CONNECTIONS

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Terminations.
 - 2. Splices.
 - 3. Junctions.

1.02 REFERENCES

- A. Abbreviations:
 - 1. BIL - Basic insulation level.
- B. Standards:
 - 1. Institute of Electrical and Electronics Engineers (IEEE):
 - a. 48 - IEEE Standard for Test Procedures and Requirements for Alternating-Current Cable Terminations Used on Shielded Cables Having Laminated Insulation Rated 2.5 kV through 765 kV or Extruded Insulation Rated 2.5 kV through 500 kV.
 - b. 386 - Standard for Separable Insulated Connector Systems for Power Distribution Systems Rated 2.5 kV through 35 kV.
 - c. 404 - IEEE Standard for Extruded and Laminated Dielectric Shielded Cable Joints Rated 2.5 kV to 500 kV.
 - 2. Underwriters Laboratories, Inc. (UL).

1.03 DELEGATED DESIGN (NOT USED)

1.04 SUBMITTALS

- A. Furnish Submittals as specified in Section 01_33_00 - Submittal Procedures.
- B. Product data:
 - 1. Catalog cutsheets.
 - 2. Installation instructions.
 - 3. Medium voltage systems:
 - a. Documentation demonstrating compliance with the required tests.
 - b. Characteristics and installation procedures for splices, terminators, and junction modules.
- C. Shop Drawings:
 - 1. Showing the installation of splices, terminators, and junction modules.

- D. Operation and maintenance manuals:
 - 1. As specified in Section 01_78_24 - Operation and Maintenance Manuals.
 - 2. Drawings and data for medium voltage cable connectors, splices, terminators, and junction modules.

1.05 QUALITY ASSURANCE

- A. Materials shall be UL listed.

1.06 DELIVERY, STORAGE, AND HANDLING (NOT USED)

1.07 PROJECT OR SITE CONDITIONS

- A. As specified in Section 01_81_50 - Design Criteria.

1.08 ADMINISTRATIVE REQUIREMENTS (NOT USED)

1.09 WARRANTY

- A. As specified in Section 01_78_36 - Warranties and Bonds.

PART 2 PRODUCTS

2.01 GENERAL (NOT USED)

2.02 DESIGN AND PERFORMANCE CRITERIA

- A. Provide a complete system of cables, connectors, terminators, fittings, etc., for a complete cabling system suitable for the cables and conductors used.

2.03 MANUFACTURERS

- A. Manufacturers for each type of technology are specified with the equipment in this Section.

2.04 MATERIALS (NOT USED)

2.05 MANUFACTURED UNITS (NOT USED)

2.06 EQUIPMENT

- A. Tape:
 - 1. Fire and electric arc proofing tape:
 - a. Minimum 30-mil, flexible, elastomer tape that expands in fire to form an insulating firewall between flame and cable.
 - b. Bind in place with glass cloth electrical tape.
 - c. Manufacturers: The following or equal:
 - 1) 3M, Scotch Number 77.
 - 2. Glass cloth electrical tape:
 - a. Thermosetting, 7.4-mil silicone adhesive that performs at Class H temperatures 180 degrees Celsius (356 degrees Fahrenheit).

- b. Use for the following applications:
 - 1) To secure non-PSA insulations such as glass in high-temperature areas.
 - 2) Splice wire rated at 150 degrees Celsius, 180 degrees Celsius, and 200 degrees Celsius.
 - 3) For binding fire and electric arc proofing tape.
 - c. Meeting and complying with:
 - 1) UL recognized component listing for 200 degrees Celsius (Guide OANZ2, File E17385).
 - d. Manufacturers: The following or equal:
 - 1) 3M, Scotch Number 69.
 - 3. Self-fusing silicone rubber tape:
 - a. High-temperature, 12-mil, track resistant, insulating tape.
 - b. Composed of fully cured inorganic silicone rubber.
 - c. Use as a protective overwrap for terminating medium voltage cables.
 - d. Manufacturers: The following or equal:
 - 1) 3M, Scotch Number 70.
- B. Lugs:
 - 1. Tin-plated copper.
 - 2. Compression type.
 - 3. 2-hole blade.
 - 4. UL listed.
- C. Cable splices and terminations:
 - 1. Heat shrink splices:
 - a. Permanent in-line heat shrink splice.
 - b. Suitable for submersible, direct burial applications.
 - c. Splice insulation shall be of a uniform cross-section heat-shrinkable polymeric construction with a linear stress relief system, a high dielectric strength insulating material, and an integrally bonded outer conductive layer for shielding.
 - 1) Splice shall be covered with a heavy-wall heat-shrinkable sleeve overlapping the cable insulation, with a waterproof mastic seal on both ends.
 - d. Electrical requirements:
 - 1) Continuous current rating equal to cable.
 - 2) 5 to 8 kV voltage class:
 - a) Voltage rating phase-ground: 4.6 kV rms.
 - b) Minimum partial discharge voltage (less than 3 pC) 7 kV rms.
 - c) AC withstand, 1 minute: 23 kV rms.
 - d) AC withstand, 5 minutes: 21 kV rms.
 - e) AC withstand, 5 hours: 16 kV rms.
 - f) DC withstand, 15 minutes: 45 kV.
 - g) Impulse withstand, 1.2 by 50 microseconds: 95 kV (crest).
 - 3) 15 kV voltage class:
 - a) Voltage rating phase-ground: 8.7 kV rms.
 - b) Minimum partial discharge voltage (less than 3 pC): 13 kV rms.
 - c) AC withstand, 1 minute: 35 kV rms.
 - d) AC withstand, 5 minutes: 39 kV rms.
 - e) AC withstand, 5 hours: 31 kV rms.

- f) DC withstand, 15 minutes: 70 kV.
 - g) Impulse withstand, 1.2 by 50 microseconds: 110 kV (crest).
 - e. Power cable splices for shielded solid dielectric plastic-insulated cables shall utilize factory-engineered kits containing necessary components to maintain primary cable insulation level and metallic shielding/grounding systems.
 - f. Splice shall accommodate a range of cable sizes and be completely independent of cable manufacturer's tolerances. When assembled on cables the splice shall be capable of passing the electrical test in accordance with:
 - 1) IEEE 48.
 - 2) IEEE 404.
 - g. Manufacturers: The following or equal:
 - 1) TE Connectivity/Raychem.
- 2. Live front terminators:
 - a. Terminators for shielded solid dielectric plastic-insulated cables shall utilize factory-engineered kits containing necessary components to terminate the primary cables and shield systems.
 - b. All locations exterior of buildings shall be considered outdoors, and appropriate heat-shrinkable skirts of a non-tracking material shall be installed.
 - c. Of a material that will relieve the voltage stresses at the point of termination.
 - d. Non-tracking.
 - e. Ultraviolet resistant.
 - f. Terminator insulation shall be of a uniform cross-section heat-shrinkable polymeric construction with a linear stress relief system.
 - g. Electrical requirements:
 - 1) Continuous current rating equal to cable.
 - 2) 5 to 8 kV voltage class:
 - a) Minimum partial discharge voltage (less than 3 pC) 9 kV.
 - b) AC withstand, 1 minute: 35 kV.
 - c) DC withstand, 15 minutes: 65 kV.
 - d) Impulse withstand, 1.2 by 50 microseconds (outdoor): 95 kV (crest).
 - e) Impulse withstand, 1.2 by 50 microseconds (indoor): 80 kV (crest).
 - f) Wet withstand, 10 seconds: 30 kV rms.
 - g) Dry withstand, 6 hours: 25 kV rms.
 - 3) 15 kV voltage class:
 - a) Minimum partial discharge voltage (less than 3 pC) 13 kV.
 - b) AC withstand, 1 minute: 50 kV.
 - c) DC withstand, 15 minutes: 75 kV.
 - d) Impulse withstand, 1.2 by 50 microseconds (outdoor): 110 kV (crest).
 - e) Impulse withstand, 1.2 by 50 microseconds (indoor): 95 kV (crest).
 - f) Wet withstand, 10 seconds: 45 kV rms.
 - g) Dry withstand, 6 hours: 35 kV rms.

- h. Terminator kit shall accommodate a range of cable sizes and be completely independent of cable manufacturer's tolerances. When assembled on cables the terminator shall be capable of passing the electrical test in accordance with:
 - 1) IEEE 48.
 - i. Manufacturers: One of the following or equal:
 - 1) 3M.
 - 2) Burndy/Hubbell Power Systems.
 - 3) Prysmian Group.
 - 4) TE Connectivity/Raychem.
3. Dead front terminators (600 amps):
- a. Terminators for shielded solid dielectric plastic-insulated cables shall be factory-engineered kits containing necessary components to terminate the primary cables and shield systems.
 - b. Modular, pre-molded, fully shielded dead front system.
 - c. Submersible.
 - d. Capable of mating with any manufacturer's interface in accordance with IEEE 386.
 - e. Crimp connector suitable for copper conductors using standard compression tools to join the conductor to the interface.
 - f. To be used as an elbow or a "T."
 - g. Cable stress relief adapters to connect the cable insulation to the dead front terminator.
 - h. Heat shrink seal over the junction between the cable insulation and the terminator body.
 - i. Conductor shield shall be grounded near the termination and connected to the conductive shield of the terminator.
 - j. Bolted to the bushing or connector plug, with an insulating plug to cover the connection.
 - k. Conductive cap covering the insulating plug.
 - l. Conductive shield to provide reliable continuity between jacket of cable and connector.
 - m. Conductive insert around connector to prevent corona.
 - n. With a capacitive test point on the insulating plug to allow circuit testing without disturbing the connection.
 - o. Electrical requirements:
 - 1) Voltage class: 15 kV:
 - a) Maximum voltage:
 - (1) Phase to Ground: 8.3 kV rms.
 - (2) Phase to Phase: 14.4 kV rms.
 - b) Withstand voltage:
 - (1) Impulse (1.2 by 50 microseconds): 95 kV (crest).
 - (2) AC 1 minute: 34 kV.
 - (3) DC 15 minutes: 53 kV.
 - c) Minimum corona extinction level:
 - (1) 11 kV rms.
 - d) Continuous current rating:
 - (1) 600 amps rms.
 - e) Momentary rating:
 - (1) 25,000 amps rms at 0.17 seconds.
 - (2) 10,000 amps rms at 3.0 seconds.

- p. Manufacturers: One of the following or equal:
 - 1) 3M.
 - 2) ABB/Elastimold.
 - 3) Eaton/Cooper.
- 4. Dead front terminators (200 amps):
 - a. Terminators for shielded solid dielectric plastic-insulated cables shall be factory-engineered kits containing necessary components to terminate the primary cables and shield systems.
 - b. Modular, pre-molded, fully shielded dead front system.
 - c. Loadbreak type.
 - d. Submersible.
 - e. Capable of mating with any manufacturer's interface in accordance with IEEE 386.
 - f. Crimp connector suitable for copper conductors using standard compression tools to join the conductor to the interface.
 - g. To be used as an elbow or a "T."
 - h. Heat shrink seal over the junction between the cable insulation and the terminator body.
 - i. Conductor shield shall be grounded near the termination and connected to the conductive shield of the terminator.
 - j. Conductive shield to provide reliable continuity between jacket of cable and connector.
 - k. Conductive insert around connector to prevent corona.
 - l. With a capacitive test point with protective cover to allow circuit testing without disturbing the connection.
 - m. Electrical requirements:
 - 1) Voltage class 15 kV.
 - 2) Withstand voltage:
 - a) Impulse (1.2 by 50 microseconds): 95 kV (crest).
 - b) AC 1 minute: 34 kV.
 - c) DC 15 minutes: 53 kV.
 - 3) Minimum corona extinction level:
 - a) 11 kV rms.
 - 4) Continuous current rating:
 - a) 200 amps rms.
 - 5) Momentary rating:
 - a) 10,000 amps rms, symmetrical at 0.17 seconds.
 - b) 3,500 amps rms, symmetrical at 3.0 seconds.
 - n. Manufacturers: One of the following or equal:
 - 1) 3M.
 - 2) ABB/Elastimold.
 - 3) Eaton/Cooper.
- D. Insulated protective cap:
 - 1. Cap unused bushings/taps to electrically insulate and mechanically seal taps with an insulating cap.
 - a. Loadbreak type.
 - b. Submersible.
 - 2. Fully compliant with IEEE 386.
 - a. Electrical requirements:
 - 1) Voltage class 15 kV.

- 2) Withstand voltage:
 - a) Impulse (1.2 by 50 microseconds): 95 kV (crest).
 - b) AC 1 minute: 34 kV.
 - c) DC 15 minutes: 53 kV.
 - 3) Minimum corona extinction level:
 - a) 11 kV rms.
 - b. Manufacturers: One of the following or equal:
 - 1) 3M.
 - 2) ABB/Elastimold.
 - 3) Eaton/Cooper.
 - 4) Hubbell Power Systems.
- E. Insulated standoff bushings:
- 1. Rated for 200 amps.
 - 2. Loadbreak type.
 - 3. Submersible.
 - 4. Fully compliant with IEEE 386.
 - a. Electrical requirements:
 - 1) Voltage class 15 kV.
 - 2) Withstand voltage:
 - a) Impulse (1.2 by 50 microseconds): 95 kV (crest).
 - b) AC 1 minute: 34 kV.
 - c) DC 15 minutes: 53 kV.
 - 3) Minimum corona extinction level:
 - a) 11 kV rms.
 - 5. Molded EPDM rubber body with stainless steel base bracket.
 - 6. Eyebolt for securing the bushing in a parking stand.
 - 7. Ground lug.
 - 8. Manufacturers: One of the following or equal:
 - a. ABB/Elastimold.
 - b. Eaton/Cooper.
 - c. Hubbell Power Systems.

2.07 ACCESSORIES (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

- A. Medium voltage systems:
 - 1. Ground shield at all terminators, splices, and junctions.
 - 2. Install cable lugs, terminators, splices, and junctions in accordance with the manufacturer's specifications.
 - 3. Fireproof exposed portions of cables.
 - a. Half-lapped layer of fire and electric arc proofing tape, secured with double-wrapped band of glass cloth electrical tape at each end.

- B. Insulated standoff bushings:
 - 1. Provide an insulated standoff bushing in dead-front transformer parking stand.
- C. Medium voltage switchgear connections:
 - 1. Tape or provide insulated boots on cable connections at medium voltage switchgear to maintain the switchgear BIL rating.
 - 2. Make the connections in accordance with the manufacturer's guidelines.

END OF SECTION

SECTION 26_05_26
GROUNDING AND BONDING

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Grounding materials and requirements.

1.02 REFERENCES

- A. ASTM International (ASTM):
 - 1. B3 - Standard Specification for Soft or Annealed Copper Wire.
 - 2. B8 - Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft.
- B. Institute of Electrical and Electronics Engineers (IEEE):
 - 1. 81 - IEEE Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Grounding System.
- C. National Fire Protection Association (NFPA):
 - 1. 70 - National Electrical Code (NEC).
- D. Underwriters Laboratories, Inc. (UL):
 - 1. 467 - Ground and Bonding Equipment.

1.03 DELEGATED DESIGN (NOT USED)

1.04 SUBMITTALS

- A. Furnish Submittals as specified in Section 01_33_00 - Submittal Procedures.
- B. Product data:
 - 1. Catalog cutsheets.

1.05 QUALITY ASSURANCE

- A. Grounding components and materials shall be UL listed and labeled.

1.06 DELIVERY, STORAGE, AND HANDLING (NOT USED)

1.07 PROJECT OR SITE CONDITIONS

- A. As specified in Section 01_81_50 - Design Criteria.

1.08 ADMINISTRATIVE REQUIREMENTS (NOT USED)

1.09 WARRANTY

- A. As specified in Section 01_78_36 - Warranties and Bonds.

PART 2 PRODUCTS

2.01 GENERAL (NOT USED)

2.02 DESIGN AND PERFORMANCE CRITERIA

- A. Ground equipment and raceway systems so that the completed installation is in accordance with applicable code requirements.
- B. Provide a complete electrical grounding system as indicated on the Drawings and as specified including but not limited to:
 - 1. Grounding electrodes.
 - 2. Bonding jumpers.
 - 3. Ground connections.

2.03 MANUFACTURERS

- A. Compression connectors: One of the following or equal:
 - 1. ABB.
 - 2. Burndy.
 - 3. Erico.
 - 4. Harger.
 - 5. Panduit.
- B. Ground rods: One of the following or equal:
 - 1. Erico.
 - 2. Harger.
 - 3. Nehring.
- C. Ground cable: One of the following or equal:
 - 1. Erico.
 - 2. Harger.
 - 3. Nehring.
 - 4. Southwire.
- D. Precast ground well boxes: One of the following or equal:
 - 1. Brooks Products, 3-RT Valve Box.
 - 2. Christy Concrete Products, G12 Valve Box.

2.04 MATERIALS

- A. Ground rod:
 - 1. Minimum: 3/4-inch diameter, 10-feet long.
 - 2. Uniform 10 mil covering of electrolytic copper metallically bonded to a rigid steel core:
 - a. Copper-to-steel bond shall be corrosion resistant.

3. In accordance with UL 467.
 4. Sectional type joined by threaded copper alloy couplings.
 5. Fit the top of the rod with a threaded coupling and steel-driving stud.
- B. Ground cable:
1. Requirements:
 - a. Soft drawn (annealed).
 - b. Concentric lay, coarse stranded in accordance with ASTM B8.
 - c. Bare copper in accordance with ASTM B3.
 2. Size is as indicated on the Drawings, but not less than required by the NEC. Use the following type of wire unless otherwise indicated on the Drawings:
 - a. Size #6 AWG and smaller; solid conductor.
 - b. Size #4 AWG and larger; stranded conductor.
- C. Compression connectors:
1. Manufactured of high copper alloy specifically for the particular grounding application.
 2. Suitable for direct burial in earth and concrete.
 3. Identifying compression die number inscription to be impressed on compression fitting.
- D. Grounding electrode conductors:
1. Minimum size in accordance with the NEC.
- E. Main bonding jumpers and bonding jumpers:
1. Minimum size in accordance with the NEC.

2.05 MANUFACTURED UNITS (NOT USED)

2.06 EQUIPMENT (NOT USED)

2.07 COMPONENTS (NOT USED)

2.08 ACCESSORIES

- A. Precast ground well boxes:
1. Minimum 10-inch interior diameter.
 2. Traffic-rated cast iron cover.
 3. Permanent "GROUND" marking on cover.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

- A. Provide bonding jumpers and wire, grounding bushings, clamps and appurtenances required for complete grounding system to bond equipment and raceways to equipment grounding conductors.
- B. Provide a separate grounding conductor for each motor and connect at motor terminal box. Do not use bolts securing motor box to frame or cover for grounding connectors:
 - 1. When grounding motors driven by variable frequency drives (VFD) comply with the requirements of the VFD manufacturer.
- C. Provide a grounding type bushing with lug for connection of grounding conductor for conduits that originate from each motor control center section, switchboard, or panelboard:
 - 1. Individually bond these raceways to the ground bus in the equipment.
- D. Provide grounding type bushings with lugs for connection of grounding conductor at both ends of metallic conduit runs. Bond ground bushings to the grounding system.
- E. Provide a green insulated wire-grounding jumper from the ground screw to a box grounding screw and, for grounding type devices, to equipment grounding conductor.
- F. Interconnect the secondary switchgear, switchboard, or panelboard neutral bus to the ground bus in the secondary switchgear, switchboard, or panelboard compartment, only at service entrance point or after a transformer.
- G. Duct bank ground system:
 - 1. Provide a bare copper grounding conductor the entire length of each duct bank, embedded in the concrete of the duct bank as indicated on the Drawings and specified in the Specifications.
 - 2. Bond duct bank ground conductors together where duct banks join, merge, intersect, or split.
- H. Grounding at service (600 V or Less):
 - 1. Connect the neutral to ground only at one point within the enclosure of the first disconnecting means on the load side of the service transformer.
- I. Ground connections:
 - 1. Connections to the ground grid system, the duct bank grounding system, equipment, ground rods, etc., shall be made using compression type grounding connectors as indicated on the Drawings, UL listed, and labeled for the application.
 - 2. Make ground connections in accordance with the manufacturer's instructions.
 - 3. Do not conceal or cover any ground connections until the Engineer or authorized representative has established and provided written confirmation that every grounding connection is as indicated on the Drawings and specified in the Specifications.

- J. Grounding electrode system:
1. Ground ring:
 - a. Provide trenching and materials necessary to install the ground ring as indicated on the Drawings.
 - b. Ground ring conductor shall be in direct contact with the earth, or where embedded, concrete, of the size as indicated on the Drawings.
 - c. Minimum burial depth 36 inches or as indicated on the Drawings.
 - d. Re-compact disturbed soils to original density in 6-inch lifts.
 2. Ground rods:
 - a. Locations as indicated on the Drawings.
 - b. Length of rods forming an individual ground array shall be equal in length.
 - c. Drive ground rods and install grounding conductors before construction of concrete slabs and duct banks.
 3. Metal underground water pipe:
 - a. Bond metal underground domestic water pipe to grounding electrode system.
 4. Metal frame of building or structure:
 - a. Bond metal frame of building or structure to grounding electrode system.
 5. Extend grounding conductors through concrete to accessible points for grounding equipment and electrical enclosures.
 6. Where grounding conductors are exposed and subject to physical damage, install in Schedule 80 PVC conduit for protection.
 7. Install grounding system at each structure where switchgear, motor control centers, switchboards, panelboards, panels, or other electrical equipment are installed.
- K. Shield grounding:
1. Analog signal cables shields shall only be grounded at a single point in the loop. Unless otherwise noted, ground signal cable shields at control panel.
 2. For communication and data line signal cable shields and drain wires should be grounded at both ends of the cable run.
 3. Insulate the shielding and exposed drain wire for each signal cable with heat-shrink tubing.
 4. Terminate the signal cable shield on a dedicated grounding terminal block.
- L. Where indicated on the Drawings, install ground rods in precast ground wells.

3.04 FIELD QUALITY CONTROL

- A. Field electrical acceptance testing:
1. As specified in Section 26_08_50 - Field Electrical Acceptance Tests.
- B. Ground system resistance (electrode to ground) of the completed installation, as determined by tests, shall be:
1. 5 ohms or less for industrial systems.
 2. 1 ohm or less for electrical buildings.
- C. Measure grounding electrode system resistance to ground in accordance with IEEE 81.

3.05 ADJUSTING

- A. Under the direction of the Engineer, add additional parallel connected ground rods and/or deeper driven rods until the ground resistance measurement meets the specified resistance requirements:
 - 1. Use of salts, water, or compounds to attain the specified ground resistance is not acceptable.

END OF SECTION

SECTION 26_05_29
HANGERS AND SUPPORTS

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Mounting and supporting electrical equipment and components.

1.02 REFERENCES

- A. American National Standards Institute (ANSI).
- B. ASTM International (ASTM):
 - 1. A123 - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
 - 2. A153 - Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
 - 3. A240 - Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications.
 - 4. D635 - Standard Test Method for Rate of Burning and/or Extent and Time of Burning of Plastics in a Horizontal Position.
 - 5. E84 - Standard Test Method for Surface Burning Characteristics of Building Materials.

1.03 TERMINOLOGY

- A. The words and terms listed below are not defined terms that require initial capital letters, but, when used in this Section, have the indicated meaning.
 - 1. Anchor: Elements (including hardware) connecting hangers and supports to the structure.
 - 2. Hardware: Nuts, bolts, straps, clamps, threaded rod, etc.
 - 3. Supports: Preformed channel or other structural member on which the electrical equipment or raceway is mounted.

1.04 DELEGATED DESIGN

- A. As specified in Section 01_35_73 - Delegated Design Procedures.
- B. Anchoring and bracing.

1.05 SUBMITTALS

- A. Furnish Submittals as specified in Section 01_33_00 - Submittal Procedures.

- B. Product data:
 - 1. Supports:
 - a. Materials.
 - b. Geometry.
 - c. Manufacturer.
 - 2. Hardware:
 - a. Materials.
 - b. Manufacturer.
- C. Shop Drawings:
 - 1. Dimensioned and scalable Shop Drawings of hangers and supports for distribution systems and equipment.
 - 2. Complete details for:
 - a. Member sizes and arrangement in hangers and support assemblies.
 - b. Connections between members in hangers and support assemblies.
 - c. Anchoring hangers and supports to structures.
 - d. Bracing for hangers and supports and anchoring of bracing to structures.
 - 3. Include data on connections, attachment hardware and construction to demonstrate that hangers and supports will satisfy the design loading, bracing, and anchoring criteria.
- D. Delegated Design Submittals:
 - 1. Hangers and supports - General:
 - a. Locations and conditions:
 - 1) Hangers and supports inside structures.
 - 2) Hangers and supports that resist cable pulling/rigging loads.
 - b. Required Submittals: Details with supporting calculations for:
 - 1) Support member arrangement, sizes, and connections.
 - 2) Bracing to resist cable pulling/rigging loads.
 - 3) Connections of hangers, supports, and bracing to the structure.
 - 4) Connections between supports and the equipment or raceway(s) thereon.
 - 2. Hangers and supports - Exterior and seismic conditions:
 - a. Locations and conditions:
 - 1) Hangers and supports at structures designated as seismic design category (SDC) C, D, E, or F in Section 01_81_50 - Design Criteria.
 - 2) Hangers and supports for outdoor installations.
 - b. Required Submittals:
 - 1) Interior: Bracing to resist seismic design loads specified in Section 01_81_50 - Design Criteria.
 - 2) Exterior: Bracing to resist seismic, wind, and other environmental loads specified in Section 01_81_50 - Design Criteria.
 - 3. Hangers and supports anchored to concrete and masonry:
 - a. Locations and conditions:
 - 1) Post-installed mechanical anchors in tension.
 - 2) Post-installed adhesive-bonded all-thread rods in tension.

- b. Required Submittals:
 - 1) Calculations demonstrating that anchors have a demand/capacity ratio (D/C) not greater than the following when anchor capacity is adjusted for moisture conditions, anchor spacing and edge distances, and sustained loading conditions present at the location of installation.
 - a) Post-installed mechanical anchors maximum: 85 percent.
 - b) Post-installed adhesive-bonded anchors maximum: 75 percent.

1.06 QUALITY ASSURANCE (NOT USED)

1.07 DELIVERY, STORAGE, AND HANDLING (NOT USED)

1.08 PROJECT OR SITE CONDITIONS

- A. As specified in Section 01_81_50 - Design Criteria.

1.09 ADMINISTRATIVE REQUIREMENTS (NOT USED)

1.10 WARRANTY

- A. As specified in Section 01_78_36 - Warranties and Bonds.

PART 2 PRODUCTS

2.01 GENERAL

- A. Mount raceways, cabinets, boxes, fixtures, instruments, and devices on Contractor-fabricated supports unless otherwise indicated on the Drawings.

2.02 DESIGN AND PERFORMANCE CRITERIA

- A. Hangers and supports individually and as a system shall resist weights and code-required forces without deflections and deformations that would damage the supporting elements, the raceway or equipment supported, or the surrounding construction.
 - 1. Provide the necessary sway bracing to keep support structures from swaying due to lateral forces, including wire and cable pulling forces.
 - 2. Lateral deflection at top of slab mounted supports shall not exceed support height divided by 240, unless otherwise approved by the Engineer.

2.03 MANUFACTURERS

- A. One of the following or equal:
 - 1. Preformed channel:
 - a. Eaton B-line.
 - b. Power-Strut.
 - c. Robroy.
 - d. Tyco.
 - e. Unistrut.

2.04 MATERIALS

- A. Hot dip galvanized steel:
 - 1. Supports:
 - a. In accordance with ASTM A123 or A153.
 - b. Minimum zinc coating thickness of 2.5 mils.
 - c. Nominal dimensions: 1-5/8 inch by 1-5/8 inch.
 - 2. Hardware:
 - a. Electro-galvanized.
 - b. In accordance with ASTM A153.
- B. Stainless steel:
 - 1. Supports:
 - a. In accordance with ASTM A240.
 - b. ANSI Type 316 material.
 - c. Nominal dimensions: 1-5/8 inch by 1-5/8 inch.
 - 2. Hardware:
 - a. ANSI Type 316 material.
- C. PVC coated galvanized steel:
 - 1. Supports:
 - a. Hot dip galvanized steel as specified in this Section.
 - b. PVC coating thickness of 10 to 20 mils.
 - c. Nominal dimensions: 1-5/8 inch by 1-5/8 inch.
 - 2. Hardware:
 - a. ANSI Type 316 material.

2.05 MANUFACTURED UNITS (NOT USED)

2.06 EQUIPMENT (NOT USED)

2.07 COMPONENTS

- A. Fabricated metal supports: As specified in Section 05_50_00 - Metal Fabrications.

2.08 ACCESSORIES

- A. Anchors: As specified in Section 05_05_24 - Mechanical Anchoring and Fastening to Concrete and Masonry.

2.09 FABRICATION (NOT USED)

2.10 FINISHES

- A. Paint and finish structures: As specified in Section 09_96_01 - High-Performance Coatings.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION

- A. Anchoring and bracing to structures:
 - 1. Prepare equipment anchor setting template(s) and use to position anchors during construction of supporting structure(s).
 - 2. Install anchors of type and material indicated on approved anchoring designs.
 - 3. Install anchors with embedment indicated on approved anchoring designs.

3.03 INSTALLATION

- A. Use materials appropriate for the area as specified in Section 26_05_00 - Common Work Results for Electrical.
- B. General:
 - 1. Refer to the Drawings for details. Equipment, cabinets, boxes, instruments, and devices in damp or wet locations on minimum of 7/8-inch preformed mounting channel.
 - 2. Mount channel vertically along the length of the device so that water or moisture may run freely behind the device.
- C. Corrosion protection:
 - 1. Isolate dissimilar metals, except where required for electrical continuity.
 - a. Use neoprene washers, 9-mil polyethylene tape, or gaskets for isolation.
- D. Anchoring methods:
 - 1. Solid concrete:
 - a. Anchor bolts, anchor rods or post-installed anchors as specified in Section 05_05_24 - Mechanical Anchoring and Fastening to Concrete and Masonry.
 - 2. Metal surfaces: Machine screws or bolts.
 - 3. Hollow masonry units:
 - a. Post installed anchors as specified in Section 05_05_24 - Mechanical Anchoring and Fastening to Concrete and Masonry.
 - 4. Wood and metal studs:
 - a. When supporting devices on metal or wood stud construction, bridge studs with preformed channel, and mount the devices to the channel.
- E. Recoat or seal drilled holes, or cut/scratched surfaces with products recommended by the manufacturer.
- F. Group raceway and position on racks to minimize crossovers.

END OF SECTION

SECTION 26_05_33

CONDUITS

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Metallic conduits.
 - 2. Nonmetallic conduits.
 - 3. Conduit bodies.
 - 4. Conduit fittings and accessories.
 - 5. Conduit installation.

1.02 REFERENCES

- A. Abbreviations:
 - 1. GRC: Galvanized rigid steel conduit.
 - 2. NFC: Nonmetallic flexible conduit.
 - 3. NPT: National pipe thread.
 - 4. PCS: Polyvinyl chloride (PVC) coated rigid steel conduit.
 - 5. PVC: Polyvinyl chloride rigid nonmetallic conduit.
 - 6. SLT: Sealtight-liquidtight flexible conduit.
- B. Standards:
 - 1. American National Standards Institute (ANSI):
 - a. C80.1 - Electrical Rigid Steel Conduit.
 - 2. National Electrical Manufacturers Association (NEMA):
 - a. RN-1 - Polyvinyl Chloride (PVC) Externally Coated Galvanized Rigid Steel Conduit and Intermediate Steel Conduit.
 - 3. National Fire Protection Association (NFPA):
 - a. 70 - National Electrical Code (NEC).
 - 4. Underwriters Laboratories (UL), Inc.:
 - a. 6 - Electrical Rigid Metal Conduit - Steel.

1.03 TERMINOLOGY

- A. The words and terms listed below are not defined terms that require initial capital letters, but, when used in this Section, have the indicated meaning.
 - 1. Conduit bodies: A separate portion of a conduit system that provides access through a removable cover to the interior of the system at a junction of 2 or more conduit sections. Includes, but not limited to, shapes C, E, LB, T, X, etc.
 - 2. Conduit fitting: An accessory that primarily serves a mechanical purpose. Includes, but not limited to, bushings, locknuts, hubs, couplings, reducers, etc.

1.04 DELEGATED DESIGN

- A. As specified in Section 01_35_73 - Delegated Design Procedures and Section 26_05_29 - Hangers and Supports.

1.05 SUBMITTALS

- A. Furnish Submittals as specified in Section 01_33_00 - Submittal Procedures.
- B. Product data:
 - 1. Furnish complete manufacturer's catalog sheets for every type and size of conduit, fitting, conduit body, and accessories to be used on the Project.
 - 2. Furnish complete manufacturer's recommended special tools to be used for installation, if required.
 - 3. Certified test results for PVC-coated metallic conduit showing the adhesive bond is stronger than the tensile strength of the PVC.
- C. Delegated Design Submittals:
 - 1. As specified in Section 26_05_29 - Hangers and Supports.
- D. Certifications:
 - 1. Furnish PVC-coated conduit manufacturer's valid, unexpired certification for each installer.
- E. Record documents:
 - 1. Incorporate changes in conduit routing on electrical plan drawings.
 - 2. Dimension underground and concealed conduits from building lines.
 - 3. Furnish hard copy drawings.

1.06 QUALITY ASSURANCE

- A. Conduits, conduit bodies, and fittings shall be UL listed and labeled.
- B. Every installer of PVC-coated metallic conduit shall be certified by the manufacturer for installation of the conduit, and be able to present a valid, unexpired installer certification card prior to installation beginning.

1.07 DELIVERY, STORAGE, AND HANDLING

- A. Do not expose non-metallic conduit to direct sunlight.
- B. Do not store conduit in direct contact with the ground.

1.08 PROJECT OR SITE CONDITIONS

- A. As specified in Section 01_81_50 - Design Criteria.

1.09 ADMINISTRATIVE REQUIREMENTS

- A. Sequencing:
 - 1. Before performing any trenching locate existing underground utilities.

1.10 WARRANTY

- A. As specified in Section 01_78_36 - Warranties and Bonds.

PART 2 PRODUCTS

2.01 GENERAL (NOT USED)

2.02 DESIGN AND PERFORMANCE CRITERIA

- A. Provide conduits, conduit bodies, fittings, junction boxes, and necessary components, whether or not indicated on the Drawings, as required, to install a complete electrical raceway system.
- B. Provide location and protection of existing underground utilities, underground conduit trenching, conduit and backfill necessary for the complete installation of underground conduits.

2.03 MANUFACTURERS

- A. Galvanized rigid steel conduit:
 - 1. One of the following or equal:
 - a. Allied Tube and Conduit.
 - b. Western Tube and Conduit.
 - c. Wheatland Tube Co.
- B. PVC-coated rigid steel conduit:
 - 1. One of the following or equal:
 - a. Allied.
 - b. Calbond.
 - c. NEC, Inc. BlackGuard.
 - d. Ocal, Inc.
 - e. Robroy Ind.
- C. Flexible nonmetallic conduit:
 - 1. One of the following or equal:
 - a. Anaconda.
 - b. Carlon.
 - c. Electri-Flex Co.
 - d. Liquatite.
- D. Sealtight-liquidtight flexible conduit:
 - 1. One of the following or equal:
 - a. AFC Cable Systems.
 - b. Anaconda.
 - c. Anamet.
 - d. Calbrite.
 - e. Electri-Flex Co.
 - f. Gibson.
 - g. Southwire.

- E. Rigid nonmetallic PVC conduit:
 - 1. One of the following or equal:
 - a. Cantex.
 - b. Carlon.
 - c. Triangle Conduit and Cable.
- F. Conduit bodies:
 - 1. One of the following or equal:
 - a. Appleton.
 - b. Calbond.
 - c. Carlon.
 - d. Crouse-Hinds.
 - e. Gibson,
 - f. O-Z/Gedney.
 - g. Ocal, Inc.
 - h. Robroy Ind.
- G. Joint compound:
 - 1. As recommended by the conduit manufacturer.
- H. Galvanized rigid steel conduit expansion fittings:
 - 1. One of the following or equal:
 - a. Appleton.
 - b. Crouse-Hinds.
 - c. O-Z/Gedney.
- I. PVC-coated rigid steel conduit expansion fittings:
 - 1. One of the following or equal:
 - a. NEC, Inc. BlackGuard.
 - b. Ocal, Inc.
 - c. Robroy Ind.
- J. Conduit sleeve:
 - 1. One of the following or equal:
 - a. Appleton.
 - b. Crouse-Hinds.
 - c. O-Z/Gedney.
- K. Conduit through wall and floor seals:
 - 1. The following or equal:
 - a. O-Z/Gedney:
 - 1) Type "WSK."
 - 2) Type "CSM."

2.04 MATERIALS

- A. Provide conduit bodies, hubs, and other accessories consistent with the conduit type specified in the table below.

Conduit Type	Conduit Bodies and Covers	Fittings	Unions	Bushings and Hubs	Outlet Boxes
GRC	Malleable iron	Malleable iron	Malleable iron or zinc-plated steel	Malleable iron	Cast ferrous
PCS	PVC-coated malleable iron	PVC-coated malleable iron	PVC-coated steel	PVC-coated malleable iron	PVC-coated cast ferrous

2.05 MANUFACTURED UNITS (NOT USED)

2.06 EQUIPMENT (NOT USED)

2.07 COMPONENTS

A. GRC:

1. NPT standard conduit threads with a 3/4-inch taper per foot:
 - a. Running conduit threads are not acceptable.
2. Hot-dip galvanized inside and out:
 - a. Ensures complete coverage and heats the zinc and steel to a temperature that ensures the zinc alloys with the steel over the entire surface.
 - b. Electro-galvanizing is not acceptable.
3. Manufactured in accordance with:
 - a. UL 6.
 - b. ANSI C80.1.

B. PCS:

1. Steel conduit, before PVC coating, shall be new, unused, hot-dip galvanized material, in accordance with to the requirements for Type GRC.
2. Coated conduit NEMA Standard RN-1:
 - a. Galvanized coating may not be disturbed or reduced in thickness during the cleaning and preparatory process.
3. Factory-bonded PVC jacket:
 - a. Exterior galvanized surfaces shall be coated with primer before PVC coating to ensure a bond between the zinc substrate and the PVC coating.
 - b. Nominal thickness of the exterior PVC coating shall be 0.040 inch, except where part configuration or application of the piece dictates otherwise.
 - c. PVC coating on conduits and associated fittings shall have no sags, blisters, lumps, or other surface defects and shall be free of holes and holidays.
 - d. PVC adhesive bond on conduits and fittings shall be greater than the tensile strength of the PVC plastic coating:
 - 1) Confirm bond with certified test results.
4. Urethane coating shall be uniformly and consistently applied to the interior of conduits and fittings:
 - a. Nominal thickness of 0.002 inch.
 - b. Conduits having areas with thin or no coating are not acceptable.
 - c. Threads shall be coated with urethane.

5. PVC exterior and urethane interior coatings applied to the conduits shall afford sufficient flexibility to permit field bending without cracking or flaking at temperature above 30 degrees Fahrenheit (-1 degree Celsius).
 6. PCS conduit bodies and fittings:
 - a. Malleable iron.
 - b. Conduit body, before PVC coating, shall be new, unused material and shall be in accordance with appropriate UL standards.
 - c. PVC coating on the outside of conduit bodies shall be 0.040 inch thick and have a series of ribs to protect the coating from tool damage during installation.
 - d. 0.002-inch interior urethane coating.
 - e. Utilize PVC coating as an integral part of the gasket design.
 - f. Stainless steel cover screw heads shall be encapsulated with plastic to ensure corrosion protection.
 - g. PVC sleeve extending 1 conduit diameter or 2 inches, whichever is less, shall be formed at each female conduit opening.
 - 1) Inside diameter of the sleeve shall be the same as the outside diameter of the conduit to be used.
 - 2) Sleeve shall provide a vapor- and moisture resistant seal at every connection.
 - 3) Fittings shall be Form 8 and supplied with plastic encapsulated stainless steel cover screws. Fittings shall be UL Type 4X. Fittings shall be from the same manufacturer as the conduit in order to maintain system continuity and warranty.
- A. NFC:
1. Provide liquidtight and corrosion-resistant flexible nonmetallic conduits and fittings.
 2. Fabricated from a hard PVC spiral completely surrounded by flexible PVC:
 - a. UL listed for sunlight resistance.
 - b. Suitable for use at conduit temperatures of 80 degrees Celsius dry, 60 degrees Celsius wet, and 60 degrees Celsius oil resistant.
 - c. Temperature range: -20 to 80 degrees Celsius.
- B. SLT:
1. Temperature rated for use in the ambient temperature at the installed location but not less than the following:
 - a. General purpose:
 - 1) Temperature range: -20 to 80 degrees Celsius.
 - b. Oil-resistant:
 - 1) Temperature range: -20 to 60 degrees Celsius.
 2. Sunlight-resistant, weatherproof, and watertight.
 3. Core:
 - a. Galvanized steel for use with RGS and PCS.
 - b. Aluminum for use with RAC and PCA.
 - c. Stainless steel for use with SSC.
 4. Overall PVC jacket.
 5. Smooth interior.
 6. With integral copper ground wire, built in the core, in conduit trade sizes 1/2 inch through 1-1/4 inch.

- C. PVC:
 - 1. Extruded from virgin PVC compound:
 - a. Schedule 40 unless otherwise specified.
 - b. Schedule 80 extra-heavy wall where specified.
 - 2. Rated for 90 degrees Celsius conductors or cable.
 - 3. Rated for use in direct sunlight.
- D. Conduit bodies:
 - 1. In accordance with Form 8, Mark 9, or Mogul design:
 - a. Mogul design in accordance with NEC requirements for bending space for large conductors for conduit trade sizes of 1 inch and larger with conductors #4 AWG and larger, or where required for wire-bending space.
 - 2. Gasketed covers attached to bodies with stainless steel screws secured to threaded holes in conduit body.

2.08 ACCESSORIES

- A. Connectors and fittings:
 - 1. Manufactured with compatible materials to the corresponding conduit.
- B. Insulated throat metallic bushings:
 - 1. Construction:
 - a. Positive metallic conduit end stop.
 - b. Integrally molded non-combustible phenolic-insulated surfaces rated at 150 degrees Celsius.
 - c. Use fully insulated bushings on nonmetallic conduit system made of high-impact 150 degrees Celsius rated non-combustible thermosetting phenolic.
- C. Insulated grounding bushings:
 - 1. Construction:
 - a. Integrally molded non-combustible phenolic-insulated surfaces rated at 150 degrees Celsius.
 - b. Tin-plated copper grounding saddle for use with copper or aluminum conductors.
- D. Electrical unions:
 - 1. Construction:
 - a. Concrete tight, 3-piece construction for rigid metallic conduit.
 - b. 2-piece construction for PVC-coated conduit.
 - c. Rated for Class I, Division 1, Group D in hazardous areas.
- E. SLT fittings:
 - 1. Construction:
 - a. Malleable iron.
 - b. Stainless steel for use with SSC and stainless steel SLT.
 - c. Furnished with locknut and sealing ring.
 - d. Liquidtight, raintight, oiltight.
 - e. Insulated throat.
 - f. Furnish as straight, 45-degree elbows, and 90-degree elbows.

- g. Designed to prevent sleeving:
 - 1) Verify complete bonding of the raceway jacket to the plastic gasket seal.
 - h. Equipped with grounding device to provide ground continuity irrespective of raceway core construction. Grounding device, if inserted into raceway and directly in contact with conductors, shall have rolled-over edges for sizes under 5 inches.
 - i. Where terminated into a threadless opening using a threaded hub fitting, a suitable moisture-resistant/oil-resistant synthetic rubber gasket shall be provided between the outside of the box or enclosure and the fitting shoulder. Gasket shall be adequately protected by and permanently bonded to a metallic retainer.
- 2. Corrosion-resistant and outdoor SLT fittings:
 - a. Construction:
 - 1) PVC-coated liquidtight fittings with a bonded 0.040-inch-thick PVC coating on the metal connector to form a seal around the SLT conduit.
 - 2) Insulated throat and an integral sealing ring.
- F. Hubs for threaded attachment of steel conduit to sheet metal enclosures:
- 1. Construction:
 - a. Insulated throat.
 - b. PVC-coated when used in corrosive areas.
 - c. Bonding locknut.
 - d. Recessed neoprene O-ring to ensure watertight and dusttight connector.
 - e. 1/2-inch through 1-1/4-inch steel zinc electroplated.
 - f. 1-1/2-inch through 6-inch malleable iron zinc plated.
 - 2. Usage:
 - a. Conduits in damp, wet, outdoor, and corrosive areas shall use threaded hubs for connections to sheet metal enclosures.
- G. PVC fittings:
- 1. Materials:
 - a. Devices shall be made of PVC, using the same materials as used for Type PVC conduit.
 - b. Metal hardware shall be stainless steel.
- H. Through wall and floor seals:
- 1. Materials:
 - a. Body: Casting of malleable or ductile iron with a hot-dip galvanized finish.
 - b. Grommet: Neoprene.
 - c. Pressure rings: PVC-coated steel.
 - d. Disc material: PVC-coated steel.
- I. Expansion/deflection couplings:
- 1. Use to compensate for movement in any directions between 2 conduit ends where they connect.
 - 2. Shall allow movement of 3/4 inch from the normal in all directions.
 - 3. Shall allow angular movement for a deflection of 30 degrees from normal in any direction.
 - 4. Constructed to maintain electrical continuity of the conduit system.

- 5. Materials:
 - a. End couplings: Bronze or galvanized ductile iron.
 - b. Sleeve: Neoprene.
 - c. Bands: Stainless steel.
 - d. Bonding jumper: Tinned copper braid.
- J. Expansion couplings:
 - 1. Shall allow for expansion and contraction of conduit:
 - a. Permitting 8-inch movement, 4 inches in either direction.
 - 2. Constructed to maintain electrical continuity of the conduit system.
- K. Conduit markers:
 - 1. As specified in Section 26_05_53 - Identification for Electrical Systems.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Before installing any conduit or locating any device box:
 - 1. Examine the complete set of Drawings and Specifications, and applicable Shop Drawings.
- B. Verify all dimensions and space requirements and make any minor adjustments to the conduit system as required to avoid conflicts with the building structure, other equipment, or the work of other trades.

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

- A. General:
 - 1. Conduit routing:
 - a. Electrical drawings are diagrammatic in nature:
 - 1) Install conduit runs as specified with schematic representation indicated on the Drawings and as specified.
 - 2) Modify conduit runs to suit field conditions, as accepted by the Engineer:
 - a) Make changes in conduit locations that are consistent with the design intent but are dimensionally different, or routing to bypass obstructions.
 - b) Make changes in conduit routing due to the relocation of equipment.
 - c) Install conduits and equipment in such a manner as to avoid obstructions and to preserve headroom and keep openings and passageways clear.
 - 3) Where the Drawings do not indicate the exact mounting and/or supporting method to be used, use materials and methods similar to the mounting details indicated on the Drawings.

- 4) Electrical drawings do not indicate all required junction boxes and pull boxes:
 - a) Provide junction boxes and pull boxes to facilitate wire pulling as required:
 - (1) To meet cable manufacturer's pulling tension requirements.
 - (2) To limit total conduit bends between pull locations.
 - b) Install junction boxes and pull boxes at locations acceptable to the Engineer.
- b. Contractor is responsible for any deviations in general location, conduit size, routing, or changes to the conduit schedule without the express written approval or direction by the Engineer:
 - 1) Engineer is the sole source in determining whether the change is constituted as a deviation.
 - 2) Perform any changes resulting in additional conduits, or extra work from such deviations.
 - 3) Incorporate any deviations on the Record Documents.
2. Use only tools recommended by the conduit manufacturer for assembling the conduit system.
3. Provide adequate clearances from high-temperature surfaces for conduit runs. Provide minimum clearances as follows:
 - a. Clearance of 6 inches from surfaces 113 to 149 degrees Fahrenheit.
 - b. Clearance of 12 inches from surfaces greater than 149 degrees Fahrenheit.
 - c. Keep conduits at least 6 inches from the coverings on hot water and steam pipes, 18 inches from the coverings on flues and breechings, and 12 inches from fuel lines and gas lines.
 - d. Where it is necessary to route conduits close to high-temperature surfaces, provide a high-reflectance thermal barrier between the conduit and the surface.
4. Support conduit runs on water-bearing walls a minimum of 7/8 inch away from the wall on an accepted preformed channel:
 - a. Do not run conduits within water-bearing walls unless otherwise indicated on the Drawings.
5. Do not install 1-inch or larger conduits in or through structural members unless approved by the Engineer.
6. Run conduits exposed to view parallel with or at right angles to structural members, walls, or lines of the building:
 - a. Install straight and true conduit runs with uniform and symmetrical elbows, offsets, and bends.
 - b. Make changes in direction with long radius bends or with conduit bodies.
7. Install conduits with total conduit bends between pull locations less than or equal to 270 degrees.
8. Route exposed conduits to preserve headroom, access space and workspace, and to prevent tripping hazards and clearance problems:
 - a. Install conduit runs so that runs do not interfere with proper and safe operation of equipment and do not block or interfere with ingress or egress, including equipment-removal hatches.
 - b. Route conduits to avoid drains or other gravity lines. Where conflicts occur, relocate the conduit as required.

9. When installing conduits through existing slabs or walls, make provisions for locating any possible conflicting items where the conduit is to penetrate. Use tone signal or X-ray methods to make certain that no penetrations will be made into the existing conduits, piping, cables, post-tensioning cables, etc.
 10. Plug conduits brought into pull boxes, manholes, handholes, and other openings until used to prevent entrance of moisture.
 11. Install conduits through wall and floor seals where indicated on the Drawings.
 12. For new and existing underground and embedded conduits 1 inch and larger, snake conduits with a conduit cleaner equipped with a cylindrical mandrel of a diameter not less than 85 percent of nominal diameter of the conduit.
 13. Provide sleeves and openings required for the passage of electrical raceways or cables even when these openings or sleeves are not specifically indicated on the Drawings.
 14. Install complete conduit systems before conductors are installed.
 15. Provide metallic conduits terminating in transformer, switchgear, motor control center, or other equipment conduit windows with grounding bushings and ground with a minimum No. 6 AWG ground wire.
 16. Underground conduits:
 - a. Install underground conduits, including conduit runs below slabs-on-grade in concrete-reinforced duct bank construction:
 - 1) As specified in Section 26_05_44 - Duct Banks.
 - b. Make underground conduit size transitions at handholes and manholes.
 - c. Install spare conduits in underground duct banks towards top center of runs to allow for ease of installation of future cables as conduits enter underground manholes and handholes.
 - d. Seal around conduit penetrations of below grade walls with a mechanical seal.
 17. Underground conduit trenching:
 - a. Perform trenching as specified in Section 31_23_35 - Trenching.
 - b. Trench must be uniformly graded with the bottom, rock free and covered with select material.
 - c. Damage occurring to existing ducts, conduits, cables, and other utilities during underground conduit installation shall be remediated to the satisfaction of the Owner.
 - d. Whenever possible, use the walls of the trench as forms for concrete encasement:
 - 1) Forms are required where the soil is not self-supporting.
- B. Equipment grounding conductors:
1. Provide a separate, green insulated, grounding conductor in each raceway independent of raceway material:
 - a. Multi-conductor power and control cables shall include an integral green insulated grounding conductor.
 - b. Provide a separate grounding conductor in each individual raceway for parallel feeders.
 - c. Do not apply for conduits to flow meters on pipes with cathodic protection.
 2. Conductors shall be the same type and insulation as the circuit conductors:
 - a. Use 600-volt insulation for the equipment grounding conductors for medium voltage systems.
 3. Minimum size in accordance with the NEC.

- C. Lighting and receptacle conduits:
1. Provide conduit runs for lighting and receptacle circuits, whether or not indicated on the Drawings.
 2. Install conduits in accordance with the requirements of this Section unless otherwise indicated.
 3. Minimum conduit size:
 - a. 3/4 inch for exposed conduits.
 - b. 1 inch for underground or in-slab conduits.
 4. Provide conduit materials for the installed location as specified in Section 26_05_00 - Common Work Results for Electrical.
- D. Conduit usage:
1. Exposed conduits:
 - a. Rigid conduit:
 - 1) Install the rigid conduit type for each location as specified in Section 26_05_00 - Common Work Results for Electrical.
 - 2) Minimum size: 3/4 inch.
 - b. Flexible conduit:
 - 1) Use flexible conduit for final connections between rigid conduit and motors, vibrating equipment, instruments, control equipment, or where required for equipment servicing:
 - a) Use Type SLT with rigid metallic conduit.
 - 2) Minimum size: 3/4 inch:
 - a) 1/2 when required for connection to instruments.
 - 3) Maximum length:
 - a) Fixed equipment:

Conduit Trade Size	Flexible Conduit Length (inch)
3/4	18
1	18
1-1/4	18
1-1/2	18
2	36
2-1/2	36
3	36
3-1/2	38
4	40

- b) Removable instruments or hinged equipment:
 - (1) As required to allow complete removal or full movement without disconnecting or stressing the conduit.
2. Concrete-encased and embedded conduits:
 - a. Straight runs and bends less than 45 degrees:
 - 1) Type PVC Schedule 40.
 - b. Bends with total deflection greater than 45 degrees:
 - 1) PCS.

- c. Entering and exiting duct bank, underground or embedded conduit runs a minimum 12 inches above and below grade, finished floor, or entering equipment:
 - 1) PCS.
 - d. Minimum size:
 - 1) 2 inches in duct banks.
 - 2) 1 inch for in-slab conduits.
 - 3) Provide conduit fittings to enlarge the conduit from the exposed size in the conduit schedule as required.
 - 3. Below-slab conduits:
 - a. Type PCS.
 - b. Minimum size: 1 inch.
 - 4. PVC-coated rigid metallic conduit:
 - a. Use specifically manufactured or machined threading dies to manufacturer's specifications to accommodate the PVC jacket.
 - b. Repair damage to PVC coatings with manufacturer supplied touchup compound or PVC Coating Repair Kit for PVC Coated Raceway Systems.
 - 5. GRC:
 - a. Conduit shall be cut square and reamed before threading.
 - 6. Exposed PVC:
 - a. Conduit terminations shall be via threaded adapters into threaded hubs on the junction boxes or conduit bodies.
 - b. Conduit terminations into boxes without threaded hubs shall utilize a threaded adapter and a flat neoprene washer on the outside of the box.
 - 1) Use a locknut on the inside of the box to tighten the adapter to the box.
 - c. Route conduit to afford it the maximum physical protection.
 - 1) If necessary, cover conduit to afford additional protection when it cannot be shielded by the structure or machinery frames.
 - a) Use Schedule 80 where exposed runs may be subject to physical damage.
- E. Conduit joints and bends:
- 1. General:
 - a. Where conduit is underground, under slabs on grade, exposed to the weather, or in NEMA Type 4 or NEMA Type 4X locations, make joints liquidtight.
 - b. Keep bends and offsets in conduit runs to an absolute minimum.
 - c. Bends shall be symmetrical.
 - d. The following conduit systems shall use large-radius sweep elbows:
 - 1) Underground conduits.
 - 2) Conduits containing medium-voltage cables.
 - 3) Conduits containing shielded cables.
 - 4) Conduits containing fiber optic cables.
 - e. Provide factory-made elbows for large-radius bends for conduits 1-1/4-inch trade size or larger.
 - f. Make field bends with a radius of not less than the requirements found in the NEC:
 - 1) Minimum bending radius of the cable must be less than the radius of the conduit bend.

- 2) Make field bends with power bending equipment or manual benders specifically intended for the purpose:
 - a) Make bends so that the conduit is not damaged and the internal diameter is not effectively reduced.
 - b) For the serving utilities, make bends to meet their requirements.
 - 3) For PCS conduit, field bends are permitted on conduits 1 inch and smaller. Manufactured elbows shall be used on conduits larger than 1 inch.
 - g. Replace deformed, flattened, or kinked conduit.
 - 2. Threaded conduit:
 - a. Cut threads on rigid metallic conduit with a standard conduit-cutting die that provides a 3/4-inch per foot taper and to a length such that bare metal exposed by the threading operation is completely covered by the couplings or fittings used. In addition, cut the lengths of the thread such that joints become secure and wrench-tight just preceding the point where the conduit ends would butt together in couplings or where conduit ends would butt into the ends or shoulders of other fittings.
 - b. Thoroughly ream conduit after threads have been cut to remove burrs.
 - c. Use bushings or conduit fittings at conduit terminations.
 - d. On exposed conduits, repair scratches and other defects with galvanizing repair stick, Enterprise Galvanizing Galvabar™, or CRC Zinc It.
 - e. Coat conduit threads with an approved electrically conductive sealant and corrosion inhibitor that is not harmful to the conductor insulation:
 - 1) Apply to the male threads and tighten joints securely.
 - 2) Clean excess sealant from exposed threads after assembly.
 - f. Securely tighten threaded connections.
 - g. Any exposed threaded surfaces must be cleaned and coated with a galvanizing solution so that exposed surfaces have a galvanized protective coating.
 - 3. PVC:
 - a. Use approved solvent-weld cement specifically manufactured for the purpose. Spray-type cement is not allowed.
 - b. Apply heat for bends so that conduit does not distort or discolor. Use a spring mandrel as required to ensure full inside diameter at bends:
 - 1) Utilize a heater specifically for PVC conduit as recommended by the conduit manufacturer.
- F. Conduit sealing and drainage:
- 1. Other than required for hazardous and classified areas:
 - a. Provide sealing and drainage in vertical drops of long (in excess of 20 feet), exterior, above-grade conduit runs at the points at which the conduit enters buildings, switchgear, control panels, lighting panelboards, and other similar enclosures.
 - b. Provide seal fittings with drains in vertical drops directly above grade for exterior and above-grade conduit runs that are extended below grade.
 - c. Provide conduit seals with drains in areas of high humidity and rapidly changing temperatures:
 - 1) Where portions of an interior raceway pass through walls, ceilings, or floors that separate adjacent areas having widely different temperatures.

- d. Provide conduit seals similar to O-Z/Gedney (Type CSM) on conduits between corrosive and non-corrosive areas.
 - e. Seal one end only of underground conduits at highest point with O-Z/Gedney sealing (non-hazardous) filling, or equal.
 - 2. Install seals with drains at any location along conduit runs where moisture may condense or accumulate. This requirement includes, but is not limited to, the following locations: Control panels, junction boxes, pullboxes, or low points of the conduit.
- G. Hangers and supports:
 - 1. General:
 - a. Provide appropriate hangers, supports, fasteners, and seismic restraints to suit applications:
 - 1) As specified in Section 26_05_29 - Hangers and Supports.
 - 2) Provide support materials consistent with the type of conduit being installed as specified in Section 26_05_00 - Common Work Results for Electrical.
 - b. Support conduit at the intervals required by the NEC.
 - c. Perforated strap and plumbers' tape are not acceptable for conduit supports.
 - 2. Conduit on concrete or masonry:
 - a. Use 1-hole malleable iron straps with metallic or plastic expansion anchors and screws or support from preset inserts.
 - b. Use preset inserts in concrete when possible.
 - c. Use pipe spacers (clamp backs) in wet locations.
 - 3. Suspended conduit:
 - a. Use malleable-iron factory-made split-hinged pipe rings with threaded suspension rods sized for the weight to be carried (minimum 3/8-inch diameter), Kindorf, or equal.
 - b. For grouped conduits, construct racks with threaded rods and tiered angle iron or preformed channel cross members. Clamp each conduit individually to a cross member. Where rods are more than 2 feet long, provide rigid sway bracing.
 - 4. Supports at structural steel members:
 - a. Use beam clamps.
 - b. Drilling or welding may be used only as specified or with approval of the Engineer.
 - 5. PVC-coated rigid metal systems:
 - a. Provide right-angle beam clamps and "U" bolts specially formed and sized to snugly fit the outside diameter of the coated conduit. Provide "U" bolts with PVC-encapsulated nuts that cover the exposed portions of the threads.
 - b. Securely fasten exposed conduits with Type 316 stainless steel clamps or straps.
- H. Expansion or expansion/deflection fittings:
 - 1. General:
 - a. Align expansion coupling with the conduit run to prevent binding.
 - b. Follow manufacturer's instructions to set the piston opening.

- c. Install expansion fittings across concrete expansion joints and at other locations where necessary to compensate for thermal or mechanical expansion and contraction.
 - d. Furnish fittings of the same material as the conduit system.
 - 2. For metallic conduit, provide expansion or expansion/deflection couplings, as appropriate, where:
 - a. Install expansion fittings a minimum of every 200 feet in straight conduit runs.
- I. Empty conduits:
 - 1. Provide a pull tape in each empty conduit more than 10 feet in length.
 - 2. Seal ends of conduits with approved, manufactured conduit seals, caps, or plugs immediately after installation:
 - a. Keep ends sealed until immediately before pulling conductors.
- J. Miscellaneous:
 - 1. Seal roof penetrations for raceways and other items that penetrate the roof in accordance with roofing manufacturer's instructions and as indicated on the Drawings.
 - 2. Provide electrical unions at all points of union between ends of rigid conduit systems that cannot otherwise be coupled:
 - a. Running threads and threadless couplings are not allowed.
 - 3. Replace any conduits installed that the Engineer determines do not meet the requirements of this Specification.
 - 4. Provide conduit housekeeping curb around embedded or below-grade conduits exiting or entering the slab, in accordance with the Typical Details.

END OF SECTION

SECTION 26_05_34

BOXES

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Device boxes.
 - 2. Raceway system boxes.

1.02 REFERENCES

- A. American Association of State Highway and Transportation Officials (AASHTO):
 - 1. Standard Specifications for Highway Bridges.
- B. ASTM International (ASTM):
 - 1. A47 - Standard Specification for Ferritic Malleable Iron Castings.
- C. Joint Industry Conference (JIC).
- D. National Electrical Manufacturers Association (NEMA):
 - 1. 250 - Enclosures for Electrical Equipment (1,000 V Maximum).
- E. National Fire Protection Association (NFPA):
 - 1. 70 - National Electrical Code (NEC).
- F. Underwriters Laboratories, Inc. (UL):
 - 1. 514A - Metallic Outlet Boxes.

1.03 TERMINOLOGY

- A. The words and terms listed below are not defined terms that require initial capital letters, but, when used in this Section, have the indicated meaning.
 - 1. Arcing parts: Circuit breakers, motor controllers, switches, fuses, or any device intended to interrupt current during its operation.
 - 2. Raceway system boxes: Boxes that are used for wire and cable pullboxes, conduit junction boxes, or terminal boxes.

1.04 DELEGATED DESIGN (NOT USED)

1.05 SUBMITTALS

- A. Furnish Submittals as specified in Section 01_33_00 - Submittal Procedures.
- B. Product data:
 - 1. Manufacturer.
 - 2. Materials.

3. Dimensions:
 - a. Height.
 - b. Width.
 - c. Depth.
 - d. Weight.
 - e. NEMA rating.
 4. Conduit entry locations.
 5. Catalog cutsheets.
 6. Installation instructions.
- C. Shop Drawings:
1. Include identification and sizes of pullboxes.

1.06 QUALITY ASSURANCE

- A. Regulatory requirements:
1. Outlet boxes shall comply with applicable standards of:
 - a. JIC.
 - b. NEC.
 - c. NEMA.
 - d. UL.

1.07 DELIVERY, STORAGE, AND HANDLING (NOT USED)

1.08 PROJECT OR SITE CONDITIONS

- A. As specified in Section 01_81_50 - Design Criteria.

1.09 ADMINISTRATIVE REQUIREMENTS (NOT USED)

1.10 WARRANTY

- A. As specified in Section 01_78_36 - Warranties and Bonds.

PART 2 PRODUCTS

2.01 GENERAL (NOT USED)

2.02 DESIGN AND PERFORMANCE CRITERIA

- A. Provide outlet boxes for wiring devices, security systems, junction, and pullboxes for use in the raceway systems, etc.
- B. Provide boxes as indicated on the Drawings and as needed to complete the raceway installation.
- C. Size pullboxes in accordance with NEC requirements and to provide sufficient room for any future conduits, components, and cables as indicated on the Drawings.

- D. Provide materials and construction suitable for environmental conditions at the location of the box as specified in Section 26_05_00 - Common Work Results for Electrical.
- E. For boxes not indicated:
 - 1. Provide outlet boxes to match the exposed conduit system. Provide junction boxes and pull boxes as specified in Section 26_05_00 - Common Work Results for Electrical.

2.03 MANUFACTURERS

- A. One of the following or equal:
 - 1. Cast device boxes:
 - a. Appleton.
 - b. Calbrite.
 - c. Crouse-Hinds.
 - d. Gibson.
 - e. O-Z/Gedney.
 - 2. Formed steel enclosures:
 - a. Hoffman.
 - b. Rittal
 - c. Stahlin.
 - 3. Stainless steel enclosures:
 - a. Hoffman.
 - b. Rittal.
 - c. Stahlin.

2.04 MATERIALS (NOT USED)

2.05 MANUFACTURED UNITS

- A. Cast device boxes:
 - 1. Construction:
 - a. With internal green ground screw.
 - b. Furnished with a suitable gasketed cover.
 - c. With integral cast mounting lugs when surface mounted.
 - d. Conduit sizes range from 3/4 inch to 1 inch.
 - e. Tapered threaded hubs with integral bushing.
 - 2. Aluminum (copper free) boxes:
 - a. High strength copper free 4/10 of 1 percent maximum alloy for use with aluminum rigid conduit.
 - 3. Malleable iron boxes:
 - a. In accordance with ASTM A47 Grade 32510.
 - 4. Stainless steel boxes:
 - a. Type 316 stainless steel for use with stainless steel conduit.
- B. Plastic coated cast device boxes:
 - 1. Construction:
 - a. With internal green ground screw.
 - b. Furnished with a suitable gasketed cover.
 - c. With integral cast mounting lugs when surface mounted.

- d. Conduit sizes range from 3/4 inch to 1 inch.
 - e. Double coated with a nominal 0.002-inch (2 mil) urethane on both the interior and exterior before application of PVC coating.
 - f. With a minimum 0.040-inch (40 mil) PVC coating bonded to exterior.
 - g. With pressure sealing sleeve to protect the connection with conduit.
- C. Formed steel enclosures:
- 1. Steel:
 - a. NEMA Type 12.
 - b. Fabricated from 14-gauge steel, minimum.
 - c. Seams continuously welded ground smooth.
 - d. Door:
 - 1) Rolled lip around 3 sides.
 - 2) Attached to enclosure by means of a continuous stainless steel hinge and pin.
 - e. Neoprene door gasket to provide a watertight, dusttight, oiltight seal:
 - 1) Attached with an adhesive.
 - 2) Retained by a retaining strip.
 - f. Fabricate external removable hardware for clamping the door to the enclosure body from zinc-plated heavy gauge steel:
 - 1) With a hasp and staple for padlocking.
 - g. Provide large enclosures with door and body stiffeners for extra rigidity.
 - h. No holes or knockouts.
 - i. Finish:
 - 1) ANSI 61 gray electrostatically applied polyester powder inside and out over cleaned and primed surfaces.
 - 2) White electrostatically applied polyester powder mounting plate.
 - j. Heavy gauge steel external mounting brackets when surface mounted.
 - 2. Stainless steel:
 - a. NEMA Type 4X.
 - b. Fabricated from 14-gauge Type 316 stainless steel.
 - c. Seams continuously welded.
 - d. Door:
 - 1) Rolled lip around 3 sides.
 - 2) Attached to enclosure by means of a continuous stainless steel hinge and pin.
 - e. Neoprene door gasket to provide a watertight seal:
 - 1) Attached with an adhesive.
 - 2) Retained by a retaining strip.
 - f. Fabricate external removable hardware for clamping the door to the enclosure body from heavy gauge stainless steel:
 - 1) With a hasp and staple for padlocking.
 - g. Provide large enclosures with door and body stiffeners for extra rigidity.
 - h. No holes or knockouts.
 - i. Finish:
 - 1) Brushed.
 - j. Stainless steel external mounting brackets when surface mounted.

- D. Cast iron junction boxes:
 - 1. NEMA Type 4.
 - 2. Recessed cover boxes.
 - 3. Suitable for use outdoors where subject to rain, dripping, or splashing water.
 - 4. Designed for flush mounting in walls or floors:
 - a. Can be surface mounted using mounting lugs.
 - 5. Construction:
 - a. Cast iron.
 - b. Covers:
 - 1) Checkered plate covers suitable for foot traffic.
 - 2) When used in areas subject to vehicular traffic, design to support an AASHTO Standard Specifications for Highway Bridges, H-20 vehicle loading.
 - c. Hot dip galvanized.
 - d. Neoprene gasket.
 - e. Stainless steel screw covers.

2.06 EQUIPMENT (NOT USED)

2.07 COMPONENTS (NOT USED)

2.08 ACCESSORIES

- A. Fasteners:
 - 1. Electroplated or stainless steel in boxes with wiring devices.
 - 2. Screws, nuts, bolts, and other threaded fasteners:
 - a. Stainless steel.
- B. Provide breather and drain fittings where appropriate.
- C. Internal panels:
 - 1. Provide internal panels where required for mounting of terminal strips or other equipment.
 - 2. With plated steel shoulder studs.
 - 3. Steel with white polyester powder finish.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

- A. General:
 - 1. Provide outlet box materials to match the exposed conduit system as specified in Section 26_05_33 - Conduits.
 - 2. Solid type gang boxes:
 - a. For more than 2 wiring devices.
 - b. For barriered outlets.

3. Support wall mounted NEMA Type 4 or NEMA Type 4X boxes to maintain a minimum of 7/8-inch free air space between the back of the enclosure and the wall:
 - a. Use machined spacers to maintain air space; built-up washers are not acceptable.
 - b. Use stainless steel or nylon materials for spacers.
 4. Use cast boxes when box must support other devices.
 5. Boxes serving luminaires or wiring devices:
 - a. Use as pullboxes wherever possible.
 6. In terminal boxes, furnish terminals as indicated on the Drawings with a minimum of 50 percent spare terminals:
 - a. Furnish wireways for discrete and analog/DC wiring.
 - b. Separate analog wiring from 120 V discrete or power wiring.
 7. For fire-rated construction, provide materials and installation for use in accordance with the listing requirements of the classified construction.
- B. Outlet boxes:
1. Locate outlet boxes as indicated on the Drawings:
 - a. Adjust locations so as not to conflict with structural requirements or other trades.
 2. Use deep threaded-hub cast boxes:
 - a. In hazardous areas.
 - b. Where exposed to the weather.
 - c. In unheated areas.
 - d. Where subject to mechanical damage:
 - 1) Defined as exposed boxes less than 10 feet above the floor.
 - e. To act as a pullbox for conductors in a conduit system.
 3. Outlet boxes may be used as junction boxes wherever possible.
- C. Pullboxes and junction boxes:
1. Provide junction box materials and NEMA ratings as specified in Section 26_05_00 - Common Work Results for Electrical.
 2. Install pullboxes such that access to them is not restricted.

END OF SECTION

SECTION 26_05_44

DUCT BANKS

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Electrical underground duct banks.
 - 2. Duct bank installation requirements.

1.02 REFERENCES

- A. Underwriters Laboratories, Inc. (UL).

1.03 DELEGATED DESIGN (NOT USED)

1.04 SUBMITTALS

- A. Furnish Submittals as specified in Section 01_33_00 - Submittal Procedures.
- B. Product data:
 - 1. PVC conduit spacers.
 - 2. Detectable underground marking tape.
 - 3. Pull line.
 - 4. Duct seal.
- C. Shop Drawings:
 - 1. Submit Site plan drawings of duct banks, including underground profiles indicating underground utilities.
 - 2. Submit cross section of each duct bank with dimensions.
 - 3. For duct bank routings crossing under building footers or foundations alternative to designed routings indicated on the Drawings:
 - a. Submit Shop Drawings detailing the new building footer crossing locations and plan drawings labeling equipment to be installed on top of the new routing for approval by the Project structural engineer.

1.05 QUALITY ASSURANCE (NOT USED)

1.06 DELIVERY, STORAGE, AND HANDLING (NOT USED)

1.07 PROJECT OR SITE CONDITIONS

- A. As specified in Section 01_81_50 - Design Criteria.

1.08 ADMINISTRATIVE REQUIREMENTS

- A. Sequencing:
 - 1. Before performing any trenching locate existing underground utilities:
 - a. Review of existing civil record drawings for recorded underground utilities.
 - 1) Determine underground utility horizontal and vertical location by at least one of the following methods:
 - a) Soft excavation.
 - b) Local utility location service, CALL BEFORE YOU DIG, or equal.
- B. Scheduling:
 - 1. Schedule a coordination meeting to adjust duct bank configurations and routing for each duct bank section after trenching and exposure of any underground utilities within the vicinity of the duct bank route. Meeting shall determine the final configuration of the duct bank before installation.

1.09 WARRANTY

- A. As specified in Section 01_78_36 - Warranties and Bonds.

PART 2 PRODUCTS

2.01 GENERAL (NOT USED)

2.02 DESIGN AND PERFORMANCE CRITERIA

- A. Duct bank sections indicated on the Drawings are an initial arrangement and may need to be modified due to existing Site conditions, existing underground utilities, and infrastructure.
 - 1. Reorganize duct bank section with approval of the Engineer.
 - 2. Make changes required to accommodate duct bank configuration and routing changes due to field conditions.
 - a. Where changes in a duct bank configuration extend to a manhole or handhole, coordinate manhole/handhole blockouts and size with the new configuration.
- B. Provide location and protection of existing underground utilities, duct bank, trenching, forming, rebar, spacers, conduit, concrete, backfill, and compaction necessary for the complete installation of the duct banks.
- C. Provide reinforced concrete duct banks for conduits installed below grade, on the Site, below structures, or in contact with the earth, unless otherwise indicated on the Drawings.

2.03 MANUFACTURERS

- A. Conduit spacers:
 - 1. One of the following or equal:
 - a. Cantex.
 - b. Osburn Associates, Inc.

- B. Detectable underground marking tape:
 - 1. One of the following or equal:
 - a. Blackburn Manufacturing Co.
 - b. Panduit.
- C. Pull line:
 - 1. One of the following or equal:
 - a. Arnco.
 - b. Greenlee.
 - c. Osburn Associates, Inc.
- D. Duct seal:
 - 1. The following or equal:
 - a. O-Z/Gedney type DUX.

2.04 MATERIALS

- A. Provide conduit as specified in Section 26_05_33 - Conduits.
- B. Provide reinforcing steel as specified in Section 03_20_00 - Concrete Reinforcing:
 - 1. Provide minimum Number 4 reinforcing steel.
- C. Concrete:
 - 1. Mix requirements as specified in Section 03_30_00 - Cast-in-Place Concrete.
 - 2. Provide a red-oxide conduit encasement coloring agent as specified in Section 03_30_00 - Cast-in-Place Concrete.

2.05 MANUFACTURED UNITS

- A. Conduit spacers:
 - 1. Recommended by the conduit manufacturer or specified above.
 - 2. Saddle type.
 - 3. Non-metallic, non-corrosive, non-conductive.
 - 4. Interlocking type:
 - a. Vertical interlocking.
 - b. Horizontal interlocking.
 - 5. Suitable for concrete encasement.
 - 6. Molded-in rebar holder.
 - 7. Accommodates 2-inch through 6-inch conduit sizes.
 - 8. Relieves the conduit from both horizontal and vertical stresses.
- B. Pull line:
 - 1. Minimum 1/4-inch wide, flat design.
 - 2. Polyester.
 - 3. Minimum pulling strength 1,200 pounds.
 - 4. Sequential footage markings.

- C. Detectable marking tape:
 - 1. Locatable by a cable or metal detector from above the undisturbed grade.
 - 2. Aluminum core laminated between polyethylene film.
 - 3. 6-inch-wide red tape imprinted with black lettering stating "CAUTION - BURIED ELECTRIC LINE BELOW", or equivalent.
- D. Duct seal:
 - 1. Non-hardening sealing compound.
 - 2. Flexible, can be applied by hand.
 - 3. UL Listed for use with installed conductors.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

- A. Duct banks:
 - 1. Encased in concrete at least 24 inches below finish grade, unless otherwise indicated on the Drawings.
 - 2. Damage minimization:
 - a. Conduit should not be left exposed in an open trench longer than is necessary.
 - b. Protect underground duct banks against damage during pouring of concrete or backfilling.
 - 3. Plastic conduit fittings to be joined should be exposed to the same temperature conditions for a reasonable length of time before assembly.
 - 4. Provide No. 4/0 American Wire Gauge bare copper ground wire the entire length of duct bank and bond to the grounding system at each end of the duct bank:
 - a. Where duct bank terminates at structures with a grounding electrode, bond duct bank ground wire to the grounding electrode.
 - b. Where duct bank terminates at electrical equipment, bond duct bank ground wire to the equipment ground bus.
 - c. Where duct bank terminates at structure without either a grounding electrode or electrical equipment, provide ground rod adjacent to structure and bond duct bank ground wire to ground rod.
 - 5. Install underground ducts to be self-draining:
 - a. Slope duct banks away from buildings to manholes, handholes, or pullboxes.
 - b. Slope duct banks uniformly from manholes, handholes, or pullboxes to manholes, handholes, or pullboxes or both ways from high points between manholes, handholes, or pullboxes.
 - c. Slope a minimum of 1/4 inch per 10 feet.
 - 6. Where new duct banks join to existing manholes, handholes, or pullboxes, make the proper fittings and fabricate the concrete envelopes to ensure smooth durable transitions, as indicated on the Drawings.

7. Install pull line in spare conduits:
 - a. Provide adequate pull line at both ends of conduits to facilitate conductor pulling.
 - b. Cap above ground spare conduit risers at each end with screw-on conduit caps.
- B. Trenching:
 1. Perform as specified in Section 31_23_35 - Trenching.
 2. Trench must be uniformly graded with the bottom rock free and covered with select material.
 3. Whenever possible, use the walls of the trench as forms for concrete encasement:
 - a. Forms are required where the soil is not self-supporting.
 4. Damage occurring to existing ducts, conduits, cables, and other utilities during duct bank installation shall be remediated to the satisfaction of the Owner.
- C. Duct spacing:
 1. Separate conduits with manufactured plastic spacers using a minimum space between the outside surfaces of adjacent conduits of 2 inches, 3 inches for medium voltage conduits 4-inch and smaller, unless otherwise indicated on the Drawings:
 - a. Separate medium voltage ducts a minimum of 7.5 inches on center.
 2. Install spacers to maintain uniform spacing of duct assembly a minimum of 4 inches above the bottom of the trench during concrete pour. Install spacers on 8-foot maximum intervals:
 - a. Due to some distortion of conduit from heat, and other means, it may be necessary to install extra spacers within the duct bank:
 - 1) Install the intermediate set of spacers within normal required spacing to maintain the proper horizontal clearance:
 - a) Clearance is required to allow the proper amount of concrete to infiltrate vertically among the duct to ensure proper protection.
 3. Spacers shall not be located at the center of a bend:
 - a. Locate spacer in the tangent, free of the coupling on fabricated bends.
 - b. Locate spacers midway between the tangent and the center bend on trench formed sweeps.
- D. Terminating:
 1. Use bell ends in duct at entrances into cable vaults.
 2. Make conduit entrances into cable vaults tangential to walls of cable vault.
 3. Form trapezoidal transitions between duct bank and cable vaults as needed in order to ensure adequate cable bending radius for the duct bank-to-vault transition.
 4. Install duct seal in all conduits, including spare conduits, at both ends, entrance to manholes/handholes, and building/equipment stub-ups. Form by hand to conduit and around cables to develop moisture barrier.
 5. New manhole or handhole applications, provide a single opening or "window" per duct bank, sized to accommodate the duct bank envelope.

- E. Concrete:
1. Install concrete as specified in Section 03_30_00 - Cast-in-Place Concrete.
 2. Provide tie wires as specified in Section 03_20_00 - Concrete Reinforcing to prevent displacement of the conduits during pouring of concrete:
 - a. Tie wire shall not act as a substitute for spacers.
 3. Install minimum 3-inch cover around conduit and rebar.
 4. Consolidation of encasement concrete around duct banks shall be by hand puddling. Mechanical vibrators are acceptable for use outside of the rebar cage.
 5. Conduit is subject to temperature rise. As concrete cures, allow the free end to expand by pouring the concrete from the center of the run or from one tie in point.
- F. Marking tape:
1. Install a detectable marking tape 12 inches above the duct bank the entire length of the duct bank.
- G. For conduit installations beneath building slabs:
1. Duct banks shall be continued under building slabs to the final destination of the conduits.
 - a. Construct separate duct banks as required.
 - b. Concrete for encasement under building slabs need not be colored red.
 - c. For duct banks crossing under building footers or foundations, install the top of the duct bank a minimum of 6 inches below the footer.
 - d. Where duct banks enter through building walls, foundation walls, stem walls, etc., make connections as indicated on the Drawings.
 - e. Where duct banks terminate with conduit risers entering building walls, install an expansion/deflection fitting or a flat-wise elbow (elbow parallel to building wall) in order to accommodate differential movement between the conduits and structure.
- H. Restore surfaces to their original condition, unless otherwise specified.

3.04 FIELD QUALITY CONTROL (NOT USED)

3.05 ADJUSTING (NOT USED)

3.06 CLEANING

- A. Clean conduits of dirt and debris by use of an appropriately sized steel mandrel no less than 1/2 inch smaller than the inside diameter of the conduit.

3.07 PROTECTION

- A. Provide shoring and pumping to protect the excavation and safety of workers.
- B. Protect excavations with barricades as required by applicable safety regulations.

END OF SECTION

SECTION 26_05_53

IDENTIFICATION FOR ELECTRICAL SYSTEMS

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Identification of electrical equipment, devices and components.
 - 2. Material, manufacturing and installation requirements for identification devices.

1.02 REFERENCES

- A. National Electrical Manufacturers Association (NEMA):
 - 1. 250 - Enclosures for Electrical Equipment (1,000 V Maximum).
- B. National Fire Protection Association (NFPA):
 - 1. 70 - National Electrical Code (NEC).
- C. Occupational Safety and Health Administration (OSHA).

1.03 DELEGATED DESIGN (NOT USED)

1.04 SUBMITTALS

- A. Furnish Submittals as specified in Section 01_33_00 - Submittal Procedures.
- B. Product data:
 - 1. Nameplates:
 - a. Color.
 - b. Size:
 - 1) Outside dimensions.
 - 2) Lettering.
 - c. Material.
 - d. Mounting means.
 - 2. Nameplate schedule:
 - a. Show exact wording for each nameplate.
 - b. Include nameplate and letter sizes.
 - 3. Wire numbers:
 - a. Manufacturer's catalog data for wire labels and label printer.
- C. Record documents:
 - 1. Update the conduit schedule to reflect the exact quantity of wire numbers, including spares and destination points for all wires.

1.05 QUALITY ASSURANCE (NOT USED)

1.06 DELIVERY, STORAGE, AND HANDLING (NOT USED)

1.07 PROJECT OR SITE CONDITIONS

- A. As specified in Section 01_81_50 - Design Criteria.

1.08 ADMINISTRATIVE REQUIREMENTS (NOT USED)

1.09 WARRANTY

- A. As specified in Section 01_78_36 - Warranties and Bonds.

PART 2 PRODUCTS

2.01 GENERAL

- A. Nameplates:
 - 1. Provide for control panel operator devices (e.g., pushbuttons, selector switches, pilot lights, etc.):
 - a. Same material and same color and appearance as the device nameplates to achieve an aesthetically consistent and coordinated system.

2.02 DESIGN AND PERFORMANCE CRITERIA

- A. Nameplates:
 - 1. Provide for each piece of electrical equipment, device, control panel, and control panel components.
 - 2. Identical style, color, and material throughout the facility.
 - 3. Device nameplates information:
 - a. Equipment tag number as indicated on the Drawings.
- B. Wire numbers:
 - 1. Coordinate the wire numbering system with vendors of equipment so that every field wire has a unique number associated with it for the entire system:
 - a. Correspond to the wire numbers on the control drawings or the panel and circuit numbers for receptacles and lighting.
 - b. Correspond to the terminal block number to which they are attached in the control panel.
 - c. Internal panel wires on a common terminal shall have the same wire number.
 - d. Multi-conductor cables shall be assigned a cable number that shall be attached to the cable at intermediate pull boxes and stub-up locations beneath freestanding equipment. Multi-conductor and instrumentation cables shall be identified at pull points as described above:
 - 1) Label armored multi-conductor cable using the conduit number as indicated on the Drawings, following the requirements for conduit markers specified in Section 26_05_33 - Conduits.
 - 2. Provide the following wiring numbering schemes throughout the Project for field wires between process control module (PCM), vendor control panels (VCP), motor control centers (MCC), field starters, field instruments, etc.

(ORIGIN LOC.)–(ORIGIN TERM.)/(DEST. LOC.)–(DEST. TERM.)

(ORIGIN LOC.)–(ORIGIN TERM.)
(DEST. LOC.)–(DEST. TERM.)

OR:

Where:

ORIGIN LOC. = Designation for originating panel or device

ORIGIN TERM. = Terminal designation at originating panel or device

DEST. LOC. = Designation for destination panel or device

DEST. TERM. = Terminal designation at destination panel or device or PLC

3. I/O address at destination panel:
 - a. Identify equipment and field instruments as the origin.
 - b. PCMs are always identified as the destination.
 - c. Location is the panel designation for VCP, LCP, or PCM. For connections to MCCs, location is the specific starter tag and loop number. Location is the tag and loop number for motor starters, field instruments and equipment. Any hyphen in the panel designation or tag and loop number shall be omitted.
 - d. Terminal designation is the actual number on the terminal block where the conductor terminates at field devices and vendor control panels. For multi-conductor cables, all terminal numbers shall be shown, separated by commas.
 - e. Terminal designations at motor leads shall be the motor manufacturer's standard terminal designation (e.g., T1, T2, T3, etc.).
 - f. Terminal designations at PCMs where the field conductor connects to field terminal blocks for a PLC input or output shall be the PLC address (Note: The following PLC I/O numbering scheme is typical for Allen-Bradley. The numbering scheme should be modified to match that of the actual PLC manufacturer used for the Project):

Discrete Point: W:X:Y/Z.

Analog Point: W:X:Y.Z.

Where:

W = I for input, O for output

X = PLC number (1, 2, 3...)

Y = Slot number (01, 02, 03...)

Z = Terminal number (00, 01, 02...) for a discrete point or a word number for an analog point (1, 2, 3...)

- g. Terminal designations at PCMs where the conductor does not connect to a PLC I/O point shall be the terminal number with a "C" prefix (e.g., C0010). For common power after a fuse or neutrals after a switch, the subsequent points shall have and capital letter suffix starting with "A" (e.g., C0010A).

4. **Case 1:** Vendor control panel (VCP) to process control module (PCM):

Field wire number/label: A-B/C-D:

A = Vendor control panel number without hyphen (VCP#)

B = Terminal number within VCP (manufacturer's or vendor's standard terminal number)

C = Process control module number without hyphen (PCM#)

D = Either the PLC address if the field terminal is connected directly to a PLC input or output point or the terminal number with a "C" prefix if not connected directly to a PLC I/O point (C0010)

Examples:

VCP#-10/PCM#-I: 1:01/01

VCP#-10/PCM#-O: 1:10/07

VCP#-10/PCM#-C0100

5. **Case 2:** Field instrument to process control module (PCM):

Field wire number/label: E-F/C-D:

C = Process control module number without hyphen (PCM#)

D = Either the PLC address if the field terminal is connected directly to a PLC input or output point or the terminal number with a "C" prefix if not connected directly to a PLC I/O point (C0010)

E = Field mounted instrument tag and loop numbers without hyphen (EDV#)

F = Manufacturer's standard terminal number within instrument. Use both terminal numbers for analog points separated by a comma

Examples:

TIT#-2,3/PCM#-I: 1:01.1

TSH#-1/PCM#-I: 2:01/00

6. **Case 3:** Motor control center (MCC) to process control module (PCM):

Field wire number/label: G-B/C-D:

B = Terminal number within Motor Control Center (manufacturer's or vendor's standard terminal number)

C = Process control module without hyphen (PCM#)

D = Either the PLC address if the field terminal is connected directly to a PLC input or output point or the terminal number with a "C" prefix if not connected directly to a PLC I/O point (C0010)

G = Actual starter designation in the motor control center without hyphen (MMS#)

Examples:

MMS#-10/PCM#-I: 1:01/01

MMS#-10/PCM#-O: 1:10/07

MMS#-10/PCM#-C0100

7. **Case 4:** Motor control center (MCC) to vendor control panel (VCP):

Field wire number/label: G-B/A-B:

A = Vendor control panel number without hyphen (VCP#)

B = Terminal number within motor control center or vendor control panel (manufacturer's or vendors standard terminal number)

G = Actual starter designation in the motor control center without hyphen (MMS#)

Example:

MMS#-X2/VCP#-10

8. **Case 5:** Motor leads to a motor control center (MCC):

Field wire number/label: H-I/G-B:

B = Terminal number within motor control center (manufacturer's standard terminal number)

G = Actual starter designation in the motor control center without hyphen (MMS#)

H = Equipment tag and loop number without hyphen (PMP#)

I = Motor manufacturer's standard motor lead identification (e.g., T1, T2, T3, etc.)

Example:

PMP#-T3/MMS#-T3

9. **Case 6:** Remote or separately mounted starter or variable frequency drive (VFD) to process control module (PCM):

Field wire number/label: J-B/C-D:

B = Terminal number within starter or variable frequency drive (manufacturer's standard terminal number)

C = Process control module number without hyphen (VCP#)

D = Either the PLC address if the field terminal is connected directly to a PLC input or output point or the terminal number with a "C" prefix if not connected directly to a PLC I/O point (C0010)

J = Starter or variable frequency drive tag and loop number without hyphen (MMS#)

Examples:

MMS#-10/PCM#-I: 1:01/01

MMS#-10/PCM#-O: 2: 10/07

MMS#-10/PCM#-C0010

10. **Case 7:** Field bus trunk segment:

Field cable number/label: C/K-L/M; C/K-L/H; C/K-L/J:

C = Process control module without hyphen (PCM#)

K = Field bus cable type

L = Field bus segment number

M = Field Bus field network component without hyphen (PTB1), or

H = Equipment tag and loop number without hyphen (EMV#), or

J = Starter or variable frequency drive tag and loop number without hyphen (VFD60.0112)

Examples:

PCM#/PA-1A/PTB1PTB1/PA-1B/PTB2

PCM#/DN-1A/VFD#

PCM#/DP-2A/ EMV#

11. **Case 8:** Field bus spur (drop):

Field cable number/label: E/K-L/M:

E = Field mounted instrument tag and loop numbers without hyphen (FIT#)

K = Field bus cable type.

L = Field bus segment number

M = Field bus field network component without hyphen (PTB1), identify ports on the device.

Examples:

FIT#/PA-1C/PTB1-1

FIT#/PA-1D/PTB1-2

12. Identify spare conductors as required for other field wires with an "S" prefix:

Example:

S MMS#-10/PCM#-C011

2.03 MANUFACTURERS

A. Nameplates and signs:

1. One of the following or equal:

- a. Brady.
- b. Seton.

B. Conductor and cable markers:

1. Heat-shrinkable tubing:

- a. One of the following or equal:
 - 1) Brady.
 - 2) Kroy.

- 3) Panduit.
 - 4) Raychem.
- C. Conduit and raceway markers:
 - 1. Stainless steel: One of the following or equal:
 - a. Panduit.
- D. Medium voltage raceway voltage labels:
 - 1. One of the following or equal:
 - a. Brady.
 - b. Seton.

2.04 MATERIALS

- A. Nameplates:
 - 1. Colors:
 - a. Warning: White-center, red face.
 - b. Other: Black-center, white face.
 - 2. Laminated plastic engraving stock:
 - a. 3/32-inch thick material.
 - b. 2-ply.
 - 3. With chamfered edges.
 - 4. Lettering:
 - a. Block style engraved characters of adequate size to be read easily from a distance of 6 feet.
 - b. Minimum letter height: 1/8 inch.
- B. Signs:
 - 1. Automatic equipment and high voltage signs:
 - a. Suitable for exterior use.
 - b. In accordance with OSHA regulations.
- C. Conductor and cable markers:
 - 1. Lettering:
 - a. Machine printed black characters on white tubing.
 - b. Minimum letter height: 10-point type or larger.
- D. Conduit and raceway markers:
 - 1. Stainless steel:
 - a. Type 304 or 316.
 - b. Minimum letter height: 3/16 inch.
- E. Medium voltage circuit raceway labels:
 - 1. Vinyl plastic.
 - 2. Minimum letter height: 1 inch.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. Nameplates:

1. Attach to equipment with rivets, bolts, or sheet metal screws, approved waterproof epoxy-based cement or install in metal holders welded to the equipment.
2. Provide for each disconnecting means with the following:
 - a. Equipment served, voltage, and fuse size as required.
 - b. Identification of the circuit source that supplies the disconnecting means.
3. On NEMA Type 4, NEMA Type 4X, or NEMA Type 7 enclosures, use epoxy-based cement to attach nameplates.
4. Aligned and level or plumb to within 1/64 inch over the entire length:
 - a. Misaligned or crooked nameplates shall be remounted or provide new enclosures at the discretion of the Engineer.

B. Conductor and cable markers:

1. Apply before termination.
2. Heat-shrinkable tubing:
 - a. Shrunk using a heat gun that produces low temperature heated air.
 - b. Tight on the wire after it has been heated.
 - c. Characters shall face the open panel and shall read from left to right or top to bottom.
 - d. Marker shall start within 1/32 inch of the end of the stripped insulation point.

C. Conduit markers:

1. Furnish and install markers for every conduit in the electrical system that is identified in the conduit schedule or part of the process system:
 - a. Markings shall match the conduit schedule.
2. Mark conduits at the following locations:
 - a. Each end of conduits that are greater than 10 feet in length.
 - b. The middle of conduits that are 10 feet or less in length.
 - c. Where the conduit penetrates a wall, structure, manhole, or handhole.
 - 1) Marker shall be non-metallic with stainless steel hardware.
 - d. Where the conduit emerges from the ground, slab, etc.
3. Mark conduits after the conduits have been fully painted.
4. Position conduit markers so that they are easily read from the floor.
5. Attach stainless steel tags with stainless steel cable ties.
6. Mark conduits before construction review by the Engineer for punch list purposes.
7. Label intrinsically safe conduits in accordance with the requirements of the NEC.
8. Stainless steel tags and cable ties shall not be used in areas with high chlorine concentrations.

- D. Medium voltage raceway labels:
 - 1. Apply at 50-foot intervals stating the voltage level contained within the raceway.
- E. Signs and labeling:
 - 1. Furnish and install permanent warning signs at mechanical equipment that may be started automatically or from remote locations:
 - a. Fasten warning signs with round head stainless steel screws or bolts.
 - b. Locate and mount in a manner to be clearly legible to operations personnel.
 - 2. Furnish and install permanent and conspicuous warning signs on equipment (front and back), doorways to equipment rooms, pull boxes, manholes, etc., where the voltage exceeds 600 volts.
 - 3. Furnish and install warning signs on equipment that has more than one source of power.
 - a. Warning signs to identify every panel and circuit number of the disconnecting means of external power sources.
 - 4. Place warning signs on equipment that has 120 VAC control voltage source used for interlocking.
 - a. Identify panel and circuit number or conductor tag for control voltage source disconnecting means.
 - 5. Label service entrance equipment, switchgear, switchboards, MCCs, panelboards, and transfer switches with the available short circuit current, equipment label, and date of application in accordance with NEC. Coordinate with Section 26_05_74 - Electrical System Studies for available fault current data.

3.04 FIELD QUALITY CONTROL

- A. Replace any nameplates, signs, conductor markers, cable markers, or raceway labels that in the sole opinion of the Engineer do not meet the Engineer's aesthetic requirements.

END OF SECTION

SECTION 26_05_74

ELECTRICAL SYSTEM STUDIES

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Short-circuit fault analysis studies.
 - 2. Protective device coordination study.
 - 3. Machine and electrical system settings.
 - 4. Arc-flash hazard study.

1.02 REFERENCES

- A. American National Standards Institute (ANSI).
- B. Institute of Electrical and Electronics Engineers (IEEE):
 - 1. 1584 - IEEE Guide for Performing Arc-Flash Hazard Calculations.
- C. National Fire Protection Association (NFPA):
 - 1. 70E - Standard for Electrical Safety in the Workplace.

1.03 TERMINOLOGY

- A. The words and terms listed below are not defined terms that require initial capital letters, but, when used in this Section, have the indicated meaning.
 - 1. Final electrical system study report: The Delegated Design final report that incorporates installed cable lengths, and all construction changes.
 - 2. Initial short-circuit fault analysis: An analysis done based on the Drawings and utility information. The purpose is to identify the available fault current at each piece of equipment to make sure it is properly rated.
 - 3. Modified: Equipment with load additions or with loads being removed that affect fault current, include new overcurrent protective devices that require settings and device coordination.
 - 4. Preliminary electrical system studies:
 - a. If startup and sequencing occur before the final study is completed, perform a preliminary study as needed to determine temporary protective device settings.
 - b. Preliminary studies will not be reviewed by the Engineer but shall be submitted for record.

1.04 DELEGATED DESIGN

- A. As specified in Section 01_35_73 - Delegated Design Procedures.
- B. Signed and sealed electrical system study reports.

1.05 SUBMITTALS

- A. Furnish Submittals as specified in Section 01_33_00 - Submittal Procedures.
- B. Credentials of the individual(s) performing the study and the individual in responsible charge of the study.
- C. General:
 - 1. Format and quantity:
 - a. 6 bound copies of all final reports.
 - b. 3 complete sets of electronic files on CD or DVD media, including the electrical system model(s), configuration files, custom libraries, and any other files used to perform the studies and produce the reports. Also provide an electronic version of the bound reports in PDF format.
 - 2. One-line diagrams:
 - a. The following information shall be included at a minimum:
 - 1) Motor horsepower.
 - 2) Transformer data:
 - a) kVA.
 - b) Configuration.
 - 3) Cable data:
 - a) Insulation.
 - b) Size.
 - c) Length.
 - b. Fully legible at 11-inch by 17-inch size.
- D. Initial short-circuit fault analysis:
 - 1. Based on the Contract Documents and electric utility information.
 - 2. Incorporate information from the initial short-circuit fault analysis, performed as part of the owner procured electrical equipment, into this analysis.
 - 3. Include a description of all operating scenarios.
 - 4. One-line diagrams.
 - 5. Indicate the estimated available short-circuit current at the line side terminals of each piece of equipment covered by the scope of the study.
 - a. Measure conductor lengths from the Drawings. Use of arbitrary short conductor lengths is not allowed.
 - b. Provide a list of assumptions used in the initial study.
- E. Delegated Design final studies and reports:
 - 1. Include the following sections at a minimum:
 - a. Copies of correspondence and data obtained from the electric utility company.
 - b. Letter certifying the inspection and verification of existing equipment and incorporation of applicable RFIs and change orders.
 - c. Short-circuit fault analysis:
 - 1) Modify the initial short-circuit fault analysis as follows:
 - a) Utilize the actual equipment provided on the Project.
 - b) Utilize conductor lengths based on installation.
 - c) Update one-line diagrams to show as-built conditions.
 - 2) Descriptions, purpose, basis, assumptions, recommendations, and scope of the study.

- 3) Normal system connections and those that result in maximum fault conditions.
- 4) Tabulation of circuit breaker, fuse, and other protective device ratings compared to maximum calculated short-circuit duties.
- 5) Fault current calculations for the cases run, including a definition of terms and guide for interpretation of computer software printouts.
- d. Protective device coordination study shall include:
 - 1) Descriptions, purpose, basis, assumptions, recommendations, and scope of the study.
 - 2) List requirements used in the selection and setting criteria for any protective devices.
 - 3) Manufacturer's time-current curves for circuit breakers, fuses, motor circuit protectors, and other protective devices for new equipment.
 - 4) TCCs graphically indicating the coordination proposed for the system on log-log graphs:
 - a) All TCCs shall be in color.
 - 5) Tabulation of relay, fuse, circuit breaker, and other protective devices in graphical form with a one-line diagram to display area coordination.
 - 6) Where coordination could not be achieved, an explanation shall be included in the report to support the statement along with recommendations to improve coordination. Recommended equipment modifications or settings shall be in a tabulated form.
 - 7) Protective device settings in a tabulated format.
- e. Include in the arc-flash hazard study:
 - 1) Descriptions, purpose, basis, assumptions, recommendations, and scope of the study.
 - 2) Normal system connections and those that result in maximum arc-flash conditions.
 - 3) Arc-flash raw data, calculations, and assumptions.
- f. Form and format of arc-flash labels.
 - 1) Label data:
 - a) Identifying the content of each label.
 - b) Identifying the location of each label.

F. Signature page identifying the name for the person entering the setting and a representative of the Contractor for each protective device requiring setting or adjustment.

G. Submit course outline for Owner Training.

1.06 QUALITY ASSURANCE

- A. Qualifications of the entity responsible for electrical system studies:
1. Short-circuit fault analysis, protective device coordination, and arc-flash hazard studies shall be performed with the aid of a digital computer program:
 - a. Point-to-point calculations are not acceptable.

1.07 DELIVERY, STORAGE, AND HANDLING (NOT USED)

1.08 PROJECT OR SITE CONDITIONS (NOT USED)

1.09 ADMINISTRATIVE REQUIREMENTS

A. Coordination:

1. Individual performing the studies shall visit the Site and collect necessary field data in order to perform and complete comprehensive electrical system studies.
2. Obtain, for all equipment, the required data for preparation of the study, including, but not limited to:
 - a. Transformer kilovolt-ampere (kVA), nameplate data, and impedances.
 - b. Generator impedances, kilovolt-ampere (kVA), and voltage.
 - c. Generator decrement curves.
 - d. Bus withstand ratings.
 - e. Cable and bus data.
 - f. Protective device taps, time dials, instantaneous pickups, and time-delay settings.
 - g. As-built lengths for new wire and cable installations covered by the studies.
 - h. Grounding schemes (solidly grounded or resistive grounded).
3. Obtain the electric utility information on the minimum and maximum available fault current, minimum and maximum utility impedances, utility protective device settings, including manufacturer and model number, interrupting ratings, X/R ratios, and model information one level above the point of connection:
 - a. Utility tolerances and voltage variations.
 - b. Coordinate with the utility for changes to their protective devices and settings to achieve a coordinated system between the utility and the Owner.
4. Obtain equipment layouts and configurations from the manufacturer's final Submittal requirements and project layout drawings as required.
5. Bus and conductor data:
 - a. Use impedances of the actual installed or specified conductors, unless otherwise indicated.
 - b. Use cable and bus impedances calculated at 25 degrees Celsius, unless otherwise indicated.
 - c. Use 600-volt cable reactance based on typical dimensions of actual installed or specified conductors, unless otherwise indicated.
 - d. Use bus withstand values for all equipment having buses.

- B. Use medium-voltage cable reactance based on typical dimensions of shielded cables with 133 percent insulation levels, unless otherwise indicated.

C. Certification:

1. Submit written certification signed by the professional engineer conducting the study, equipment supplier, and electrical subcontractor, stating that the data used in the study is correct and captures all RFIs, as-builts, and change orders affecting the study.

D. Meetings:

1. Electrical system study meetings:
 - a. As specified in Section 01_31_19 - Project Meetings.
 - b. The individual conducting the electrical system studies leads the meeting.
 - c. Meet with the Owner and Engineer 3 times.
 - d. First meeting:
 - 1) Discuss the scope of the studies.

- 2) Confirm electrical system operating modes.
 - 3) Confirm assumptions to be used in the electrical system study with the Owner, including, but not limited to:
 - a) Maximum protective device fault clearing time.
 - 4) Discuss the Owner's operational requirements for both normal operation and maintenance.
 - e. Second meeting:
 - 1) Inform the Owner of the results of the study and impacts on normal operation and maintenance, including:
 - a) Protective device coordination problems and recommended solutions.
 - b) Explanation of the arc-flash hazard study results and its potential impact on operations.
 - c) Recommendations for reduction of arc-flash category levels, including reduction of protective device settings or changes in operational practices.
 - f. Final meeting:
 - 1) Prior to Substantial Completion.
 - 2) Discuss changes to the studies based on the previous meeting.
 - 3) Discuss with the Owner how changes to the electrical system may change the arc-flash hazard category.
- E. Sequencing:
- 1. Below is an outline of the typical work sequence. Proposed changes to the work sequence may be reviewed and approved by the Engineer.
 - a. First system study meeting.
 - b. Submit the initial short-circuit fault analysis study before submittal of any electrical equipment.
 - 1) Only the initial short-circuit results will be reviewed.
 - c. Conduct preliminary protective device coordination analysis and overcurrent device settings as required to accommodate project and sequencing.
 - d. Submit the draft short-circuit fault analysis, protective device coordination, and arc-flash hazard studies after the approval of all electrical equipment.
 - e. Second system study meeting for preliminary results.
 - f. Update the model with changes to the electrical system made during start-up and commissioning.
 - g. Final system study meeting.
 - h. Submit the final electrical system studies.
 - i. Label equipment with approved arc-flash labels.
 - j. Owner Training.

PART 2 PRODUCTS

2.01 GENERAL (NOT USED)

2.02 DESIGN AND PERFORMANCE CRITERIA

A. General study requirements:

1. Scope:
 - a. Short-circuit fault analysis, protective device coordination, and arc-flash hazard studies shall include all equipment in the power distribution system, including, but not limited to:
 - 1) Utility equipment (utility transformer and primary protective device).
 - 2) Available utility fault contribution current.
 - 3) All electrical equipment, including:
 - a) Dry-type transformers.
 - b) 240- and 208-volt panelboards.
 - 4) Motors.
 - 5) Vendor control panels.
 - 6) HVAC equipment.
 - b. Study scenarios:
 - 1) Include all possible electrical system configurations, for example:
 - a) Operation on normal (utility) source.
2. Motors:
 - a. Each motor shall be individually modeled:
 - 1) Grouping of motors for fault contribution current is not acceptable.
 - b. Motors with variable frequency drives (VFDs) may be assumed to have no contribution to fault current, unless VFDs are equipped with bypass contactors.
 - 1) If VFDs are equipped with bypass contactors, perform the fault current and arc flash study assuming 1 of bypass contactors are in the closed position.
3. Use the equipment, bus, and device designations as indicated on the Drawings for all studies.

B. Short-circuit fault analysis study additional requirements:

1. Calculate 3-phase bolted fault, line-to-line fault, line-to-ground fault, double line-to-ground fault, short-circuit 1/2 cycle momentary symmetrical and asymmetrical RMS, 1-1/2 to 4 cycle interrupting symmetrical RMS, and 30-cycle steady-state short-circuit current values at each piece of equipment in the distribution system.
2. Evaluate bus bracing, short-circuit ratings, fuse interrupting capacity and circuit-breaker-adjusted interrupting capacities against the fault currents, and calculate X/R values:
 - a. Identify and document all devices and equipment as either inadequate or acceptable.
3. Calculate line-to-ground and double line-to-ground momentary short-circuit values at buses having ground-fault devices.
4. Provide calculation methods, assumptions, one-line diagrams, and source impedance data, including utility X/R ratios, typical values, recommendations, and areas of concern.

- C. Protective device coordination study additional requirements:
1. Furnish protective device settings for functions indicated on the Drawings, including, but not limited to:
 - a. Current.
 - b. Voltage:
 - 1) Provide settings for voltage relays based upon actual utility and generator tolerances and specifications.
 - c. Bus differential.
 - d. Machine protection functions:
 - 1) Provide settings for motor and generator protective relays based on the manufacturer's recommended protection requirements.
 2. Provide log-log form time-current curves (TCCs) graphically indicating the coordination proposed for the system:
 - a. Include with each TCC a complete title and one-line diagram with legend identifying the specific portion of the system covered by the particular TCC:
 - 1) Typical TCCs for identical portions of the system, such as motor circuits, are acceptable as allowed by the Engineer.
 - b. Include a detailed description of each protective device identifying its type, function, manufacturer, and time-current characteristics:
 - 1) These details can be included on the TCC.
 - c. Include a detailed description of each protective device tap, time dial, pickup, instantaneous, and time delay settings:
 - 1) These details can be included on the TCC.
 3. TCCs shall include all equipment in the power distribution system where required to demonstrate coordination. Include utility relay and fuse characteristics, medium-voltage equipment protective relay and fuse characteristics, low-voltage equipment circuit breaker trip device characteristics, transformer characteristics, motor and generator characteristics, and characteristics of other system load protective devices:
 - a. Include devices down to the largest branch circuit and largest feeder circuit breaker in each motor control center, main breaker in branch panelboards, and fused disconnect switches.
 - b. Provide ground fault TCCs with adjustable settings for ground fault protective devices.
 - c. Include manufacturing tolerances and damage bands in plotted fuse and circuit breaker characteristics.
 - d. On the TCCs, show transformer full load currents, transformer magnetizing inrush, ANSI transformer withstand parameters, and transformer damage curves.
 - e. Cable damage curves.
 - f. Terminate device characteristic curves at a point reflecting the maximum symmetrical or asymmetrical fault current to which the device is exposed based on the short-circuit fault analysis study.
 - g. Coordinate time interval medium-voltage relay characteristics with upstream and downstream devices to avoid nuisance tripping.
 4. When site generation (including cogeneration, standby, and emergency generators) is part of the electrical system, include phase and ground coordination of the generator protective devices:
 - a. Show the generator decrement curve and damage curve along with the operating characteristic of the protective devices.

5. Suggest modifications or additions to equipment rating or settings in a tabulated form.
- D. Arc-flash hazard study additional requirements:
1. Include the calculated arc-flash boundary and incident energy (calories/square centimeter) at each piece of equipment in the distribution system:
 - a. Perform study with 15 percent arcing fault variation in accordance with IEEE 1584.
 - b. Perform arc-flash calculations at minimum and maximum utility fault contributions.
 - c. Perform arc-flash calculations for both the line side and load side of the switchgear, switchboard, motor control center, and panelboard main breakers.
 - d. Perform arc-flash calculations for short-circuit scenarios with all motors on for 3 to 5 cycles and with all motors off.
 2. Provide executive summary of the study results:
 - a. Provide summary based upon worst case results.
 3. Provide a detailed written discussion and explanation of the tabulated outputs:
 - a. Include all scenarios.
 4. Provide alternative device settings to allow the Owner to select the desired functionality of the system:
 - a. Minimize the arc-flash energy by selective trip and time settings for equipment maintenance purposes.
 - b. Identify the arc-flash energy based upon the criteria of maintaining coordination and selectivity of the protective devices.

2.03 MANUFACTURERS

- A. Electrical system study software: One of the following or equal:
1. Operation Technology, Inc., ETAP.
 2. SKM Systems Analysis, Powertools.

2.04 EXISTING PRODUCTS (NOT USED)

2.05 MATERIALS (NOT USED)

2.06 MANUFACTURED UNITS (NOT USED)

2.07 EQUIPMENT (NOT USED)

2.08 COMPONENTS

- A. Arc-flash hazard labels:
1. Dimensions:
 - a. Minimum 5 inches by 3.5 inches.
 2. Materials:
 - a. Polyester with polyvinyl polymer over-laminate.
 - b. Self-adhesive.
 - c. Resistant to:
 - 1) UV.
 - 2) Chemicals and common cleaning solvents.

- 3) Scuffing.
 - 4) Wide temperature changes.
- 3. Contents:
 - a. Short-circuit bus identification.
 - b. Calculated incident energy (calories/square centimeter) range:
 - 1) Based on worst-case study results.
 - c. Site-specific personal protective equipment level number.
 - d. Arc-flash protection boundary.
 - e. Shock hazard boundary:
 - 1) Provide separate labels for indication of the shock hazard boundary.
 - f. Fed from:
 - 1) Identify the tag number of the upstream equipment providing power.
- 4. Color scheme:
 - a. For locations above 40 calories/square centimeter:
 - 1) White label with red "DANGER" strip across the top.
 - 2) Black lettering.
 - b. For locations below 40 calories/square centimeter:
 - 1) White label with orange "WARNING" strip across the top.
 - 2) Black lettering.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

- A. After review and acceptance of the arc-flash hazard study by the Engineer, install arc-flash hazard labels:
 - 1. At all locations required by NFPA, ANSI, or IEEE standards.
 - 2. At a minimum, in the following locations:
 - a. Front of each main or incoming service compartment.
 - b. Front of each low-voltage switchgear section.
 - c. Front of each medium-voltage circuit breaker door.
 - d. Front of each accessible auxiliary or conductor compartment.
 - e. Each accessible rear or side vertical section.
 - f. Each motor control center vertical section.
 - g. Each panelboard covered by the study.
 - h. Each control panel, individual starter or VFD, or other equipment covered by the scope of the study.

3.04 OWNER TRAINING

- A. Including, but not limited to:
 - 1. Introduction and basics of NFPA 70E: 2 hours 2 sessions.
 - 2. Detailed review of the electrical system study: 2 hours 1 session.

3.05 FIELD QUALITY CONTROL

- A. Individual performing the arc-flash hazard study shall direct the installation of the arc-flash hazard labels:
 - 1. Remove existing labels from previous studies that are outdated.
 - 2. Remove and replace any improperly applied labels.
 - 3. Repair the equipment finish damaged by removal of any label.
 - 4. Install labels level or plumb across the entire dimension of the label.

3.06 ADJUSTING

- A. After review and acceptance of the draft arc-flash hazard study and protective device coordination study by the Engineer, adjust protective device settings in accordance with final study prior to equipment energization.
 - 1. Devices that require power for configuration may be set during energization, but before any subfed loads are energized.
 - 2. Ensure that settings for upstream equipment are set prior to energizing downstream devices. Provide documentation that protective devices are set in accordance with the study recommendation.

END OF SECTION

SECTION 26_06_01

CONDUIT SCHEDULE AREA 30

PART 1 GENERAL

1.01 SUMMARY

- A. Conduit requirements:
 - 1. As defined in Section 26_05_00 and Section 26_05_33.
- B. Cable requirements and definitions:
 - 1. As defined in Section 26_05_00 and Section 26_05_18.
 - 2. 2/CS#16: 2 conductor, 16 gauge, twisted shielded pair.
 - 3. 3/CS#16: 3 conductor, 16 gauge, twisted shielded triplet.
 - 4. */FO: Fiber optic (* indicates strand count).
 - 5. CAT6: Category 6 Ethernet cable.
 - 6. MFR: Manufacturer or vendor furnished cable.
 - 7. PULL: Pull Rope.

PART 2 PRODUCTS

Not Used.

PART 3 EXECUTION

3.01 CONDUIT SCHEDULE

- A. Conduit Schedule is presented on the following pages.

CONDUIT SCHEDULE AREA

THORNTON SOURCE WATER

SOURCE WATER PUMP STATION

ENGINEER

JD

REVISION

DATE

5/5/26

CONDUIT			CONDUCTORS			GROUND				
NUMBER	DWG	SIZE	#	SIZE	TYPE	#	SIZE	TYPE	DESCRIPTION	CONNECTING SEGMENTS
L-10-700	30E19	0.75"	2	#12	XHHW-2	1	#12	XHHW-2	FR: FACP-SW TO: LP-SW 2 #12 >> FACP-SW POWER	
C-30-003	30E19	0.75"	4	#14	XHHW-2	1	#14	XHHW-2	FR: ZSOC-302 TO: CONDUIT TEE 4 #14 >> ZSOC-302 CONTROL	C-30-020
C-30-004	30E19	0.75"	10	#14	XHHW-2	1	#14	XHHW-2	FR: FCV-302 TO: CONDUIT TEE 10 #14 >> FCV-302 CONTROL	C-30-014
C-30-005	30E19	0.75"	4	#14	XHHW-2	1	#14	XHHW-2	FR: ZSOC-303 TO: CONDUIT TEE 4 #14 >> ZSOC-303 CONTROL	C-30-013
C-30-006	30E19	0.75"	10	#14	XHHW-2	1	#14	XHHW-2	FR: FCV-303 TO: CONDUIT TEE 10 #14 >> FCV-303 CONTROL	C-30-013
C-30-007	30E19	0.75"	2	#14	XHHW-2	1	#14	XHHW-2	FR: PSH-305 TO: CONDUIT TEE 2 #14 >> PSH-305 CONTROL	C-30-016
C-30-008	30E19	0.75"	2	#14	XHHW-2	1	#14	XHHW-2	FR: PSH-306 TO: CONDUIT TEE 2 #14 >> PSH-306 CONTROL	C-30-018
C-30-009	30E19	1"	12	#14	XHHW-2	1	#14	XHHW-2	FR: CONDUIT TEE TO: J-BOX 4 #14 >> ZSOC-306 CONTROL 2 #14 >> PSH-305 CONTROL 4 #14 >> ZSOC-305 CONTROL 2 #14 >> PSH-306 CONTROL	C-30-027 C-30-018 C-30-018 C-30-016 C-30-016
C-30-010	30E19	0.75"	2	#12	XHHW-2				FR: FIT-311 TO: CONDUIT TEE 2 #12 >> FIT-311 CONTROL	C-30-019
C-30-011	30E19	0.75"	2	#12	XHHW-2				FR: FIT-300 TO: CONDUIT TEE 2 #12 >> FIT-300 CONTROL	C-30-019
C-30-012	30E19	0.75"	2	#14	XHHW-2	1	#14	XHHW-2	FR: PSH-310 TO: CONDUIT TEE 2 #14 >> PSH-310 CONTROL	C-30-027
C-30-013	30E19	1"	14	#14	XHHW-2	1	#14	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 10 #14 >> FCV-303 CONTROL 4 #14 >> ZSOC-303 CONTROL	C-30-014 C-30-006 C-30-005
C-30-014	30E19	1.5"	24	#14	XHHW-2	1	#14	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 10 #14 >> FCV-303 CONTROL 4 #14 >> ZSOC-303 CONTROL 10 #14 >> FCV-302 CONTROL	C-30-020 C-30-013 C-30-013 C-30-004
C-30-015	30E19	0.75"	4	#14	XHHW-2	1	#14	XHHW-2	FR: ZSOC-305 TO: CONDUIT TEE 4 #14 >> ZSOC-305 CONTROL	C-30-016
C-30-016	30E19	0.75"	6	#14	XHHW-2	1	#14	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 4 #14 >> ZSOC-305 CONTROL 2 #14 >> PSH-309 CONTROL	C-30-009 C-30-015 C-30-007
C-30-017	30E19	0.75"	4	#14	XHHW-2	1	#14	XHHW-2	FR: ZSOC-306 TO: CONDUIT TEE 4 #14 >> ZSOC-306 CONTROL	C-30-018
C-30-018	30E19	0.75"	6	#14	XHHW-2	1	#14	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 4 #14 >> ZSOC-306 CONTROL 2 #14 >> PSH-306 CONTROL	C-30-009 C-30-017 C-30-008
C-30-019	30E19	0.75"	4	#12	XHHW-2	1	#12	XHHW-2	FR: CONDUIT TEE TO: J-BOX 2 #12 >> FIT-311 CONTROL 2 #12 >> FIT-300 CONTROL	C-30-028 C-30-010 C-30-011

Conduits Schedule

26_06_01-2

CO/Thornton/203505-100000/04 Design/04 Specs/Carollo/SWPS/26_06_01 (IFB2)

203505

Thornton Water Project (12-777XP)

Source Water Pump Station

May 2026

CONDUIT SCHEDULE AREA

THORNTON SOURCE WATER

SOURCE WATER PUMP STATION

ENGINEER

JD

REVISION

DATE

5/5/26

CONDUIT			CONDUCTORS			GROUND				
NUMBER	DWG	SIZE	#	SIZE	TYPE	#	SIZE	TYPE	DESCRIPTION	CONNECTING SEGMENTS
C-30-020	30E19	1.5"	28	#14	XHHW-2	1	#14	XHHW-2	FR: CONDUIT TEE TO: J-BOX 10 #14 >> FCV-303 CONTROL 4 #14 >> ZSOC-303 CONTROL 10 #14 >> FCV-302 CONTROL 4 #14 >> ZSOC-302 CONTROL	C-30-050 C-30-014 C-30-014 C-30-014 C-30-003
C-30-021	30E19	0.75"	2	#14	XHHW-2	1	#14	XHHW-2	FR: LSL-301 TO: J-BOX 2 #14 >> LSL-301 CONTROL	C-30-050
C-30-022	30E19	1"	10 2	#14 PULL	XHHW-2 ROPE	1	#14	XHHW-2	FR: LSL-301 TO: J-BOX 2 #14 >> LSL-301 CONTROL 2 #14 >> VFD-302 LSL FLOAT CONTROL 2 #14 >> VFD-303 LSL FLOAT CONTROL 1 PULL >> VFD-304 LSL FLOAT CONTROL (FUTUR 2 #14 >> VFD-305 LSL FLOAT CONTROL 2 #14 >> VFD-306 LSL FLOAT CONTROL 1 PULL >> VFD-301 LSL FLOAT CONTROL (FUTUR	C-30-050
C-30-025	30E19	1.5"	20	#14	XHHW-2	1	#14	XHHW-2	FR: CONDUIT TEE TO: J-BOX 10 #14 >> FV-310 CONTROL 10 #14 >> FV-311 CONTROL	C-30-040 C-30-030 C-30-026
C-30-026	30E19	0.75"	10	#14	XHHW-2	1	#14	XHHW-2	FR: FV-311 TO: CONDUIT TEE 10 #14 >> FV-311 CONTROL	C-30-025
C-30-027	30E19	1"	14	#14	XHHW-2	1	#14	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 4 #14 >> ZSOC-306 CONTROL 2 #14 >> PSH-305 CONTROL 4 #14 >> ZSOC-305 CONTROL 2 #14 >> PSH-306 CONTROL 2 #14 >> PSH-306 CONTROL 2 #14 >> PSH-310 CONTROL	C-30-028 C-30-009 C-30-009 C-30-009 C-30-009 C-30-012
C-30-028	30E19	1"	4 14	#12 #14	XHHW-2 XHHW-2	1	#12	XHHW-2	FR: CONDUIT TEE TO: J-BOX 4 #14 >> ZSOC-306 CONTROL 2 #14 >> PSH-305 CONTROL 4 #14 >> ZSOC-305 CONTROL 2 #14 >> PSH-306 CONTROL 2 #14 >> PSH-306 CONTROL 2 #14 >> PSH-310 CONTROL 2 #12 >> FIT-311 CONTROL 2 #12 >> FIT-300 CONTROL	C-30-040 C-30-027 C-30-027 C-30-027 C-30-027 C-30-027 C-30-019 C-30-019
C-30-029	30E19	0.75"	6	#14	XHHW-2	1	#14	XHHW-2	FR: LCP-311 TO: FV-311 6 #14 >> LCP-311 CONTROL	
C-30-030	30E19	0.75"	10	#14	XHHW-2	1	#14	XHHW-2	FR: FV-310 TO: CONDUIT TEE 10 #14 >> FV-310 CONTROL	C-30-025
C-30-040	30E19	2.5"	99	#14	XHHW-2	1	#14	XHHW-2	FR: J-BOX TO: PCM-SW 4 #14 >> ZSOC-306 CONTROL 2 #14 >> PSH-305 CONTROL 4 #14 >> ZSOC-305 CONTROL 2 #14 >> PSH-306 CONTROL 2 #14 >> PSH-310 CONTROL 2 #14 >> FIT-311 CONTROL 2 #14 >> FIT-300 CONTROL 10 #14 >> FV-310 CONTROL 10 #14 >> FV-311 CONTROL 10 #14 >> FCV-303 CONTROL 4 #14 >> ZSOC-303 CONTROL 10 #14 >> FCV-302 CONTROL 2 #14 >> AIT-341 CONTROL 2 #14 >> AIT-342 CONTROL 2 #14 >> AIT-343 CONTROL 2 #14 >> LSL-301 CONTROL 2 #14 >> LSL-301 CONTROL 4 #14 >> ZSOC-302 CONTROL 10 #14 >> FV-310 CONTROL 10 #14 >> FV-311 CONTROL 2 #14 >> FCG-341 CONTROL 1 #14 >> FCG-340 CONTROL	C-30-028 C-30-028 C-30-028 C-30-028 C-30-028 C-30-028 C-30-028 C-30-025 C-30-025 C-30-050 C-30-050 C-30-050 C-30-050 C-30-050 C-30-050 C-30-050 C-30-050 C-30-050 C-30-050 C-30-025 C-30-025 C-30-600 C-30-600

CONDUIT SCHEDULE AREA

THORNTON SOURCE WATER
SOURCE WATER PUMP STATION

ENGINEER JD
REVISION
DATE 5/5/26

CONDUIT			CONDUCTORS			GROUND				
NUMBER	DWG	SIZE	#	SIZE	TYPE	#	SIZE	TYPE	DESCRIPTION	CONNECTING SEGMENTS
C-30-050	30E19	1.5"	41	#14	XHHW-2	1	#14	XHHW-2	FR: J-BOX TO: J-BOX 10 #14 >> FCV-303 CONTROL 4 #14 >> ZSOC-303 CONTROL 10 #14 >> FCV-302 CONTROL 2 #14 >> AIT-341 CONTROL 2 #14 >> AIT-342 CONTROL 2 #14 >> AIT-343 CONTROL 2 #14 >> LSL-301 CONTROL 2 #14 >> LSL-301 CONTROL 4 #14 >> ZSOC-302 CONTROL 2 #14 >> FCG-341 CONTROL 1 #14 >> FCG-340 CONTROL	C-30-040 C-30-020 C-30-020 C-30-020 C-30-270 C-30-271 C-30-272 C-30-021 C-30-020 C-30-599 C-30-599
C-30-070	30E19	1"	16	#14	XHHW-2	1	#14	XHHW-2	FR: SW-NR-01 TO: PCM-SW 16 #14 >> SW-NR-01 CONTROL	
C-30-077	30E19	2"	80	#14	XHHW-2	1	#14	XHHW-2	FR: SWGR-SW BKR CONTROL PNL TO: SWGR-SW 68 #14 >> SWGR-SW BKR CONTROL PNL CONTRC 12 #14 >> SPARE	
C-30-078	30E19	2"	80	#14	XHHW-2	1	#14	XHHW-2	FR: SWGR-SW BKR CONTROL PNL TO: SWGR-SW 68 #14 >> SWGR-SW BKR CONTROL PNL CONTRC 12 #14 >> SPARE	
C-30-090	30E19	1.5"	10	#8	XHHW-2	1	#10	XHHW-2	FR: SWGR-SW TO: LP-DCSW 2 #8 >> SWGR-SW CUBICLE 2A (52-M1 & RELAY 2 #8 >> SWGR-SW CUBICLE 1B (52-M1 & RELAY 2 #8 >> SWGR-SW CUBICLE 2B (52-M1 & RELAY 2 #8 >> SWGR-SW CUBICLE 1C (52-M1 & RELAY 2 #8 >> SWGR-SW CUBICLE 2C (52-M1 & RELAY	
C-30-095	30E19	1.5"	10	#8	XHHW-2	1	#10	XHHW-2	FR: SWGR-SW TO: LP-DCSW 2 #8 >> SWGR-SW CUBICLE 1G (52-21 & RELAY 2 #8 >> SWGR-SW CUBICLE 2G (52-22 & RELAY 2 #8 >> SWGR-SW CUBICLE 1H (52-23 & RELAY 2 #8 >> SWGR-SW CUBICLE 2H (52-24 & RELAY 2 #8 >> SWGR-SW CUBICLE 2J (52-M2 & RELAY	
C-30-105	30E20	1"	1	PULL	ROPE				FR: FUTURE PMP-301 TO: FUTURE VFD-301 1 PULL >> SPARE	
C-30-131	30E19	0.75"	2	#14	XHHW-2	1	#14	XHHW-2	FR: LCP-302 TO: JBOX 2 #14 >> LCP-302 CONTROL	C-30-135
C-30-132	30E19	0.75"	4	#14	XHHW-2	1	#14	XHHW-2	FR: FSL-302 TO: JBOX 4 #14 >> FSL-302 CONTROL	C-30-135
C-30-133	30E19	0.75"	2	#12	XHHW-2	1	#12	XHHW-2	FR: PMP-302 TO: JBOX 2 #12 >> MWH-302 CONTROL	C-30-135
C-30-135	30E19 30E20	1"	2 6	#12 #14	XHHW-2 XHHW-2	1	#12	XHHW-2	FR: JBOX TO: VFD-302 2 #14 >> LCP-302 CONTROL 4 #14 >> FSL-302 CONTROL 2 #12 >> MWH-302 POWER	C-30-131 C-30-132 C-30-133
C-30-161	30E19	0.75"	2	#14	XHHW-2	1	#14	XHHW-2	FR: LCP-303 TO: JBOX 2 #14 >> LCP-303 CONTROL	C-30-165
C-30-162	30E19	0.75"	4	#14	XHHW-2	1	#14	XHHW-2	FR: FSL-303 TO: JBOX 4 #14 >> FSL-303 CONTROL	C-30-165
C-30-163	30E19	0.75"	2	#12	XHHW-2	1	#12	XHHW-2	FR: PMP-303 TO: JBOX 2 #12 >> MWH-303 POWER	C-30-165
C-30-165	30E19 30E20	1"	2 6	#12 #14	XHHW-2 XHHW-2	1	#12	XHHW-2	FR: JBOX TO: VFD-303 2 #14 >> LCP-303 CONTROL 4 #14 >> FSL-303 CONTROL 2 #12 >> MWH-303 POWER	C-30-161 C-30-162 C-30-163

Conduits Schedule

26_06_01-4

CO/Thornton/203505-100000/04 Design/04 Specs/Carollo/SWPS/26_06_01 (IFB2)

203505

Thornton Water Project (12-777XP)

Source Water Pump Station

May 2026

CONDUIT SCHEDULE AREA

THORNTON SOURCE WATER

SOURCE WATER PUMP STATION

ENGINEER

JD

REVISION

DATE

5/5/26

CONDUIT			CONDUCTORS			GROUND			DESCRIPTION	CONNECTING SEGMENTS
NUMBER	DWG	SIZE	#	SIZE	TYPE	#	SIZE	TYPE		
C-30-205	30E20	1"	1	PULL	ROPE				FR: FUTURE PMP-304 TO: FUTURE VFD-304 1 PULL >> SPARE	
C-30-231	30E19	0.75"	2	#14	XHHW-2	1	#14	XHHW-2	FR: LCP-305 TO: JBOX 2 #14 >> LCP-305 CONTROLS	C-30-235
C-30-232	30E19	0.75"	4	#14	XHHW-2	1	#14	XHHW-2	FR: FSL-305 TO: JBOX 4 #14 >> FSL-305 CONTROL	C-30-235
C-30-233	30E19	0.75"	2	#12	XHHW-2	1	#12	XHHW-2	FR: PMP-305 TO: JBOX 2 #12 >> MWH-305 POWER	C-30-235
C-30-235	30E19 30E20	1"	2 6	#12 #14	XHHW-2 XHHW-2	1	#12	XHHW-2	FR: JBOX TO: VFD-305 2 #14 >> LCP-308 CONTROLS 4 #14 >> FSL-308 CONTROL 2 #12 >> MWH-308 POWER	C-30-231 C-30-232 C-30-233
C-30-261	30E19	0.75"	2	#14	XHHW-2	1	#14	XHHW-2	FR: LCP-306 TO: JBOX 2 #14 >> LCP-306 CONTROL	C-30-265
C-30-262	30E19	0.75"	4	#14	XHHW-2	1	#14	XHHW-2	FR: FSL-306 TO: JBOX 4 #14 >> FSL-306 CONTROL	C-30-265
C-30-263	30E19	0.75"	2	#12	XHHW-2	1	#12	XHHW-2	FR: PMP-306 TO: JBOX 2 #12 >> MWH-306 POWER	C-30-265
C-30-265	30E19 30E20	1"	2 6	#12 #14	XHHW-2 XHHW-2	1	#12	XHHW-2	FR: JBOX TO: VFD-306 2 #14 >> LCP-306 CONTROL 4 #14 >> FSL-306 CONTROL 2 #12 >> MWH-306 POWER	C-30-261 C-30-262 C-30-263
C-30-270	30E19	0.75"	2	#14	XHHW-2	1	#14	XHHW-2	FR: AIT-341 TO: J-BOX 2 #14 >> AIT-341 CONTROL	C-30-050
C-30-271	30E19	0.75"	2	#14	XHHW-2	1	#14	XHHW-2	FR: AIT-342 TO: J-BOX 2 #14 >> AIT-342 CONTROL	C-30-050
C-30-272	30E19	0.75"	2	#14	XHHW-2	1	#14	XHHW-2	FR: AIT-343 TO: J-BOX 2 #14 >> AIT-343 CONTROL	C-30-050
C-30-350	30E19	1"	16	#14	XHHW-2	1	#14	XHHW-2	FR: FACP-SW TO: SW-NR-01 16 #14 >> FACP-SW CONTROL	
C-30-400	30E23	0.75"	1	PULL	ROPE				FR: JBOX TO: JBOX 1 PULL >> SECURITY CABLE	
C-30-401	30E23	0.75"	1	PULL	ROPE				FR: JBOX TO: JBOX 1 PULL >> SECURITY CABLE	
C-30-402	30E23	0.75"	1	PULL	ROPE				FR: J-BOX TO: ACP-SW 1 PULL >> SECURITY CABLE	
C-30-403	30E23	0.75"	1	PULL	ROPE				FR: JBOX TO: JBOX 1 PULL >> SECURITY CABLE	
C-30-404	30E23	1"	1	PULL	ROPE				FR: JBOX TO: ACP-SW 1 PULL >> SECURITY CABLE	
C-30-405	30E23	0.75"	1	PULL	ROPE				FR: JBOX TO: JBOX 1 PULL >> SECURITY CABLE	
C-30-406	30E23	1"	1	PULL	ROPE				FR: JBOX TO: ACP-SW 1 PULL >> SECURITY CABLE	

Conduits Schedule

26_06_01-5

CO/Thornton/203505-100000/04 Design/04 Specs/Carollo/SWPS/26_06_01 (IFB2)

203505

Thornton Water Project (12-777XP)

Source Water Pump Station

May 2026

CONDUIT SCHEDULE AREA

THORNTON SOURCE WATER

SOURCE WATER PUMP STATION

ENGINEER

JD

REVISION

DATE

5/5/26

CONDUIT			CONDUCTORS			GROUND			DESCRIPTION	CONNECTING SEGMENTS
NUMBER	DWG	SIZE	#	SIZE	TYPE	#	SIZE	TYPE		
C-30-407	30E23	0.75"	1	PULL	ROPE				FR: JBOX TO: JBOX 1 PULL >> SECURITY CABLE	
C-30-408	30E23	0.75"	1	PULL	ROPE				FR: JBOX TO: JBOX 1 PULL >> SECURITY CABLE	
C-30-409	30E24	0.75"	1	MFR	CABLE	1	#14	XHHW-2	FR: AHU-305 TO: HP-301 1 MFR >> ACU-305 CONTROL AND POWER	
C-30-410	30E24	0.75"	4	#14	XHHW-2	1	#14	XHHW-2	FR: AHU-305 TO: AHU-305 THERMOSTAT 4 #14 >> AHU-305 CONTROL	
C-30-411	30E24	0.75"	4	#14	XHHW-2	1	#14	XHHW-2	FR: AHU-305 THERMOSTAT TO: DDC-SW 4 #14 >> AHU-305 THERMOSTAT CONTROL	
C-30-421	30E24	0.75"	4	#14	XHHW-2	1	#14	XHHW-2	FR: SF-301 THERMOSTAT TO: J-BOX 4 #14 >> SF-301 THERMOSTAT CONTROL	C-30-435
C-30-422	30E24	0.75"	4	#14	XHHW-2	1	#14	XHHW-2	FR: XS-1 TO: J-BOX 4 #14 >> XS-1 CONTROL	C-30-435
C-30-423	30E24	0.75"	4	#14	XHHW-2	1	#14	XHHW-2	FR: XS-2 TO: J-BOX 4 #14 >> XS-2 CONTROL	C-30-433
C-30-424	30E24	0.75"	4	#14	XHHW-2	1	#14	XHHW-2	FR: SF-302 THERMOSTAT TO: J-BOX 4 #14 >> SF-302 THERMOSTAT CONTROL	C-30-433
C-30-425	30E24	0.75"	4	#14	XHHW-2	1	#14	XHHW-2	FR: SF-303 THERMOSTAT TO: J-BOX 4 #14 >> SF-303 THERMOSTAT CONTROL	C-30-431
C-30-426	30E24	0.75"	4	#14	XHHW-2	1	#14	XHHW-2	FR: XS-3 TO: J-BOX 4 #14 >> XS-3 CONTROL	C-30-431
C-30-428	30E24	0.75"	4	#14	XHHW-2	1	#14	XHHW-2	FR: SF-304 THERMOSTAT TO: J-BOX 4 #14 >> SF-304 THERMOSTAT CONTROL	C-30-430
C-30-429	30E24	0.75"	4	#14	XHHW-2	1	#14	XHHW-2	FR: XS-4 TO: J-BOX 4 #14 >> XS-4 CONTROL	C-30-430
C-30-430	30E24	0.75"	8	#14	XHHW-2	1	#14	XHHW-2	FR: J-BOX TO: CONDUIT TEE 4 #14 >> SF-304 THERMOSTAT CONTROL 4 #14 >> XS-4 CONTROL	C-30-432 C-30-428 C-30-429
C-30-431	30E24	0.75"	8	#14	XHHW-2	1	#14	XHHW-2	FR: J-BOX TO: CONDUIT TEE 4 #14 >> SF-303 THERMOSTAT CONTROL 4 #14 >> XS-3 CONTROL	C-30-432 C-30-425 C-30-426
C-30-432	30E24	1"	16	#14	XHHW-2	1	#14	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 4 #14 >> SF-303 THERMOSTAT CONTROL 4 #14 >> XS-3 CONTROL 4 #14 >> SF-304 THERMOSTAT CONTROL 4 #14 >> XS-4 CONTROL	C-30-434 C-30-431 C-30-431 C-30-430 C-30-430
C-30-433	30E24	0.75"	8	#14	XHHW-2	1	#14	XHHW-2	FR: J-BOX TO: CONDUIT TEE 4 #14 >> SF-302 THERMOSTAT CONTROL 4 #14 >> XS-2 CONTROL	C-30-434 C-30-424 C-30-423
C-30-434	30E24	1.5"	24	#14	XHHW-2	1	#14	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 4 #14 >> SF-303 THERMOSTAT CONTROL 4 #14 >> XS-3 CONTROL 4 #14 >> SF-304 THERMOSTAT CONTROL 4 #14 >> XS-4 CONTROL 4 #14 >> SF-302 THERMOSTAT CONTROL 4 #14 >> XS-2 CONTROL	C-30-436 C-30-432 C-30-432 C-30-432 C-30-432 C-30-433 C-30-433

Conduits Schedule

26_06_01-6

CO/Thornton/203505-100000/04 Design/04 Specs/Carollo/SWPS/26_06_01 (IFB2)

203505

Thornton Water Project (12-777XP)

Source Water Pump Station

May 2026

CONDUIT SCHEDULE AREA

THORNTON SOURCE WATER

SOURCE WATER PUMP STATION

ENGINEER

JD

REVISION

DATE

5/5/26

CONDUIT			CONDUCTORS			GROUND				
NUMBER	DWG	SIZE	#	SIZE	TYPE	#	SIZE	TYPE	DESCRIPTION	CONNECTING SEGMENTS
C-30-435	30E24	0.75"	8	#14	XHHW-2	1	#14	XHHW-2	FR: J-BOX TO: CONDUIT TEE 4 #14 >> XS-1 CONTROL 4 #14 >> SF-301 THERMOSTAT CONTROL	C-30-436 C-30-422 C-30-421
C-30-436	30E24	1.5"	32	#14	XHHW-2	1	#14	XHHW-2	FR: CONDUIT TEE TO: J-BOX 4 #14 >> XS-1 CONTROL 4 #14 >> SF-301 THERMOSTAT CONTROL 4 #14 >> SF-303 THERMOSTAT CONTROL 4 #14 >> XS-3 CONTROL 4 #14 >> SF-304 THERMOSTAT CONTROL 4 #14 >> XS-4 CONTROL 4 #14 >> SF-302 THERMOSTAT CONTROL 4 #14 >> XS-2 CONTROL	C-30-437 C-30-435 C-30-435 C-30-434 C-30-434 C-30-434 C-30-434 C-30-434 C-30-434
C-30-437	30E24	1.5"	32	#14	XHHW-2	1	#14	XHHW-2	FR: J-BOX TO: MCC-SW 4 #14 >> XS-1 CONTROL 4 #14 >> SF-301 THERMOSTAT CONTROL 4 #14 >> SF-303 THERMOSTAT CONTROL 4 #14 >> XS-3 CONTROL 4 #14 >> SF-304 THERMOSTAT CONTROL 4 #14 >> XS-4 CONTROL 4 #14 >> SF-302 THERMOSTAT CONTROL 4 #14 >> XS-2 CONTROL	C-30-436 C-30-436 C-30-436 C-30-436 C-30-436 C-30-436 C-30-436 C-30-436
C-30-447	30E24	0.75"	2	#12	XHHW-2	1	#12	XHHW-2	FR: DDC-SW TO: PCM-SW 2 #12 >> DDC-SW 120 VAC POWER	
C-30-448	30E24	0.75"	2	#12	XHHW-2	1	#12	XHHW-2	FR: ACP-SW TO: PCM-SW 2 #12 >> ACP-SW 120 VAC POWER	
C-30-450	30E24	0.75"	4	#14	XHHW-2	1	#14	XHHW-2	FR: AHU-302 TO: AHU-302 THERMOSTAT 4 #14 >> AHU-302 CONTROL	
C-30-451	30E24	0.75"	4	#14	XHHW-2	1	#14	XHHW-2	FR: HTR-304 THERMOSTAT TO: HTR-304 4 #14 >> HTR-304 THERMOSTAT CONTROL	
C-30-460	30E24	0.75"	4	#14	XHHW-2	1	#14	XHHW-2	FR: AHU-301 TO: AHU-301 THERMOSTAT 4 #14 >> AHU-301 CONTROL	
C-30-461	30E24	0.75"	4	#14	XHHW-2	1	#14	XHHW-2	FR: HTR-303 THERMOSTAT TO: HTR-303 4 #14 >> HTR-303 THERMOSTAT CONTROL	
C-30-462	30E24	0.75"	4	#14	XHHW-2	1	#14	XHHW-2	FR: AHU-301 THERMOSTAT TO: CONDUIT TEE 4 #14 >> AHU-301 THERMOSTAT CONTROL	C-30-464
C-30-463	30E24	0.75"	4	#14	XHHW-2	1	#14	XHHW-2	FR: AHU-302 THERMOSTAT TO: CONDUIT TEE 4 #14 >> AHU-302 THERMOSTAT CONTROL	C-30-464
C-30-464	30E24	0.75"	8	#14	XHHW-2	1	#14	XHHW-2	FR: CONDUIT TEE TO: DDC-SW 4 #14 >> AHU-301 THERMOSTAT CONTROL 4 #14 >> AHU-302 THERMOSTAT CONTROL	C-30-462 C-30-463
C-30-470	30E24	0.75"	4	#14	XHHW-2	1	#14	XHHW-2	FR: AHU-302 TO: CU-302 4 #14 >> AHU-302 CONTROL	
C-30-471	30E24	0.75"	4	#14	XHHW-2	1	#14	XHHW-2	FR: HTR-302 DISCONNECT TO: HTR-302 4 #14 >> HTR-302 DISCONNECT CONTROL	
C-30-480	30E24	0.75"	4	#14	XHHW-2	1	#14	XHHW-2	FR: AHU-301 TO: CU-301 4 #14 >> AHU-301 CONTROL	
C-30-481	30E24	0.75"	4	#14	XHHW-2	1	#14	XHHW-2	FR: HTR-301 THERMOSTAT TO: HTR-301 4 #14 >> HTR-301 THERMOSTAT CONTROL	
C-30-495	30E24	0.75"	4	#14	XHHW-2	1	#14	XHHW-2	FR: HTR-306 THERMOSTAT TO: HTR-306 4 #14 >> HTR-306 THERMOSTAT CONTROL	

Conduits Schedule

26_06_01-7

CO/Thornton/203505-100000/04 Design/04 Specs/Carollo/SWPS/26_06_01 (IFB2)

203505

Thornton Water Project (12-777XP)

Source Water Pump Station

May 2026

CONDUIT SCHEDULE AREA

THORNTON SOURCE WATER

SOURCE WATER PUMP STATION

ENGINEER

JD

REVISION

DATE

5/5/26

CONDUIT			CONDUCTORS			GROUND				
NUMBER	DWG	SIZE	#	SIZE	TYPE	#	SIZE	TYPE	DESCRIPTION	CONNECTING SEGMENTS
C-30-497	30E24	0.75"	4	#14	XHHW-2	1	#14	XHHW-2	FR: HTR-305 THERMOSTAT TO: HTR-305 4 #14 >> HTR-305 THERMOSTAT CONTROL	
C-30-505	30E02 30E15 30E20 30E20	2"	2 12	#8 #14	XHHW-2 XHHW-2	1	#10	XHHW-2	FR: SWGR-UT1 TO: SWGR-SW BREAKER CONTROL PANEL 12 #14 >> SWGR-UT1 CONTROL 2 #8 >> SWGR CUBICLE DC POWER (52-U1 AND	
C-30-506	30E15 30E20	2"	9	#8	XHHW-2	1	#8	XHHW-2	FR: SWGR-UT1 TO: SWGR-SW (CT WIRING) 9 #8 >> SWGR-UT1 CONTROL	
C-30-507	30E02 30E14 30E20	2"	2	#8	XHHW-2	1	#10	XHHW-2	FR: SWGR-UT1 TO: LP-DCSW 2 #8 >> SWGR-UT1 CUBICLE 1 (52-U1 & RELAY)	
C-30-510	30E19	0.75"	2	#14	XHHW-2	1	#14	XHHW-2	FR: VFD-305 TO: CONDUIT TEE 2 #14 >> VFD-305 LSSL FLOAT CONTROL	C-30-514
C-30-511	30E19	0.75"	2	#14	XHHW-2	1	#14	XHHW-2	FR: VFD-303 TO: CONDUIT TEE 2 #14 >> VFD-303 LSSL FLOAT CONTROL	C-30-523
C-30-514	30E19	0.75"	4	#14	XHHW-2	1	#14	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 2 #14 >> VFD-306 LSSL FLOAT CONTROL 2 #14 >> VFD-305 LSSL FLOAT CONTROL	C-30-523 C-30-517 C-30-510
C-30-517	30E19	0.75"	2	#14	XHHW-2	1	#14	XHHW-2	FR: VFD-306 TO: CONDUIT TEE 2 #14 >> VFD-306 LSSL FLOAT CONTROL	C-30-514
C-30-521	30E19	0.75"	8	#14	XHHW-2	1	#14	XHHW-2	FR: CONDUIT TEE TO: J-BOX 2 #14 >> VFD-306 LSSL FLOAT CONTROL 2 #14 >> VFD-305 LSSL FLOAT CONTROL 2 #14 >> VFD-303 LSSL FLOAT CONTROL 2 #14 >> VFD-302 LSSL FLOAT CONTROL	C-30-523 C-30-523 C-30-523 C-30-522
C-30-522	30E19	0.75"	2	#14	XHHW-2	1	#14	XHHW-2	FR: VFD-302 TO: CONDUIT TEE 2 #14 >> VFD-302 LSSL FLOAT CONTROL	C-30-521
C-30-523	30E19	0.75"	6	#14	XHHW-2	1	#14	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 2 #14 >> VFD-306 LSSL FLOAT CONTROL 2 #14 >> VFD-305 LSSL FLOAT CONTROL 2 #14 >> VFD-303 LSSL FLOAT CONTROL	C-30-521 C-30-514 C-30-514 C-30-511
C-30-524	30E01 30E15	2"	2	#14	XHHW-2	1	#14	XHHW-2	FR: LOWER INTAKE STRUCTURE TO: HH-1 2 #14 >> FCG-341 CONTROL	C-30-599 50
C-30-525	30E15 30E20	2"	1	PULL	ROPE				FR: FUTURE SWGR-UT2 TO: SWGR-SW BREAKER CONTROL PANEL 1 PULL >> SPARE	
C-30-526	30E15 30E20	2"	1	PULL	ROPE				FR: FUTURE SWGR-UT2 TO: SSWGR-SW (CT WIRING) 1 PULL >> SPARE	
C-30-534	30E01 30E15	2"	1	#14	XHHW-2	1	#14	XHHW-2	FR: UPPER INTAKE STRUCTURE TO: HH-1 1 #14 >> FCG-340 CONTROL	C-30-599
C-30-599	30E15 30E20	2"	3	#14	XHHW-2	1	#14	XHHW-2	FR: HH-1 TO: VCP-340 2 #14 >> FCG-341 CONTROL 1 #14 >> FCG-340 CONTROL	C-30-050 C-30-524 C-30-534
C-30-600	30E19	0.75"	3	#14	XHHW-2	1	#14	XHHW-2	FR: VCP-340 TO: J-BOX 2 #14 >> FCG-341 CONTROL 1 #14 >> FCG-340 CONTROL	C-30-040 C-30-599 C-30-599
C-30-700	30E02	0.75"	2	#14	XHHW-2	1	#14	XHHW-2	FR: LSH-321 TO: CONDUIT TEE 2 #14 >> LSH-321 CONTROL	C-30-750

Conduits Schedule

26_06_01-8

CO/Thornton/203505-100000/04 Design/04 Specs/Carollo/SWPS/26_06_01 (IFB2)

203505

Thornton Water Project (12-777XP)

Source Water Pump Station

May 2026

CONDUIT SCHEDULE AREA

THORNTON SOURCE WATER
SOURCE WATER PUMP STATION

ENGINEER JD
REVISION
DATE 5/5/26

CONDUIT			CONDUCTORS			GROUND				
NUMBER	DWG	SIZE	#	SIZE	TYPE	#	SIZE	TYPE	DESCRIPTION	CONNECTING SEGMENTS
C-30-710	30E02	0.75"	2	#14	XHHW-2	1	#14	XHHW-2	FR: LSH-322 TO: CONDUIT TEE 2 #14 >> LSH-322 CONTROL	C-30-750
C-30-750	30E02 30E20	1"	4	#14	XHHW-2	1	#14	XHHW-2	FR: CONDUIT TEE TO: VCP-331 2 #14 >> LSH-321 CONTROL 2 #14 >> LSH-322 CONTROL	C-30-800 C-30-700 C-30-710
C-30-770	30E02	0.75"	8	#14	XHHW-2	1	#14	XHHW-2	FR: VCP-321 TO: CONDUIT TEE 8 #14 >> VCP-321 CONTROL	C-30-790
C-30-780	30E02	0.75"	8	#14	XHHW-2	1	#14	XHHW-2	FR: VCP-322 TO: CONDUIT TEE 8 #14 >> VCP-322 CONTROL	C-30-790
C-30-790	30E02 30E20	1"	16	#14	XHHW-2	1	#14	XHHW-2	FR: CONDUIT TEE TO: PCM-SW 8 #14 >> VCP-321 CONTROL 8 #14 >> VCP-322 CONTROL	C-30-770 C-30-780
C-30-800	30E19	1"	10	#14	XHHW-2	1	#14	XHHW-2	FR: VCP-331 TO: PCM-SW 6 #14 >> VCP-331 CONTROL 2 #14 >> LSH-321 CONTROL 2 #14 >> LSH-322 CONTROL	C-30-750 C-30-750
L-30-070	30E19	1"	2	#12	XHHW-2	1	#12	XHHW-2	FR: PCM-SW TO: LP-SW 2 #12 >> PCM-SW POWER	
L-30-071	30E19	0.75"	4	#12	XHHW-2	1	#12	XHHW-2	FR: SW-NR-01 TO: LP-SW 2 #12 >> ATS-SW POWER 2 #12 >> UPS-SW POWER	
L-30-072	30E19	0.75"	2	#12	XHHW-2	1	#12	XHHW-2	FR: PCM-SW TO: SW-NR-01 2 #12 >> PCM-SW UPS POWER	
L-30-075	30E19	0.75"	2	#8	XHHW-2	1	#8	XHHW-2	FR: BATTERY CHARGER TO: LP-SW 2 #8 >> BATTERY CHARGER POWER	
L-30-076	30E19	1"	2	#3	XHHW-2	1	#8	XHHW-2	FR: BATTERIES TO: BATTERY CHARGER 2 #3 >> BATTERIES POWER	
L-30-078	30E19	0.75"	2	#8	XHHW-2	1	#10	XHHW-2	FR: BATTERY CHARGER TO: LP-DCSW 2 #8 >> LP-DCSW POWER	
L-30-079	30E19	1"	2	#3	XHHW-2	1	#6	XHHW-2	FR: BATTERIES TO: LP-DCSW 2 #3 >> LP-DCSW POWER	
L-30-210	30E19	0.75"	2	#12	XHHW-2	1	#12	XHHW-2	FR: DDC-SW TO: LP-SW 2 #12 >> DDC-SW POWER	
L-30-220	30E19	0.75"	2	#12	XHHW-2	1	#12	XHHW-2	FR: ACP-SW TO: LP-SW 2 #12 >> DDC-SW POWER	
L-30-290	30E24	0.75"	2	#12	XHHW-2	1	#12	XHHW-2	FR: EF-301 TO: DISCONNECT 2 #12 >> EF-301 POWER	L-30-291
L-30-291	30E24	0.75"	2	#12	XHHW-2	1	#12	XHHW-2	FR: DISCONNECT TO: CONDUIT TEE 2 #12 >> EF-301 POWER	L-30-302 L-30-290
L-30-300	30E24	0.75"	2	#12	XHHW-2	1	#12	XHHW-2	FR: HTR-307 TO: DISCONNECT 2 #12 >> HTR-307 POWER	L-30-301
L-30-301	30E24	0.75"	2	#12	XHHW-2	1	#12	XHHW-2	FR: DISCONNECT TO: CONDUIT TEE 2 #12 >> HTR-307 POWER	L-30-302 L-30-300

CONDUIT SCHEDULE AREA

THORNTON SOURCE WATER

SOURCE WATER PUMP STATION

ENGINEER

JD

REVISION

DATE

5/5/26

CONDUIT			CONDUCTORS			GROUND				
NUMBER	DWG	SIZE	#	SIZE	TYPE	#	SIZE	TYPE	DESCRIPTION	CONNECTING SEGMENTS
L-30-302	30E24	0.75"	4	#12	XHHW-2	1	#12	XHHW-2	FR: CONDUIT TEE TO: J-BOX 2 #12 >> HTR-307 POWER 2 #12 >> EF-301 POWER	L-30-303 L-30-301 L-30-291
L-30-303	30E24	0.75"	4	#12	XHHW-2	1	#12	XHHW-2	FR: J-BOX TO: LP-SW 2 #12 >> HTR-307 POWER 2 #12 >> EF-301 POWER	L-30-302 L-30-302
L-30-412	30E24	0.75"	2	#10	XHHW-2	1	#12	XHHW-2	FR: HP-301 TO: DISCONNECT 2 #10 >> HP-301 POWER	L-30-426
L-30-426	30E24	0.75"	2	#10	XHHW-2	1	#12	XHHW-2	FR: DISCONNECT TO: LP-SW 2 #10 >> HP-301 POWER	L-30-412
L-30-501	30E19	2"	4	#1/0	XHHW-2	1	#6	XHHW-2	FR: LP-SW TO: XFMR-LP-SW 4 #1/0 >> LP-SW POWER	
L-30-700	30E19	0.75"	2	#12	XHHW-2	1	#12	XHHW-2	FR: FACP-SW TO: LP-SW 2 #12 >> FACP-SW POWER	
M-30-101	30E20	3"	1	PULL	ROPE				FR: FUTURE PMP-301 TO: FUTURE VFD-301 1 PULL >> SPARE	
M-30-131	30E19 30E20	3"	3	#2:5KV	5KV-EPR	1	#6	XHHW-2	FR: PMP-302 TO: VFD-302 3 #2:5KV >> PMP-302 POWER	
M-30-132	30E19	3"	3	#1/0:5KV	5KV-EPR	1	#6	XHHW-2	FR: VFD-302 TO: SWGR-SW 3 #1/0:5KV >> VFD-302 POWER	
M-30-161	30E19 30E20	3"	3	#2:5KV	5KV-EPR	1	#6	XHHW-2	FR: PMP-303 TO: VFD-303 3 #2:5KV >> PMP-303 POWER	
M-30-162	30E19	3"	3	#1/0:5KV	5KV-EPR	1	#6	XHHW-2	FR: VFD-303 TO: SWGR-SW 3 #1/0:5KV >> VFD-303 POWER	
M-30-201	30E20	4"	1	PULL	ROPE				FR: FUTURE VFD-304 TO: FUTURE PMP-304 1 PULL >> SPARE (1 OF 2)	
M-30-202	30E20	4"	1	PULL	ROPE				FR: FUTURE VFD-304 TO: FUTURE PMP-304 1 PULL >> SPARE (2 OF 2)	
M-30-231	30E19 30E20	4"	3	250:5KV	5KV-EPR	1	#1	XHHW-2	FR: PMP-305 TO: VFD-305 3 250:5KV >> PMP-305 POWER	
M-30-232	30E19 30E20	4"	3	250:5KV	5KV-EPR	1	#1	XHHW-2	FR: PMP-305 TO: VFD-305 3 250:5KV >> PMP-305 POWER	
M-30-233	30E19	5"	3	350:15KV	15KV-EPR	1	#1	XHHW-2	FR: VFD-305 TO: SWGR-SW 3 350:15KV >> VFD-305 POWER (1 OF 2)	
M-30-234	30E19	5"	3	350:15KV	15KV-EPR	1	#1	XHHW-2	FR: VFD-305 TO: SWGR-SW 3 350:15KV >> VFD-305 POWER (2 OF 2)	
M-30-261	30E19 30E20	4"	3	250:5KV	5KV-EPR	1	#1	XHHW-2	FR: PMP-306 TO: VFD-306 3 250:5KV >> PMP-306 POWER	
M-30-262	30E19 30E20	4"	3	250:5KV	5KV-EPR	1	#1	XHHW-2	FR: PMP-306 TO: VFD-306 3 250:5KV >> PMP-306 POWER	
M-30-263	30E19	5"	3	350:15KV	15KV-EPR	1	#1	XHHW-2	FR: VFD-306 TO: SWGR-SW 3 350:15KV >> VFD-306 POWER (1 OF 2)	

Conduits Schedule

26_06_01-10

CO/Thornton/203505-100000/04 Design/04 Specs/Carollo/SWPS/26_06_01 (IFB2)

203505

Thornton Water Project (12-777XP)

Source Water Pump Station

May 2026

CONDUIT SCHEDULE AREA

THORNTON SOURCE WATER
SOURCE WATER PUMP STATION

ENGINEER JD
REVISION
DATE 5/5/26

CONDUIT			CONDUCTORS			GROUND				
NUMBER	DWG	SIZE	#	SIZE	TYPE	#	SIZE	TYPE	DESCRIPTION	CONNECTING SEGMENTS
M-30-264	30E19	5"	3	350:15KV	15KV-EPR	1	#1	XHHW-2	FR: VFD-306 TO: SWGR-SW 3 350:15KV >> VFD-306 POWER (2 OF 2)	
M-30-501	30E15	6"	3	350:15KV	15KV-EPR	1	#1/0	XHHW-2	FR: XFMR-SW1 TO: SWGR-UT1 3 350:15KV >> XFMR-SW1 POWER (1 OF 3)	
M-30-502	30E15	6"	3	350:15KV	15KV-EPR	1	#1/0	XHHW-2	FR: XFMR-SW1 TO: SWGR-UT1 3 350:15KV >> XFMR-SW1 POWER (2 OF 3)	
M-30-503	30E15	6"	3	350:15KV	15KV-EPR	1	#1/0	XHHW-2	FR: XFMR-SW1 TO: SWGR-UT1 3 350:15KV >> XFMR-SW1 POWER (3 OF 3)	
M-30-505	30E15 30E20	6"	3	350:5KV	5KV-EPR	1	#2	XHHW-2	FR: SWGR-SW TO: XFMR-SW1 3 350:5KV >> SWGR-SW POWER (1 OF 4)	
M-30-506	30E15 30E20	6"	3	350:5KV	5KV-EPR	1	#2	XHHW-2	FR: SWGR-SW TO: XFMR-SW1 3 350:5KV >> SWGR-SW POWER (2 OF 4)	
M-30-507	30E15 30E20	6"	3	350:5KV	5KV-EPR	1	#2	XHHW-2	FR: SWGR-SW TO: XFMR-SW1 3 350:5KV >> SWGR-SW POWER (3 OF 4)	
M-30-508	30E15 30E20	6"	3	350:5KV	5KV-EPR	1	#2	XHHW-2	FR: SWGR-SW TO: XFMR-SW1 3 350:5KV >> SWGR-SW POWER (4 OF 4)	
M-30-510	30E15 30E20	4"	3	350:5KV	5KV-EPR	1	#4	XHHW-2	FR: XFMR-PP1 TO: SWGR-SW 3 350:5KV >> XFMR-PP1 POWER	
M-30-525	30E15 30E20	6"	1	PULL	ROPE				FR: SWGR-SW TO: FUTURE XFMR-SW2 1 PULL >> SPARE (1 OF 4)	
M-30-526	30E15 30E20	6"	1	PULL	ROPE				FR: SWGR-SW TO: FUTURE XFMR-SW2 1 PULL >> SPARE (2 OF 4)	
M-30-527	30E15 30E20	6"	1	PULL	ROPE				FR: SWGR-SW TO: FUTURE XFMR-SW2 1 PULL >> SPARE (3 OF 4)	
M-30-528	30E15 30E20	6"	1	PULL	ROPE				FR: SWGR-SW TO: FUTURE XFMR-SW2 1 PULL >> SPARE (4 OF 4)	
M-30-530	30E15 30E20	4"	1	PULL	ROPE				FR: FUTURE XFMR-PP2 TO: SWGR-SW 1 PULL >> SPARE	
M-30-700	30E01 30E02 30E15	6"	3	500:15KV	15KV-EPR	1	#1/0	XHHW-2	FR: SWGR-UT1 TO: UTILITY PRIMARY METER CABINET 3 500:15KV >> SWGR-UT1 POWER	
M-30-710	30E01 30E02 30E15	6"	1	PULL	ROPE		#1/0		FR: SWGR-UT1 TO: UTILITY PRIMARY METER CABINET 1 PULL >> SWGR-UT1 POWER SPARE	
N-30-070	30E19	0.75"	1		CAT6	1	#14	XHHW-2	FR: SW-NR-01 TO: PCM-SW 1 CAT6 >> PCM-SW NETWORK	
N-30-077	30E19	1.5"	4		CAT6	1	#14	XHHW-2	FR: SWGR-SW TO: SW-NR-01 4 CAT6 >> SWGR-SW NETWORK	
N-30-100	30E19	1.5"	4		CAT6	1	#14	XHHW-2	FR: SWBD-SW TO: SW-NR-01 4 CAT6 >> SWBD-SW NETWORK	
N-30-300	30E23	0.75"	1		CAT6	1	#14	XHHW-2	FR: SW-CAM-06 TO: SW-NR-01 1 CAT6 >> SW-CAM-06 NETWORK	
N-30-302	30E23	0.75"	1		CAT6	1	#14	XHHW-2	FR: SW-CAM-01 TO: JBOX 1 CAT6 >> SW-CAM-01 NETWORK	N-30-311

CONDUIT SCHEDULE AREA

THORNTON SOURCE WATER

SOURCE WATER PUMP STATION

ENGINEER

JD

REVISION

DATE

5/5/26

CONDUIT			CONDUCTORS			GROUND				
NUMBER	DWG	SIZE	#	SIZE	TYPE	#	SIZE	TYPE	DESCRIPTION	CONNECTING SEGMENTS
N-30-303	30E23	0.75"	1		CAT6	1	#14	XHHW-2	FR: SW-CAM-07 TO: JBOX 1 CAT6 >> SW-CAM-07 NETWORK	N-30-309
N-30-304	30E23	0.75"	1		CAT6	1	#14	XHHW-2	FR: SW-CAM-03 TO: JBOX 1 CAT6 >> SW-CAM-03 NETWORK	N-30-309
N-30-305	30E23	0.75"	1		CAT6	1	#14	XHHW-2	FR: SW-CAM-02 TO: JBOX 1 CAT6 >> SW-CAM-02 NETWORK	N-30-309
N-30-306	30E23	0.75"	1		CAT6	1	#14	XHHW-2	FR: SW-CAM-04 TO: CONDUIT TEE 1 CAT6 >> SW-CAM-04 NETWORK	N-30-310
N-30-309	30E23	1"	3		CAT6	1	#14	XHHW-2	FR: J-BOX TO: CONDUIT TEE 1 CAT6 >> SW-CAM-02 NETWORK 1 CAT6 >> SW-CAM-07 NETWORK 1 CAT6 >> SW-CAM-03 NETWORK	N-30-310 N-30-305 N-30-303 N-30-304
N-30-310	30E23	1.5"	4		CAT6	1	#14	XHHW-2	FR: CONDUIT TEE TO: J-BOX 1 CAT6 >> SW-CAM-04 NETWORK 1 CAT6 >> SW-CAM-02 NETWORK 1 CAT6 >> SW-CAM-07 NETWORK 1 CAT6 >> SW-CAM-03 NETWORK	N-30-311 N-30-306 N-30-309 N-30-309 N-30-309
N-30-311	30E23	1.5"	6		CAT6	1	#14	XHHW-2	FR: J-BOX TO: SW-NR-01 1 CAT6 >> SW-CAM-04 NETWORK 1 CAT6 >> SW-CAM-07 NETWORK 1 CAT6 >> SW-CAM-02 NETWORK 1 CAT6 >> SW-CAM-03 NETWORK 1 CAT6 >> SW-CAM-05 NETWORK 1 CAT6 >> SW-CAM-01 NETWORK	N-30-310 N-30-310 N-30-310 N-30-310 N-30-313 N-30-302
N-30-313	30E23	0.75"	1		CAT6	1	#14	XHHW-2	FR: SW-CAM-05 TO: J-BOX 1 CAT6 >> SW-CAM-05 NETWORK	N-30-311
N-30-345	30E24	0.75"	1		CAT6	1	#14	XHHW-2	FR: ACP-SW TO: SW-NR-01 1 CAT6 >> ACP-SW NETWORK	
N-30-346	30E24	0.75"	1		CAT6	1	#14	XHHW-2	FR: DDC-SW TO: SW-NR-01 1 CAT6 >> DDC-SW NETWORK	
N-30-500	30E01	2.5"	1		72/FO	1	#14	XHHW-2	FR: HH-2 TO: EXISTING HANDHOLE 1 72/FO >> SW-NR-01 NETWORK	
N-30-502	30E19	0.75"	1		CAT6	1	#14	XHHW-2	FR: ACP-SW TO: SW-NR-01 1 CAT6 >> ACP-SW NETWORK	
N-30-506	30E15 30E20	2"	1		12/FO	1	#14	XHHW-2	FR: SWGR-UT1 TO: SW-NR-01 1 12/FO >> SWGR-UT1 NETWORK	
N-30-510	30E01	2.5"	1	PULL	ROPE				FR: CONTROL ROOM STUB UP TO: HH-2 1 PULL >> SPARE NETWORK	
N-30-520	30E01	2.5"	1	PULL	ROPE				FR: CONTROL ROOM STUB UP TO: HH-2 1 PULL >> SPARE NETWORK	
N-30-526	30E15 30E20	2"	1	PULL	ROPE				FR: SWGR-UT2 TO: SW-NR-01 1 PULL >> SPARE	
N-30-550	30E01	2.5"	1		72/FO	1	#14	XHHW-2	FR: SW-NR-01 TO: HH-2 1 72/FO >> SW-NR-01 NETWORK	
N-30-560	30E01 30E02	2.5"	1	PULL	ROPE				FR: CONTROL ROOM STUB UP TO: HH-2 1 PULL >> SPARE NETWORK	

CONDUIT SCHEDULE AREA

THORNTON SOURCE WATER
SOURCE WATER PUMP STATION

ENGINEER JD
REVISION
DATE 5/5/26

CONDUIT			CONDUCTORS			GROUND				
NUMBER	DWG	SIZE	#	SIZE	TYPE	#	SIZE	TYPE	DESCRIPTION	CONNECTING SEGMENTS
N-30-570	30E01 30E02	2.5"	1	PULL	ROPE				FR: CONTROL ROOM STUB UP TO: HH-2 1 PULL >> SPARE NETWORK	
P-30-003	30E19	0.75"	3	#12	XHHW-2	1	#12	XHHW-2	FR: FCV-302 TO: DISCONNECT 3 #12 >> FCV-302 POWER	P-30-004
P-30-004	30E19	0.75"	3	#12	XHHW-2	1	#12	XHHW-2	FR: DISCONNECT TO: CONDUIT TEE 3 #12 >> FCV-302 POWER	P-30-020 P-30-003
P-30-005	30E19	0.75"	3	#12	XHHW-2	1	#12	XHHW-2	FR: FCV-303 TO: DISCONNECT 3 #12 >> FCV-303 POWER	
P-30-020	30E19	0.75"	6	#12	XHHW-2	1	#12	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 3 #12 >> FCV-303 POWER 3 #12 >> FCV-302 POWER	P-30-041 P-30-006 P-30-004
P-30-030	30E19	0.75"	3	#12	XHHW-2	1	#12	XHHW-2	FR: FV-311 TO: DISCONNECT 3 #12 >> FV-311 POWER	P-30-031
P-30-031	30E19	0.75"	3	#12	XHHW-2	1	#12	XHHW-2	FR: DISCONNECT TO: J-BOX 3 #12 >> FV-311 POWER	P-30-060 P-30-030
P-30-040	30E19	0.75"	3	#12	XHHW-2	1	#12	XHHW-2	FR: FV-310 TO: DISCONNECT 3 #12 >> FV-310 POWER	
P-30-041	30E19	0.75"	3	#12	XHHW-2	1	#12	XHHW-2	FR: DISCONNECT TO: J-BOX 3 #12 >> FV-311 POWER	P-30-020
P-30-050	30E19	0.75"	6	#12	XHHW-2	1	#12	XHHW-2	FR: J-BOX TO: J-BOX 3 #12 >> FCV-303 POWER 3 #12 >> FCV-302 POWER	P-30-061 P-30-020 P-30-020
P-30-060	30E19	0.75"	6	#12	XHHW-2	1	#12	XHHW-2	FR: J-BOX TO: PP-SW 3 #12 >> FV-310 POWER 3 #12 >> FV-311 POWER	P-30-021 P-30-031
P-30-061	30E19	0.75"	6	#12	XHHW-2	1	#12	XHHW-2	FR: J-BOX TO: PP-SW 3 #12 >> FCV-303 POWER 3 #12 >> FCV-302 POWER	P-30-050 P-30-050
P-30-400	30E24	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: AHU-302 TO: AHU-302 DISC 3 #10 >> AHU-03 POWER	P-30-408
P-30-402	30E24	1"	3	#4	XHHW-2	1	#8	XHHW-2	FR: CU-301 DISC TO: SWBD-SW 3 #4 >> CU-301 POWER	P-30-404
P-30-403	30E24	1"	3	#4	XHHW-2	1	#8	XHHW-2	FR: CU-302 DISC TO: SWBD-SW 3 #4 >> CU-302 POWER	P-30-405
P-30-404	30E24	1"	3	#4	XHHW-2	1	#8	XHHW-2	FR: CU-301 TO: CU-301 DISC 3 #4 >> CU-301 POWER	P-30-402
P-30-405	30E24	1"	3	#4	XHHW-2	1	#8	XHHW-2	FR: CU-302 TO: CU-302 DISC 3 #4 >> CU-302 POWER	P-30-403
P-30-408	30E24	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: AHU-302 DISC TO: SWBD-SW 3 #10 >> AHU-03 POWER	P-30-400
P-30-410	30E24	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: AHU-301 DISC TO: SWBD-SW 3 #10 >> AHU-301 POWER	P-30-414
P-30-414	30E24	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: AHU-301 TO: AHU-301 DISC 3 #10 >> AHU-301 POWER	P-30-410

CONDUIT SCHEDULE AREA

THORNTON SOURCE WATER

SOURCE WATER PUMP STATION

ENGINEER

JD

REVISION

DATE

5/5/26

CONDUIT			CONDUCTORS			GROUND				
NUMBER	DWG	SIZE	#	SIZE	TYPE	#	SIZE	TYPE	DESCRIPTION	CONNECTING SEGMENTS
P-30-420	30E24	1"	3	#12	XHHW-2	1	#12	XHHW-2	FR: DISC TO: J-BOX 3 #12 >> SF-301 POWER	P-30-440 P-30-421
P-30-421	30E24	0.75"	3	#12	XHHW-2	1	#12	XHHW-2	FR: SF-301 TO: DISC 3 #12 >> SF-301 POWER	P-30-420
P-30-423	30E24	1"	3	#12	XHHW-2	1	#12	XHHW-2	FR: DISCONNECT TO: CONDUIT TEE 3 #12 >> SF-302 POWER	P-30-432 P-30-424
P-30-424	30E24	0.75"	3	#12	XHHW-2	1	#12	XHHW-2	FR: SF-302 TO: DISCONNECT 3 #12 >> SF-302 POWER	P-30-423
P-30-425	30E24	0.75"	3	#12	XHHW-2	1	#12	XHHW-2	FR: SF-303 TO: DISCONNECT 3 #12 >> SF-303 POWER	P-30-427
P-30-427	30E24	0.75"	3	#12	XHHW-2	1	#12	XHHW-2	FR: DISCONNECT TO: CONDUIT TEE 3 #12 >> SF-303 POWER	P-30-431 P-30-425
P-30-428	30E24	0.75"	3	#12	XHHW-2	1	#12	XHHW-2	FR: SF-304 TO: DISCONNECT 3 #12 >> SF-304 POWER	P-30-429
P-30-429	30E24	0.75"	3	#12	XHHW-2	1	#12	XHHW-2	FR: DISCONNECT TO: CONDUIT TEE 3 #12 >> SF-304 POWER	P-30-431 P-30-428
P-30-431	30E24	0.75"	6	#12	XHHW-2	1	#12	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 3 #12 >> SF-303 POWER 3 #12 >> SF-304 POWER	P-30-432 P-30-427 P-30-429
P-30-432	30E24	1"	9	#12	XHHW-2	1	#12	XHHW-2	FR: CONDUIT TEE TO: J-BOX 3 #12 >> SF-303 POWER 3 #12 >> SF-304 POWER 3 #12 >> SF-302 POWER	P-30-441 P-30-431 P-30-431 P-30-423
P-30-440	30E24	0.75"	6	#12	XHHW-2	1	#12	XHHW-2	FR: J-BOX TO: J-BOX 3 #12 >> SF-301 POWER 3 #12 >> HTR-304 POWER	P-30-420 P-30-451
P-30-441	30E24	1"	9	#12	XHHW-2	1	#12	XHHW-2	FR: J-BOX TO: J-BOX 3 #12 >> SF-303 POWER 3 #12 >> SF-304 POWER 3 #12 >> SF-302 POWER	P-30-432 P-30-432 P-30-432
P-30-445	30E24	0.75"	6	#12	XHHW-2	1	#12	XHHW-2	FR: J-BOX TO: MCC-SW 3 #12 >> SF-301 POWER 3 #12 >> SF-304 POWER	
P-30-446	30E24	0.75"	6	#12	XHHW-2	1	#12	XHHW-2	FR: J-BOX TO: MCC-SW 3 #12 >> SF-301 POWER 3 #12 >> SF-304 POWER	
P-30-447	30E24	0.75"	6	#12	XHHW-2	1	#12	XHHW-2	FR: J-BOX TO: PP-SW 3 #12 >> HTR-301 POWER 3 #12 >> HTR-302 POWER	P-30-490 P-30-490
P-30-448	30E24	0.75"	6	#12	XHHW-2	1	#12	XHHW-2	FR: J-BOX TO: PP-SW 3 #12 >> HTR-304 POWER 3 #12 >> HTR-303 POWER	
P-30-450	30E24	0.75"	3	#12	XHHW-2	1	#12	XHHW-2	FR: HTR-304 TO: DISCONNECT 3 #12 >> HTR-304 POWER	P-30-451
P-30-451	30E24	0.75"	3	#12	XHHW-2	1	#12	XHHW-2	FR: DISCONNECT TO: J-BOX 3 #12 >> HTR-304 POWER	P-30-440 P-30-450

Conduits Schedule

26_06_01-14

CO/Thornton/203505-100000/04 Design/04 Specs/Carollo/SWPS/26_06_01 (IFB2)

203505

Thornton Water Project (12-777XP)

Source Water Pump Station

May 2026

CONDUIT SCHEDULE AREA

THORNTON SOURCE WATER
SOURCE WATER PUMP STATION

ENGINEER JD
REVISION
DATE 5/5/26

CONDUIT			CONDUCTORS			GROUND				
NUMBER	DWG	SIZE	#	SIZE	TYPE	#	SIZE	TYPE	DESCRIPTION	CONNECTING SEGMENTS
P-30-460	30E24	0.75"	3	#12	XHHW-2	1	#12	XHHW-2	FR: HTR-303 TO: DISCONNECT 3 #12 >> HTR-303 POWER	P-30-461
P-30-461	30E24	0.75"	3	#12	XHHW-2	1	#12	XHHW-2	FR: DISCONNECT TO: J-BOX 3 #12 >> HTR-303 POWER	P-30-460
P-30-470	30E24	0.75"	3	#12	XHHW-2	1	#12	XHHW-2	FR: HTR-302 TO: DISCONNECT 3 #12 >> HTR-302 POWER	P-30-471
P-30-471	30E24	0.75"	3	#12	XHHW-2	1	#12	XHHW-2	FR: DISCONNECT TO: CONDUIT TEE 3 #12 >> HTR-302 POWER	P-30-490 P-30-470
P-30-480	30E24	0.75"	3	#12	XHHW-2	1	#12	XHHW-2	FR: HTR-301 TO: DISCONNECT 3 #12 >> HTR-301 POWER	P-30-481
P-30-481	30E24	0.75"	3	#12	XHHW-2	1	#12	XHHW-2	FR: DISCONNECT TO: CONDUIT TEE 3 #12 >> HTR-301 POWER	P-30-490 P-30-480
P-30-490	30E24	0.75"	6	#12	XHHW-2	1	#12	XHHW-2	FR: CONDUIT TEE TO: J-BOX 3 #12 >> HTR-301 POWER 3 #12 >> HTR-302 POWER	P-30-447 P-30-481 P-30-471
P-30-495	30E24	0.75"	3	#12	XHHW-2	1	#12	XHHW-2	FR: HTR-306 TO: DISCONNECT 3 #12 >> HTR-306 POWER	P-30-496
P-30-496	30E24	0.75"	3	#12	XHHW-2	1	#12	XHHW-2	FR: DISCONNECT TO: PP-SW 3 #12 >> HTR-306 POWER	P-30-495
P-30-497	30E24	0.75"	3	#12	XHHW-2	1	#12	XHHW-2	FR: HTR-305 TO: DISCONNECT 3 #12 >> HTR-305 POWER	P-30-498
P-30-498	30E24	0.75"	3	#12	XHHW-2	1	#12	XHHW-2	FR: DISCONNECT TO: PP-SW 3 #12 >> HTR-305 POWER	P-30-497
P-30-501	30E15 30E20	4"	4	350	XHHW-2	1	#2	XHHW-2	FR: SWBD-SW TO: XFMR-PP1 4 350 >> SWBD-SW POWER (1 OF 4)	
P-30-502	30E15 30E20	4"	4	350	XHHW-2	1	#2	XHHW-2	FR: SWBD-SW TO: XFMR-PP1 4 350 >> SWBD-SW POWER (2 OF 4)	
P-30-503	30E15 30E20	4"	4	350	XHHW-2	1	#2	XHHW-2	FR: SWBD-SW TO: XFMR-PP1 4 350 >> SWBD-SW POWER (3 OF 4)	
P-30-504	30E15 30E20	4"	4	350	XHHW-2	1	#2	XHHW-2	FR: SWBD-SW TO: XFMR-PP1 4 350 >> SWBD-SW POWER (4 OF 4)	
P-30-510	30E19	2.5"	3	250	XHHW-2	1	#4	XHHW-2	FR: MTS-PP TO: SWBD-SW 3 250 >> MTS-PP POWER (REDUNDANT)	
P-30-521	30E15 30E20	4"	1	PULL	ROPE				FR: SWBD-SW TO: FUTURE XFMR-PP2 1 PULL >> SPARE (1 OF 4)	
P-30-522	30E15 30E20	4"	1	PULL	ROPE				FR: SWBD-SW TO: FUTURE XFMR-PP2 1 PULL >> SPARE (2 OF 4)	
P-30-523	30E15 30E20	4"	1	PULL	ROPE				FR: SWBD-SW TO: FUTURE XFMR-PP2 1 PULL >> SPARE (3 OF 4)	
P-30-524	30E15 30E20	4"	1	PULL	ROPE				FR: SWBD-SW TO: FUTURE XFMR-PP2 1 PULL >> SPARE (4 OF 4)	

CONDUIT SCHEDULE AREA

THORNTON SOURCE WATER
SOURCE WATER PUMP STATION

ENGINEER JD
REVISION
DATE 5/5/26

CONDUIT			CONDUCTORS			GROUND				
NUMBER	DWG	SIZE	#	SIZE	TYPE	#	SIZE	TYPE	DESCRIPTION	CONNECTING SEGMENTS
P-30-530	30E19	2.5"	3	250	XHHW-2	1	#4	XHHW-2	FR: MTS-PP TO: SWBD-SW 3 250 >> MTS-PP POWER (NORMAL)	
P-30-531	30E19	2.5"	3	250	XHHW-2	1	#4	XHHW-2	FR: PP-SW TO: MTS-PP 3 250 >> PP-SW POWER	
P-30-532	30E19	1.5"	3	#1	XHHW-2	1	#6	XHHW-2	FR: XFMR-LP-SW TO: PP-SW 3 #1 >> XFMR-LP-SW POWER	
P-30-535	30E19	1.5"	3	#1/0	XHHW-2	1	#6	XHHW-2	FR: MCC-SW TO: PP-SW 3 #1/0 >> MCC-SW POWER	
P-30-540	30E19	0.75"	3	#8	XHHW-2	1	#10	XHHW-2	FR: BRIDGE CRANE TO: DISCONNECT 3 #8 >> BRIDGE CRANE POWER	P-30-541
P-30-541	30E19	0.75"	3	#8	XHHW-2	1	#10	XHHW-2	FR: DISCONNECT TO: SWBD-SW 3 #8 >> BRIDGE CRANE POWER	P-30-540
P-30-700	30E19	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: ARC-331A TO: VCP-331 3 #10 >> ARC-331A POWER	
P-30-710	30E19	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: ARC-331B TO: VCP-331 3 #10 >> ARC-331B POWER	
P-30-761	30E02	0.75"	1	MFR	CABLE	1	#14	XHHW-2	FR: PMP-321A TO: VCP-321 1 MFR >> PMP-321A POWER	
P-30-762	30E02	0.75"	1	MFR	CABLE	1	#14	XHHW-2	FR: PMP-321B TO: VCP-321 1 MFR >> PMP-321B POWER	
P-30-765	30E02	0.75"	1	MFR	CABLE	1	#14	XHHW-2	FR: PMP-322A TO: VCP-322 1 MFR >> PMP-322A POWER	
P-30-766	30E02	0.75"	1	MFR	CABLE	1	#14	XHHW-2	FR: PMP-322B TO: VCP-322 1 MFR >> PMP-322B POWER	
P-30-770	30E02	0.75"	3	#12	XHHW-2	1	#12	XHHW-2	FR: VCP-321 TO: CONDUIT TEE 3 #12 >> VCP-321 POWER	P-30-790
P-30-780	30E02	0.75"	3	#12	XHHW-2	1	#12	XHHW-2	FR: VCP-322 TO: CONDUIT TEE 3 #12 >> VCP-322 POWER	P-30-790
P-30-790	30E02 30E20	1"	6	#12	XHHW-2	1	#12	XHHW-2	FR: CONDUIT TEE TO: PP-SW 3 #12 >> VCP-321 POWER 3 #12 >> VCP-322 POWER	P-30-770 P-30-780
P-30-800	30E19	1"	3	#6	XHHW-2	1	#10	XHHW-2	FR: VCP-331 TO: SWBD-SW 3 #6 >> VCP-331 POWER	
S-30-003	30E19	0.75"	1	2/CS-#16		1	#14	XHHW-2	FR: PIT-302 TO: CONDUIT TEE 1 2/CS-#16 >> PIT-302 SIGNAL	S-30-019
S-30-004	30E19	0.75"	1	2/CS-#16		1	#14	XHHW-2	FR: FCV-302 TO: CONDUIT TEE 1 2/CS-#16 >> FCV-302 SIGNAL	S-30-020
S-30-005	30E19	0.75"	1	2/CS-#16		1	#14	XHHW-2	FR: PIT-303 TO: CONDUIT TEE 1 2/CS-#16 >> PIT-303 SIGNAL	S-30-018
S-30-006	30E19	0.75"	1	2/CS-#16		1	#14	XHHW-2	FR: FCV-303 TO: CONDUIT TEE 1 2/CS-#16 >> FCV-303 SIGNAL	S-30-018

CONDUIT SCHEDULE AREA

THORNTON SOURCE WATER

SOURCE WATER PUMP STATION

ENGINEER

JD

REVISION

DATE

5/5/26

CONDUIT			CONDUCTORS			GROUND				
NUMBER	DWG	SIZE	#	SIZE	TYPE	#	SIZE	TYPE	DESCRIPTION	CONNECTING SEGMENTS
S-30-007	30E19	0.75"	1	2/CS-#16		1	#14	XHHW-2	FR: PIT-305 TO: CONDUIT TEE 1 2/CS-#16 >> PIT-305 SIGNAL	S-30-009
S-30-008	30E19	0.75"	1	2/CS-#16		1	#14	XHHW-2	FR: PIT-306 TO: CONDUIT TEE 1 2/CS-#16 >> PIT-306 SIGNAL	S-30-009
S-30-009	30E19	0.75"	2	2/CS-#16		1	#14	XHHW-2	FR: CONDUIT TEE TO: J-BOX 1 2/CS-#16 >> PIT-306 SIGNAL 1 2/CS-#16 >> PIT-305 SIGNAL	S-30-028 S-30-008 S-30-007
S-30-010	30E19	0.75"	1	2/CS-#16					FR: FIT-311 TO: J-BOX 1 2/CS-#16 >> FIT-311 SIGNAL	S-30-021
S-30-011	30E19	0.75"	1	2/CS-#16					FR: FIT-300 TO: J-BOX 1 2/CS-#16 >> FIT-300 SIGNAL	S-30-021
S-30-012	30E19	0.75"	1	2/CS-#16		1	#14	XHHW-2	FR: PIT-310 TO: J-BOX 1 2/CS-#16 >> PIT-310 SIGNAL	S-30-040
S-30-015	30E19	0.75"	1	MFR	CABLE	1	#14	XHHW-2	FR: LT-302 TO: DESICCANT JBOX 1 MFR >> LT-302 SIGNAL	
S-30-018	30E19	0.75"	2	2/CS-#16		1	#14	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 1 2/CS-#16 >> PIT-303 SIGNAL 1 2/CS-#16 >> FCV-303 SIGNAL	S-30-019 S-30-005 S-30-006
S-30-019	30E19	1"	3	2/CS-#16		1	#14	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 1 2/CS-#16 >> PIT-303 SIGNAL 1 2/CS-#16 >> FCV-303 SIGNAL 1 2/CS-#16 >> PIT-302 SIGNAL	S-30-020 S-30-018 S-30-018 S-30-003
S-30-020	30E19	1"	4	2/CS-#16		1	#14	XHHW-2	FR: CONDUIT TEE TO: J-BOX 1 2/CS-#16 >> PIT-303 SIGNAL 1 2/CS-#16 >> FCV-303 SIGNAL 1 2/CS-#16 >> PIT-302 SIGNAL 1 2/CS-#16 >> FCV-302 SIGNAL	S-30-023 S-30-019 S-30-019 S-30-019 S-30-004
S-30-021	30E19	0.75"	2	2/CS-#16		1	#14	XHHW-2	FR: CONDUIT TEE TO: J-BOX 1 2/CS-#16 >> FIT-311 SIGNAL 1 2/CS-#16 >> FIT-300 SIGNAL	S-30-028 S-30-010 S-30-011
S-30-022	30E19	0.75"	1	2/CS-#16		1	#14	XHHW-2	FR: DESICANT JBOX TO: CONDUIT TEE 1 2/CS-#16 >> LT-302 SIGNAL	S-30-023
S-30-023	30E19	1.5"	5	2/CS-#16		1	#14	XHHW-2	FR: CONDUIT TEE TO: J-BOX 1 2/CS-#16 >> PIT-303 SIGNAL 1 2/CS-#16 >> FCV-303 SIGNAL 1 2/CS-#16 >> PIT-302 SIGNAL 1 2/CS-#16 >> FCV-302 SIGNAL 1 2/CS-#16 >> LT-302 SIGNAL	S-30-050 S-30-020 S-30-020 S-30-020 S-30-020 S-30-022
S-30-028	30E19	1"	4	2/CS-#16		1	#14	XHHW-2	FR: CONDUIT TEE TO: J-BOX 1 2/CS-#16 >> PIT-306 SIGNAL 1 2/CS-#16 >> PIT-305 SIGNAL 1 2/CS-#16 >> FIT-311 SIGNAL 1 2/CS-#16 >> FIT-300 SIGNAL	S-30-040 S-30-009 S-30-009 S-30-021 S-30-021

CONDUIT SCHEDULE AREA

THORNTON SOURCE WATER

SOURCE WATER PUMP STATION

ENGINEER

JD

REVISION

DATE

5/5/26

CONDUIT			CONDUCTORS			GROUND			DESCRIPTION	CONNECTING SEGMENTS
NUMBER	DWG	SIZE	#	SIZE	TYPE	#	SIZE	TYPE		
S-30-040	30E19	2.5"	2 17	3/CS-#16 2/CS-#16		1	#14	XHHW-2	FR: J-BOX TO: PCM-SW 1 2/CS-#16 >> AIT-341 SIGNAL 1 2/CS-#16 >> AIT-342 SIGNAL 1 3/CS-#16 >> TIT-342 SIGNAL 1 2/CS-#16 >> AIT-343 SIGNAL 1 2/CS-#16 >> PIT-303 SIGNAL 1 2/CS-#16 >> FCV-303 SIGNAL 1 2/CS-#16 >> PIT-302 SIGNAL 1 2/CS-#16 >> FCV-302 SIGNAL 1 2/CS-#16 >> LT-302 SIGNAL 1 3/CS-#16 >> TIT-343 SIGNAL 1 2/CS-#16 >> PIT-310 CONTROL 1 2/CS-#16 >> PIT-306 SIGNAL 1 2/CS-#16 >> PIT-305 SIGNAL 1 2/CS-#16 >> FIT-311 SIGNAL 1 2/CS-#16 >> FIT-300 SIGNAL 1 2/CS-#16 >> LT-311 SIGNAL 1 2/CS-#16 >> FCG-341 SIGNAL 1 2/CS-#16 >> LT-310 SIGNAL 1 2/CS-#16 >> FCG-340 SIGNAL	S-30-050 S-30-050 S-30-050 S-30-050 S-30-050 S-30-050 S-30-050 S-30-050 S-30-050 S-30-050 S-30-012 S-30-028 S-30-028 S-30-028 S-30-028 S-30-600 S-30-600 S-30-600 S-30-600
S-30-050	30E19	2"	2 12	3/CS-#16 2/CS-#16		1	#14	XHHW-2	FR: J-BOX TO: J-BOX 1 2/CS-#16 >> AIT-341 SIGNAL 1 2/CS-#16 >> AIT-342 SIGNAL 1 3/CS-#16 >> TIT-342 SIGNAL 1 2/CS-#16 >> AIT-343 SIGNAL 1 2/CS-#16 >> PIT-303 SIGNAL 1 2/CS-#16 >> FCV-303 SIGNAL 1 2/CS-#16 >> PIT-302 SIGNAL 1 2/CS-#16 >> FCV-302 SIGNAL 1 2/CS-#16 >> LT-302 SIGNAL 1 3/CS-#16 >> TIT-343 SIGNAL 1 2/CS-#16 >> LT-311 SIGNAL 1 2/CS-#16 >> FCG-341 SIGNAL 1 2/CS-#16 >> LT-310 SIGNAL 1 2/CS-#16 >> FCG-340 SIGNAL	S-30-040 S-30-270 S-30-271 S-30-272 S-30-273 S-30-023 S-30-023 S-30-023 S-30-023 S-30-023 S-30-274 S-30-600 S-30-600 S-30-600
S-30-070	30E19	0.75"	1	2/CS-#16		1	#14	XHHW-2	FR: SW-NR-01 TO: PCM-SW 1 2/CS-#16 >> SW-NR-01 SIGNAL	
S-30-105	30E20	2"	1	PULL	ROPE				FR: FUTURE PMP-301 TO: FUTURE VFD-301 1 PULL >> SPARE	
S-30-131	30E19	2"	8 2	3/CS-#16 2/CS-#16		1	#14	XHHW-2	FR: PMP-302 TO: JBOX 8 3/CS-#16 >> PMP-302 RTD SIGNAL 2 2/CS-#16 >> PMP-302 XVT SIGNAL	S-30-135
S-30-135	30E19 30E20	2"	8 2	3/CS-#16 2/CS-#16		1	#14	XHHW-2	FR: JBOX TO: VFD-302 8 3/CS-#16 >> PMP-302 RTD SIGNAL 2 2/CS-#16 >> PMP-302 XVT SIGNAL	S-30-131 S-30-131
S-30-161	30E19	2"	8 2	3/CS-#16 2/CS-#16		1	#14	XHHW-2	FR: PMP-303 TO: JBOX 8 3/CS-#16 >> PMP-303 RTD SIGNAL 2 2/CS-#16 >> PMP-303 XVT SIGNAL	S-30-165
S-30-165	30E19 30E20	2"	8 2	3/CS-#16 2/CS-#16		1	#14	XHHW-2	FR: JBOX TO: VFD-303 8 3/CS-#16 >> PMP-303 RTD SIGNAL 2 2/CS-#16 >> PMP-303 XVT SIGNAL	S-30-161 S-30-161
S-30-205	30E20	2"	1	PULL	ROPE				FR: FUTURE PMP-304 TO: FUTURE VFD-304 1 PULL >> SPARE	
S-30-231	30E19	2"	8 2	3/CS-#16 2/CS-#16		1	#14	XHHW-2	FR: PMP-305 TO: JBOX 8 3/CS-#16 >> PMP-305 RTD SIGNAL 2 2/CS-#16 >> PMP-305 XVT SIGNAL	S-30-235
S-30-235	30E19 30E20	2"	8 2	3/CS-#16 2/CS-#16		1	#14	XHHW-2	FR: JBOX TO: VFD-305 8 3/CS-#16 >> PMP-305 RTD SIGNAL 2 2/CS-#16 >> PMP-305 XVT SIGNAL	S-30-231 S-30-231

CONDUIT SCHEDULE AREA

THORNTON SOURCE WATER

SOURCE WATER PUMP STATION

ENGINEER

JD

REVISION

DATE

5/5/26

CONDUIT			CONDUCTORS			GROUND				
NUMBER	DWG	SIZE	#	SIZE	TYPE	#	SIZE	TYPE	DESCRIPTION	CONNECTING SEGMENTS
S-30-261	30E19	2"	8 2	3/CS-#16 2/CS-#16		1	#14	XHHW-2	FR: PMP-306 TO: JBOX 8 3/CS-#16 >> PMP-306 RTD SIGNAL 2 2/CS-#16 >> PMP-306 XVT SIGNAL	S-30-265
S-30-265	30E19 30E20	2"	8 2	3/CS-#16 2/CS-#16		1	#14	XHHW-2	FR: JBOX TO: VFD-306 8 3/CS-#16 >> PMP-306 RTD SIGNAL 2 2/CS-#16 >> PMP-306 XVT SIGNAL	S-30-261 S-30-261
S-30-270	30E19	0.75"	1	2/CS-#16		1	#14	XHHW-2	FR: AIT-341 TO: J-BOX 1 2/CS-#16 >> AIT-341 SIGNAL	S-30-050
S-30-271	30E19	0.75"	1	2/CS-#16		1	#14	XHHW-2	FR: AIT-342 TO: J-BOX 1 2/CS-#16 >> AIT-342 SIGNAL	S-30-050
S-30-272	30E19	0.75"	1	3/CS-#16		1	#14	XHHW-2	FR: TIT-342 TO: J-BOX 1 3/CS-#16 >> TIT-342 SIGNAL	S-30-050
S-30-273	30E19	0.75"	1	2/CS-#16		1	#14	XHHW-2	FR: AIT-343 TO: J-BOX 1 2/CS-#16 >> AIT-343 SIGNAL	S-30-050
S-30-274	30E19	0.75"	1	3/CS-#16		1	#14	XHHW-2	FR: TIT-343 TO: J-BOX 1 3/CS-#16 >> TIT-343 SIGNAL	S-30-050
S-30-510	30E19	0.75"	2	2/CS-#16		1	#14	XHHW-2	FR: VFD-305 TO: CONDUIT TEE 1 2/CS-#16 >> VF-305 VOLTAGE FEEDBACK 1 2/CS-#16 >> AF-305 CURRENT FEEDBACK	S-30-526
S-30-511	30E19	0.75"	2	2/CS-#16		1	#14	XHHW-2	FR: VFD-303 TO: CONDUIT TEE 1 2/CS-#16 >> VF-303 VOLTAGE FEEDBACK 1 2/CS-#16 >> AF-303 CURRENT FEEDBACK	S-30-514
S-30-514	30E19	1"	4	2/CS-#16		1	#14	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 1 2/CS-#16 >> VF-302 VOLTAGE FEEDBACK 1 2/CS-#16 >> AF-302 CURRENT FEEDBACK 1 2/CS-#16 >> VF-303 VOLTAGE FEEDBACK 1 2/CS-#16 >> AF-303 CURRENT FEEDBACK	S-30-526 S-30-522 S-30-522 S-30-511 S-30-511
S-30-517	30E19	0.75"	2	2/CS-#16		1	#14	XHHW-2	FR: VFD-306 TO: CONDUIT TEE 1 2/CS-#16 >> VF-306 VOLTAGE FEEDBACK 1 2/CS-#16 >> AF-306 CURRENT FEEDBACK	S-30-530
S-30-518	30E01	1"	1	MFR	CABLE	1	#14	XHHW-2	FR: LT-311 TO: CONDUIT TEE 1 MFR >> LT-311 SIGNAL	S-30-524
S-30-519	30E01	1"	1	MFR	CABLE	1	#14	XHHW-2	FR: LT-310 TO: CONDUIT TEE 1 MFR >> LT-310 SIGNAL	S-30-534
S-30-520	30E01	0.75"	1	2/CS-#16		1	#14	XHHW-2	FR: FCG-341 TO: CONDUIT TEE 1 2/CS-#16 >> FCG-341 SIGNAL	S-30-524
S-30-521	30E01	0.75"	1	2/CS-#16		1	#14	XHHW-2	FR: FCG-340 TO: CONDUIT TEE 1 2/CS-#16 >> FCG-340 SIGNAL	S-30-534
S-30-522	30E19	0.75"	2	2/CS-#16		1	#14	XHHW-2	FR: VFD-302 TO: CONDUIT TEE 1 2/CS-#16 >> VF-302 VOLTAGE FEEDBACK 1 2/CS-#16 >> AF-302 CURRENT FEEDBACK	S-30-514
S-30-524	30E01 30E15	2"	1 1	MFR 2/CS-#16	CABLE	1	#14	XHHW-2	FR: LT-311 TO: HH-1 1 MFR >> LT-311 SIGNAL 1 2/CS-#16 >> FCG-341 SIGNAL	S-30-599 S-30-518 S-30-520

CONDUIT SCHEDULE AREA

THORNTON SOURCE WATER

SOURCE WATER PUMP STATION

ENGINEER

JD

REVISION

DATE

5/5/26

CONDUIT			CONDUCTORS			GROUND			DESCRIPTION	CONNECTING SEGMENTS
NUMBER	DWG	SIZE	#	SIZE	TYPE	#	SIZE	TYPE		
S-30-526	30E19	1.5"	6	2/CS-#16		1	#14	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 1 2/CS-#16 >> VF-302 VOLTAGE FEEDBACK 1 2/CS-#16 >> AF-302 CURRENT FEEDBACK 1 2/CS-#16 >> VF-303 VOLTAGE FEEDBACK 1 2/CS-#16 >> AF-303 CURRENT FEEDBACK 1 2/CS-#16 >> VF-305 VOLTAGE FEEDBACK 1 2/CS-#16 >> AF-305 CURRENT FEEDBACK	S-30-530 S-30-514 S-30-514 S-30-514 S-30-514 S-30-510 S-30-510
S-30-530	30E19	1.5"	8	2/CS-#16		1	#14	XHHW-2	FR: CONDUIT TEE TO: PCM-SW 1 2/CS-#16 >> VF-302 VOLTAGE FEEDBACK 1 2/CS-#16 >> AF-302 CURRENT FEEDBACK 1 2/CS-#16 >> VF-303 VOLTAGE FEEDBACK 1 2/CS-#16 >> AF-303 CURRENT FEEDBACK 1 2/CS-#16 >> VF-305 VOLTAGE FEEDBACK 1 2/CS-#16 >> AF-305 CURRENT FEEDBACK 1 2/CS-#16 >> VF-306 VOLTAGE FEEDBACK 1 2/CS-#16 >> AF-306 CURRENT FEEDBACK	S-30-526 S-30-526 S-30-526 S-30-526 S-30-526 S-30-526 S-30-517 S-30-517
S-30-534	30E01 30E15	2"	1 1	MFR 2/CS-#16	CABLE	1	#14	XHHW-2	FR: LT-310 TO: HH-1 1 MFR >> LT-310 SIGNAL 1 2/CS-#16 >> FCG-340 SIGNAL	S-30-599 S-30-519 S-30-521
S-30-599	30E15 30E20	2"	2 2	MFR 2/CS-#16	CABLE	1	#14	XHHW-2	FR: HH-1 TO: JB-340 1 MFR >> LT-311 SIGNAL 1 2/CS-#16 >> FCG-341 SIGNAL 1 MFR >> LT-310 SIGNAL 1 2/CS-#16 >> FCG-340 SIGNAL	S-30-524 S-30-524 S-30-534 S-30-534
S-30-600	30E19	1"	4	2/CS-#16		1	#14	XHHW-2	FR: JB-340 TO: JBOX 1 2/CS-#16 >> LT-311 SIGNAL 1 2/CS-#16 >> FCG-341 SIGNAL 1 2/CS-#16 >> LT-310 SIGNAL 1 2/CS-#16 >> FCG-340 SIGNAL	S-30-040
S-30-700	30E02	0.75"	1	3/CS-#16		1	#14	XHHW-2	FR: LIT-321 TO: CONDUIT TEE 1 3/CS-#16 >> LIT-321 SIGNAL	S-30-750
S-30-710	30E02	0.75"	1	3/CS-#16		1	#14	XHHW-2	FR: LIT-322 TO: CONDUIT TEE 1 3/CS-#16 >> LIT-322 SIGNAL	S-30-750
S-30-750	30E02 30E20	1"	2	3/CS-#16		1	#14	XHHW-2	FR: CONDUIT TEE TO: VCP-331 1 3/CS-#16 >> LIT-321 SIGNAL 1 3/CS-#16 >> LIT-322 SIGNAL	S-30-800 S-30-700 S-30-710
S-30-800	30E19	1"	2 1	3/CS-#16 2/CS-#16		1	#14	XHHW-2	FR: VCP-331 TO: PCM-SW 1 3/CS-#16 >> LIT-321 SIGNAL 1 3/CS-#16 >> LIT-322 SIGNAL 1 2/CS-#16 >> SPARE	S-30-750 S-30-750
X-30-022	30E19	0.75"	2	PULL	ROPE				FR: J-BOX TO: STUB-UP IN ELECTRICAL ROOM 1 PULL >> VFD-304 LSLF FLOAT CONTROL (FUTUR 1 PULL >> VFD-301 LSLF FLOAT CONTROL (FUTUR	
X-30-506	30E02 30E15 30E20 30E20	2"	1	PULL	ROPE				FR: SWGR-UT1 TO: SWGR-SW BREAKER CONTROL PANEL 1 PULL >> SPARE	
X-30-526	30E15 30E20	2"	1	PULL	ROPE				FR: FUTURE SWGR-UT2 TO: SWGR-SW BREAKER CONTROL PANEL 1 PULL >> SPARE	
X-30-589	30E15 30E20	2"	1	PULL	ROPE				FR: HH-1 TO: CONTROL ROOM 1 PULL >> SPARE	
X-30-599	30E15 30E20	2"	1	PULL	ROPE				FR: HH-1 TO: ELECTRIC ROOM 1 PULL >> SPARE	
X-30-750	30E02	1"	1	PULL	ROPE				FR: SURGE TANK VAULT TO: STUB UP (VCP-331 PUMP ROOM) 1 PULL >> SPARE	

Conduits Schedule

26_06_01-20

CO/Thornton/203505-100000/04 Design/04 Specs/Carollo/SWPS/26_06_01 (IFB2)

203505

Thornton Water Project (12-777XP)

Source Water Pump Station

May 2026

CONDUIT SCHEDULE AREA									ENGINEER	JD
THORNTON SOURCE WATER									REVISION	
SOURCE WATER PUMP STATION									DATE	5/5/26
CONDUIT			CONDUCTORS			GROUND				
NUMBER	DWG	SIZE	#	SIZE	TYPE	#	SIZE	TYPE	DESCRIPTION	CONNECTING SEGMENTS

END OF CONDUIT SCHEDULE

END OF SECTION

SECTION 26_08_50

FIELD ELECTRICAL ACCEPTANCE TESTS

TABLE OF CONTENTS

PART 1	GENERAL	2
1.01	SUMMARY	2
1.02	REFERENCES	2
1.03	TERMINOLOGY	3
1.04	DELEGATED DESIGN (NOT USED)	3
1.05	SUBMITTALS	3
1.06	QUALITY ASSURANCE	4
1.07	DELIVERY, STORAGE, AND HANDLING (NOT USED)	5
1.08	PROJECT OR SITE CONDITIONS	5
1.09	ADMINISTRATIVE REQUIREMENTS	5
1.10	WARRANTY	6
PART 2	PRODUCTS (NOT USED)	6
PART 3	EXECUTION	6
3.01	EXAMINATION (NOT USED)	6
3.02	PREPARATION	6
3.03	INSTALLATION	7
3.04	COMMISSIONING	7
3.05	FIELD QUALITY CONTROL (NOT USED)	44
3.06	ADJUSTING (NOT USED)	44
3.07	CLEANING	44

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Responsibilities for testing the electrical installation.
 - 2. Adjusting and calibration.
 - 3. Acceptance tests.
- B. Copyright information:
 - 1. Some portions of this Section are copyrighted by the InterNational Electrical Testing Association, Inc. (NETA). See NETA publication ATS for details.

1.02 REFERENCES

- A. Project references:
 - 1. Specification sections for the electrical equipment being tested.
 - 2. Electrical equipment Shop Drawings.
- B. Standards:
 - 1. American National Standards Institute (ANSI).
 - 2. ASTM International (ASTM):
 - a. D877 - Standard Test Method for Dielectric Breakdown Voltage of Insulating Liquids Using Disk Electrodes.
 - b. D923 - Standard Practices for Sampling Electrical Insulating Liquids.
 - c. D924 - Standard Test Method for Dissipation Factor (or Power Factor) and Relative Permittivity (Dielectric Constant) of Electrical Insulating Liquids.
 - d. D971 - Standard Test Method for Interfacial Tension of Oil Against Water by the Ring Method.
 - e. D974 - Standard Test Method for Acid and Base Number by Color-Indicator Titration.
 - f. D1298 - Standard Test Method for Density, Relative Density, or API Gravity of Crude Petroleum and Liquid Petroleum Products by Hydrometer Method.
 - g. D1500 - Standard Test Method for ASTM Color of Petroleum Products (ASTM Color Scale).
 - h. D1524 - Standard Test Method for Visual Examination of Used Electrical Insulating Liquids in the Field.
 - i. D1533 - Standard Test Method for Water in Insulating Liquids by Coulometric Karl Fischer Titration.
 - j. D1816 - Standard Test Method for Dielectric Breakdown Voltage of Insulating Liquids Using VDE Electrodes.
 - k. D3612 - Standard Test Method for Analysis of Gases Dissolved in Electrical Insulating Oil by Gas Chromatography.
 - 3. Institute of Electrical and Electronics Engineers (IEEE):
 - a. 43 - IEEE Recommended Practice for Testing Insulation Resistance of Rotating Machinery.
 - b. 81 - IEEE Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Grounding System.
 - c. 95 - IEEE Recommended Practice for Insulation Testing of AC Electric Machinery (2,300 V and Above) With High Direct Voltage.

- d. 450 - IEEE Recommended Practice for Maintenance, Testing, and Replacement of Vented Lead-Acid Batteries for Stationary Applications.
- e. 1106 - IEEE Recommended Practice for Installation, Maintenance, Testing, and Replacement of Vented Nickel-Cadmium Batteries for Stationary Applications.
- f. 1188 - IEEE Recommended Practice for Maintenance, Testing, and Replacement of Valve-Regulated Lead-Acid (VRLA) Batteries for Stationary Applications.
- g. C57.13 - IEEE Standard Requirements for Instrument Transformers.
- h. C57.13.1 - IEEE Guide for Field Testing of Relaying Current Transformers.
- i. C57.13.3 - IEEE Guide for Grounding of Instrument Transformer Secondary Circuits and Cases.
- j. C57.104 - IEEE Guide for the Interpretation of Gases Generated in Oil-Immersed Transformers.
- 4. Insulated Cable Engineer's Association (ICEA).
- 5. InterNational Electrical Testing Association (NETA).
 - a. ATS- Standard for Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems.
- 6. International Electrotechnical Commission (IEC).
- 7. National Electrical Manufacturers Association (NEMA):
 - a. 250 - Enclosures for Electrical Equipment (1,000 V Maximum).
 - b. MG1 - Motors and Generators.
- 8. National Fire Protection Association (NFPA):
 - a. 70 - National Electrical Code (NEC).
 - b. 110 - Standard for Emergency and Standby Power Systems.
- 9. National Institute of Standards and Technology (NIST).

1.03 TERMINOLOGY

- A. The words and terms listed below are not defined terms that require initial capital letters, but, when used in this Section, have the indicated meaning.
 - 1. Testing laboratory: Organization performing the acceptance tests.

1.04 DELEGATED DESIGN (NOT USED)

1.05 SUBMITTALS

- A. Furnish Submittals as specified in Section 01_33_00 - Submittal Procedures.
- B. Copper Ethernet test form:
 - 1. Cable test reports:
 - a. Submit 3 copies of test reports showing the results of all tests specified in this Section:
 - 1) Test type.
 - 2) Test location.
 - 3) Test date.
 - 4) Cable number.
 - 5) Cable length.
 - 6) Certification that the cable meets or exceeds the specified standard.
 - b. Furnish hard copy and electronic copy for all traces.

- C. Manufacturers' testing procedures:
 - 1. Submit manufacturers' recommended testing procedures and acceptable test results for review by the Engineer prior to beginning testing.
- D. Test report:
 - 1. Include the following:
 - a. Summary of Project.
 - b. Description of equipment tested.
 - c. Description of tests performed.
 - d. Test results.
 - e. Conclusions and recommendations.
 - f. Completed test forms.
 - g. List of test equipment used and calibration dates.
 - h. LAN cable test reports.
- E. Test data records:
 - 1. Include the following:
 - a. Identification of the testing organization.
 - b. Equipment identification.
 - c. Nameplate data.
 - d. Humidity, temperature and/or other conditions that may affect the results of the tests and/or calibrations.
 - e. Dates of inspections, tests, maintenance and/or calibrations.
 - f. Indication of the inspections, tests, maintenance, and/or calibrations to be performed and recorded.
 - g. Expected results when calibrations are to be performed.
 - h. Indication of as-found and as-left results as applicable.
 - i. Indication of test results outside specified tolerances.
- F. Testing laboratory qualifications:
 - 1. Submit a complete resume and statement of qualifications from the proposed testing laboratory detailing their experiences in performing the tests specified:
 - a. This statement will be used to determine whether the laboratory is acceptable and shall include:
 - 1) Corporate history and references.
 - 2) Resume of individual performing test.
 - 3) Equipment list and test calibration data.
- G. Division of responsibilities:
 - 1. Submit a list identifying who is responsible for performing each portion of the testing.

1.06 QUALITY ASSURANCE

- A. Testing laboratory qualifications:
 - 1. May be qualified testing personnel from the electrical subcontractor's staff or an independent testing company.
 - 2. NETA certification required.
 - 3. Selection of the testing laboratory and testing personnel is subject to approval by the Engineer based on testing experience and certifications of the individuals and testing capabilities of the organization.

1.07 DELIVERY, STORAGE, AND HANDLING (NOT USED)

1.08 PROJECT OR SITE CONDITIONS

- A. As specified in Section 01_81_50 - Design Criteria.

1.09 ADMINISTRATIVE REQUIREMENTS

- A. General requirements:
1. Testing of electrical equipment installed under this Contract in accordance with the manufacturer's requirements and as specified in this Section.
 2. Conduct tests in the presence of the Engineer or the Engineer's representative:
 - a. Engineer will witness visual, mechanical, and electrical tests, and inspections.
 3. Testing and inspections shall verify that the equipment is operational within the tolerances required and expected by the manufacturer, and these Specifications.
- B. Responsibilities:
1. Contractor responsibilities:
 - a. Ensure that resources are made available for testing and that testing requirements are met.
 2. Electrical subcontractor responsibilities:
 - a. Perform routine tests during installation.
 - b. Demonstrate operation of electrical equipment.
 - c. Commission the electrical installation.
 - d. Provide the necessary services during testing and provide these services to the testing laboratory, Contractor, and other subcontractors, including, but not limited to:
 - 1) Providing electrical power as required.
 - 2) Operating of electrical equipment in conjunction with testing of other equipment.
 - 3) Activating and shutting down electrical circuits.
 - 4) Making and recording electrical measurements.
 - 5) Replacing blown fuses.
 - 6) Installing temporary jumpers.
 3. Testing laboratory responsibilities:
 - a. Perform acceptance tests specified in this Section.
 - b. Provide required equipment, materials, labor, and technical support during acceptance tests.
- C. Sequencing:
1. Prior to testing:
 - a. At least 30 days before commencement of the acceptance tests, submit the manufacturer's complete field testing procedures to the Engineer and to the testing laboratory, complete with expected test results and tolerances for equipment to be tested.
 2. Perform testing in the following sequence:
 - a. Perform routine tests as the equipment is installed, including:
 - 1) Insulation-resistance tests.

- 2) Continuity tests.
- 3) Rotational tests.
- b. Adjusting and preliminary calibration.
- c. Acceptance tests.
- d. Demonstration.
- e. Commissioning and plant start-up.

1.10 WARRANTY

- A. As specified in Section 01_78_36 - Warranties and Bonds.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION

- A. Test instrument calibration:
 - 1. Utilize a testing laboratory with a calibration program which maintains applicable test instrumentation within rated accuracy.
 - a. Calibrating standard shall be of better accuracy than that of the equipment tested.
 - 2. Accuracy shall be traceable to the NIST in an unbroken chain.
 - 3. Calibrate instruments in accordance with the following frequency schedule:
 - a. Field instruments: 6 months maximum.
 - b. Laboratory instruments: 12 months maximum.
 - c. Leased specialty equipment where the accuracy is guaranteed by the lessor (such as Doble): 12 months maximum.
 - 4. Dated calibration labels shall be visible on test equipment.
 - 5. Maintain an up-to-date instrument calibration record for each test instrument:
 - a. Records shall show the date and results of each calibration or test.
 - 6. Maintain an up-to-date instrument calibration instruction and procedure for each test instrument.
- B. Requirements prior to testing:
 - 1. Do not begin testing until the following conditions have been met:
 - a. Instruments required are available and in proper operating condition.
 - b. Required dispensable materials such as solvents, rags, and brushes are available.
 - c. Equipment handling devices such as cranes, vehicles, chain falls, and other lifting equipment are available or scheduled.
 - d. Instruction books, calibration curves, or other printed material to cover the electrical devices are available.
 - e. Datasheets to record test results are available.

3.03 INSTALLATION

- A. Test decal:
 - 1. Testing laboratory shall affix a test decal on the exterior of equipment or equipment enclosure of protective devices after performing electrical tests.
 - 2. Color coded to communicate the condition of maintenance of the protective. Color scheme for condition of maintenance of overcurrent protective devices shall be:
 - a. White: Electrically and mechanically acceptable.
 - b. Yellow: Minor deficiency not affecting fault detection and operation, but minor electrical or mechanical condition exists.
 - 3. Shall include the following information at a minimum:
 - a. Testing organization.
 - b. Project identifier.
 - c. Test date.
 - d. Technician identifier.

3.04 COMMISSIONING

- A. As specified in Section 01_75_17 - Commissioning.
- B. Functional Testing:
 - 1. Also called Field Acceptance Testing.
- C. Panelboards:
 - 1. Cleaning:
 - a. Visually inspect panelboard for evidence of discoloration, abnormal dust accumulation, metal shards, or any other indication of overheating, wear, or other abnormal conditions prior to cleaning.
 - b. Clean cabinet with a brush, vacuum cleaner, or clean, dry, lint-free rags to remove any accumulation of dust, dirt, or other foreign matter. Do not use liquids, solvents or detergents when cleaning panelboards or components.
 - c. Avoid blowing dust into panelboards. Do not use a blower or compressed air.
 - d. Clean supports, terminals, and other major insulating surfaces with clean, dry, lint-free rags or soft bristled brushes.
 - e. Remove dust, soot, grease, moisture, and foreign material from surface of circuit breakers.
 - 2. General:
 - a. Compare equipment nameplate data with the Contract Documents.
 - b. Check panelboard circuit schedule for accuracy.
 - c. Verify appropriate anchorage, required area clearances, and correct alignment.
 - d. Inspect overall general condition for physical damage.
 - 1) Check for broken studs and loose or damaged wires, connector, terminations, etc.
 - 2) Check bolts, nuts, washer, and pins for tightness.
 - 3) Tighten or use manufacturer's replacement parts as required.
 - e. Inspect cabinets for signs of rust, corrosion, or deteriorating paint. Inspect cabinets for evidence of localized heat damage to the paint. Investigate sources of heat. Repair painted surfaces.

- f. Check that covers are in place and fastened. Plug any open unused knockouts.
 - g. Inspect panelboard for moisture. Seal off any cracks or openings which have allowed moisture to enter the cabinet. Inspect component devices. Replace any components that show evidence of damage from moisture.
 - h. Look for any recent changes in sprinklers or other plumbing that might expose indoor panelboards to a source of liquids. Eliminate sources of water, moisture, or liquids, or provide adequate barriers to protect panelboards from sources of water, moisture, or liquids.
 - i. Inspect panelboards and internal components for evidence of overheating, arc spatter, sooty deposits, and tracking.
 - 1) Investigate and correct sources of arcing or overheating.
 - 2) Consult the panelboard manufacturer for recommendations.
 - j. Verify that fuse and/or circuit breaker sizes and types correspond to record drawings, if available, as well as to the circuit breakers' address for microprocessor communications packages, if equipped.
 - k. Set adjustable circuit breakers in accordance with engineering coordination study supplied by the Contractor.
3. Terminations, connections, and lugs:
- a. Inspect bolted electrical connections for high resistance using one of the following methods:
 - 1) Use of low-resistance ohmmeter.
 - a) Compare bolted connection resistance values to values of similar connections:
 - (1) Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
 - 2) Verify tightness of accessible bolted electrical connections by the calibrated torque wrench method:
 - a) Refer to the manufacturer's instructions for proper foot-pound levels or NETA ATS tables.
 - b. Inspect terminations, connection, and lugs for alignment, physical damage, burns, corrosion, discoloration, flaking, heat damage, arcing, pitting, melting, deterioration, carbonization, cracks, chips, breaks, partial discharge, or moisture. Investigate and eliminate sources of any damage.
 - c. Follow manufacturer recommendations for cleaning, repairing, and replacing damaged parts.
 - d. Replace overheated connections. Tighten connections to proper torque levels as specified above.
4. Conductors and raceways:
- a. Inspect supply conductors and terminations for overheating, discoloration, and oxidation. Investigate and correct any deficiencies.
 - b. Ensure the conductors are protected within their ampacities.
 - c. Visually check panelboard, cables, and raceways for proper bonding and grounding. Correct improper bonding and grounding.
 - d. Inspect conductors for discoloration, arcing, pitting, melting, flaking of insulation and/or metal parts. Repair or replace damaged components in accordance with the manufacturer's recommendations.
 - e. Inspect for frayed or broken wires. Replace or repair damaged components in accordance with manufacturer recommendations.

- f. Inspect for frayed or broken wires. Replace or repair conductors as necessary.
 - g. Inspect conduits for moisture. Seal conduits which are a source of moisture and provide means to drain moisture away from the panelboard.
- 5. Circuit breakers:
 - a. Perform visual and mechanical inspection as specified in this Section.
 - b. Operate several times in order to exercise the mechanisms and the contacts, and to ensure smooth operation. Do not oil or grease parts of molded case circuit breakers.
 - c. Visually check for evidence of overheating and thermal damage. Investigate and eliminate sources of overheating.
 - d. Check for visual defects, chipping, cracks, breaks, burns, and deterioration. Replace damaged circuit breakers.
 - e. Verify correct operation of any auxiliary features such as trip and pickup indicators, zone interlocking, electrical close and trip operation, trip-free, and anti-pump function.
 - f. Inspect interchangeable trip-unit circuit breakers for tightness of trip units.
 - g. Check terminals and connections for tightness as specified above.
 - h. Breakers rated 100 A and higher:
 - 1) Perform electrical tests as specified in this Section.
- D. Switchgear and switchboard:
 - 1. Visual and mechanical inspection:
 - a. Compare equipment nameplate data with the Contract Documents.
 - b. Inspect physical and mechanical condition.
 - c. Inspect anchorage, alignment, grounding and required area clearances.
 - d. Verify the unit is clean and shipping bracing, loose parts, and documentation shipped inside cubicles have been removed.
 - e. Verify that circuit breaker/fuse sizes and types correspond to the approved Submittals and the coordination study as well as to the circuit breakers address for microprocessor-communication packages.
 - f. Verify that current and voltage transformer ratios correspond to those indicated on the Drawings.
 - g. Verify that wiring connections are tight and that wiring is secure to prevent damage during routine operation of moving parts.
 - h. Inspect bolted electrical connections for high resistance using one of the following methods:
 - 1) Use of low-resistance ohmmeter.
 - 2) Verify tightness of accessible bolted electrical connections by the calibrated torque wrench method:
 - a) Refer to the manufacturer's instructions for proper foot-pound levels or NETA ATS tables.
 - i. Verify operation and sequencing of interlocking systems:
 - 1) Attempt closure on locked-open devices.
 - 2) Attempt to open locked-closed devices.
 - 3) Make/attempt key-exchanges in all positions.
 - j. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.
 - k. Inspect insulators for evidence of physical damage or contaminated surfaces.
 - l. Verify correct barrier and shutter installation and operation.

- m. Exercise active components.
 - n. Inspect mechanical indicating devices for correct operation.
 - o. Verify that filters are in place and/or vents are clear.
 - p. Perform visual and mechanical inspection of instrument transformers as specified in this Section.
 - q. Perform visual and mechanical inspection of surge arresters as specified in this Section.
 - r. Control power transformers:
 - 1) Inspect for physical damage, cracked insulation, broken leads, tightness of connections, defective wiring, and overall general condition.
 - 2) Verify that primary and secondary fuse/circuit breaker ratings match the Submittal Drawings.
 - 3) Verify correct functioning of drawout disconnecting contacts grounding contacts, and interlocks.
2. Electrical tests:
- a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter.
 - b. Perform insulation-resistance tests on each bus section, phase-to-phase and phase-to-ground for 1 minute.
 - 1) Perform test in accordance with NETA ATS tables.
 - c. Perform a dielectric withstand voltage test on each bus section, each phase-to-ground with phases not under test grounded, in accordance with the manufacturer's published data:
 - 1) Refer to NETA ATS tables in the absence of the manufacturer's published data.
 - 2) Test voltage shall be applied for 1 minute.
 - d. Perform electrical tests on instrument transformers as specified in this Section.
 - e. Perform ground-resistance tests:
 - 1) Perform point-to-point tests to determine the resistance between the main grounding system and major electrical equipment frames, system neutral and derived neutral points.
 - f. Test metering devices as specified in this Section.
 - g. Control power transformers:
 - 1) Perform insulation-resistance tests. Perform measurements from winding-to-winding and each winding-to-ground:
 - a) Test voltages shall be in accordance with NETA ATS tables or as specified by the manufacturer.
 - b) Perform a turns-ratio test on all tap positions.
 - 2) Perform secondary wiring integrity test:
 - a) Disconnect transformer at secondary terminals and connect secondary wiring to a rated secondary voltage source:
 - (1) Verify correct potential at all devices.
 - 3) Verify correct secondary voltage by energizing primary winding with system voltage:
 - a) Measure secondary voltage with the secondary wiring disconnected.

- h. Perform current injection tests on the entire current circuit of each switchgear or switchboard:
 - 1) Perform current tests by secondary injection with magnitudes such that a minimum current of 1.0 amp flows in the secondary circuit:
 - a) Verify the correct magnitude of current at each device in the circuit.
 - 2) Perform current tests by primary injection with magnitudes such that a minimum current of 1.0 amp flows in the secondary circuit:
 - a) Verify the correct magnitude of current at each device in the circuit.
- i. Perform system function tests.
- j. Verify operation of space heaters.
- k. Perform phasing check on double-ended or dual-source equipment to ensure correct bus phasing from each source.
- l. Perform electrical tests of surge arresters as specified in this Section.
- 3. Test values:
 - a. Compare bolted connection resistance values to values of similar connections:
 - 1) Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
 - b. Bolt-torque levels shall be in accordance with the manufacturer's published data:
 - 1) Refer to NETA ATS tables in the absence of the manufacturer's published data.
 - c. Insulation resistance values of bus insulation shall be in accordance with the manufacturer's published data:
 - 1) Refer to NETA ATS tables in the absence of the manufacturer's published data.
 - 2) Investigate insulation values less than the allowable minimum.
 - 3) Do not proceed with dielectric withstand voltage tests until insulation-resistance values are above minimum values.
 - d. If no evidence of distress or insulation failure is observed by the end of the total time of voltage application during the dielectric withstand test, the test specimen is considered to have passed the test.
 - e. Instrument transformer test values shall be as specified in this Section.
 - f. Meter test values shall be as specified in this Section.
 - g. Investigate grounding system point-to-point resistance values that exceed 0.5 ohm.
 - h. Control power transformers:
 - 1) Insulation-resistance values of control power transformers shall be in accordance with the manufacturer's published data:
 - a) Refer to NETA ATS tables in the absence of the manufacturer's published data.
 - b) Investigate insulation values less than the allowable minimum.
 - 2) Turns-ratio test results shall not deviate by more than 1/2 percent from either the adjacent coils or the calculated ratio.
 - a) Do not proceed with dielectric withstand voltage tests until insulation-resistance values are above minimum values.
 - 3) Secondary wiring shall be as indicated on the Drawings and specified in the Specifications.

- 4) Secondary voltage shall be as indicated on the Drawings.
 - 5) Control transfer relays shall perform as designed.
 - i. Current-injection tests shall prove current wiring is as indicated on the Drawings and specified in the Specifications.
 - j. Results of system function tests shall match the Drawings and Specifications.
 - k. Heaters shall be operational.
 - l. Phasing checks shall prove the switchgear or switchboard phasing is correct and in accordance with the system design.
 - m. Results of electrical tests on surge arresters shall be as specified in this Section.
- E. Dry type transformers:
- 1. Visual and mechanical inspection:
 - a. Compare equipment nameplate data with the Contract Documents.
 - b. Inspect physical and mechanical condition.
 - c. Inspect anchorage, alignment, and grounding.
 - d. Verify that resilient mounts are free and that any shipping brackets have been removed.
 - e. Inspect equipment for cleanliness.
 - f. Inspect bolted electrical connections for high resistance using one of the following methods:
 - 1) Use of low-resistance ohmmeter.
 - 2) Verify tightness of accessible bolted electrical connections by the calibrated torque wrench method:
 - a) Refer to the manufacturer's instructions for proper foot-pound levels or NETA ATS tables.
 - g. Verify that as-left tap connections are as specified.
 - 2. Electrical tests:
 - a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter.
 - b. Perform insulation-resistance tests winding-to-winding and each winding-to-ground:
 - 1) Apply voltage in accordance with the manufacturer's published data.
 - a) Refer to NETA ATS tables in the absence of the manufacturer's published data.
 - c. Calculate dielectric absorption ration or polarization index.
 - d. Perform turns ratio tests at all tap positions.
 - e. Verify correct secondary voltage, phase-to-phase and phase-to-neutral after energization and before loading.
 - 3. Test values:
 - a. Compare bolted connection resistance values to values of similar connections:
 - 1) Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
 - b. Bolt-torque levels shall be in accordance with the manufacturer's published data:
 - 1) Refer to NETA ATS tables in the absence of the manufacturer's published data.
 - c. Tap connections are left as found unless otherwise specified.

- d. Minimum insulation-resistance values of transformer insulation shall be in accordance with the manufacturer's published data:
 - 1) Refer to NETA ATS tables in the absence of the manufacturer's published data.
 - 2) Investigate insulation values less than the allowable minimum.
- e. Dielectric absorption ratio or polarization index shall not be less than 1.0.
- f. Turns-ratio results should not deviate more than 1/2 percent from either the adjacent coils or calculated ratio.
- g. Phase-to-phase and phase-to-neutral secondary voltages shall be in agreement with nameplate data.

F. Liquid-filled transformers:

- 1. Visual and mechanical inspection:
 - a. Compare equipment nameplate data with the Contract Documents.
 - b. Inspect physical and mechanical condition.
 - c. Inspect impact recorder before unloading.
 - d. Test dew point of tank gases, if applicable.
 - e. Inspect anchorage, alignment, grounding and required clearances.
 - f. Verify the presence of PCB content labeling.
 - g. Verify removal of any shipping bracing after placement.
 - h. Verify the bushings are clean.
 - i. Verify that alarm, control and trip settings on temperature and level indicators are as specified.
 - j. Verify operation of alarm, control, and trip circuits from temperature and level indicators, pressure relief device, gas accumulator, and fault pressure relay, if applicable.
 - k. Verify that cooling fans operate correctly and that fan motors have correct overcurrent protection.
 - l. Inspect bolted electrical connections for high resistance using one of the following methods:
 - 1) Use of low-resistance ohmmeter.
 - 2) Verify tightness of accessible bolted electrical connections by the calibrated torque wrench method:
 - a) Refer to the manufacturer's instructions for proper foot-pound levels or NETA ATS tables.
 - m. Verify correct liquid level in tanks and bushings.
 - n. Verify valves are in the correct operating position.
 - o. Verify that positive pressure is maintained on gas-blanketed transformers.
 - p. Perform inspections and mechanical tests as recommended by the manufacturer.
 - q. Test load tap-changer in accordance with NETA ATS requirements.
 - r. Verify presence of transformer surge arresters.
 - s. Verify de-energized tap-changer position is left as specified.
- 2. Electrical tests:
 - a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter.

- b. Perform insulation-resistance tests winding-to-winding and each winding-to-ground:
 - 1) Apply voltage in accordance with the manufacturer's published data:
 - a) Refer to NETA ATS tables in the absence of the manufacturer's published data.
 - 2) Calculate polarization index.
- c. Perform turns ratio tests at all tap positions.
- d. Perform insulation power-factor or dissipation-factor tests on windings in accordance with the test equipment manufacturer's published data.
- e. Perform power-factor or dissipation-factor tests on each bushing equipped with a power-factor/capacitance tap:
 - 1) In the absence of a power-factor/capacitance tap, perform hot-collar tests.
 - 2) Perform tests in accordance with the test equipment manufacturer's published data.
- f. Perform excitation-current tests in accordance with the test equipment manufacturer's published data.
- g. Perform sweep frequency response analysis tests.
- h. Measure the resistance of each primary winding in each no-load tap changer position. Measure the resistance of each secondary winding in each no-load tap changer position.
- i. Remove a sample of insulating liquid in accordance with ASTM D923 and test in accordance with the following standards:
 - 1) Dielectric breakdown voltage: ASTM D877 or ASTM D1816.
 - 2) Acid neutralization number: ASTM D974.
 - 3) Interfacial tension: ASTM D971.
 - 4) Color: ASTM D1500.
 - 5) Visual condition: ASTM D1524.
 - 6) Water in insulating fluids: ASTM D1533.
- j. Remove a sample of insulating liquid in accordance with ASTM D924. Sample shall be tested for the following:
 - 1) Dissolved-gas analysis: IEEE C57.104 or ASTM D3612.
- k. Test instrument transformers as specified in this Section.
- l. Test surge arresters as specified in this Section, if applicable.
- m. Test transformer neutral grounding impedance device, if applicable.
- n. Verify operation of cubicle or air terminal compartment space heaters.
- 3. Test values:
 - a. Alarm control and trip circuits from temperature and level indicators, as well as pressure relief device and fault pressure relay, shall operate within the manufacturer's recommendations for their specified settings.
 - b. Cooling fans and pumps shall operate.
 - c. Compare bolted connection resistance values to values of similar connections:
 - 1) Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
 - d. Bolt-torque levels shall be in accordance with the manufacturer's published data:
 - 1) Refer to NETA ATS tables in the absence of the manufacturer's published data.
 - e. Liquid levels in the transformer tanks and bushings shall be within indicated tolerances.

- f. Positive pressure shall be indicated on pressure gauge for gas-blanketed transformers.
 - g. Minimum insulation-resistance values of transformer insulation shall be in accordance with the manufacturer's published data:
 - 1) Refer to NETA ATS tables in the absence of the manufacturer's published data.
 - 2) Investigate insulation values less than the allowable minimum.
 - h. Polarization index shall be greater than 1.0:
 - 1) Compare to any previous values.
 - i. Turns-ratio test result shall not deviate by more than 1/2 percent from either the adjacent coils or the calculated ratio.
 - j. Maximum winding insulation power-factor/dissipation-factor values shall be in accordance with the manufacturer's published data:
 - 1) Refer to NETA ATS tables in the absence of the manufacturer's published data.
 - k. Investigate bushing power-factor values that vary from nameplate values by more than 150 percent. Investigate bushing capacitance values that vary from nameplate values by more than 5 percent. Investigate bushing hot-collar test values that exceed 0.1 watts.
 - l. Typical excitation-current test data pattern for a 3-legged core transformer is 2 similar current readings and 1 lower current reading.
 - m. Sweep frequency response analysis test results shall be comparable to previously obtained results.
 - n. Consult the manufacturer if winding-resistance test values vary by more than 2 percent from factory test values or between adjacent phases.
 - o. Investigate leakage reactance per phase test results that deviate from the average of the 3 readings by more than 3 percent. 3 phase equivalent test results serve as a benchmark for future tests.
 - p. Core insulation values shall be comparable to previously obtained results but not be less than 1.0 megohm at 500 VDC.
 - q. Investigate the presence of oxygen in the nitrogen gas blanket.
 - r. Insulating liquid values shall be in accordance with NETA ATS tables.
 - s. Evaluate results of dissolved-gas analysis in accordance with IEEE C57.104.
 - t. Results of electrical tests on instrument transformers shall be as specified in this Section.
 - u. Results of surge arrester tests shall be as specified in this Section.
 - v. Compare grounding impedance device results to the manufacturer's published data.
 - w. Heaters shall be operational.
- G. Low voltage cables, 600-volt maximum:
- 1. Visual and mechanical inspection:
 - a. Compare cable data with the Drawings and Specifications.
 - b. Inspect exposed sections of cable for physical damage and correct connection as indicated on the Drawings.
 - c. Inspect bolted electrical connections for high resistance by one of the following methods:
 - 1) Use of low-resistance ohmmeter.

- 2) Verify tightness of accessible bolted electrical connections by the calibrated torque wrench method:
 - a) Refer to the manufacturer's instructions for proper foot-pound levels or NETA ATS tables.
 - d. Inspect compression applied connectors for correct cable match and indentation.
 - e. Inspect for correct identification and arrangement.
 - f. Inspect cable jacket insulation and condition.
 - 2. Electrical tests:
 - a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter.
 - b. Perform insulation resistance test on each conductor sized #8 AWG or larger with respect to ground and adjacent conductors:
 - 1) Applied potential shall be 500 volts DC for 300-volt rated cable and 1,000 volts DC for 600-volt rated cable.
 - 2) Test duration shall be 1 minute.
 - c. Perform continuity tests on power and control conductors to ensure correct cable connection.
 - d. Verify uniform resistance of parallel conductors.
 - 3. Test values:
 - a. Compare bolted connection resistance values to values of similar connections:
 - 1) Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
 - b. Insulation-resistance values shall be in accordance with the manufacturer's published data:
 - 1) Refer to NETA ATS tables in the absence of the manufacturer's published data.
 - 2) Investigate values of insulation-resistance less than the allowable minimum.
 - c. Cable shall exhibit continuity.
 - d. Deviations in resistance between parallel conductors shall be investigated.
- H. Medium voltage cables:
 - 1. Visual and mechanical inspection:
 - a. Compare cable data with the Contract Documents.
 - b. Inspect exposed sections of cables for physical damage.
 - c. Inspect bolted electrical connections for high resistance using one of the following methods:
 - 1) Use of low-resistance ohmmeter.
 - 2) Verify tightness of accessible bolted electrical connections by the calibrated torque wrench method:
 - a) Refer to the manufacturer's instructions for proper foot-pound levels or NETA ATS tables.
 - d. Inspect compression-applied connectors for correct cable match and indentation.
 - e. Inspect shield grounding, cable support, and terminations.
 - f. Verify the visible bends meet or exceed ICEA and the manufacturer's published minimum allowable bending radius.

- g. If cables are terminated through window-type current transformers, inspect to verify that neutral and ground conductors are correctly placed and that shields are correctly terminated for operation of protective devices.
 - h. Inspect for correct identification and arrangements.
 - i. Inspect jacket insulation and condition.
2. Electrical tests:
- a. Perform resistance measurements through bolted connections with low-resistance ohmmeter.
 - b. Perform an insulation-resistance test individually on each conductor with all other conductors and shields grounded:
 - 1) Apply voltage in accordance with the manufacturer's published data:
 - a) Refer to NETA ATS tables in the absence of the manufacturer's published data.
 - c. Perform shield-continuity test on each power cable.
 - d. Perform cable and time domain reflectometer (TDR) measurements on each conductor.
 - e. In accordance with ICEA, IEC, IEEE, and other power cable consensus standards, testing can be performed by means of direct current, power frequency alternating current, very low frequency alternating current, or damped alternating current.
 - 1) These sources may be used to perform insulation-resistance tests and baseline diagnostic tests such as partial discharge analysis, and power factor or power dissipation factor.
 - 2) Selection shall be made after an evaluation of the available test methods and a review of the installed cable system.
 - 3) Some of available test methods are as follows:
 - a) Dielectric withstand:
 - (1) Direct current dielectric withstand voltage.
 - (2) Very low frequency dielectric withstand voltage.
 - (3) Power frequency dielectric withstand voltage.
 - (4) Damped alternating current voltage.
 - b) Baseline diagnostic tests:
 - (1) Power factor/dissipation factor (tan delta):
 - (a) Power frequency.
 - (b) Very low frequency.
 - (2) Direct current insulation-resistance.
 - (3) Partial discharge:
 - (a) Online (50/60 hertz).
 - (b) Offline:
 - Power frequency.
 - Very low frequency.
3. Test values:
- a. Compare bolted connection resistance values to values of similar connections:
 - 1) Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
 - b. Bolt-torque levels shall be in accordance with the manufacturer's published data:
 - 1) Refer to NETA ATS tables in the absence of the manufacturer's published data.

- c. Minimum bend radius to which insulated cables may be bent for permanent training shall be in accordance with NETA ATS tables.
 - d. Insulation-resistance values shall be in accordance with the manufacturer's published data:
 - 1) Refer to NETA ATS tables in the absence of the manufacturer's published data.
 - 2) Investigate values of insulation-resistance less than the allowable minimum.
 - e. Shielding shall exhibit continuity:
 - 1) Investigate resistance values in excess of 10 ohms per 1,000 feet of cable.
 - f. If no evidence of distress of insulation failure is observed by the end of the total time of voltage application during the dielectric withstand test, the test specimen is considered to have passed the test.
 - g. Based on the test methodology chosen, refer to the applicable standards or manufacturer's literature for acceptable values.
- I. Low voltage molded case and insulated case circuit breakers:
- 1. Visual and mechanical inspection:
 - a. Compare equipment nameplate data with the Contract Documents.
 - b. Inspect physical and mechanical condition.
 - c. Inspect anchorage and alignment.
 - d. Verify the unit is clean.
 - e. Operate the circuit breaker to ensure smooth operation.
 - f. Inspect bolted electrical connections for high resistance by one of the following methods:
 - 1) Use of low-resistance ohmmeter.
 - 2) Verify tightness of accessible bolted electrical connections by the calibrated torque wrench method:
 - a) Refer to the manufacturer's instructions for proper foot-pound levels or NETA ATS tables.
 - g. Perform adjustments for final protective device settings in accordance with the coordination study.
 - 2. Electrical tests:
 - a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter.
 - b. For breakers 100 A and higher:
 - 1) Perform insulation-resistance tests for 1 minute on each pole, phase-to-phase and phase-to-ground with the circuit breaker closed, and across each open pole:
 - a) Apply voltage in accordance with the manufacturer's published data.
 - b) Refer to NETA ATS tables in the absence of the manufacturer's published data.
 - 2) Perform a contact/pole-resistance test.
 - 3) Determine long-time pickup and delay by primary current injection.
 - 4) Determine short-time pickup and delay by primary current injection.
 - 5) Determine ground-fault pickup and delay by primary current injection.
 - 6) Determine instantaneous pickup value by primary current injection.
 - 7) Test functions of the trip unit by means of secondary injection.

- 8) Perform minimum pickup voltage tests on shunt trip and close coils in accordance with the manufacturer's published data.
 - 9) Verify correct operation of any auxiliary features such as trip and pickup indicators, zone interlocking, electrical close and trip operation, trip-free, anti-pump function and trip unit battery condition:
 - a) Reset trip logs and indicators.
 - 10) Verify operation of charging mechanism.
3. Test values:
- a. Compare bolted connection resistance values to values of similar connections:
 - 1) Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
 - b. Bolt-torque levels shall be in accordance with the manufacturer's published data:
 - 1) Refer to NETA ATS tables in the absence of the manufacturer's published data.
 - c. Insulation-resistance values shall be in accordance with the manufacturer's published data:
 - 1) Refer to NETA ATS tables in the absence of the manufacturer's published data.
 - 2) Investigate values of insulation-resistance less than the allowable minimum.
 - d. Micro-ohm or DC millivolt drop values shall not exceed the high levels of the normal range as indicated in the manufacturer's published data:
 - 1) If the manufacturer's data is not available, investigate any values which deviate from adjacent poles or similar breakers by more than 50 percent of the lowest value.
 - e. Long-time pickup values shall be as specified, and the trip characteristic shall not exceed the manufacturer's published time-current characteristic tolerance band, including adjustment factors:
 - 1) If the manufacturer's curves are not available, trip times shall not exceed the value shown in NETA ATS tables.
 - f. Short-time pickup values shall be as specified, and the trip characteristic shall not exceed the manufacturer's published time-current tolerance band.
 - g. Ground fault pickup values shall be as specified, and the trip characteristic shall not exceed the manufacturer's published time-current tolerance band.
 - h. Instantaneous pickup values shall be as specified and within the manufacturer's published tolerances:
 - 1) Refer to NETA ATS tables in the absence of the manufacturer's published data.
 - i. Pickup values and trip characteristics shall be within the manufacturer's published tolerances.
 - j. Determine energy reducing maintenance switch pickup value by primary current injection.
 - k. Breaker open, close, trip, trip-free, anti-pump, and auxiliary features shall function as designed.
 - l. Charging mechanism shall operate in accordance with the manufacturer's published data.

- J. Medium voltage vacuum circuit breakers:
1. Visual and mechanical inspection:
 - a. Compare equipment nameplate data with the Contract Documents.
 - b. Inspect physical and mechanical condition.
 - c. Inspect anchorage and alignment and grounding.
 - d. Verify that maintenance devices, such as special tools and gauges specified by the manufacturer, are available for servicing and operating the breaker.
 - e. Verify the unit is clean.
 - f. Perform mechanical operation tests on the operating mechanism in accordance with the manufacturer's published data.
 - g. Measure critical distances such as contact gap as recommended by the manufacturer.
 - h. Inspect bolted electrical connections for high resistance by one of the following methods:
 - 1) Use of low-resistance ohmmeter.
 - 2) Verify tightness of accessible bolted electrical connections by the calibrated torque wrench method:
 - a) Refer to the manufacturer's instructions for proper foot-pound levels or NETA ATS tables.
 - i. Verify cell fit and element alignment.
 - j. Verify racking mechanism operation.
 - k. Perform time-travel analysis.
 - l. Lubrication requirements:
 - 1) Verify appropriate lubrication on moving current-carrying parts.
 - 2) Verify appropriate lubrication on moving and sliding surfaces.
 - m. Perform contact-timing test.
 - n. Record as-found and as-left operation counter readings.
 2. Electrical tests:
 - a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter.
 - b. Perform insulation-resistance tests for 1 minute on each pole, phase-to-phase and phase-to-ground with the circuit breaker closed, and across each open pole:
 - 1) Test voltage shall be in accordance with the manufacturer's published data.
 - 2) Refer to NETA ATS tables in the absence of the manufacturer's published data.
 - c. Perform a static contact/pole-resistance test.
 - d. Perform a dynamic contact/pole resistance test.
 - e. Perform minimum pickup voltage tests on trip and close coils in accordance with the manufacturer's published data.
 - f. Verify correct operation of any auxiliary features such as electrical close and trip operation, trip-free and anti-pump function.
 - g. Trip circuit breaker by operation of each protective device.
 - 1) Reset trip logs and indicators.
 - h. Perform power-factor or dissipation-factor tests on each pole with the breaker open and each phase with the breaker closed.

- i. Perform power-factor or dissipation-factor tests on each bushing equipped with a power-factor/capacitance tap. In the absence of power-factor/capacitance tap, perform hot-collar tests:
 - 1) Perform tests in accordance with the manufacturer's published data.
- j. Perform magnetron atmospheric condition (MAC) test on each vacuum interrupter.
- k. Perform vacuum bottle integrity (dielectric withstand) test across each vacuum bottle with the breaker in the open position in accordance with the manufacturer's published data. Do not exceed the maximum voltage stipulated for this test:
 - 1) Provide adequate barriers and protection against x-radiation during this test.
 - 2) Do not perform this test unless the contact displacement of each interrupter is within the manufacturer's published tolerance.
 - 3) Be aware that some DC high-potential test sets are half-wave rectified and may produce peak voltages in excess of the breaker manufacturer's recommended maximum.
- l. Perform a dielectric withstand voltage test in accordance with the manufacturer's published data.
- m. Verify operation of heaters.
- n. Test instrument transformers as specified in this Section.
- 3. Test values:
 - a. Critical distance measurements such as contact gap shall be in accordance with the manufacturer's published data.
 - b. Compare bolted connection resistance values to values of similar connections:
 - 1) Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
 - c. Bolt-torque levels shall be in accordance with the manufacturer's published data:
 - 1) Refer to NETA ATS tables in the absence of the manufacturer's published data.
 - d. Contact timing values shall be in accordance with the manufacturer's published data.
 - e. Trip/close coil current values shall be in accordance with the manufacturer's published data.
 - f. Travel and velocity values shall be in accordance with the manufacturer's published data.
 - g. Operations counter shall advance 1 digit per close-open cycle.
 - h. Insulation-resistance values shall be in accordance with the manufacturer's published data:
 - 1) Refer to NETA ATS tables in the absence of the manufacturer's published data.
 - 2) Investigate values of insulation-resistance less than the allowable minimum.
 - i. Micro-ohm or DC millivolt drop values shall not exceed the high levels of the normal range as indicated in the manufacturer's published data:
 - 1) If the manufacturer's data is not available, investigate any values which deviate from adjacent poles or similar breakers by more than 50 percent of the lowest value.

- j. Dynamic contact resistance values shall be in accordance with the manufacturer's published data.
 - k. Minimum pickup voltage of the trip and close coils shall conform to the manufacturer's published data:
 - 1) Refer to NETA ATS tables in the absence of the manufacturer's published data.
 - l. Auxiliary features shall operate in accordance with the manufacturer's published data.
 - m. Protective devices shall operate the breaker per system design.
 - n. Power-factor or dissipation-factor values shall be compared to the manufacturer's published data:
 - 1) In the absence of the manufacturer's published data, the comparison shall be made to similar breakers.
 - o. Power-factor or dissipation-factor and capacitance values shall be within 10 percent of nameplate ratings for bushings. Hot collar tests are evaluated on a milliampere/milliwatt loss basis and the results shall be compared to values of similar bushings.
 - p. Evaluate each vacuum interrupter in accordance with the test equipment manufacturer's instructions.
 - q. If no evidence of distress of insulation failure is observed by the end of the total time of voltage application during the vacuum bottle integrity test, the test specimen is considered to have passed the test.
 - r. If no evidence of distress of insulation failure is observed by the end of the total time of voltage application during the dielectric withstand test, the test specimen is considered to have passed the test.
 - s. Heaters shall be operational.
 - t. Results of instrument transformer tests shall be as specified in this Section.
- K. Protective relays, microprocessor based:
- 1. Visual and mechanical inspection:
 - a. Record model number, style number, serial number, firmware revision, software revision and rated control voltage.
 - b. Verify operation of light-emitting diodes, display, and targets.
 - c. Record passwords for all access levels.
 - d. Clean the front panel and remove foreign material from the case.
 - e. Check tightness of connections.
 - f. Verify that the frame is grounded in accordance with the manufacturer's instructions.
 - g. Set the relay in accordance with the coordination study.
 - h. Download settings from the relay. Print a copy of the settings for the report and compare the settings to those specified in the coordination study.
 - i. Connect back-up battery.
 - j. Set clock if not controlled externally.
 - k. Check with the manufacturer for applicable firmware updates and product recalls.
 - l. Inspect, clean and verify operation of shorting devices.
 - 2. Electrical tests:
 - a. Perform insulation-resistance tests from each circuit to the grounded frame in accordance with the manufacturer's published data.
 - b. Apply voltage or current to analog inputs and verify correct registration of the relay meter functions.

- c. Verify SCADA metering values at remote terminals.
- d. Functional operation:
 - 1) Check functional operation of each element used in the protection scheme.
 - 2) 27 undervoltage relay:
 - a) Determine dropout voltage.
 - b) Determine time delay.
 - c) Determine time delay at a second point on the timing curve for inverse time relays.
 - 3) 47 phase sequence or phase balance voltage relay:
 - a) Determine positive sequence voltage to close the normally open contact.
 - b) Determine positive sequence voltage to open the normally closed contact (undervoltage trip).
 - c) Verify negative sequence trip.
 - d) Determine time delay to close the normally open contact with sudden application of 120 percent of pickup.
 - e) Determine time delay to close the normally closed contact upon removal of voltage when previously set to rated system voltage.
 - 4) 49R thermal replica relay:
 - a) Determine time delay at 300 percent of setting.
 - b) Determine a second point on the operating curve.
 - c) Determine pickup.
 - 5) 49T temperature (RTD) relay:
 - a) Determine trip resistance.
 - b) Determine reset resistance.
 - 6) 50 instantaneous overcurrent relay:
 - a) Determine pickup.
 - b) Determine dropout.
 - c) Determine time delay.
 - 7) 51 time overcurrent:
 - a) Determine minimum pickup.
 - b) Determine time delay at 2 points on the time current curve.
 - 8) 87 differential:
 - a) Determine operating unit pickup.
 - b) Determine the operation of each restraint unit.
 - c) Determine slope.
 - d) Determine harmonic restraint.
 - e) Determine instantaneous pickup.
 - f) Plot operating characteristics for each restraint.
- e. Control verification:
 - 1) Functional tests:
 - a) Check operation of active digital inputs.
 - b) Check output contacts or SCRs preferably by operating the controlled device such as circuit breaker, auxiliary relay or alarm.
 - c) Check internal logic functions used in the protection scheme.
 - d) For pilot schemes, perform a loop-back test to check the receive and transmit communications circuits.
 - e) Upon completion of testing, reset min/max recorders, communications statistics, fault counters, sequence of events recorder, and event records.

- f) Verify trip and close coil monitoring functions.
- g) Verify setting change alarm to SCADA.
- h) Verify relay SCADA communication and indications such as protection operate, protection fail, communication fail, fault recorder trigger.
- i) Verify communication links are operational.
- j) Light-emitting diodes, displays and targets should illuminate.
- k) Relay should be clean and operational.
- l) Settings and logic should agree with the most recent engineering files.
- m) Verify relay displays the correct date and time.
- 2) Insulation-resistance values should be in accordance with the manufacturer's published data.
 - a) Investigate values of insulation resistance less than the manufacturer's recommendation.
- 3) Voltage and current analog readings should be in accordance with the manufacturer's published tolerances.
- 4) SCADA readings should be in accordance with the manufacturer's published tolerances.
- 5) Operation of protection elements should be within the manufacturer's published tolerances.
- 6) Control verification inputs, outputs, and protection schemes should operate in accordance with the design. Results should be within the manufacturer's published tolerances.

L. Instrument transformers - current transformers:

- 1. Visual and mechanical inspection:
 - a. Compare equipment nameplate data with the Contract Documents.
 - b. Inspect physical and mechanical condition.
 - c. Verify correct connection of transformers with system requirements.
 - d. Verify that adequate clearances exist between primary and secondary circuit wiring.
 - e. Verify the unit is clean.
 - f. Inspect bolted electrical connections for high resistance using one of the following methods:
 - 1) Use of low-resistance ohmmeter.
 - 2) Verify tightness of accessible bolted electrical connections by calibrated torque wrench method:
 - a) Refer to the manufacturer's instructions for proper foot-pound levels or NETA ATS tables.
 - g. Verify that required grounding and shorting connections provide contact.
 - h. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.
- 2. Electrical tests:
 - a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter.
 - b. Perform insulation-resistance test of each current transformer and its secondary wiring with respect to ground at 1,000 VDC for 1 minute:
 - 1) For solid state devices that cannot tolerate the applied voltage, follow the manufacturer's recommendation.

- c. Perform a polarity test of each current transformer in accordance with IEEE C57.13.1.
 - d. Perform a ratio verification test using the voltage or current method in accordance with IEEE C57.13.1.
 - e. Perform an excitation test on current transformers used for relaying applications in with accordance with IEEE C57.13.1.
 - f. Measure current circuit burdens at transformer terminals in accordance with IEEE C57.13.1.
 - g. When applicable, perform insulation-resistance tests on the primary winding with the secondary grounded:
 - 1) Test voltages shall be in accordance with NETA ATS tables.
 - h. When applicable, perform dielectric withstand tests on the primary winding with the secondary grounded:
 - 1) Test voltages shall be in accordance with NETA ATS tables.
 - i. Perform power-factor or dissipation-factor tests in accordance with the test equipment manufacturer's published data.
 - j. Verify that current transformer secondary circuits are grounded and have only 1 grounding point in accordance with IEEE C57.13.3:
 - 1) That grounding point should be located as specified by the Engineer in the Contract Documents.
3. Test values:
- a. Compare bolted connection resistance values to values of similar connections:
 - 1) Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
 - b. Bolt-torque levels shall be in accordance with the manufacturer's published data:
 - 1) Refer to NETA ATS tables in the absence of the manufacturer's published data.
 - c. Insulation-resistance values of instrument transformers shall be in accordance with the manufacturer's published data:
 - 1) Refer to NETA ATS tables in the absence of the manufacturer's published data.
 - d. Polarity results shall agree with transformer markings.
 - e. Ratio errors shall be in accordance with IEEE C57.13.
 - f. Excitation results for current transformers shall match the curve supplied by the manufacturer or be in accordance with IEEE C57.13.1.
 - g. Measured burdens shall be compared to instrument transformer ratings.
 - h. If no evidence of distress or insulation failure is observed by the end of the total time of voltage application during the dielectric withstand test, the primary winding is considered to have passed the test.
 - i. Power-factor or dissipation-factor values shall be compared to the manufacturer's published data:
 - 1) In the absence of the manufacturer's published data, use the test equipment manufacturer's published data.
 - j. Test results shall indicate that the circuits have only 1 grounding point.

M. Instrument transformers - voltage transformers:

- 1. Visual and mechanical inspection:
 - a. Compare equipment nameplate data with the Contract Documents.
 - b. Inspect physical and mechanical condition.

- c. Verify correct connection of transformers with system requirements.
 - d. Verify that adequate clearances exist between primary and secondary circuit wiring.
 - e. Verify the unit is clean.
 - f. Inspect bolted electrical connections for high resistance using one of the following methods:
 - 1) Use of low-resistance ohmmeter.
 - 2) Verify tightness of accessible bolted electrical connections by calibrated torque wrench method:
 - a) Refer to the manufacturer's instructions for proper foot-pound levels or NETA ATS tables.
 - g. Verify that required grounding and connections provide contact.
 - h. Verify correct primary and secondary fuse sizes for voltage transformers.
 - i. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.
 - j. Perform as-left tests.
2. Electrical tests - voltage transformers:
- a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter.
 - b. Perform insulation-resistance tests winding-to-winding and winding-to-ground:
 - 1) Test voltage shall be applied for 1 minute in accordance with NETA ATS requirements.
 - 2) For solid state devices that cannot tolerate the applied voltage, follow the manufacturer's recommendation.
 - c. Perform a polarity test on each voltage transformer to verify the polarity marks on H_1 - X_1 relationship as applicable.
 - d. Perform a turns ratio test on all tap positions.
 - e. Measure voltage circuit burdens at transformer terminals.
 - f. Perform a dielectric withstand test on the primary windings with the secondary windings grounded:
 - 1) Dielectric voltage shall be in accordance with NETA ATS tables.
 - 2) Apply the test voltage for 1 minute.
 - g. Perform power-factor or dissipation-factor tests in accordance with the test equipment manufacturer's published data.
 - h. Verify that voltage transformer secondary circuits are grounded and have only 1 grounding point in accordance with IEEE C57.13.3:
 - 1) That grounding point should be located as specified by the Engineer in the Contract Documents.
3. Test values:
- a. Compare bolted connection resistance values to values of similar connections:
 - 1) Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
 - b. Bolt-torque levels shall be in accordance with the manufacturer's published data:
 - 1) Refer to NETA ATS tables in the absence of the manufacturer's published data.

- c. Insulation-resistance values of instrument transformers shall be in accordance with the manufacturer's published data:
 - 1) Refer to NETA ATS tables in the absence of the manufacturer's published data.
 - d. Polarity results shall agree with transformer markings.
 - e. Ratio errors shall be in accordance with IEEE C57.13.
 - f. Measured burdens shall be compared to instrument transformer ratings.
 - g. If no evidence of distress or insulation failure is observed by the end of the total time of voltage application during the dielectric withstand test, the primary winding is considered to have passed the test.
 - h. Power-factor or dissipation-factor values shall be compared to the manufacturer's published data:
 - 1) In the absence of the manufacturer's published data, use the test equipment manufacturer's published data.
 - i. Test results shall indicate that the circuits have only 1 grounding point.
- N. Metering devices, microprocessor based:
- 1. Visual and mechanical inspection:
 - a. Compare equipment nameplate data with the Contract Documents.
 - b. Inspect meters and cases for physical damage.
 - c. Clean front panel.
 - d. Verify tightness of electrical connections.
 - e. Record the following:
 - 1) Model number.
 - 2) Serial number.
 - 3) Firmware revision.
 - 4) Software revision.
 - 5) Rated control voltage.
 - f. Verify operation of display and indicating devices.
 - g. Record passwords.
 - h. Verify the unit is grounded in accordance with the manufacturer's instructions.
 - i. Set required parameters, including instrument transformer ratios, system type, frequency, power demand methods/intervals, and communications requirements.
 - 2. Electrical tests:
 - a. Apply voltage or current as appropriate to each analog input and verify correct measurement and indication.
 - b. Confirm correct operation and setting of each auxiliary input/output feature, including mechanical relay, digital and analog.
 - c. After initial system energization, confirm measurements and indications are consistent with loads present.
 - 3. Test values:
 - a. Nameplate data shall match the Contract Documents.
 - b. Tightness of electrical connections shall ensure a low resistance connection.
 - c. Display and indicating devices shall operate in accordance with the manufacturer's published data.
 - d. Measurement and indication of applied voltages and currents shall be within the manufacturer's published tolerances for accuracy.

- e. Auxiliary input/output features shall operate in accordance with the settings and the manufacturer's published data.
 - f. Measure and indications shall be consistent with energized system loads.
- O. Grounding systems:
- 1. Visual and mechanical inspection:
 - a. Inspect ground system for compliance with the Contract Documents and the NEC.
 - b. Inspect physical and mechanical condition.
 - c. Inspect bolted electrical connections for high resistance using one of the following methods:
 - 1) Use of low-resistance ohmmeter.
 - 2) Verify tightness of accessible bolted electrical connections by calibrated torque wrench method:
 - a) Refer to the manufacturer's instructions for proper foot-pound levels or NETA ATS tables.
 - d. Inspect anchorage.
 - 2. Electrical tests:
 - a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter.
 - b. Perform fall of potential test or alternative test in accordance with IEEE 81 on the main grounding electrode or system.
 - c. Perform point-to-point tests to determine the resistance between the main grounding system and major electrical equipment frames, the system neutral and any derived neutral points.
 - 3. Test values:
 - a. Grounding system electrical and mechanical connections shall be free of corrosion.
 - b. Compare bolted connection resistance values to values of similar connections:
 - 1) Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
 - c. Bolt-torque levels shall be in accordance with the manufacturer's published data:
 - 1) Refer to NETA ATS tables in the absence of the manufacturer's published data.
 - d. Resistance between the main grounding electrode and ground shall be as specified in Section 26_05_26 - Grounding and Bonding.
 - e. Investigate point-to-point resistance values that exceed 0.5 ohm.
- P. Rotating machinery, AC induction motors and generators:
- 1. Visual and mechanical inspection:
 - a. Compare equipment nameplate information with the Contract Documents.
 - b. Inspect physical and mechanical condition.
 - c. Inspect anchorage, alignment, and grounding.
 - d. Inspect air baffles, filter media, cooling fans, slip rings, brushes, and brush rigging.
 - e. Inspect bolted electrical connections for high resistance using one or more of the following methods:
 - 1) Use of low-resistance ohmmeter.

- 2) Verify tightness of accessible bolted electrical connections by calibrated torque wrench method:
 - a) Refer to the manufacturer's instructions for proper foot-pound levels or NETA ATS tables.
 - f. Perform special tests such as airgap spacing and machine alignment.
 - g. Manually rotate the rotor and check for problems with the bearings or shaft.
 - h. Rotate the shaft and measure and record the shaft extension runout.
 - i. Rotating equipment:
 - 1) Operate at rated design load conditions.
 - 2) Confirm that equipment is properly assembled.
 - 3) Confirm the equipment moves or rotates in the proper direction.
 - 4) Confirm shafting, drive elements, and bearings are installed and lubricated in accordance with proper tolerances.
 - 5) Confirm that no unusual power consumption, lubrication temperatures, bearing temperatures, or other conditions are observed.
 - j. Verify correct application of appropriate lubrication and lubrication systems.
 - k. Verify that resistance temperature detector (RTD) circuits conform to that indicated on the Drawings.
2. Electrical tests - AC induction:
- a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter.
 - b. Perform insulation-resistance test in accordance with IEEE 43:
 - 1) On motors 200 horsepower and smaller, test duration shall be 1 minute. Calculate dielectric absorption ratio for 60/30-second periods.
 - 2) On motors larger than 200 horsepower, test duration shall be 10 minutes. Calculate polarization index.
 - c. On machines rated at 2,300 volts and greater, perform dielectric withstand voltage tests in accordance with:
 - 1) IEEE 95 for DC dielectric withstand voltage tests.
 - 2) NEMA MG1 for AC dielectric withstand voltage tests.
 - d. Perform phase-to-phase stator resistance test on machines rated at 2,300 volts and greater.
 - e. Perform insulation power-factor or dissipation-factor tests.
 - f. Perform power-factor tip-up tests.
 - g. Perform surge comparison tests.
 - h. Perform insulation-resistance test on insulated bearings in accordance with the manufacturer's published data.
 - i. Test surge protection devices as specified in this Section.
 - j. Test motor starter as specified in this Section.
 - k. Perform resistance tests on resistance temperature detector (RTD) circuits.
 - l. Verify operation of motor space heater, if applicable.
 - m. Perform vibration test while machine is running under load.
3. Test values:
- a. Inspection:
 - 1) Air baffles shall be clean and installed in accordance with the manufacturer's published data.
 - 2) Filter media shall be clean and installed in accordance with the manufacturer's published data.
 - 3) Cooling fans shall operate.

- 4) Slip ring alignment shall be within the manufacturer's published tolerances.
- 5) Brush alignment shall be within the manufacturer's published tolerances.
- 6) Brush rigging shall be within the manufacturer's published tolerances.
- b. Compare bolted connection resistance values to values of similar connections:
 - 1) Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
- c. Bolt-torque levels shall be in accordance with the manufacturer's published data:
 - 1) Refer to NETA ATS tables in the absence of the manufacturer's published data.
- d. Airgap spacing and machine alignment shall be in accordance with the manufacturer's published data.
- e. Recommended minimum insulation-resistance ($IR_{1\min}$) test results in megohms shall be in accordance with NETA ATS tables.
 - 1) Polarization index value shall not be less than 2.0.
 - 2) Dielectric absorption ratio shall not be less than 1.4.
- f. If no evidence of distress or insulation failure is observed by the end of the total time of voltage application during the dielectric withstand test, the test specimen is considered to have passed the test.
- g. Investigate phase-to-phase stator resistance values that deviate by more than 5 percent.
- h. Power factor or dissipation factor values shall be compared to the manufacturer's published data:
 - 1) In the absence of the manufacturer's published data, compare values of similar machines.
- i. Tip-up values shall indicate no significant increase in power factor.
- j. If no evidence of distress, insulation failure, or waveform nesting is observed by the end of the total time of voltage application during the surge comparison test, the test specimen is considered to have passed the test.
- k. Bearing insulation-resistance measurements shall be within manufacturer's published tolerances:
 - 1) In the absence of the manufacturer's published data, compare values of similar machines.
- l. Test results of surge protection devices shall be as specified in this Section.
- m. Test results of motor starter equipment shall be as specified in this Section.
- n. RTD circuits shall conform to the design intent and machine protection device manufacturer's published data.
- o. Heaters shall be operational.
- p. Vibration amplitudes of the uncoupled and unloaded machine shall be in accordance with the manufacturer's published data:
 - 1) In the absence of the manufacturer's published data, vibration amplitudes shall not exceed values in NETA ATS tables.
 - 2) If values exceed those in the NETA ATS tables, perform a complete vibration analysis.

Q. Motor starters, low voltage:

1. Visual and mechanical inspection:
 - a. Compare equipment nameplate information with the Contract Documents.

- b. Inspect physical and mechanical condition.
- c. Inspect anchorage, alignment, and grounding.
- d. Verify the unit is clean.
- e. Inspect contactors:
 - 1) Verify mechanical operation.
 - 2) Verify contact gap, wipe, alignment, and pressure is in accordance with the manufacturer's published data.
- f. Motor-running protection:
 - 1) Verify overload element rating/motor protection settings are correct for its application.
 - 2) If motor running protection is provided by fuses, verify correct fuse rating.
- g. Inspect bolted electrical connections for high resistance using one of the following methods:
 - 1) Use of low-resistance ohmmeter.
 - 2) Verify tightness of accessible bolted electrical connections by calibrated torque wrench method:
 - a) Refer to the manufacturer's instructions for proper foot-pound levels or NETA ATS tables.
- h. Lubrication requirements:
 - 1) Verify appropriate lubrication on moving current-carrying parts.
 - 2) Verify appropriate lubrication on moving and sliding surfaces.
- 2. Electrical tests:
 - a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter.
 - b. Perform insulation-resistance tests for 1 minute on each pole, phase-to-phase and phase-to-ground with the starter closed, and across each open pole for 1 minute:
 - 1) Test voltage shall be in accordance with the manufacturer's published data.
 - 2) Refer to NETA ATS tables in the absence of the manufacturer's published data.
 - c. Test motor protection devices in accordance with the manufacturer's published data.
 - d. Test circuit breakers as specified in this Section.
 - e. Perform operational tests by initiating control devices.
- 3. Test values:
 - a. Compare bolted connection resistance values to values of similar connections:
 - 1) Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
 - b. Bolt-torque levels shall be in accordance with the manufacturer's published data:
 - 1) Refer to NETA ATS tables in the absence of the manufacturer's published data.
 - c. Insulation-resistance values shall be in accordance with the manufacturer's published data:
 - 1) Refer to NETA ATS tables in the absence of the manufacturer's published data.
 - 2) Investigate values of insulation-resistance less than the allowable minimum.

- d. Motor protection parameters shall be in accordance with the manufacturer's published data.
 - e. Circuit breaker test results shall be as specified in this Section.
 - f. Control devices shall perform in accordance with system design requirements.
- R. Motor control centers, low voltage:
- 1. Visual and mechanical inspection:
 - a. Compare equipment nameplate data with the Contract Documents.
 - b. Inspect physical and mechanical condition.
 - c. Inspect anchorage, alignment, grounding and required clearances.
 - d. Verify the unit is clean and shipping bracing, loose parts, and documentation shipped inside cubicles have been removed.
 - e. Verify that circuit breaker/fuse sizes and types correspond to the approved Submittals and the coordination study.
 - f. Verify that current and voltage transformer ratios correspond to those indicated on the Drawings.
 - g. Verify that wiring connections are tight and that wiring is secure to prevent damage during routine operation of moving parts.
 - h. Inspect bolted electrical connections for high resistance using one of the following methods:
 - 1) Use of low-resistance ohmmeter.
 - 2) Verify tightness of accessible bolted electrical connections by the calibrated torque wrench method:
 - a) Refer to the manufacturer's instructions for proper foot-pound levels or NETA ATS tables.
 - i. Verify operation and sequencing of interlocking systems:
 - 1) Attempt closure on locked-open devices.
 - 2) Attempt to open locked-closed devices.
 - 3) Make/attempt key-exchanges in all positions.
 - j. Lubrication requirements:
 - 1) Verify appropriate lubrication on moving current-carrying parts.
 - 2) Verify appropriate lubrication on moving and sliding surfaces.
 - k. Inspect insulators for evidence of physical damage or contaminated surfaces.
 - l. Verify correct barrier and shutter installation and operation.
 - m. Exercise active components.
 - n. Inspect indicating devices for correct operation.
 - o. Verify that filters are in place and/or vents are clear.
 - p. Perform visual and mechanical inspection of instrument transformers as specified in this Section.
 - q. Perform visual and mechanical inspection of surge arresters as specified in this Section.
 - r. Inspect control power transformers:
 - 1) Inspect for physical damage, cracked insulation, broken leads, and tightness of connections, defective wiring, and overall general condition.

- 2) Verify that primary and secondary fuse/circuit breaker ratings match the Submittal Drawings.
- 3) Verify correction functioning of grounding contacts.
- s. Perform visual and mechanical inspection of motor control center components as specified in this Section.
2. Electrical tests:
 - a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter.
 - b. Perform insulation-resistance tests on each bus section, phase-to-phase and phase-to-ground for 1 minute:
 - 1) Perform test in accordance with NETA ATS tables.
 - c. Perform a dielectric withstand test on each bus section, each phase-to-ground with phases not under test grounded, in accordance with the manufacturer's published data or NETA ATS tables. Apply the test voltage for 1 minute.
 - d. Perform ground-resistance tests:
 - 1) Perform point-to-point tests to determine the resistance between the main grounding system and major electrical equipment frames, system neutral and derived neutral points.
 - e. Control power transformers:
 - 1) Perform insulation-resistance tests, winding-to-winding and winding-to-ground:
 - a) Test voltages shall be in accordance with NETA ATS tables or as specified by the manufacturer.
 - 2) Perform secondary wiring integrity test:
 - a) Disconnect transformer at secondary terminals and connect secondary wiring to a rated secondary voltage source:
 - (1) Verify correct potential at all devices.
 - 3) Verify correct secondary voltage by energizing primary winding with system voltage:
 - a) Measure secondary voltage with the secondary wiring disconnected.
 - f. Verify operation of space heaters.
 - g. Perform electrical tests of motor control center components as specified in this Section.
3. Test values:
 - a. Compare bolted connection resistance values to values of similar connections:
 - 1) Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
 - b. Bolt-torque levels shall be in accordance with the manufacturer's published data:
 - 1) Refer to NETA ATS tables in the absence of the manufacturer's published data.
 - c. Insulation-resistance values for bus and control power transformers shall be in accordance with the manufacturer's published data:
 - 1) Refer to NETA ATS tables in the absence of the manufacturer's published data.
 - 2) Investigate insulation values less than the allowable minimum.
 - 3) Do not proceed with dielectric withstand voltage tests until insulation-resistance values are above minimum values.

- d. Bus insulation shall withstand the over potential test voltage applied.
 - e. Instrument transformer test values shall be as specified in this Section.
 - f. Investigate grounding system point-to-point resistance values that exceed 0.5 ohm.
 - g. Meter accuracy shall be in accordance with the manufacturer's published data.
 - h. Control power transformers:
 - 1) Insulation-resistance values of control power transformers shall be in accordance with the manufacturer's published data:
 - a) Refer to NETA ATS tables in the absence of the manufacturer's published data.
 - b) Investigate insulation values less than the allowable minimum.
 - c) Do not proceed with dielectric withstand voltage tests until insulation-resistance values are above minimum values.
 - 2) Secondary wiring shall be as indicated on the Drawings and specified in the Specifications.
 - 3) Secondary voltage shall be as indicated on the Drawings.
 - i. Heaters shall be operational.
 - j. Test values for motor control center components shall be as specified in this Section.
- S. Variable frequency drive systems:
- 1. Visual and mechanical inspection:
 - a. Compare equipment nameplate data with the Contract Documents.
 - b. Inspect physical and mechanical condition.
 - c. Inspect anchorage, alignment, and grounding.
 - d. Verify the unit is clean.
 - e. Ensure vent path openings are free from debris and that heat transfer surfaces are clean.
 - f. Verify correct connections of circuit boards, wiring, disconnects, and ribbon cables.
 - g. Motor running protection:
 - 1) Verify drive overcurrent setpoints are correct for their application.
 - 2) If drive is used to operate multiple motors, verify individual overload element ratings are correct for their application.
 - 3) Apply minimum and maximum speed setpoints. Verify setpoints are within limitations of the load coupled to the motor.
 - h. Inspect bolted electrical connections for high resistance using one of the following methods:
 - 1) Use of low-resistance ohmmeter.
 - 2) Verify tightness of accessible bolted electrical connections by the calibrated torque wrench method:
 - a) Refer to the manufacturer's instructions for proper foot-pound levels or NETA ATS tables.
 - i. Verify correct fuse sizing in accordance with the manufacturer's published data.
 - j. Perform visual and mechanical inspection of input circuit breaker as specified in this Section.
 - 2. Electrical tests:
 - a. Perform resistance measurements through bolted connections with low resistance ohmmeter.

- b. Test the motor overload relay elements by injecting primary current through the overload circuit and monitoring trip time of the overload element.
 - c. Test for the following parameters in accordance with relay calibration procedures specified in NETA ATS, or as recommended by the manufacturer:
 - 1) Input phase loss protection.
 - 2) Input overvoltage protection.
 - 3) Output phase rotation.
 - 4) Overtemperature protection.
 - 5) Direct current overvoltage protection.
 - 6) Overfrequency protection.
 - 7) Drive overload protection.
 - 8) Fault alarm outputs.
 - d. Harmonic distortion measurements for both voltage and current is within the specification limits at the installed site.
 - e. Peak voltage at the motor terminations is less than 90 percent of the motor insulation dielectric withstand level.
 - f. Perform continuity tests on bonding conductors as specified in accordance with NETA ATS.
 - g. Perform start-up of drive in accordance with the manufacturer's published data. Calibrate drive to the system's minimum and maximum speed control signals.
 - h. Perform operational tests by initiating control devices:
 - 1) Slowly vary drive speed between minimum and maximum. Observe motor and load for unusual noise or vibration.
 - 2) Verify operation of drive from remote start/stop and speed control signals.
 - i. Perform electrical tests of input circuit breaker as specified in this Section.
 - j. Measure fuse resistance.
3. Test values:
- a. Compare bolted connection resistance values to values of similar connections:
 - 1) Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
 - b. Bolt-torque levels shall be in accordance with the manufacturer's published data:
 - 1) Refer to NETA ATS tables in the absence of the manufacturer's published data.
 - c. Overload test trip times at 300 percent of overload element rating shall be in accordance with the manufacturer's published time-current curve.
 - d. Test values for input circuit breaker shall be as specified in this Section.
 - e. Relay calibration results shall be as specified in this Section.
 - f. Continuity of bonding conductors shall be in accordance with NETA ATS.
 - g. Control devices shall perform in accordance with system requirements.
 - h. Operational tests shall conform to system design requirements.
 - i. Investigate fuse resistance values that deviate from each other by more than 15 percent.

- T. Surge arresters, low-voltage:
1. Visual and mechanical inspection:
 - a. Compare equipment nameplate data with the Contract Documents.
 - b. Inspect physical and mechanical condition.
 - c. Inspect anchorage, alignment, grounding, and clearances.
 - d. Verify the arresters are clean.
 - e. Inspect bolted electrical connections for high resistance using one of the following methods:
 - 1) Use of low-resistance ohmmeter.
 - 2) Verify tightness of accessible bolted electrical connections by the calibrated torque wrench method:
 - a) Refer to the manufacturer's instructions for proper foot-pound levels or NETA ATS tables.
 - f. Verify that the ground lead on each device is individually attached to a ground bus or ground electrode.
 - g. Verify that stroke counter is correctly mounted and electrically connected, if applicable.
 - h. Record stroke counter reading.
 2. Electrical tests:
 - a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter.
 - b. Perform an insulation-resistance test on each arrester, phase terminal-to-ground:
 - 1) Apply voltage in accordance with manufacturer's published data.
 - 2) Refer to NETA ATS tables in the absence of the manufacturer's published data.
 - c. Test grounding connection as specified in this Section.
 3. Test values:
 - a. Compare bolted connection resistance values to values of similar connections:
 - 1) Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
 - b. Bolt-torque levels shall be in accordance with the manufacturer's published data:
 - 1) Refer to NETA ATS tables in the absence of the manufacturer's published data.
 - c. Insulation-resistance values shall be in accordance with the manufacturer's published data:
 - 1) Refer to NETA ATS tables in the absence of the manufacturer's published data.
 - 2) Investigate insulation values less than the allowable minimum.
 - d. Resistance between the arrester ground terminal and the ground system shall be less than 0.5 ohm.
- U. Surge arresters, medium and high voltage:
1. Visual and mechanical inspection:
 - a. Compare equipment nameplate data with the Contract Documents.
 - b. Inspect physical and mechanical condition.
 - c. Inspect anchorage, alignment, grounding, and clearances.
 - d. Verify the arresters are clean.

- e. Inspect bolted electrical connections for high resistance using one of the following methods:
 - 1) Use of low-resistance ohmmeter.
 - 2) Verify tightness of accessible bolted electrical connections by the calibrated torque wrench method:
 - a) Refer to the manufacturer's instructions for proper foot-pound levels or NETA ATS tables.
 - f. Verify that the ground lead on each device is individually attached to a ground bus or ground electrode.
 - g. Verify that stroke counter is correctly mounted and electrically connected, if applicable.
 - h. Record stroke counter reading.
 - 2. Electrical tests:
 - a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter.
 - b. Perform an insulation-resistance test on each arrester, phase terminal-to-ground:
 - 1) Apply voltage in accordance with manufacturer's published data.
 - 2) Refer to NETA ATS tables in the absence of the manufacturer's published data.
 - c. Test grounding connection as specified in this Section.
 - d. Perform a watts-loss test.
 - 3. Test values:
 - a. Compare bolted connection resistance values to values of similar connections:
 - 1) Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
 - b. Bolt-torque levels shall be in accordance with the manufacturer's published data:
 - 1) Refer to NETA ATS tables in the absence of the manufacturer's published data.
 - c. Insulation-resistance values shall be in accordance with the manufacturer's published data:
 - 1) Refer to NETA ATS tables in the absence of the manufacturer's published data.
 - 2) Investigate insulation values less than the allowable minimum.
 - d. Resistance between the arrester ground terminal and the ground system shall be less than 0.5 ohm.
 - e. Watts-loss values are evaluated on a comparison basis with similar units and the test equipment manufacturer's published data.
- V. Uninterruptible power systems:
- 1. Testing and settings shall be conducted by the UPS manufacturer's field engineer. Test the complete operation of:
 - a. Static transfer system.
 - b. Static bypass system.
 - c. Maintenance bypass system.
 - 2. Visual and mechanical inspection:
 - a. Compare equipment nameplate data with the Contract Documents.
 - b. Inspect physical and mechanical condition.
 - c. Inspect anchorage, alignment, grounding, and required clearances.

- d. Verify that fuse sizes and types correspond to that indicated on the Drawings.
 - e. Verify the unit is clean.
 - f. Test electrical and mechanical interlock systems for correct operation and sequencing.
 - g. Inspect bolted electrical connections for high resistance using one of the following methods:
 - 1) Use of low-resistance ohmmeter.
 - 2) Verify tightness of accessible bolted electrical connections by calibrated torque wrench method:
 - a) Refer to the manufacturer's instructions for proper foot-pound levels or NETA ATS tables.
 - h. Verify operation of forced ventilation.
 - i. Verify that filters are in place and/or vents are clear.
3. Electrical tests:
- a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter.
 - b. Test static transfer from inverter to bypass and back. Use normal load, if possible.
 - c. Set free running frequency of oscillator.
 - d. Test DC undervoltage trip level on inverter input breaker. Set according to manufacturer's published data.
 - e. Test alarm circuits.
 - f. Verify synchronizing indicators for static switch and bypass switches.
 - g. Perform electrical tests for:
 - 1) UPS system breakers as specified in this Section.
 - 2) UPS system automatic transfer switches as specified in this Section.
 - 3) UPS system batteries as specified in this Section.
 - 4) UPS rotating machinery as specified in this Section.
4. Test values:
- a. Electrical and mechanical interlock systems shall operate in accordance with system design requirements.
 - b. Compare bolted connection resistance values to values of similar connections:
 - 1) Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
 - c. Bolt-torque levels shall be in accordance with the manufacturer's published data:
 - 1) Refer to NETA ATS tables in the absence of the manufacturer's published data.
 - d. Static transfer shall function in accordance with the manufacturer's published data.
 - e. Oscillator free running frequency shall be within the manufacturer's published tolerances.
 - f. Direct current undervoltage shall trip inverter input breaker.
 - g. Alarm circuits shall operate in accordance with design requirements.
 - h. Synchronizing indicators shall operate in accordance with design requirements.
 - i. Breaker performance shall be as specified in this Section.
 - j. Automatic transfer switch performance shall be as specified in this Section.
 - k. Battery test results shall be as specified in this Section.

- I. Rotating machinery performance shall be as specified in this Section.
- W. Automatic transfer switches:
 - 1. Visual and mechanical inspection:
 - a. Compare equipment nameplate data with the Contract Documents.
 - b. Inspect physical and mechanical condition.
 - c. Inspect anchorage, alignment, grounding, and required clearances.
 - d. Verify the unit is clean.
 - e. Lubrication requirements:
 - 1) Verify appropriate lubrication on moving current-carrying parts.
 - 2) Verify appropriate lubrication on moving and sliding surfaces.
 - f. Verify that manual transfer warnings are attached and visible.
 - g. Verify tightness of control connections.
 - h. Inspect bolted electrical connections for high resistance using one of the following methods:
 - 1) Use of low-resistance ohmmeter.
 - 2) Verify tightness of accessible bolted electrical connections by calibrated torque wrench:
 - a) Refer to the manufacturer's instructions for proper foot-pound levels or NETA ATS tables.
 - i. Perform manual transfer operation.
 - j. Verify positive mechanical interlocking between normal and alternate sources.
 - 2. Electrical tests:
 - a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter.
 - b. Perform insulation-resistance tests for 1 minute on each pole, phase-to-phase and phase-to-ground with switch in both source positions, and across each open pole. Test voltage shall be in accordance with the manufacturer's published data:
 - 1) Refer to NETA ATS tables in the absence of the manufacturer's published data.
 - c. Perform a contact/pole-resistance test.
 - d. Verify settings and operation of control devices.
 - e. Calibrate and set relays and timers as specified in this Section.
 - f. Verify phase rotation, phasing, and synchronized operation as required by the application.
 - g. Perform automatic transfer tests:
 - 1) Simulate loss of normal power.
 - 2) Return to normal power.
 - 3) Simulate loss of emergency power.
 - 4) Simulate all forms of single-phase conditions.
 - h. Verify correct operation and timing of the following functions:
 - 1) Normal source voltage-sensing and frequency-sensing relays.
 - 2) Engine start sequence.
 - 3) Time delay upon transfer.
 - 4) Alternate source voltage-sensing and frequency-sensing relays.
 - 5) Automatic transfer operation.
 - 6) Interlocks and limit switch function.
 - 7) Time delay and retransfer upon normal power restoration.
 - 8) Engine cool down and shutdown feature.

3. Test values:
 - a. Compare bolted connection resistance values to values of similar connections:
 - 1) Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
 - b. Bolt-torque levels shall be in accordance with the manufacturer's published data:
 - 1) Refer to NETA ATS tables in the absence of the manufacturer's published data.
 - c. Insulation resistance values of transfer switches shall be in accordance with the manufacturer's published data:
 - 1) Refer to NETA ATS tables in the absence of the manufacturer's published data.
 - 2) Values of insulation resistance less than this table or the manufacturer's recommendations shall be investigated.
 - d. Micro-ohm or DC millivolt drop values shall not exceed the high levels of the normal range as indicated in the manufacturer's published data:
 - 1) If the manufacturer's published data is not available, investigate values that deviate from adjacent poles or similar switches by more than 50 percent of the lowest value.
 - e. Control devices shall operate in accordance with the manufacturer's published data.
 - f. Relay test results shall be as specified in this Section.
 - g. Phase rotation, phasing, and synchronization shall be as specified in the system design specifications.
 - h. Operation and timing shall be in accordance with the manufacturer's and system design requirements.
- X. Fiber-optic cables:
 1. Visual and mechanical inspection:
 - a. Compare cable, connector, and splice data with the Contract Documents.
 - b. Inspect cable and connections for physical and mechanical damage.
 - c. Verify that connectors and splices are correctly installed.
 2. Optical tests:
 - a. Perform cable length measurement, fiber fracture inspection, and construction defect inspection using an optical time domain reflectometer (OTDR):
 - 1) OTDR test performed on fiber cables less than 100 meters shall be performed with the aid of a launch cable.
 - 2) Adjust OTDR pulse width settings to a maximum setting of 1/1,000th of the cable length or 10 nanoseconds.
 - b. Perform connector and splice integrity test using an optical time domain reflectometer.
 - c. Perform cable attenuation loss measurement with an optical power loss test set:
 - 1) Perform attenuation tests with an optical loss test set capable and calibrated to show anomalies of 0.1 dB as a minimum.
 - 2) Test multimode fibers at 850 nanometer and 1,300 nanometer.
 - 3) Test single mode fibers at 1,310 nanometer and 1,550 nanometer.

- d. Perform connector and splice attenuation loss measurement from both ends of the optical cable with an optical power loss test set:
 - 1) At the conclusion of all outdoor splices at 1 location, and before they are enclosed and sealed, splices shall be tested with OTDR at the optimal wavelengths (850 and 1,300 for multimode, 1,310 and 1,550 for single mode), in both directions. Splices shall be tested for integrity as well as attenuation.
 - e. Perform fiber links integrity and attenuation tests using each link shall be an OTDR and an optical loss test set:
 - 1) OTDR traces shall be from both directions on each fiber at the 2 optimal wavelengths, 850 nanometer, and 1,300 nanometer for multimode fibers.
 - 2) Optical loss testing shall be done with handheld test sets in 1 direction at the 2 optimal wavelengths for the appropriate fiber type. Test equipment shall equal or exceed the accuracy and resolution of Agilent/HP 8147 high performance OTDR.
 - 3. Test values:
 - a. Cable and connections shall not have been subjected to physical or mechanical damage.
 - b. Connectors and splices shall be installed in accordance with industry standards.
 - c. Optical time domain reflectometer signal should be analyzed for excessive connection, splice, or cable backscatter by viewing the reflected power/distance graph.
 - d. Attenuation loss measurement shall be expressed in dB/km. Losses shall be within the manufacturer's recommendations when no local site specifications are available.
 - e. Individual fusion splice losses shall not exceed 0.1 dB. Measurement results shall be recorded, validated by trace, and filed with the records of the respective cable runs.
- Y. Copper Ethernet cable installation testing:
 - 1. Pre-installation:
 - a. Immediately prior to installation, verify that cable to be installed matches that which was submitted.
 - b. Verify that no damage has been done to the cable during shipping or handling.
 - c. Inspect cable for physical and mechanical damage.
 - d. Engineer shall be notified if a cable fails to meet inspection and the cable shall not be installed unless otherwise directed by the Engineer.
 - 2. Post-installation:
 - a. Prior to copper Ethernet cable termination, perform cable end-to-end continuity validation testing on installed cables, conductor pairs and cable shields using toner and probe kit. Any cable that fails testing shall be removed and replaced.
 - b. Inspect equipment outlet connectors for damage and ensure connectors hold tightly in field device ports.
 - 3. Test equipment:
 - a. Certification equipment used for the testing shall be capable of verifying twisted pair cable installation with end-to-end continuity testing.

- b. Use only test cords and adapters that are qualified by the test equipment manufacturer for channel or link test configuration.
 - c. Manufacturers: The following or equal:
 - 1) Fluke Networks, IntelliTone Pro 200 Toner and Probe Kit, MT-8200-60-KIT.
 - d. Permanent link testing requirements: As specified in Section 40_80_01 - Commissioning for Instrumentation and Controls.
- Z. Direct-current systems, batteries, vented nickel-cadmium:
 - 1. Visual and mechanical inspection:
 - a. Verify that batteries are adequately located.
 - b. Verify that battery area ventilation system is operable.
 - c. Verify existence of suitable eyewash equipment.
 - d. Compare equipment nameplate data with the Contract Documents.
 - e. Inspect physical and mechanical condition.
 - f. Verify adequacy of battery support racks or cabinets, mounting, battery spill containment system, anchorage, alignment, grounding, and clearances.
 - g. Verify electrolyte level. Measure pilot-cell electrolyte temperature.
 - h. Verify the units are clean.
 - i. Verify application of an oxide inhibitor on battery terminal connections.
 - j. Inspect bolted electrical connections for high resistance using one of the following methods:
 - 1) Use of a low resistance ohmmeter.
 - 2) Verify tightness of accessible bolted electrical connections by calibrated torque wrench method:
 - a) Refer to the manufacturer's instructions for proper foot-pound levels or NETA ATS tables.
 - 2. Electrical tests:
 - a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter.
 - b. Measure charger float and equalizing voltage levels. Adjust to the battery manufacturer's recommended settings.
 - c. Verify charger functions and alarms.
 - d. Measure each cell voltage and total battery voltage with charger energized and in float mode of operation.
 - e. Measure intercell connection resistances.
 - f. Perform internal ohmic measurement tests.
 - g. Perform a load test in accordance with the manufacturer's published data or IEEE 1106.
 - h. Measure the battery system voltage from positive to ground and negative to ground.
 - 3. Test values:
 - a. Electrolyte level shall be within normal limits.
 - b. Compare bolted connection resistance values to values of similar connections:
 - 1) Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
 - c. Bolt-torque levels shall be in accordance with the manufacturer's published data:
 - 1) Refer to NETA ATS tables in the absence of the manufacturer's published data.

4. Test values - electrical:
 - a. Compare bolted connection resistance values to values of similar connections:
 - 1) Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
 - b. Charger float and equalize voltage levels shall be in accordance with the battery manufacturer's published data.
 - c. Results of charger functions and alarms shall be in accordance with the manufacturer's published data.
 - d. Cell voltages shall be within 0.05 volt of each other or in accordance with the manufacturer's published data.
 - e. Cell internal ohmic values (resistance, impedance, or conductance) shall not vary by more than 25 percent between identical cells that are in a fully charged state, or shall be in accordance with the manufacturer's published data.
 - f. Results of load tests shall be in accordance with the manufacturer's published data.
 - g. Voltage measured from positive to ground shall be equal in magnitude to the voltage measured from negative to ground.

AA. Direct-current systems, chargers:

1. Visual and mechanical inspection:
 - a. Compare equipment nameplate data with the Contract Documents.
 - b. Inspect for physical and mechanical condition.
 - c. Inspect anchorage, alignment, and grounding.
 - d. Verify the unit is clean.
 - e. Inspect bolted electrical connections for high resistance using one of the following methods:
 - 1) Use of low resistance ohmmeter.
 - 2) Verify tightness of accessible bolted electrical connections by calibrated torque wrench method:
 - a) Refer to the manufacturer's instructions for proper foot-pound levels or NETA ATS tables.
 - f. Inspect filter and tank capacitors.
 - g. Verify operation of cooling fans and presence of filters.
2. Electrical tests:
 - a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter.
 - b. Verify float voltage, equalize voltage, and high voltage shutdown settings.
 - c. Verify current limit.
 - d. Verify correct load sharing (parallel chargers).
 - e. Verify calibration of meters as specified in this Section.
 - f. Verify operation of alarms.
 - g. Measure and record input and output voltage and current.
 - h. Measure and record AC ripple current and voltage imposed on the battery.
 - i. Perform full-load testing of charger.
3. Test values:
 - a. Compare bolted connection resistance values to values of similar connections:
 - 1) Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.

- b. Bolt-torque levels shall be in accordance with the manufacturer's published data:
 - 1) Refer to NETA ATS tables in the absence of the manufacturer's published data.
- 4. Test values - electrical:
 - a. Compare bolted connection resistance values to values of similar connections:
 - 1) Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.
 - b. Float and equalize voltage settings shall be in accordance with the battery manufacturer's published data.
 - c. Current limit shall be within the manufacturer's recommended maximum.
 - d. Results of load sharing between parallel chargers shall be in accordance with system design specifications.
 - e. Results of meter calibration shall be as specified in this Section.
 - f. Results of alarm operation shall be in accordance with the manufacturer's published data and system design.
 - g. Input and output voltage shall be in accordance with the manufacturer's published data.
 - h. AC ripple current and voltage imposed on the battery shall be in accordance with the manufacturer's published data.
 - i. Charger shall be capable of the manufacturer's specified full load.

3.05 FIELD QUALITY CONTROL (NOT USED)

3.06 ADJUSTING (NOT USED)

3.07 CLEANING

- A. Dispose of testing expendables.
- B. Vacuum cabinets.
- C. Sweep clean surrounding areas.

END OF SECTION

SECTION 26_09_13
ELECTRICAL POWER MONITORING

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Power meters and accessories.

1.02 REFERENCES

- A. American National Standard Institute (ANSI):
 - 1. C12.20 - Electricity Meters - 0.2 and 0.5 Accuracy Classes.
- B. Institute of Electrical and Electronics Engineers (IEEE):
 - 1. C57.13.6 - Standard for High Accuracy Instrument Transformers.

1.03 TERMINOLOGY

- A. The words and terms listed below are not defined terms that require initial capital letters, but, when used in this Section, have the indicated meaning.
 - 1. FS - Full scale.
 - 2. SSM - Solid state multifunction power meter.
 - 3. THD - Total harmonic distortion.

1.04 DELEGATED DESIGN (NOT USED)

1.05 SUBMITTALS

- A. Furnish Submittals as specified in Section 01_33_00 - Submittal Procedures.
- B. Product data:
 - 1. Power meter data, including, but not limited to:
 - a. Power requirements.
 - b. Communications protocols.
 - c. Input/outputs.
 - d. Dimensions.
 - e. Measurement functions.
 - f. Front panel controls.
 - g. Display characteristics.
 - 2. Accessory data:
 - a. Test switch dimensions and wiring diagrams.
- C. Owner Training Submittals:
 - 1. As specified in Section 01_75_17 - Commissioning.

- D. Operation and maintenance manuals:
 - 1. As specified in Section 01_78_24 - Operation and Maintenance Manuals.
 - 2. Descriptive and technical bulletins and sales aids edited to reflect only the equipment to be provided and covering each of the components in the system.
 - 3. A maintenance section including instruction leaflets and technical data necessary to setup, change setup and maintain the power meters.
 - 4. Original licensed copies of software and software manuals.
- E. Configuration files and reports:
 - 1. Settings, including, but not limited to:
 - a. Device tag name.
 - b. IP addresses.
 - c. Alarm settings.
 - d. Time synchronization settings.
 - e. Security settings.
 - 2. Configuration files are to be provided in the selected manufacturer's native format.
 - 3. Configuration reports are to be submitted in .PDF format, listing each configured parameter setting and description of each parameter.

1.06 QUALITY ASSURANCE (NOT USED)

1.07 DELIVERY, STORAGE, AND HANDLING (NOT USED)

1.08 PROJECT OR SITE CONDITIONS

- A. As specified in Section 01_81_50 - Design Criteria.

1.09 ADMINISTRATIVE REQUIREMENTS (NOT USED)

1.10 WARRANTY

- A. As specified in Section 01_78_36 - Warranties and Bonds.

PART 2 PRODUCTS

2.01 GENERAL (NOT USED)

2.02 DESIGN AND PERFORMANCE CRITERIA (NOT USED)

2.03 MANUFACTURERS

- A. One of the following or equal:
 - 1. ABB.
 - 2. Allen-Bradley.
 - 3. Eaton.
 - 4. Electro Industries/GaugeTech Power Meters.
 - 5. GE Multilin.
 - 6. Schneider Electric.

2.04 MATERIALS (NOT USED)

2.05 MANUFACTURED UNITS (NOT USED)

2.06 EQUIPMENT (NOT USED)

2.07 COMPONENTS

A. Power meters:

1. Power meter type 1 (SSM1) device shall be used in MCCs, SWBD, and shall include at a minimum:
 - a. Individual phase currents, within 0.5 percent FS.
 - b. Phase-to-phase and phase-to-neutral voltages, within 0.5 percent FS.
 - c. Watts, VARs, VA, within 1 percent FS.
 - d. Watt-hours, VAR-hours, VA-hours, within 1 percent FS.
 - e. PF (apparent and displacement), within 2 percent FS.
 - f. Frequency, within 1 percent hertz.
 - g. Demand:
 - 1) Ampere, within 0.5 percent FS.
 - 2) Watt, VAR, VA, within 1 percent FS.
 - h. Minimum and maximum values:
 - 1) Volts (L-L), volts (L-N), current, watts, VARs, VA.
 - 2) Power factor:
 - a) Apparent.
 - b) Displacement.
 - c) Frequency.
 - i. Synch-input kilowatts utility.
 - j. LCD with LED backlight.
 - k. Communications:
 - 1) Modbus TCP.

2.08 ACCESSORIES

A. Current transformers:

1. Ring type:
 - a. Suitable for service within low or medium voltage equipment as indicated on the Drawings.
 - b. Designed to have a mechanical and thermal rating to withstand short-circuit current, stresses, and heating effects equal to the rating of the equipment of the application.
2. Current ratio: As indicated on the Drawings.
3. Rated in accordance with IEEE C57.13.6 with accuracy of the current transformers suitable for relay accuracy class and rated for 200 percent burden for the required connected devices.
4. Identify polarity with standard marking or symbols.
5. Capable of carrying rated primary current continuously without damage.
6. Install secondary wiring from current transformers in a suitable wiring trough, or conduit to proper short-circuiting type terminal blocks for connection to relays, instruments, and other devices.
7. 3 CTs for 3-wire systems. 4CTs for 4-wire systems.

- B. Test switches:
 - 1. Ten-pole:
 - a. 3 voltage poles, for phase voltage:
 - 1) 600 V rated.
 - b. Four 30 A, non-shorting current poles, for neutral current and let-thru phase currents.
 - c. Three 30 A, shorting current poles, for shorting phase currents.
 - 2. Base to be made of electrical grade plastic.
 - 3. Barriers between poles for pole isolation and separation.
 - 4. Clear cover encapsulating the test switch to enable visual verification of each switch position.
 - 5. Knife-blade type switches, accepting a horizontal gang interlocking bar.
 - 6. Screw type terminals on each switch.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

- A. Install power meters in accordance with the manufacturer's instructions in the electrical equipment as indicated on the Drawings.

3.04 FIELD QUALITY CONTROL

- A. Field electrical acceptance testing:
 - 1. As specified in Section 26_08_50 - Field Electrical Acceptance Tests.

3.05 OWNER TRAINING

- A. Perform Owner Training as specified in Section 01_75_17 - Commissioning.

END OF SECTION

SECTION 26_12_20

LIQUID FILLED PAD MOUNTED TRANSFORMERS

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Installation of Owner procured medium voltage, outdoor, liquid-filled pad mounted transformers.

1.02 REFERENCES

- A. American National Standards Institute (ANSI).
- B. ASTM International (ASTM).
- C. Institute of Electrical and Electronic Engineers (IEEE):
 - 1. C57.12.00 - IEEE Standard General Requirements for Liquid-Immersed Distribution, Power and Regulating Transformers.
 - 2. C57.12.10 - IEEE Standard Requirements for Liquid-Immersed Power Transformers.
 - 3. C57.12.26 - IEEE Standard for Pad-Mounted, Compartmental-Type, Self-Cooled, Three-Phase Distribution Transformers.
 - 4. C57.12.28 - IEEE Standard for Pad-Mounted Equipment-Enclosure Integrity.
 - 5. C57.12.90 - IEEE Standard Test Code for Liquid-Immersed Distribution, Power and Regulating Transformers.
 - 6. C57.91 - IEEE Guide for Loading Mineral-Oil-Immersed Power Transformers up to and including 100 MVA with 65 degrees or 55 degrees Average Winding Rise.
 - 7. C57.93 - IEEE Guide for Installation of Liquid-immersed Power Transformers.
 - 8. C57.98 - IEEE Guide for Transformer Impulse Tests.
 - 9. C57.106 - IEEE Guide for Acceptance and Maintenance of Insulating Mineral Oil in Electrical Equipment.
 - 10. C57.147 - IEEE Guide for Acceptance and Maintenance of Natural Ester Fluids in Transformers.
- D. National Electrical Manufacturers Association (NEMA):
 - 1. TR-1 - Transformers, Regulators, and Reactors.
- E. National Fire Protection Association (NFPA):
 - 1. 70 - National Electrical Code (NEC).
- F. U.S. Department of Energy (DOE):
 - 1. 10 CFR Part 431 - Energy Efficiency Program for Certain Commercial and Industrial Equipment.

1.03 DELEGATED DESIGN

- A. As specified in Section 01_35_73 - Delegated Design Procedures.
- B. Anchoring and bracing.

1.04 SUBMITTALS

- A. Furnish Submittals as specified in Section 01_33_00 - Submittal Procedures.
- B. Delegated Design Submittals:
 - 1. Anchoring and bracing: Provide project-specific calculations based on support conditions and requirements to resist loads specified in Section 01_81_50 - Design Criteria:
 - a. To structures for equipment installed in structures designated as seismic design category C, D, E, or F.
 - b. For equipment installed outdoors.
 - 2. Provide manufacturer's installation instructions.
- C. Quality Control Submittals:
 - 1. Test reports.
- D. Record documents.

1.05 QUALITY ASSURANCE (NOT USED)

1.06 DELIVERY, STORAGE, AND HANDLING (NOT USED)

1.07 PROJECT OR SITE CONDITIONS

- A. As specified in Section 01_81_50 - Design Criteria.

1.08 ADMINISTRATIVE REQUIREMENTS

- A. Sequencing:
 - 1. Make necessary field measurements to verify the equipment will fit in the allocated space in full compliance with the minimum clearances required by the NEC and local codes.
 - 2. Assemble equipment in the field.
 - 3. Conduct field acceptance test and submit certified test results for the Engineer's review.
 - 4. Verify installation is in accordance with IEEE C57.93.
 - 5. Set taps.
 - 6. Commissioning as specified in Section 01_75_17 - Commissioning.

1.09 WARRANTY

- A. As specified in Section 01_78_36 - Warranties and Bonds.

PART 2 PRODUCTS

2.01 GENERAL (NOT USED)

2.02 DESIGN AND PERFORMANCE CRITERIA (NOT USED)

2.03 MANUFACTURERS (NOT USED)

2.04 MATERIALS (NOT USED)

2.05 MANUFACTURED UNITS (NOT USED)

2.06 EQUIPMENT (NOT USED)

2.07 COMPONENTS (NOT USED)

2.08 ACCESSORIES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION

- A. Anchoring and bracing to structures:
 - 1. Prepare equipment anchor setting template(s) and use to position anchors during construction of supporting structure(s).
 - 2. Install anchors of type and material indicated on approved anchoring designs.
 - 3. Install anchors with embedment indicated on approved anchoring designs.

3.03 INSTALLATION

- A. Install the equipment in accordance with the accepted installation instructions and anchorage details.
- B. General:
 - 1. Furnish concrete pad and lugs, bolts, and other accessories needed to complete the installation of the transformer.
 - 2. Assemble and install the transformer in the location and layout indicated on the Drawings.
 - 3. Perform Work in accordance with the manufacturer's instructions and Shop Drawings.
 - 4. Raise the tank above the pad to protect the bottom finish during installation and to minimize corrosion due to moisture accumulation.
 - 5. Furnish components and equipment as required to complete the installation.

6. Replace any hardware lost or damaged during installation or handling.
7. Position the transformer so required working space and clearance requirements of the NEC and the local building authorities are met.

3.04 FIELD QUALITY CONTROL

- A. As specified in Section 26_05_00 - Common Work Results for Electrical.
- B. Field electrical acceptance testing:
 1. As specified in Section 26_08_50 - Field Electrical Acceptance Tests.
- C. Energize transformer according to the manufacturer's recommended procedure and in accordance with IEEE C57.91.

3.05 OWNER TRAINING (NOT USED)

3.06 ADJUSTING

- A. Set the transformer taps as required to obtain nominal output voltage on the secondary terminals.

END OF SECTION

SECTION 26_13_01

5-KILOVOLT MEDIUM VOLTAGE METAL CLAD SWITCHGEAR

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Installation of the Owner procured 5-kilovolt class metal clad switchgear.

1.02 REFERENCES

- A. Institute of Electrical and Electronic Engineers (IEEE):
 - 1. C37.06 - IEEE Standard for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis - Preferred Ratings and Related Required Capabilities for Voltages Above 1000 V.
 - 2. C37.20.6 - IEEE Standard for 4.76 kV Rated Ground and Test Devices Used in Enclosures.
 - 3. C62.11 - IEEE Standard for Metal Oxide Surge Arresters of AC Power Circuits (> 1 kV).
- B. National Electrical Manufacturers Association (NEMA).
- C. National Fire Protection Association (NFPA):
 - 1. 70 - National Electrical Code (NEC).
- D. Underwriters Laboratories, Inc. (UL).

1.03 DELEGATED DESIGN

- A. As specified in Section 01_35_73 - Delegated Design Procedures.
- B. Anchoring and bracing.

1.04 SUBMITTALS

- A. Furnish Submittals as specified in Section 01_33_00 - Submittal Procedures.
- B. Delegated Design Submittals:
 - 1. Anchoring and bracing: Provide project-specific calculations based on support conditions and requirements to resist loads specified in Section 01_81_50 - Design Criteria:
 - a. To structures for equipment installed in structures designated as seismic design category C, D, E, or F.
 - b. For equipment installed outdoors.
- C. Quality Control Submittals:
 - 1. Test reports.

1.05 QUALITY ASSURANCE (NOT USED)

1.06 DELIVERY, STORAGE, AND HANDLING (NOT USED)

1.07 PROJECT OR SITE CONDITIONS

A. As specified in Section 01_81_50 - Design Criteria.

1.08 ADMINISTRATIVE REQUIREMENTS

A. Sequencing:

1. Install equipment in the field.
2. Conduct final fault current and coordination study.
3. Set relays in accordance with coordination study.
4. Conduct field acceptance test.
5. Commissioning as specified in Section 01_75_17 - Commissioning.

1.09 WARRANTY

A. As specified in Section 01_78_36 - Warranties and Bonds.

PART 2 PRODUCTS

2.01 GENERAL (NOT USED)

2.02 DESIGN AND PERFORMANCE CRITERIA (NOT USED)

2.03 MANUFACTURERS (NOT USED)

2.04 MATERIALS (NOT USED)

2.05 MANUFACTURED UNITS (NOT USED)

2.06 EQUIPMENT(NOT USED)

2.07 COMPONENTS(NOT USED)

2.08 ACCESSORIES(NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES(NOT USED)

2.11 SOURCE QUALITY CONTROL (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION

- A. Anchoring and bracing to structures:
 - 1. Prepare equipment anchor setting template(s) and use to position anchors during construction of supporting structure(s).
 - 2. Install anchors of type and material indicated on approved anchoring designs.
 - 3. Install anchors with embedment indicated on approved anchoring designs.

3.03 INSTALLATION

- A. Install the equipment in accordance with the accepted installation instructions and anchorage details.
- B. General:
 - 1. Furnish cables, conduit, lugs, bolts, and other accessories needed to complete the installation of the switchgear.
 - 2. Assemble and install the switchgear in the location and layout indicated on the Drawings.
 - 3. Make bus splice connections.
 - 4. Perform Work in accordance with the manufacturer's instructions and Shop Drawings.
 - 5. Furnish components and equipment as required to complete the installation.
 - 6. Replace hardware lost or damaged during the installation or handling to provide a complete installation.
 - 7. Install the switchgear on a raised concrete housekeeping pad:
 - a. Provide structural leveling channels in accordance with the manufacturer's recommendations to provide proper alignment of the units.
 - b. Weld and/or bolt switchgear frame to leveling channels embedded in the concrete housekeeping pad.

3.04 FIELD QUALITY CONTROL

- A. As specified in Section 26_05_00 - Common Work Results for Electrical.
- B. Field electrical acceptance testing:
 - 1. As specified in Section 26_08_50 - Field Electrical Acceptance Tests.

3.05 OWNER TRAINING (NOT USED)

3.06 ADJUSTING

- A. Make adjustments as necessary and recommended by the manufacturer, Engineer, or testing firm.

- B. Provide the services of a qualified manufacturer's representative to:
1. Adjust the carriages and racking mechanisms.
 2. Adjust doors for proper operation.
 3. Adjust shutters for proper operation.

END OF SECTION

SECTION 26_13_02

15-KILOVOLT MEDIUM VOLTAGE METAL CLAD SWITCHGEAR

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Installation of the Owner procured 15-kilovolt class metal clad switchgear.

1.02 REFERENCES

- A. American National Standard Institute (ANSI).
- B. Institute of Electrical and Electronic Engineers (IEEE):
 - 1. C37.06 - IEEE Standard for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis - Preferred Ratings and Related Required Capabilities for Voltages Above 1000 V.
 - 2. C37.20.6 - IEEE Standard for 4.76 kV to 38 kV Rated Ground and Test Devices Used in Enclosures.
 - 3. C62.11 - IEEE Standard for Metal Oxide Surge Arresters of AC Power Circuits (>1kV).
- C. National Electrical Manufacturers Association (NEMA).
- D. National Fire Protection Association (NFPA):
 - 1. 70 - National Electrical Code (NEC).
- E. Underwriters Laboratories, Inc. (UL).

1.03 DELEGATED DESIGN

- A. As specified in Section 01_35_73 - Delegated Design Procedures.
- B. Anchoring and bracing.

1.04 SUBMITTALS

- A. Furnish Submittals as specified in Section 01_33_00 - Submittal Procedures.
- B. Delegated Design Submittals:
 - 1. Anchoring and bracing: Provide project-specific calculations based on support conditions and requirements to resist loads specified in Section 01_81_50 - Design Criteria:
 - a. To structures for equipment installed in structures designated as seismic design category C, D, E, or F.
 - b. For equipment installed outdoors.

- C. Quality Control Submittals:
 - 1. Test reports.

1.05 QUALITY ASSURANCE (NOT USED)

1.06 DELIVERY, STORAGE, AND HANDLING (NOT USED)

1.07 PROJECT OR SITE CONDITIONS

- A. As specified in Section 01_81_50 - Design Criteria.

1.08 ADMINISTRATIVE REQUIREMENTS

- A. Sequencing:
 - 1. Assemble equipment in the field.
 - 2. Conduct final fault current and coordination study.
 - 3. Set relays in accordance with the coordination study.
 - 4. Conduct field acceptance test and submit results for the Engineer's review.
 - 5. Commissioning as specified in Section 01_75_17 - Commissioning.

1.09 WARRANTY

- A. As specified in Section 01_78_36 - Warranties and Bonds.

PART 2 PRODUCTS

2.01 GENERAL (NOT USED)

2.02 DESIGN AND PERFORMANCE CRITERIA (NOT USED)

2.03 MANUFACTURERS (NOT USED)

2.04 MATERIALS (NOT USED)

2.05 MANUFACTURED UNITS (NOT USED)

2.06 EQUIPMENT (NOT USED)

2.07 COMPONENTS (NOT USED)

2.08 ACCESSORIES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION

- A. Anchoring and bracing to structures:
 - 1. Prepare equipment anchor setting template(s) and use to position anchors during construction of supporting structure(s).
 - 2. Install anchors of type and material indicated on approved anchoring designs.
 - 3. Install anchors with embedment indicated on approved anchoring designs.

3.03 INSTALLATION

- A. Install the equipment in accordance with the accepted installation instructions and anchorage details.
- B. General:
 - 1. Furnish cables, conduit, lugs, bolts, and other accessories needed to complete the installation of the switchgear.
 - 2. Assemble and install the switchgear in the location and layout indicated on the Drawings and in complete conformance with the manufacturer's recommended procedures.
 - 3. Make bus splice connections.
 - 4. Perform Work in accordance with the manufacturer's instructions and Shop Drawings.
 - 5. Furnish components and equipment as required to complete the installation.
 - 6. Replace hardware lost or damaged during the installation or handling to provide a complete installation.
 - 7. Install the switchgear on a raised concrete housekeeping pad:
 - a. Provide structural leveling channels in accordance with the manufacturer's recommendations to provide proper alignment of the units.
 - b. Weld and/or bolt switchgear frame to leveling channels embedded in the concrete housekeeping pad.

3.04 FIELD QUALITY CONTROL

- A. As specified in Section 26_05_00 - Common Work Results for Electrical.
- B. Field electrical acceptance testing:
 - 1. As specified in Section 26_08_50 - Field Electrical Acceptance Test.

3.05 OWNER TRAINING (NOT USED)

3.06 ADJUSTING

- A. Make adjustments as necessary and recommended by the manufacturer, Engineer, or testing firm.

- B. Provide the services of a qualified manufacturer's representative to:
1. Adjust the carriages and racking mechanisms.
 2. Adjust doors for proper operation.
 3. Adjust shutters for proper operation.

END OF SECTION

SECTION 26_13_05

PROTECTIVE RELAYS

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Protective relays.
 - 2. Current transformers.
 - 3. Voltage transformers.

1.02 REFERENCES

- A. Abbreviations:
 - 1. CPT: Control power transformer.
 - 2. CT: Current transformers.
 - 3. FPS: Feeder protection system.
 - 4. GPS: Generator protection system.
 - 5. PF (pf): Power factor.
 - 6. PU (pu): Per unit.
 - 7. VT: Voltage transformers.
- B. Standards:
 - 1. Institute of Electrical and Electronics Engineers (IEEE):
 - a. 1588 - IEEE Standard for a Precision Clock Synchronization Protocol for Networked Measurement and Control Systems.
 - b. 1613 - IEEE Standard Environmental and Testing Requirements for Communications Networking Devices in Electric Power.
 - c. C37.90.1 - IEEE Standard for Surge Withstand Capability (SWC) Tests for Relays and Relay Systems Associated with Electric Power Apparatus.
 - d. C37.90.2 - IEEE Standard for Withstand Capability of Relay Systems to Radiated Electromagnetic Interference from Transceivers.
 - e. C37.118 - IEEE Standard for Synchrophasor for Power Systems.
 - f. C57.13 - IEEE Standard Requirements for Instrument Transformers.
 - 2. International Electrotechnical Commission (IEC):
 - a. 60068 - Environmental testing.
 - b. 60255 - Measuring relays and protection equipment.
 - c. 60870 - Telecontrol equipment and systems.
 - d. 61131 - Programmable controllers.
 - e. 61850 - Communication networks and systems for power utility automation.
 - 3. Underwriters Laboratories, Inc. (UL).

1.03 TERMINOLOGY

- A. The words and terms listed below are not defined terms that require initial capital letters, but, when used in this Section, have the indicated meaning.
 - 1. HMI: Human machine interface is a software application that presents information to an operator or user about the state of a process, and to accept and implement the operators control instructions. Typically, information is displayed in a graphical format.
 - 2. LOI: Local operator interface is an operator interface device consisting of an alphanumeric or graphic display with operator input functionality. The LOI is typically a flat panel type of display mounted on the front of an enclosure with either a touch screen or tactile button interface, or a display on the face of the protective relay.

1.04 DELEGATED DESIGN (NOT USED)

1.05 SUBMITTALS

- A. Furnish Submittals as specified in Section 01_33_00 - Submittal Procedures.
- B. Product data:
 - 1. Manufacturer of relay.
 - 2. Descriptive literature.
 - 3. Relay ANSI device functions.
 - 4. Power requirements and connections.
 - 5. Communications provisions and connections.
 - 6. Controls.
 - 7. Mounting.
 - 8. Nameplate schedule.
 - 9. Itemized bill of material, including manufacturer, complete model number, and options included.
 - 10. Description of operation.
 - 11. Cut sheets for components, electrical devices, and mechanical devices:
 - a. Catalog information.
 - b. Descriptive literature.
 - c. External power and signal connections.
 - 12. List of recommended spare parts.
 - 13. Name, address, telephone number, and cell phone number of relay manufacturer's authorized local field service technician.
- C. Shop Drawings:
 - 1. Provide complete terminal block connection diagrams for the protective relays.
 - 2. Manufacturer's recommended wiring and interconnection diagrams for the specific project to be used to compare with the electrical equipment manufacturer's detailed Submittal.
- D. Calculations:
 - 1. Direct current power and current requirements needed to operate the protective relays and associated equipment.

2. Current transformer sizing calculations to substantiate that the current transformers will not saturate under a maximum fault current event.
 3. Burden, cable sizing, CT class, for differential CTs located remote from the switchgear or relay.
- E. Resumes:
1. Provide the following resumes for review and acceptance by the Engineer:
 - a. Protective relay manufacturer qualifications: A minimum of 15 years of documented experience in the Work of this Section.
 - b. Documented list of a minimum of 15 electric utilities using the protective relays used on the project along with complete contact information.
 - c. Protective relay programmer:
 - 1) Must have a minimum of 5 years' experience in programming, setting, and testing of protective relays used on the project.
 - 2) Certified by the protective relay manufacturer:
 - a) Employee of the protective relay manufacturer.
 - b) Employee of the switchgear manufacturer.
 - c) Employee of the testing firm as specified in Section 26_08_50 - Field Electrical Acceptance Tests.
 - d. Must fully document and substantiate experience with programming and setting the actual protective relays provided for this Project.
- F. Owner Training Submittals:
1. As specified in Section 01_75_17 - Commissioning.
- G. Operation and maintenance manuals:
1. Submit operating and installation instructions and a maintenance manual presenting full details for care and maintenance of equipment of every nature furnished and/or installed under this Contract.
 2. Maintenance manual:
 - a. Furnish with instructions covering details pertaining to care and maintenance of the equipment as well as data identifying the parts.
 - b. Shall include, but are not limited to, the following:
 - 1) Adjustment and test instructions covering the steps involved in the initial test, adjustment, and start-up procedures.
 - 2) Detailed control instructions that outline the purpose and operation of every control device used in normal operation.
- H. Test reports:
1. Provide .csv file, or similar format, for Engineer review of relay settings and programming.
 2. Information such as 1-line diagrams, time-current curves, calculations, etc., used to determine the settings shall be submitted with the exported relay file for review.

1.06 QUALITY ASSURANCE

- A. Relays, instrument transformers, and associated equipment shall be UL listed and labeled.

- B. Specific protective relay manufacturer requirements:
 - 1. Minimum of 15 years of documented experience in providing electric utility grade protective relays to electrical utilities.
 - 2. Protective relay programmer must have a minimum of 5 years' experience in programming, setting, and testing of protective relays used on the project.

1.07 DELIVERY, STORAGE, AND HANDLING (NOT USED)

1.08 PROJECT OR SITE CONDITIONS

- A. As specified in Section 01_81_50 - Design Criteria.

1.09 ADMINISTRATIVE REQUIREMENTS (NOT USED)

1.10 WARRANTY

- A. As specified in Section 01_78_36 - Warranties and Bonds.

PART 2 PRODUCTS

2.01 GENERAL

- A. Protective relays, current transformers, and voltage transformers with the protective functions as indicated on the Drawings.

2.02 DESIGN AND PERFORMANCE CRITERIA

- A. Specifications and Drawings show the desired functionality:
 - 1. It is understood that the named manufacturers' protective relays do not have the same functionality on a device-by-device comparison.
 - 2. It is the protective relay manufacturer's responsibility to configure the system with their products in order to provide the functionality as indicated on the Drawings and specified in this Section, using their standard products.

2.03 MANUFACTURERS

- A. Refer to the individual relay specifications for additional listings of acceptable manufacturers and model numbers.

2.04 MATERIALS (NOT USED)

2.05 MANUFACTURED UNITS (NOT USED)

2.06 EQUIPMENT (NOT USED)

2.07 COMPONENTS

- A. Protective relays:
 - 1. General:
 - a. Furnish relays complete with devices and associated circuitry necessary to perform the required functions as specified or indicated on the Drawings.

- b. Manufacturers of relays and controls are listed to describe system operating requirements.
 - c. Furnish material not specifically listed or shown but necessary to perform required functions.
 - d. Mounting:
 - 1) As indicated on the Drawings.
 - e. Provide nameplates as specified in Section 26_05_53 - Identification for Electrical Systems.
2. Lockout relay:
- a. Where indicated on the Drawings, provide an ANSI function 86 lockout relay.
 - b. Operating voltage: 125 VDC.
 - c. Functions:
 - 1) Trip control.
 - 2) Block close control.
 - 3) Green LED for ready indication.
 - 4) Red LED for tripped indication.
 - 5) Black RESET target.
 - 6) Orange TRIP target.
 - 7) Manual reset.
 - d. Manufacturers: One of the following or equal:
 - 1) Electroschwitch, Series 24.
 - 2) General Electric, Type SB.
3. Solid state digital relays:
- a. General:
 - 1) Multifunction, microprocessor based with monitoring and communications capabilities, with native IEC 61850 support.
 - 2) Continuous self-diagnostics.
 - 3) Fault recording:
 - a) Monitor and record fault data.
 - b) Fault events stored in event reports.
 - c) Event reports saved to non-volatile memory.
 - 4) Front keypad and display for programming and configuration:
 - a) 1 control pushbutton programmed to set relay protective functions to the minimum values.
 - b) Password protection for security.
 - 5) A minimum of 2 programmable digital inputs and 4 Form C programmable outputs.
 - 6) Installation and control connections, one of the following:
 - a) Draw-out case that allows removal of the relay without having to disconnect wiring. CT circuits shall be self-shorting with make before-break operation on removal of the relay.
 - b) Connectorized terminals with shorting for each current input.
 - 7) Selection for coordination with common IEC, WH-CO, and GE-IAC curves as specified in Section 26_05_74 - Electrical System Studies. For each individual protective relay:
 - a) Definite time.
 - b) Moderately inverse.
 - c) Inverse.
 - d) Very inverse.
 - e) Extremely inverse.

- 8) Power supply: 125 VDC.
- 9) Provide common communications media for protective relays as follows, or as indicated on the Drawings:
 - a) Copper Ethernet.
- 10) Provide common communications protocols for protective relays as follows, or as indicated on the Drawings:
 - a) Modbus TCP.
- 4. Feeder protection system (FPS):
 - a. Description:
 - 1) Provide protective, metering, and control functionality, with setup, control, and monitoring programmable logic, front panel LOI, and remote communications.
 - b. Specific requirements:
 - 1) Directional inverse time overcurrent elements monitoring current on all 3 phases, 2 sets of neutral current calculated by the relay from phase current summation or an independent ground CT and calculated negative sequence current:
 - a) Each element may be set as forward, reverse, or non-directional.
 - b) User shall have the option of phase element being voltage controlled, voltage restrained, or neither (e.g., normal voltage independent overcurrent relays).
 - c) Functions: 51P, 51N, 51G, 51Q or 46.
 - 2) 2 sets of directional instantaneous time overcurrent elements with a user-settable time delay monitoring all 3 phases, the neutral calculated by the relay from phase current summation, the independent ground CT, and the calculated negative sequence current:
 - a) Each element may be set as forward, reverse, or non-directional.
 - b) Functions: 50P, 50N, 50G, 50Q or 46 Instantaneous.
 - c) Targeting shall show 67 if element is set as forward or reverse.
 - 3) Selection for coordination with common protective device coordination curves:
 - a) As specified in Section 26_05_74 - Electrical System Studies.
 - b) User-selectable reset rate to either integrating reset, to mimic the slow return to zero of induction disks, or instantaneous reset.
 - 4) Suitable for monitoring either 3-wire or 4-wire PT configurations:
 - a) Monitor phase overvoltage, phase undervoltage, and calculate and monitor negative sequence (V2) voltage.
 - b) User-settable phase overvoltage element to trip only for 1, 2, or 3 phases out of range.
 - c) User-settable fixed time delay tripping for each element.
 - d) User-settable phase element monitoring for either phase-phase or phase-ground.
 - e) Maximum phase setting shall be 300 VPP.
 - f) Function: 27, 59, 47N or 59Q.
 - 5) Monitor line currents and voltages and provide the following information:
 - a) Present values: Phase, neutral and negative sequence currents, volts; forward and reverse watts, VARs, watt-hours, VAR-hours.
 - b) Demand values: Phase, neutral, and negative sequence current, 3-phase watts and VARs, and peak since last demand reset.

- 6) User-definable programmable logic:
 - a) Logic able to inter-tie relay control inputs, output contacts, LOI and HMI addressable switches, protective element logical I/O, reclosing element I/O, timer element I/O, settings group control, and relay internal alarms.
- 7) 4 independent setting groups selectable by user logic:
 - a) Logic may utilize relay hardwire inputs, LOI or remote communications commands, relay internal logic, reclose status, or an automatic dynamic selection based on recent load levels.
- 8) Self-testing and alarming:
 - a) Capable of monitoring breaker systems, including the trip circuit, breaker trip time, breaker duty statistics, as well as power system conditions, including overloads and unbalances and alarming for such conditions.
 - b) User-defined logic points programmable as major or minor alarms.
- 9) Detailed sequence of events logger showing internal logic change of state for an event:
 - a) With multiple oscillographic reports for currents showing pre-fault, faulted, and post-fault currents.
- 10) LOI that allows reading of measured values and performing basic setting changes.
 - a) Capable of being programmed to automatically display and scroll user-specified information.
- 11) Controllable via virtual switches which are HMI or LOI addressable:
 - a) Switches may be usable for on/off/pulse of any user-selected function or logic point (e.g., instantaneous element block or reclose enable).
- 12) 1 virtual breaker control switch, accessible locally from the LOI or remotely from the communications ports, to provide trip and close control of a selected breaker:
 - a) Function: 101.
 - b) 4 virtual switches with 3 modes of operation, accessible locally from the LOI or remotely from the communications ports, can be used (e.g., to trip and close additional switches or breakers, or to enable and disable certain functions).
- 13) Minimum of 4 hardwired control inputs:
 - a) Each input programmable to represent system status, e.g., breaker position, or control any user-defined function or logic point.
 - b) Minimum of 5 normally open output contacts plus 1 normally closed major/relay alarm contact.
 - c) Contacts programmable to follow custom user-defined logic schemes.
 - d) Minimum make and carry 30 A, 0.2 s, 6 A continuous.
 - e) Break 0.3 ADC at L/R=0.04.
- 14) With a breaker or lockout relay trip circuit monitor to monitor for loss of voltage, fuse blown, or loss of continuity, trip coil open.

- 15) Meeting the isolation, surge withstand, fast transient, impulse, and radio interference standards in accordance with IEEE C37.90.1 and IEEE C37.90.2.
- 16) Future firmware enhancements made through flash memory.
- c. Manufacturers: One of the following:
 - 1) ABB, REF615.
 - 2) Basler. Model BE1-11f.
 - 3) Schweitzer, SEL-751A.
5. High-impedance bus differential relay (87B):
 - a. Description:
 - 1) High-speed, high-impedance, solid state bus differential relay, providing high speed fault protection.
 - b. Specific requirements:
 - 1) 3-phase current sensing zone between line-side of the switchgear's main breaker and associated feeder breakers.
 - 2) Operation time:
 - a) Maximum operating time for any fault: 1.25 cycles (21 msec).
 - 3) Sensing range input: 0.25 to 2.50 A.
 - 4) Timing: Instantaneous or 20 msec delay.
 - 5) CT overvoltage:
 - a) Alarm voltage selectable range: 10 to 80 percent in 10 percent increments.
 - b) Detect unbalance voltages.
 - c) CT overvoltage LED alarm lights.
 - 6) Pickup voltage control:
 - a) Pickup voltage setting range from 50 to 400 volts in 50-volt increments.
 - 7) Pickup current control:
 - a) Current setting of 0.25 to 2.50 A RMS in 0.25 A increments.
 - b) Setting determines the level of current sensing input resulting in the trip output contact closure.
 - c) With trip LED lights.
 - d) Operation based on the instantaneous peak value of the sinusoidal current detected.
 - 8) Pickup current trip LED:
 - a) Indicates when the level of current through the relay exceeds the setting of the pickup current control.
 - b) Latches on until reset button is pressed.
 - 9) Trip test pushbutton:
 - a) Used to simulate a trip condition to verify operation of output trip contacts, verify operation of trip LED lights.
 - 10) CT test pushbutton:
 - a) Used to verify the health of the CT input circuit.
 - b) Provide 1 CT Diagnostic Test Source.
 - c. Function: 87B.
 - d. Manufacturers: One of the following:
 - 1) ABB, REF615-N + 3 ph voltage dependent resistors.
 - 2) Basler, BE1-87B:
 - a) Basler P/N 9282300014 - CT Diagnostic.
 - 3) Schweitzer, SEL-587Z.

6. Current differential relay (87M, 87T):
 - a. Description:
 - 1) Provide current differential protection with programmable single- or dual-slope percentage restraint for 2-winding transformers, reactors, generator, large motors, and other 2-terminal apparatuses.
 - 2) Use second- and fourth-harmonic blocking or restraint along with DC blocking to supervise differential elements during transformer energization conditions.
 - 3) Calculate fifth harmonic to supervise differential element operations during transformer over excitation events.
 - 4) Solid-state relay that compares 3-phase current entering and leaving the generator.
 - b. Specific requirements:
 - 1) Sensing input: As indicated on the Drawings.
 - 2) Restraint factor that is proportional to input current when the restraining current is greater than nominal by comparing the sensed input and output current and the lesser of the 2 sensed current level becomes the restraining current.
 - a) Difference between the 2 sensed currents is compared to a reference established by the sensitivity setting, adjusted by an amount proportional to the restraining current, increasing the sensitivity to low current internal faults and less sensitive to external faults with high level of through current.
 - 3) Function: 87M.
 - c. Manufacturers: One of the following:
 - 1) ABB:
 - a) Generator: REG615-D.
 - b) Transformer: RET615-B.
 - 2) Basler:
 - a) BE1-FLEX.
 - 3) Schweitzer:
 - a) SEL-587.
 - b) SEL-710.
 - c) SEL-787.
7. Instantaneous/Time overcurrent relay (50/51):
 - a. Description:
 - 1) Microprocessor based, multifunction protective that provides instantaneous (50) and time (51) overcurrent protection for the monitoring and control of power systems equipment.
 - 2) 3 current inputs to measure phase current:
 - a) Fundamental algorithm that responds to the fundamental component of the current and rejects the harmonic components.
 - b) Measures magnitude of the negative-sequence component of the fundamental phase current.
 - b. Specific requirements:
 - 1) Instantaneous overcurrent functions each with settable time delays: 50P, 50G, 50Q.
 - 2) Time overcurrent: 51P, 51G, 51Q.
 - 3) General purpose logic timers: 62.

- 4) AC current inputs:
 - a) 5A nominal:
 - (1) 15 A continuous; 500 A for 1 second linear to 100 A symmetrical.
 - (2) Limiting dynamic value: 625 A for 1 cycle.
 - (3) Burden: 0.16 VA at 5 A, 1.15 VA at 15 A.
 - b) 1A nominal:
 - (1) 3 A continuous; 100 A for 1 second linear to 20 A symmetrical.
 - (2) Limiting dynamic value: 250 A for 1 cycle.
- 5) Burden: 0.06 VA at 1A, 0.18 VA at 3 A.
- 6) Control switches:
 - a) 1 breaker control switch.
 - b) 4 virtual control switches.
 - c) Trip and close control of a selected breaker either locally or from HMI.
- 7) Metering:
 - a) Measured current and derived neutral and negative-sequence currents.
 - b) Demand reporting for all phases, neutral, and negative-sequence currents with user settable demand intervals.
 - c) Measurement accuracy: Within 2 percent.
- 8) Sequence of events recorder:
 - a) User-programmable.
 - b) Time stamped.
- 9) Sensing input:
 - a) 3-phase.
- c. Function: 50, 51, 50/51.
- d. Manufacturers: One of the following:
 - 1) ABB, REF615.
 - 2) Basler, Model BE1-851.
 - 3) Schweitzer, Model SEL-501.
8. Motor protection relay MPR Type 2:
 - a. Description:
 - 1) Provides protection of medium-voltage 3-phase induction and synchronous motors using a slip-dependent thermal model.
 - 2) Provides locked rotor, overload, over temperature, differential protection.
 - 3) Provide voltage transformers, current transformers, and a digital motor protection and management relay as indicated on the Drawings.
 - b. Specific requirements:
 - 1) Protection:
 - a) Primary protective function shall be a thermal model consisting of:
 - (1) Overload curves.
 - (2) Negative sequence unbalance/single phase biasing.
 - (3) RTD biasing (hot/cold motor compensation).
 - (4) Motor cooling time constants.
 - (5) Start inhibit and emergency restart.
 - (6) RTD biasing.
 - (7) Combine inputs from positive and negative sequence currents and RTD winding feedback.

- (8) Dynamic in nature in order to follow the loading and temperature of the motor.
- (9) Provide protection of the rotor during stall and acceleration:
 - (a) Stall/acceleration curve shall be voltage compensated.
 - (b) A speed switch input shall be available.
- (10) INOM = 5 A secondary as indicated on the Drawings.
- b) Thermal overload 49:
 - (1) Full-load current (FLA) Limits: 0.2 to 5,000.0 A primary (limited to 20 to 160 percent of CT rating).
 - (2) Locked rotor current: 2.5 to 12.0*FLA.
 - (3) Hot locked rotor time: 1.0 to 600.0 seconds.
 - (4) Service factor: 1.01 to 1.5.
 - (5) Accuracy: 5 percent within 25 ms at multiples of FLA greater than 2 (cold curve method).
- c) Short circuit 50P:
 - (1) Setting range: Off, 0.10 to 20.00*FLA in 0.01*FLA increments.
 - (2) Accuracy: Within 5 percent of setting within 0.02* INOM RMS secondary.
 - (3) Maximum pickup/dropout time: 1.5 cycles.
 - (4) Time delay: 0.0 to 5.0 seconds in 0.01 second increments.
 - (5) Accuracy: Within 0.5 percent of setting within 0.25 cycle.
- d) Ground fault 50G:
 - (1) Setting range: Off, 0.10 to 20.00*FLA in 0.01*FLA increments.
 - (2) Accuracy: Within 5 percent of setting within 0.02* INOM RMS secondary.
 - (3) Maximum pickup/dropout time: 1.5 cycles.
 - (4) Time delay: 0.0 to 5.0 seconds in 0.01 second increments.
 - (5) Accuracy: Within 0.5 percent of setting within 0.25 cycle.
- e) Ground fault 50N:
 - (1) Setting range:
 - (a) 1A, 5A: Off, 0.01 to 650.00 A primary in 0.01 A RMS increments.
 - (b) 2.5 mA: Off, 0.01 to 25.00 A primary in 0.01 A RMS increments.
 - (2) Accuracy: Within 5 percent of setting within 0.05 mA secondary.
 - (3) Maximum pickup/dropout time:
 - (a) 1A, 5A: 1.5 cycles/1.5 cycles.
 - (b) 2.5 mA: 100 msec plus 1.5 cycles/1.5 cycles.
 - (4) Time delay: 0.0 to 5.0 seconds in 0.01 second increments.
 - (5) Accuracy: Within 0.5 percent of setting within 0.25 cycles.
- f) Negative-sequence overcurrent 50Q:
 - (1) Setting range: Off, 0.10 to 20.00*FLA in 0.01*FLA increments.
 - (2) Accuracy: Within 5 percent of setting within 0.02* INOM secondary.
 - (3) Maximum pickup/dropout time: 1.5cycles.
 - (4) Time delay: 0.0 to 120.0 seconds in 0.01 second increments.
 - (5) Within 0.5 percent of setting within 0.25 cycle.

- g) Inverse-time overcurrent phase 51P:
 - (1) Pickup setting range secondary:
 - (a) 5A: Off, 0.50 to 10.00 A in 0.01 A steps.
 - (b) 1A: Off, 0.10 to 2.00 A in 0.01 A steps.
 - (2) Accuracy: Within 5 percent of setting within 0.02-INOM secondary.
 - (3) Time dial: 0.50 to 15.00 in 0.01 steps.
 - (4) Accuracy: Within 1.5 cycles within 4 percent between 2 and 30 multiples of pickup.
- h) Inverse-time overcurrent ground 51G:
 - (1) Pickup setting range secondary:
 - (a) 5A: Off, 0.50 to 10.00 A in 0.01 A steps.
 - (b) 1A: Off, 0.10 to 2.00 A in 0.01 A steps.
 - (2) Accuracy: Within 5 percent of setting within 0.02-INOM secondary.
 - (3) Time dial: 0.50 to 15.00 in 0.01 steps.
 - (4) Accuracy: Within 1.5 cycles within 4 percent between 2 and 30 multiples of pickup.
- i) Inverse-time overcurrent negative-sequence 51Q:
 - (1) Pickup setting range secondary:
 - (a) 5A: Off, 0.50 to 10.00 A in 0.01 A steps.
 - (b) 1A: Off, 0.10 to 2.00 A in 0.01 A steps.
 - (2) Accuracy: Within 5 percent of setting within 0.02-INOM secondary.
 - (3) Time dial: 0.50 to 15.00 in 0.01 steps.
 - (4) Accuracy: Within 1.5 cycles within 4 percent between 2 and 30 multiples of pickup.
- j) Differential protection 87M:
 - (1) Setting range: Off, 0.05 to 8.00 A secondary.
 - (2) Accuracy: Within 5 percent of setting within 0.10 A secondary.
 - (3) Maximum pickup/dropout time: 1.5 cycles.
 - (4) Accuracy: Within 0.5 percent of setting within 0.25 cycle.
- c. Manufacturers: One of the following:
 - 1) ABB,
 - REX640B10NN+AIM2+AIM2+ADD1+APP7+ARC1+BIO2+CMP2+COM4+LNG1+MCT2+PCL1+PSM2+RTD1+SCT1:
 - a) Additional 2 RTD inputs, 2 mA inputs, 4 mA outputs with RIO600 (PSMH+LECMIR+RTD4+AOM4) modules.
 - b) RIO600 communication with REX640 via RJ45 Ethernet port.
 - 2) Schweitzer, SEL-710-5.
- d. Transformer differential relays:
 - 1) Provide the following functions as a minimum:
 - a) Phase time overcurrent: 51P.
 - b) Phase instantaneous overcurrent: 50P.
 - c) Ground time overcurrent: 51G.
 - d) Ground instantaneous overcurrent: 50G.
 - e) Differential current: 87.
 - 2) Provide multiple relays where necessary to meet the required protective functions and the zone interlocking capability.

- 3) Manufacturers: One of the following:
 - a) ABB, RET615.
 - b) Basler, BE1-CDS-220/BE1-1051.
 - c) Schweitzer, SEL-587-1/SEL-351S.

2.08 ACCESSORIES

A. Current transformers:

1. Ring type:
 - a. Suitable for service within low or medium voltage switchgear as indicated on the Drawings.
 - b. Designed to have a mechanical and thermal rating to withstand short-circuit current, stresses, and heating effects equal to the rating of the circuit breaker of the application.
2. Current ratio: As indicated on the Drawings, for use as a guideline:
 - a. It is the switchgear manufacturer's responsibility to size the current transformers to ensure that they will not saturate under the maximum available fault current at the installed location based upon the fault current study as preformed as specified in Section 26_05_74 - Electrical System Studies.
3. Rated in accordance with IEEE C57.13 with accuracy of the current transformers suitable for relay accuracy class and rated for 200 percent burden for the required connected devices.
4. Identify polarity with standard marking or symbols.
5. Capable of carrying rated primary current continuously without damage.
6. Install secondary wiring from current transformers in a suitable wiring trough, or conduit to proper short-circuiting type terminal blocks for connection to relays, instruments, and other devices.

B. Voltage transformers:

1. Indoor dry type, single-phase, 60 hertz, with a minimum thermal capacity of not less than 400 volt-amps at 131 degrees Fahrenheit rise above 104 degrees Fahrenheit ambient.
2. Accuracy classification in accordance with IEEE C57.13, suitable for relay accuracy class, and 200 percent burden, for the required connected devices, with the secondary voltage 120 volts.
3. Insulation levels as required for the switchgear system voltage but not less than:
 - a. 600 VAC, 10 kV BIL for 480 VAC systems.
 - b. 5.6 kV, 60 kV BIL for 2300 and 4160 VAC systems.
 - c. 15.5 kV, 110 kV BIL for 12.47 kV and 13.2 kV systems.
4. Identify polarity with standard markings or symbols.
5. Connect secondaries to voltage buses as required.
6. Provide primary and secondary current-limiting fuses.

C. Test blocks and plugs:

1. Make-before-break connections for CT circuits.
2. Provide cover for each test block.
3. Manufacturers: One of the following or equal:
 - a. ABB, FT-1:
 - 1) 10-pole test switch.

- b. Multilin, PK-2:
 - 1) Current circuits: 6-pole test blocks.
 - 2) Voltage circuits: 4-pole test blocks.
- D. Satellite-synchronized clock:
 - 1. Provide a master clock to synchronize the clock functions of the protective relays:
 - a. IEEE 1588 PTP clock for IEC 61850-9-2LE.
 - 2. Surge standards:
 - a. IEEE C37.90.
 - b. IEC 60255.
 - 3. Power supply: 125 VDC:
 - a. Burden: Less than 15 W, less than 35 VA.
 - 4. Output: 6 unmodulated IRIG-B time-code outputs:
 - a. User-selectable for 1 PPS, 1 kPPS, IRIG-B.
 - b. IRIG Standard 200-02, Format B006.
 - c. Fiber-optic port:
 - 1) ST connections.
 - 2) Multiplexes an unmodulated IRIG-B signal on the data communications signal.
 - 3) 9,600 bps.
 - 5. Operating temperature: -40 degrees Fahrenheit to 176 degrees Fahrenheit.
 - 6. Altitude: 2,000 m (6,500 ft) AMSL.
 - 7. Clock accuracy to UTC time:
 - a. 1 PPS: Within 100 ns average, within 500 ns peak.
 - b. Unmodulated IRIG-B: Within 100 ns average, within 500 ns peak.
 - c. Modulated IRIG-B: Within 1 μ s peak.
 - d. Serial Port BX command: Within 500 μ s peak.
 - e. Holdover stability: Within 0.08 ppm for 20 minutes (from -40 degrees Fahrenheit to 176 degrees Fahrenheit).
 - 8. Antenna:
 - a. GPS GNSS:
 - 1) 5 V, less than 80 mA.
 - 2) 35 dB preamp.
 - b. Mounting:
 - 1) Unobstructed 360-degree view of sky.
 - 2) Low and close to the control house roof, above the maximum snow accumulation level.
 - c. Surge protector:
 - 1) Equalize the difference in voltage that can occur between the center conductor and the shield of the coaxial cable between the antenna and the clock.
 - 2) Located at building enclosure entrance.
 - 3) Ground the surge protector and clock to the same point.
 - 4) TNC female antenna connected.
 - d. Display:
 - 1) Front-panel LEDs show clock progress from start to satellite lock.
 - 2) Display: Ordinal day of the year: HH:MM:SS.
 - 3) Indicators:
 - a) Enabled.

- b) Satellite Lock.
 - c) Holdover.
 - 9. Manufacturers: The following:
 - a. Basler.
 - b. Schweitzer:
 - 1) Clock: SEL-2407.
 - 2) Antenna: SEL-9524A GPC GNSS.
 - 3) Surge protector: SEL Surge Protector Kit 915900139.
 - 4) Cable: SEL-C961.
- E. Real time process controller:
 - 1. General:
 - a. Information processor operating both serial and Ethernet communications network:
 - 1) Providing the following functions:
 - a) Deterministic logic processing.
 - b) Automatic transmission of outgoing messages.
 - c) Processing of responses.
 - d) Data scaling.
 - e) Data aggregation.
 - f) Simultaneous collection of data from multiple server devices for various manufacturers.
 - g) Simultaneous data access for multiple client (master) devices.
 - b. Suitable for use in utility substations or industrial control and automation systems.
 - c. Provides control with integrated security, seamless configuration, unified logic, and reliability.
 - d. Converts data between multiple protocols, communicates with any configured and connected device with an embedded IEC 61131 logic engine.
 - e. 32-bit microcontroller for protective relay-speed I/O, logic, and communications.
 - f. Precision time protocol (PTP) and demodulated IRIG-B input that synchronizes connected intelligent electronic devices (IEDs) to absolute time and drives the demodulated IRIG-B output, enabling synchronized control and management.
 - 2. Protocols:
 - a. Provide the following:
 - 1) FTP.
 - 2) SFTP.
 - 3) DNP3 serial.
 - 4) DNP3 LAN/WAN.
 - 5) IEC 61850 MMS.
 - 6) Modbus RTU.
 - 7) Modbus TCP.
 - 8) LG 8979.
 - 9) IEEE C37.118.
 - 10) IEC 60870-5-101/104.
 - 11) SES-92.
 - b. Client:
 - 1) CP2179.

- 2) Flex Parse.
- 3) SEL ASCII and Binary.
- 4) SNMP.
- 5) DNP3 serial.
- 6) DNP3 LAN/WAN.
- 7) IEC 61850 MMS.
- 8) Modbus RTU.
- 9) Modbus TCP.
- 10) LG 8979.
- 11) IEEE C37.118.
- 12) IEC 60870-5-101/104.
- 13) SES-92.
- 14) EtherCAT.
- c. Peer-to-peer:
 - 1) IEC 61850 GOOSE transmit and receive messages.
 - 2) Parallel Redundancy Protocol.
- 3. CPU:
 - a. Error correcting code (ECC) RAM information processor.
- 4. Intelligent and secure components:
 - a. Electronic equipment continuously self-testing and reports internal errors, including a hardwire contact indicating device health.
- 5. Programming:
 - a. Integrated IEC 61131-3 programming environment for the information processor, with the ability to continuously monitor and control every protective relay and Ethernet-distributed I/O module in the electrical system.
 - b. IEC 61131-3 programming environment integrated in 1 software package with the communications protocol mapping environment.
- 6. Role-based security:
 - a. Independent user-based security with strong passwords, role-based accounts, and settable account expiration dates.
 - b. Provide a mechanism to map security-related system tags into HMI reports.
- 7. Integrated HMI:
 - a. Integrated web-based human-machine interface (HMI) that provides visualization and control of data tags.
- 8. Central authentication:
 - a. Lightweight directory access protocol (LDAP) to provide central user account authentication.
- 9. Selectable processing interval and solve order:
 - a. Provide a method to configure the deterministic processing interval for protocol communications and custom logic, including a method to configure the processing sequence of software tasks.
 - b. Processing interval settable to as fast as 1 ms.
- 10. High-speed peer-to-peer communication:
 - a. Utilizing MIRRORED BITS® communications protocol to transmit and receive high-speed digital data to/from intelligent electronic devices (IEDs) to create custom protection and control schemes.
- 11. Communications:
 - a. Serial ports:
 - 1) Each port software configurable for RS-232 or RS-485 communications modes.

- b. Ethernet ports:
 - 1) 2 or more Ethernet ports that can operate simultaneously on different networks through independent MAC addresses.
 - 2) Ports configurable as fiber-optic or copper Ethernet ports.
- 12. Alarm output:
 - a. Programmable dry contact output to signal internal errors and malfunctions, as well as additional conditions.
- 13. Environmental testing:
 - a. Information processor tested to IEEE 1613-2003 for communications and networking equipment in electric power substations, and to the same standards as protective relays, including the following:
 - 1) Cold:
 - a) IEC 60068-2-1:2007.
 - b) IEC 61850-3:2013.
 - c) IEEE 1613-2003.
 - d) Severity level: 16 hours at -40 degrees Celsius.
 - 2) Damp heat, cyclic:
 - a) IEC 60068-2-30:2005.
 - b) IEC 61850-3:2013.
 - c) IEEE 1613-2003.
 - d) Severity level: 12 + 12-hour cycle, 25 degrees Celsius to 55 degrees Celsius, 6 cycles, 95 percent relative humidity.
 - 3) Dry heat:
 - a) IEC 60068-2-2:2007.
 - b) IEC 61850-3:2013.
 - c) IEEE 1613-2003.
 - 4) Vibration:
 - a) IEC 60255-21-1:1988.
 - b) IEC 61850-3:2013:
 - (1) Severity level: Endurance Class 2, Response Class 2.
 - c) IEC 60255-21-2:1988:
 - (1) Severity level: Shock Withstand, Bump Class 1, Shock Response Class 2.
 - d) IEC 60255-21-3:1993:
 - (1) Severity level: Quake Response Class 2.
 - e) IEEE 1613-2003:
 - (1) Severity level: V.S.4.
- 14. Synchrophasors:
 - a. Capable of receiving synchronized phasor measurement data via the IEEE C37.118 protocol on serial and Ethernet ports to as fast as 5 messages per second.
- 15. Retained memory:
 - a. Nonvolatile memory available for user-programmable retained variables.
- 16. Engineering access:
 - a. Transparent connections between any serial or Ethernet communications ports for engineering access.
- 17. Conformal coating:
 - a. Of the circuit boards.
- 18. Reliability:
 - a. Submit actual measured mean time between failures (MTBF) for the device.

19. Service:
 - a. Manufacturer provided no-cost technical support for the life of the product.
 - b. Manufacturer to support a 72-hour turn-around on warranty repairs.
20. SEL-2240 Axion®:
 - a. Deterministic ethernet fieldbus:
 - 1) Utilizing EtherCAT protocol to operate a deterministic, Ethernet-based fieldbus network for connected I/O modules.
 - b. Digital inputs sequential events:
 - 1) Maintain a user-configurable record of digital input operations on the EtherCAT network that is accurate to 1 ms.
 - c. DC analog inputs:
 - 1) Include up to 16 DC analog input modules.
 - 2) Input ranges: Within 20 mA.
 - d. DC analog outputs:
 - 1) Include up to 16 DC analog output modules.
 - 2) Output ranges: Within 20 mA.
 - e. AC metering inputs:
 - 1) Include up to 16 CT/PT analog input modules.
 - 2) Input ranges:
 - a) CT: 0 to 22 A.
 - b) PT: 5 to 400 V.
 - f. AC protection inputs:
 - 1) Include up to 16 CT/PT protection modules.
 - 2) Input ranges:
 - a) CT: 0 to 20 A.
 - b) PT: 6 to 300 V.
 - g. Redundant power supply:
 - 1) Provide 2 power supply modules that continuously share load.
 - 2) If the incoming power for 1 module becomes unavailable, the remaining power supply shall have sufficient capacity to accommodate an entire node.
21. Manufacturers: The following:
 - a. Schweitzer:
 - 1) SEL-3530.

F. Control wiring:

1. As specified in the electrical equipment specifications.

G. Miscellaneous:

1. Provide terminal blocks, wireways, wiring, device mounting brackets, and other miscellaneous items.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION (NOT USED)

3.04 FIELD QUALITY CONTROL

- A. Functional Testing:
 - 1. As specified in Section 26_08_50 - Field Electrical Acceptance Tests.
- B. Manufacturer's services:
 - 1. Provide the services of a qualified relay manufacturer's representative to test:
 - a. Differential protection schemes.
 - b. Utility paralleling schemes.
 - c. Complete testing of the power management system confirming the calibration, accuracy, and communications.

3.05 OWNER TRAINING

- A. Perform Owner Training as specified in Section 01_75_17 - Commissioning.

3.06 ADJUSTING

- A. Protective relay programmer to adjust trip settings in accordance with the protective device coordination study as accepted by the Engineer and in accordance with the protective relay manufacturer's recommendations:
 - 1. Export settings to a standard format that is reviewable for the Engineer (i.e., .csv file, etc.). Submit for review as specified in this Section.

END OF SECTION

SECTION 26_18_42

MEDIUM VOLTAGE VARIABLE FREQUENCY DRIVE

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Requirements for installation and testing of medium voltage VFD systems for tag numbers VFD-302, VFD-303, VFD-305, VFD-306 that were previously procured by the Owner.

1.02 REFERENCES

- A. Institute of Electrical and Electronics Engineers (IEEE):
 - 1. 18 - Standard for Shunt Power Capacitors.
 - 2. 519 - IEEE Standard for Harmonic Control in Electric Power Systems.
 - 3. 1036 - IEEE Guide for the Application of Shunt Power Capacitors.
 - 4. C57.12.01 - IEEE Standard for General Requirements for Dry-Type Distribution and Power Transformers.
 - 5. C57.16 - IEEE Standard for Requirement, Terminology, and Test Code for Dry-Type Air-Core Series-Connected Reactors.
 - 6. C62.11 - Standard for Metal-Oxide Surge Arresters for AC Power Circuits (>1 kV).
- B. International Organization for Standardization (ISO):
 - 1. 9001 - Quality Management Systems - Requirements.
- C. National Electrical Manufacturers Association (NEMA):
 - 1. 250 - Enclosures for Electrical Equipment (1,000 V Maximum).
- D. Underwriters Laboratories, Inc. (UL).

1.03 TERMINOLOGY

- A. The words and terms listed below are not defined terms that require initial capital letters, but, when used in this Section, have the indicated meaning.
 - 1. Point of common coupling (PCC): The point of common coupling for harmonic calculations and field measurements for both voltage and current distortion shall be defined as the primary connection of each VFD input isolation transformer.
 - 2. VFD manufacturer, Supplier and VFD supplier shall be defined as the same entity for the purposes of this document.

1.04 DELEGATED DESIGN

- A. As specified in Section 01_35_73 - Delegated Design Procedures.
- B. Anchoring and bracing.

1.05 SUBMITTALS

- A. Furnish Submittals as specified in Section 01_33_00 - Submittal Procedures:
- B. Calculations:
 - 1. Complete protective device and drive parameter study based upon the actual power system configuration and the actual motor protection parameters.
- C. Delegated Design Submittals:
 - 1. Anchoring and bracing: Provide project-specific calculations based on support conditions and requirements to resist loads specified in Section 01_81_50 - Design Criteria:
 - a. To structures for equipment installed in structures designated as seismic design category C, D, E, or F.
 - b. For equipment installed outdoors.
- D. Quality Control Submittals:
 - 1. Test reports.
 - 2. Report listing the setting of VFD adjustable parameters and their values after start-up.

1.06 QUALITY ASSURANCE (NOT USED)

1.07 DELIVERY, STORAGE, AND HANDLING

- A. Handling, and unloading:
 - 1. Complete instructions for handling and storage shall be provided before delivery of the equipment:
 - a. Equipment shall have adequate provisions for handling by overhead crane or forklift truck.
- B. Acceptance at Site:
 - 1. Upon arrival at the Site, the Contractor and the VFD manufacturer shall inspect the equipment and identify any shortcomings or damage.
 - 2. Repair damage and correct shortcomings within 30 days of delivery at the Site.

1.08 PROJECT OR SITE CONDITIONS (NOT USED)

1.09 ADMINISTRATIVE REQUIREMENTS

- A. Sequencing:
 - 1. Assemble equipment in the field.
 - 2. Conduct final fault current and coordination study.
 - 3. Set relays in accordance with coordination study.
 - 4. Conduct field acceptance test and submit results for the Engineer's review.
 - 5. Commissioning and process start-up as specified in Section 01_75_17 - Commissioning.

1.10 WARRANTY

- A. As specified in Section 01_78_36 - Warranties and Bonds.

1.11 SYSTEM START-UP (NOT USED)

1.12 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 GENERAL (NOT USED)

2.02 DESIGN AND PERFORMANCE CRITERIA (NOT USED)

2.03 MANUFACTURERS (NOT USED)

2.04 MATERIALS (NOT USED)

2.05 MANUFACTURED UNITS (NOT USED)

2.06 EQUIPMENT (NOT USED)

2.07 COMPONENTS (NOT USED)

2.08 ACCESSORIES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION

- A. Anchoring and bracing to structures:
 - 1. Prepare equipment anchor setting template(s) and use to position anchors during construction of supporting structure(s).
 - 2. Install anchors of type and material indicated on approved anchoring designs.
 - 3. Install anchors with embedment indicated on approved anchoring designs.

3.03 INSTALLATION

- A. Install the equipment in accordance with the accepted installation instructions and anchorage details.
- B. General:
 - 1. Furnish cables, conduit, lugs, bolts, and other accessories needed to complete installation of the VFD.
 - 2. Assemble and install the VFD in the locations and with the layouts indicated on the Drawings.

3. Perform Work in accordance with the manufacturer's instructions and Shop Drawings.
4. Furnish components, and equipment as required to complete the installation.
5. Replace any hardware lost or damaged during the installation or handling to provide a complete installation.
6. Install free-standing enclosures on a raised concrete housekeeping pad:
 - a. Provide structural leveling channels in accordance with the manufacturer's recommendations to provide proper alignment of the units.
 - b. Weld and/or bolt the VFD frame to the leveling channels.
7. Provide openings in top or bottom of the VFD enclosure for conduit only, no additional openings will be allowed:
 - a. Improperly cut holes will require that the entire panel be replaced:
 - 1) No hole closers or patches will be allowed.
8. Bundle circuits together and terminate in each unit:
 - a. Tie with nylon wire ties. As specified in Section 26_05_18 - 600-Volt or Less Wires and Cables.
 - b. Label wires at each end with wire numbers shown on the approved control Drawings.
 - c. Connections to and from the VFD enclosure must be made via terminal blocks.

3.04 FIELD QUALITY CONTROL

- A. As specified in Section 26_05_00 - Common Work Results for Electrical.
- B. Field electrical acceptance testing:
 1. As specified in Section 26_08_50 - Field Electrical Acceptance Tests.

3.05 OWNER TRAINING (NOT USED)

3.06 ADJUSTING

- A. Make adjustments as necessary and recommended by the manufacturer, Engineer, or testing firm.

END OF SECTION

SECTION 26_22_14
DRY-TYPE TRANSFORMERS

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Enclosed dry-type transformers:
 - a. Rated 1 to 1,000 kilovolt-amperes, single and 3-phase.
 - b. Primary voltage 600 volts and below.

1.02 REFERENCES

- A. Institute of Electrical and Electronics Engineers (IEEE):
 - 1. 389 - IEEE Recommended Practice for Testing Electronics Transformers and Inductors.
 - 2. C57.96 - IEEE Guide for Loading Dry-Type Distribution and Power Transformers.
- B. Underwriters Laboratory (UL):
 - 1. 1561 - Standard for Dry-Type General Purpose and Power Transformers.
- C. United States Department of Energy (DOE):
 - 1. 10 CFR Part 431 - Energy Efficiency Program for Certain Commercial and Industrial Equipment.

1.03 DELEGATED DESIGN

- A. As specified in Section 01_35_73 - Delegated Design Procedures.
- B. Anchoring and bracing.

1.04 SUBMITTALS

- A. Furnish Submittals as specified in Section 01_33_00 - Submittal Procedures.
- B. Product data:
 - 1. Catalog cutsheets.
 - 2. Nameplate data.
 - 3. Dimensions:
 - a. Height.
 - b. Width.
 - c. Depth.
 - 4. Inrush current.
 - 5. Insulation system and temperature constraints.
 - 6. Number and rating of taps.
 - 7. Sound levels.

8. Connection diagrams:
 - a. Primary.
 - b. Secondary.
 9. BIL rating.
 10. Required clearances.
 11. Percent impedance.
 12. Efficiency.
 13. Certification of full capacity capability at the Project elevation and ambient conditions.
 14. For equipment installed in structures designated as seismic design category C, D, E, or F, submit the following as specified in Section 01_81_50 - Design Criteria:
 - a. Manufacturer's statement of seismic qualification with substantiating test data.
 - b. Manufacturer's special seismic certification with substantiating test data.
- C. Delegated Design Submittals:
1. Anchoring and bracing: Provide project-specific calculations based on support conditions and requirements to resist loads specified in Section 01_81_50 - Design Criteria:
 - a. To structures for equipment installed in structures designated as seismic design category C, D, E, or F.
 - b. For equipment installed outdoors.
- D. Installation instructions:
1. Detail the complete installation of the equipment including rigging, moving, and setting into place.
 2. Provide manufacturer's installation instructions.
- E. Quality Control Submittals:
1. Manufacturer's Certificate of Source Testing as specified in Section 01_75_17 - Commissioning.

1.05 QUALITY ASSURANCE (NOT USED)

1.06 DELIVERY, STORAGE, AND HANDLING (NOT USED)

1.07 PROJECT OR SITE CONDITIONS

- A. As specified in Section 01_81_50 - Design Criteria.

1.08 ADMINISTRATIVE REQUIREMENTS (NOT USED)

1.09 WARRANTY

- A. As specified in Section 01_78_36 - Warranties and Bonds.

PART 2 PRODUCTS

2.01 GENERAL (NOT USED)

2.02 DESIGN AND PERFORMANCE CRITERIA

- A. Provide equipment and components that are fully rated for the site elevation and operating environment where the equipment will be installed as specified in Section 01_81_50 - Design Criteria and as indicated on the Drawings.
- B. Provide 3-phase or 1-phase, 60 hertz dry-type with voltage ratings, kilovolt-ampere capacities, and connections as indicated on the Drawings:
 - 1. Transformers shall provide full capacity at the Project elevation and environmental conditions as specified in Section 01_81_50 - Design Criteria after all derating factors have been applied.
 - 2. Suitable for continuous operation at full rating with normal life expectancy in accordance with IEEE C57.96.

2.03 MANUFACTURERS

- A. One of the following or equal:
 - 1. ABB.
 - 2. Eaton.
 - 3. Jefferson.
 - 4. Schneider Electric.

2.04 MATERIALS

- A. Cores:
 - 1. Non-aging, grain-oriented silicon steel.
 - 2. Magnetic flux densities below the saturation point.
- B. Windings:
 - 1. High-grade magnet wire.
 - 2. Impregnated assembly with non-hydroscopic, thermo-setting varnish:
 - a. Cured to reduce hot-spots and seal out moisture.
 - 3. Material electrical grade:
 - a. Copper.

2.05 MANUFACTURED UNITS (NOT USED)

2.06 EQUIPMENT

- A. General:
 - 1. 10 kilovolts BIL for 600-volt class windings.
 - 2. Sound levels, in accordance with IEEE 389 test conditions, not to exceed:

Kilovolt-Amperes Range	Audible Sound Level (dB)
1-9	40
10-50	45

Kilovolt-Amperes Range	Audible Sound Level (dB)
51-150	50
151-300	55
301-500	60
501-700	62
701-1,000	64

3. Taps:
 - a. 15 kilovolt-amperes and less:
 - 1) Two 5 percent full capacity primary taps below rated voltage.
 - b. 25 kilovolt-amperes and larger:
 - 1) Four 2.5 percent full capacity primary taps below rated voltage.
 - 2) Two 2.5 percent full capacity primary taps above rated voltage.
 - c. Operated by a tap changer handle or tap jumpers accessible through a panel.
 4. Terminals:
 - a. UL listed for either copper or aluminum conductors.
 - b. Rated for 75 degrees Celsius.
 5. Daily overload capacities, at rated voltage and without reduction in life, in accordance with IEEE C57.96.
- B. Transformers less than 15 kilovolt-amperes:
1. Insulation class: 185 degrees Celsius.
 2. Temperature rise: 115 degrees Celsius.
- C. Energy efficient transformers 15 kilovolt-amperes and larger:
1. Insulation class: 220 degrees Celsius.
 2. Temperature rise: 80 degrees Celsius, except as noted below:
 - a. 150-degree Celsius rise for dry-type transformers located in motor control centers.
 3. Efficiency:
 - a. In accordance with DOE 10 CFR Part 431.
- D. Enclosures:
1. Heavy gauge steel:
 - a. Outdoor: Moisture and water resistant with rodent screens over openings and in a weather-protected enclosure, NEMA Type 3R.
 - b. Indoor: NEMA Type 2.
 2. Louvers to limit coil temperature rise to the value stated above, and case temperature rise to 50 degrees Celsius.
 3. Built-in vibration dampeners to isolate the core and coils from the enclosure:
 - a. Neoprene vibration pads and sleeves.

2.07 COMPONENTS (NOT USED)

2.08 ACCESSORIES

A. Nameplates:

1. Non-corrosive metal or UL listed non-metallic:
 - a. Stamped, engraved or printed with the following information:
 - 1) Phases.
 - 2) Frequency.
 - 3) Kilovolt-ampere rating.
 - 4) Voltage ratings.
 - 5) Temperature rise.
 - 6) Impedance.
 - 7) Insulation class.
 - 8) BIL rating.
 - 9) Connection diagram.
 - 10) Weight.
 - 11) Manufacturer.
 - 12) Identification "transformer."
 - 13) Classes of cooling.
 - 14) Tap voltage(s).
 - 15) Vector diagram.

2.09 FABRICATION (NOT USED)

2.10 FINISHES

- ### **A.**
- Finish to consist of de-greasing, phosphate cleaning, and an electrodeposited manufacturer's standard gray enamel rust-inhibiting paint.

2.11 SOURCE QUALITY CONTROL

A. Factory tests:

1. Applied voltage test to each winding and from each winding to the core:
 - a. 600-volt class winding 4.5 kilovolt.
2. Induced voltage test at 2 times normal voltage and 400 hertz for 1,080 cycles.
3. Voltage ratio and polarity.
4. Sound level, performed in a test room with ambient sound level not exceeding 24 dB.
5. Perform tests in accordance with UL 1561.
6. Furnish test reports and Manufacturer's Certificate of Source Testing.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION

A. Anchoring and bracing to structures:

1. Prepare equipment anchor setting template(s) and use to position anchors during construction of supporting structure(s).
2. Install anchors of type and material indicated on approved anchoring designs.

3. Install anchors with embedment indicated on approved anchoring designs.

3.03 INSTALLATION

- A. Install the equipment in accordance with the accepted installation instructions and anchorage details.
- B. General:
 1. Mounted as indicated on the Drawings.
 2. Install where not in direct contact with building structure.
 3. Install on single layer vibration pad under the entire mounting surface:
 - a. Manufacturers: The following or equal:
 - 1) Korfund.
 4. Make any necessary connections to the enclosure with liquidtight flexible conduit having neoprene gaskets and insulated ground bushings.
 5. Ground the enclosure:
 - a. To an equipment ground conductor in the conduit.
 - b. To the facility grounding electrode system.
 6. Floor mounted transformers:
 - a. Install transformers on a housekeeping pads.
 - b. Install transformers with adequate space from walls or other enclosures for proper ventilation in accordance with the manufacturer's recommendations.

3.04 FIELD QUALITY CONTROL

- A. Field electrical acceptance testing:
 1. As specified in Section 26_08_50 - Field Electrical Acceptance Tests.

3.05 OWNER TRAINING (NOT USED)

3.06 ADJUSTING

- A. Set the transformer taps as required to obtain nominal output voltage on the secondary terminals.

END OF SECTION

SECTION 26_24_15

INDIVIDUALLY MOUNTED CIRCUIT BREAKER SWITCHBOARDS

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Installation of Owner procured free standing, dead-front type metal-enclosed, low voltage switchboards with individually mounted circuit protective devices.

1.02 REFERENCES

- A. International Organization for Standardization (ISO):
 - 1. 9001 - Quality Management Systems - Requirements.
- B. National Electrical Manufacturers Association (NEMA):
 - 1. 250 - Enclosures for Electrical Equipment (1,000 V Maximum).
 - 2. PB 2 - Deadfront Distribution Switchboards.
- C. National Fire Protection Association (NFPA):
 - 1. 70 - National Electrical Code.
 - 2. 70E® - Standard for Electrical Safety in the Workplace®.
- D. Underwriters Laboratories, Inc. (UL):
 - 1. 891 - Switchboards.

1.03 DELEGATED DESIGN

- A. As specified in Section 01_35_73 - Delegated Design Procedures.
- B. Anchoring and bracing.

1.04 SUBMITTALS

- A. Furnish Submittals as specified in Section 01_33_00 - Submittal Procedures.
- B. Delegated Design Submittals:
 - 1. Anchoring and bracing: Provide project-specific calculations based on support conditions and requirements to resist loads specified in Section 01_81_50 - Design Criteria:
 - a. To structures for equipment installed in structures designated as seismic design category C, D, E, or F.
 - b. For equipment installed outdoors.
- C. Quality Control Submittals:
 - 1. Test reports.

1.05 QUALITY ASSURANCE (NOT USED)

1.06 DELIVERY, STORAGE, AND HANDLING (NOT USED)

1.07 PROJECT OR SITE CONDITIONS

A. As specified in Section 01_81_50 - Design Criteria.

1.08 ADMINISTRATIVE REQUIREMENTS

A. Sequencing:

1. Assemble equipment in the field.
2. Conduct final fault current and coordination study.
3. Conduct field acceptance test and submit results for the Engineer's review.
4. Commissioning as specified in Section 01_75_17 - Commissioning.

1.09 WARRANTY

A. As specified in Section 01_78_36 - Warranties and Bonds.

PART 2 PRODUCTS

2.01 GENERAL (NOT USED)

2.02 DESIGN AND PERFORMANCE CRITERIA (NOT USED)

2.03 MANUFACTURERS (NOT USED)

2.04 MATERIALS (NOT USED)

2.05 MANUFACTURED UNITS (NOT USED)

2.06 EQUIPMENT (NOT USED)

2.07 COMPONENTS (NOT USED)

2.08 ACCESSORIES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION

- A. Anchoring and bracing to structures:
 - 1. Prepare equipment anchor setting template(s) and use to position anchors during construction of supporting structure(s).
 - 2. Install anchors of type and material indicated on approved anchoring designs.
 - 3. Install anchors with embedment indicated on approved anchoring designs.

3.03 INSTALLATION

- A. Install the equipment in accordance with the accepted installation instructions and anchorage details.
- B. General:
 - 1. Furnish cables, conduit, lugs, bolts, and other accessories needed to complete the installation of the switchboard.
 - 2. Physically assemble and install the switchboard in the location and layout indicated on the Drawings.
 - 3. Make bus splice connections.
 - 4. Perform Work in accordance with the manufacturer's instructions and Shop Drawings.
 - 5. Furnish components and equipment as required to complete the installation.
 - 6. Replace hardware lost or damaged during the installation or handling to provide a complete installation.
 - 7. Install the switchboard on a raised concrete housekeeping pad:
 - a. Provide structural leveling channels in accordance with the manufacturer's recommendations to provide proper alignment of the units.
 - b. Weld and/or bolt the switchgear frame to the leveling channels.
 - 8. Provide openings in top or bottom of the enclosure for conduit only, no additional openings will be allowed:
 - a. Improperly cut holes will require that the entire panel be replaced:
 - 1) No hole closers or patches will be allowed.

3.04 FIELD QUALITY CONTROL

- A. As specified in Section 26_05_00 - Common Work Results for Electrical.
- B. Field electrical acceptance testing:
 - 1. As specified in Section 26_08_50 - Field Electrical Acceptance Tests.

3.05 OWNER TRAINING (NOT USED)

3.06 ADJUSTING

- A. Make adjustments as necessary and recommended by the manufacturer, Engineer, or testing firm.

END OF SECTION

SECTION 26_24_16

PANELBOARDS

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Panelboards serving feeder circuits and branch circuits.

1.02 REFERENCES

- A. National Electrical Manufacturers Association (NEMA):
 - 1. 250 - Enclosures for Electrical Equipment (1,000 V Maximum).
- B. National Fire Protection Association (NFPA):
 - 1. 70 - National Electrical Code (NEC).
- C. Underwriters Laboratories, Inc. (UL):
 - 1. 67 - Standard for Panelboards.

1.03 DELEGATED DESIGN

- A. As specified in Section 01_35_73 - Delegated Design Procedures.
- B. Anchoring and bracing.

1.04 SUBMITTALS

- A. Furnish Submittals as specified in Section 01_33_00 - Submittal Procedures.
- B. Product data:
 - 1. Manufacturer of panelboard.
 - 2. Bill of material.
 - 3. Assembly ratings including:
 - a. Voltage.
 - b. Phase.
 - c. Continuous current.
 - d. Short circuit interrupting rating.
 - 4. NEMA enclosure type.
 - 5. Cable terminal sizes based upon actual feeder and sub-feeder conductors used.
 - 6. Furnish circuit breaker Submittals as specified in Section 26_28_01 - Low Voltage Molded Case Circuit Breakers.
 - 7. For equipment installed in structures designated as seismic design category C, D, E, or F, submit the following as specified in Section 01_81_50 - Design Criteria:
 - a. Manufacturer's statement of seismic qualification with substantiating test data.
 - b. Manufacturer's special seismic certification with substantiating test data.

- C. Shop Drawings:
 - 1. Overall panelboard dimensions, interior panel dimensions, and wiring gutter dimensions:
 - a. Height.
 - b. Length.
 - c. Width.
 - 2. Weight.
 - 3. Anchoring locations.
 - 4. Breaker layout drawing with dimensions:
 - a. Location of the main, branches, solid neutral, and ground.
 - 5. Conduit entry/exit locations:
 - a. Identify conduit entry/exit locations and restrictions.
 - 6. Individual panel schedules identifying breaker locations, ratings, and nameplate designations within the panelboard, for every panelboard.
- D. Calculations:
 - 1. Detailed calculations or details of the actual physical testing performed on the panelboard to prove the panelboard is suitable for the seismic requirements at the Project Site.
- E. Delegated Design Submittals:
 - 1. Anchoring and bracing: Provide project-specific calculations based on support conditions and requirements to resist loads specified in Section 01_81_50 - Design Criteria:
 - a. To structures for equipment installed in structures designated as seismic design category C, D, E, or F.
 - b. For equipment installed outdoors.
 - c. For wall mounted equipment weighing 125 pounds or more.
- F. Installation instructions:
 - 1. Detail the complete installation of the equipment including rigging, moving, and setting into place.
 - 2. Provide manufacturer's installation instructions.
- G. Quality Control Submittals:
 - 1. Manufacturer's Certificate of Source Testing as specified in Section 01_75_17 - Commissioning.
 - 2. Test reports.
- H. Operations and maintenance manual:
 - 1. As specified in Section 01_78_24 - Operation and Maintenance Manuals.
 - 2. Provide a complete manual for the operation and maintenance of the panelboard, circuit breakers, devices, and accessories:
 - a. Including, but not limited to:
 - 1) Instruction narratives and bulletins.
 - 2) Renewal parts lists.
 - 3) Time-current curves for all devices.

1.05 QUALITY ASSURANCE

- A. Where indicated as service entrance equipment, panelboards shall be UL listed and labeled "Suitable for Service Entrance."

1.06 DELIVERY, STORAGE, AND HANDLING (NOT USED)

1.07 PROJECT OR SITE CONDITIONS

- A. As specified in Section 01_81_50 - Design Criteria.

1.08 ADMINISTRATIVE REQUIREMENTS (NOT USED)

1.09 WARRANTY

- A. As specified in Section 01_78_36 - Warranties and Bonds.

PART 2 PRODUCTS

2.01 GENERAL

- A. Circuit breaker panelboards as indicated in the panelboard schedules, one-lines, and where indicated on the Drawings:
 - 1. Service voltage and configuration as indicated on the panel schedules.

2.02 DESIGN AND PERFORMANCE CRITERIA

- A. Provide equipment and components that are fully rated for the site elevation and operating environment where the equipment will be installed as specified in Section 01_81_50 - Design Criteria and as indicated on the Drawings.
- B. Non-conditioned spaces:
 - 1. Provide additional temperature conditioning equipment to maintain the equipment temperature within a band of 10 degrees Fahrenheit above the minimum operating temperature and 10 degrees Fahrenheit below maximum operating temperature.
- C. Outdoor installations:
 - 1. Provide conditioning equipment incorporated into the equipment to maintain the enclosures within the equipment manufacturer's specified operating ranges.

2.03 MANUFACTURERS

- A. One of the following or equal:
 - 1. ABB.
 - 2. Eaton.
 - 3. Schneider Electric.
- B. Circuit breakers:
 - 1. Same manufacturer as the panelboard.

2.04 MATERIALS (NOT USED)

2.05 MANUFACTURED UNITS (NOT USED)

2.06 EQUIPMENT

- A. Provide panelboards with:
 - 1. Molded-case circuit breakers with trip ratings as shown on the panel schedules.
 - 2. Spares and spaces for future circuit breakers in panels as shown on the panel schedules.
 - a. Space for future devices as specified in Section 26_05_00 - Common Work Requirements for Electrical.
- B. Short circuit rating:
 - 1. Provide as indicated on the Drawings.
 - 2. Testing method in accordance with UL 67.
 - 3. Mark each panelboard with its maximum short circuit rating at the supply voltage.
 - 4. Panelboards shall be fully rated.

2.07 COMPONENTS

- A. Enclosure:
 - 1. NEMA enclosure type as indicated on the Drawings:
 - a. Where not indicated on the Drawings, as specified in Section 26_05_00 - Common Work Results for Electrical for the installed location.
 - 2. Minimum width: 20 inches.
 - 3. Gutter space in accordance with the NEC:
 - a. Minimum of 4 inches.
 - 4. Dead-front, no live parts when the panelboard is in service.
 - 5. Enclose entire panelboard bus assembly in a corrosion resistant galvanized steel cabinet.
 - 6. 4-piece front to provide ease of wiring access.
 - 7. Lockable, hinged door over the protective devices with a flush, cylinder tumbler-type lock with catch and door pull:
 - a. Minimum 2 keys per panelboard.
 - b. Key all panelboard locks alike.
 - 8. Circuit directory frame and card on the inside of the door.
 - 9. Interior design such that replacement of circuit breakers does not require disturbing adjacent units or removal of the main bus connectors.
 - 10. Outdoor locations: Provide NEMA Type 4X enclosures with a NEMA Type 4X stainless steel outer enclosure (with a hinged door) and a NEMA Type 1 interior panelboard, unless otherwise indicated.
- B. Bus:
 - 1. General:
 - a. Tin-plated copper.
 - 2. Phase bus:
 - a. Full size and height without reduction.

- b. Dimensions and temperature rise in accordance with UL 67:
 - 1) Limit current density to less than 1,000 amps per square inch.
 - c. Insulate current carrying parts from ground and phase-to-phase with a high dielectric strength insulator.
 - 3. Ground bus:
 - a. Copper, solidly bonded.
 - 4. Neutral bus:
 - a. Provide where indicated on the Drawings.
 - b. 100 percent rated.
 - c. Provide lugs for each outgoing feeder requiring a neutral connection.
 - 5. Provide insulation barriers over the vertical bus behind the dead front shield to provide increased safety during field service.
- C. Lugs:
 - 1. UL listed for copper and aluminum wire:
 - a. Rated for 75-degree Celsius terminations.
 - b. Provide bolted or compression main lug terminations as required for the incoming cable size.
- D. Circuit breakers: As specified in Section 26_28_01 - Low Voltage Molded Case Circuit Breakers and as indicated on the Drawings:
 - 1. Provide with bolt-on connections:
 - a. Plug-in circuit breakers are not allowed.

2.08 ACCESSORIES

- A. Surge protective devices:
 - 1. Furnish panelboards with surge protective devices as indicated on the Drawings.
 - 2. As specified in Section 26_43_14 - Surge Protective Devices.
- B. Nameplates:
 - 1. As specified in Section 26_05_53 - Identification for Electrical Systems.
 - 2. Install on outside of door.
 - 3. Indicating:
 - a. Panel designation.
 - b. Voltage.
 - c. Number of phases and configuration.
- C. Circuit identification labels:
 - 1. Provide index cards behind heavy clear plastic in cardholders on the inside of the doors.
 - 2. Type all information on the cards using designations in the panel schedules.
 - 3. Laminated on both sides.
- D. Pad locking mechanism:
 - 1. Provide a pad locking attachment to allow circuit breakers to be locked in the off position.
 - 2. At a minimum, provide 1 mechanism per panelboard:
 - a. Provide multiple mechanisms if required to accommodate all circuit breaker frame sizes in the panelboard.

2.09 FABRICATION (NOT USED)

2.10 FINISHES

- A. Finish stand-alone panelboards with a primer, rust-resistant phosphate undercoat, and 2 coats of oven-baked enamel with manufacturer's standard gray.
- B. Finish panelboards mounted in motor control centers to match the motor control center finish and color.

2.11 SOURCE QUALITY CONTROL

- A. Source Testing:
 - 1. Perform standard factory tests on the panelboards.
 - 2. Test in accordance with NEMA and UL standards.
 - 3. Furnish test reports and Manufacturer's Certificate of Source Testing.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION

- A. Anchoring and bracing to structures:
 - 1. Prepare equipment anchor setting template(s) and use to position anchors during construction of supporting structure(s).
 - 2. Install anchors of type and material indicated on approved anchoring designs.
 - 3. Install anchors with embedment indicated on approved anchoring designs.

3.03 INSTALLATION

- A. Install the equipment in accordance with the accepted installation instructions and anchorage details.
- B. General:
 - 1. Mounted as indicated on the Drawings.
 - 2. Mount rigidly to structural members with exposed surfaces plumb and level to within 1/32 inch.
 - 3. Perform Work in accordance with the manufacturer's instructions and Shop Drawings.
 - 4. Provide brackets, hangers, supports, and hardware for mounting as required.
 - 5. In NEMA Type 4 and NEMA Type 4X locations, mount panelboards on 7/8-inch deep stainless steel preformed channel, with channel running vertically from top to bottom of panelboard:
 - a. Use only stainless steel mounting hardware.
 - 6. Mount panelboard so that top operating handle is not more than 6 feet-7 inches above the operating floor.
- C. Provide typewritten schedule in each panelboard.

3.04 FIELD QUALITY CONTROL

- A. As specified in Section 26_05_00 - Common Work Results for Electrical.
- B. Field electrical acceptance testing:
 - 1. As specified in Section 26_08_50 - Field Electrical Acceptance Tests.

END OF SECTION

SECTION 26_24_20

LOW VOLTAGE MOTOR CONTROL CENTERS

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Low voltage motor control centers.

1.02 REFERENCES

- A. National Electrical Manufacturers Association (NEMA):
 - 1. 250 - Enclosures for Electrical Equipment (1,000 V Maximum).
 - 2. ICS 18-2001 - Motor Control Centers.
- B. National Fire Protection Association (NFPA):
 - 1. 70 - National Electrical Code (NEC).
- C. Underwriters Laboratories (UL):
 - 1. 845 - Motor Control Centers.

1.03 TERMINOLOGY

- A. The words and terms listed below are not defined terms that require initial capital letters, but, when used in this Section, have the indicated meaning.
 - 1. SELV: Safety extra-low voltage.

1.04 DELEGATED DESIGN

- A. As specified in Section 01_35_73 - Delegated Design Procedures.
- B. Anchoring and bracing.

1.05 SUBMITTALS

- A. Furnish Submittals as specified in Section 01_33_00 - Submittal Procedures.
- B. Product data:
 - 1. Manufacturer of motor control center.
 - 2. Manufacturer of motor control center parts.
 - 3. Nameplate schedule.
 - 4. Bill of material.
 - 5. Enclosure:
 - a. NEMA rating.
 - b. Finish color.
 - 6. Ratings:
 - a. Voltage.
 - b. Phase.

- c. Current:
 - 1) Horizontal bus ampacity.
 - 2) Vertical bus ampacity.
 - 3) Ground bus ampacity.
 - d. Short circuit withstand rating.
 - e. Protective device interrupting rating.
 - 7. List of recommended spare parts.
 - 8. Catalog cutsheets:
 - a. Submit complete manufacturer's catalog information:
 - 1) Clearly indicate the features of the equipment, including any options necessary to meet the required functionality.
 - 9. Furnish component Submittals as specified in the appropriate Section.
 - 10. For equipment installed in structures designated as seismic design category C, D, E, or F, submit the following as specified in Section 01_81_50 - Design Criteria:
 - a. Manufacturer's statement of seismic qualification with substantiating test data.
 - b. Manufacturer's special seismic certification with substantiating test data.
- C. Shop Drawings:
 - 1. Layout drawings:
 - a. Provide fully dimensioned and to scale layout drawings which include:
 - 1) Dimensions:
 - a) Overall length.
 - b) Overall width.
 - c) Overall height.
 - d) Overall weight and weight of individual shipping splits.
 - 2. Interfaces to other equipment.
 - 3. Shipping splits.
 - 4. Allowable top and bottom conduit windows.
 - 5. Complete component and unit layout drawings, including control, networking, and metering components.
 - 6. Indicate lug sizes, type, and manufacturer based on the cable size specified in the Contract Documents and as indicated on the Drawings.
 - 7. Elementary schematics:
 - a. Provide 1 custom schematic diagram for each compartment:
 - 1) Include remote devices.
 - 2) Show wire numbers on the schematics:
 - a) Provide wire numbering as specified in Section 26_05_53 - Identification for Electrical Systems.
 - 8. External connection diagram showing the wiring to the external controls and devices associated with the motor control center.
 - 9. One-line diagrams:
 - a. Provide complete one-line diagrams for each motor control center, including, but not limited to: Protective devices, starters, drives, metering, and other equipment.
 - b. Indicate electrical ratings of the equipment shown on the one-line diagrams.

- D. Calculations:
 - 1. Detailed calculations or details of the actual physical testing performed on the motor control center to prove the motor control center is suitable for the seismic requirements at the Project Site.
- E. Delegated Design Submittals:
 - 1. Anchoring and bracing: Provide project-specific calculations based on support conditions and requirements to resist loads specified in Section 01_81_50 - Design Criteria:
 - a. To structures for equipment installed in structures designated as seismic design category C, D, E, or F.
 - b. For equipment installed outdoors.
- F. Installation instructions:
 - 1. Detail the complete installation of the equipment, including rigging, moving, and setting into place.
 - 2. Provide manufacturer's installation instructions.
- G. Quality Control Submittals:
 - 1. Manufacturer's representative qualifications.
 - 2. Manufacturer's Certificate of Source Testing as specified in Section 01_75_17 - Commissioning.
 - 3. Manufacturer's Certificate of Installation Verification as specified in Section 01_75_17 - Commissioning.
- H. Owner Training Submittals:
 - 1. As specified in Section 01_75_17 - Commissioning.
- I. Operation and maintenance manuals:
 - 1. As specified in Section 01_78_24 - Operation and Maintenance Manuals.
 - 2. Provide complete operating and maintenance instructions presenting full details for care and maintenance of all types of equipment furnished and/or installed under this Section. Include the following:
 - a. Electrical ratings:
 - 1) Phase.
 - 2) Wire.
 - 3) Voltage.
 - 4) Ampacity.
 - 5) Bus bracing and protective device interrupting ratings.
 - b. Manufacturer's operating and maintenance instructions for the motor control center and component parts, including:
 - 1) Starters.
 - 2) Overload relays and heater elements.
 - 3) Variable frequency drives.
 - 4) Protective devices, including, but not limited to, fuses, circuit breakers and protective relays.
 - 5) Pilot devices.
 - c. Complete renewal parts list.

- J. Test forms and reports:
 - 1. Submit complete factory acceptance test procedures and forms used during the test.
- K. Record documents:
 - 1. Elementary schematics:
 - a. Furnish as-built elementary schematics indicating final:
 - 1) Wire numbers.
 - 2) Interfaces with other equipment.
 - b. Provide 1 custom schematic diagram for each compartment:
 - 1) Include remote devices.
 - 2) Show wire numbers on the schematics.
 - c. Layout drawings: Provide complete dimensioned component and unit layout drawings.
 - 2. Record documents shall reflect modifications made during the submittal review process and during construction.

1.06 QUALITY ASSURANCE

- A. All portions of the motor control center, vertical bays, and components shall be UL listed and labeled.
 - 1. Where indicated as service entrance equipment, the motor control center shall be UL labeled and listed "Suitable for Service Entrance".

1.07 DELIVERY, STORAGE, AND HANDLING

- A. Ship the motor control center and associated equipment to the job site on a dedicated air ride vehicle that will allow the Contractor to utilize on-site off-loading equipment.
- B. Furnish temporary equipment heaters within the motor control center to prevent condensation from forming.

1.08 PROJECT OR SITE CONDITIONS

- A. As specified in Section 01_81_50 - Design Criteria.

1.09 ADMINISTRATIVE REQUIREMENTS

- A. Meetings:
- B. Sequencing:
 - 1. Conduct the initial fault current study as specified in Section 26_05_74 - Electrical System Studies and submit results for the Engineer's review.
 - 2. After successful review of the initial fault current study, as specified in Section 26_05_74 - Electrical System Studies, submit complete equipment submittal.
 - 3. Conduct factory acceptance test.
 - 4. Submit manufacturer's test results.
 - 5. Ship equipment to the Project Site after successful completion of factory acceptance test.

6. Assemble equipment in the field.
7. Conduct field acceptance test and submit results for the Engineer's review.
8. Submit manufacturer's certification that the equipment has been properly installed and is fully functional for the Engineer's review.
9. Conduct Owner's Training sessions.
10. Commissioning and process start-up as specified in Section 01_75_17 - Commissioning.

1.10 WARRANTY

- A. As specified in Section 01_78_36 - Warranties and Bonds.

PART 2 PRODUCTS

2.01 GENERAL

- A. Factory assembled, factory wired and factory tested motor control centers:
 1. Motor control centers and major components to be products of a single manufacturer.

2.02 DESIGN AND PERFORMANCE CRITERIA

- A. Provide equipment and components that are fully rated for the Site elevation and operating environment where the equipment will be installed as specified in Section 01_81_50 - Design Criteria and as indicated on the Drawings.
- B. Outdoor installations:
 1. Provide conditioning equipment incorporated into the equipment to maintain the enclosures within the equipment manufacturer's specified operating ranges.
- C. Doors:
 1. Provide snake-skin cable management sleeve or spiral wire-wrap wires where they pass from the interior of the cabinet past the door hinge to door-mounted devices.

2.03 MANUFACTURERS

- A. One of the following or equal:
 1. ABB.
 2. Allen-Bradley.
 3. Eaton.
 4. Schneider Electric.

2.04 MATERIALS (NOT USED)

2.05 MANUFACTURED UNITS (NOT USED)

2.06 EQUIPMENT

- A. General:
 - 1. Furnish motor control centers as specified in the Contract Documents and indicated on the Drawings.
 - 2. Arrange the equipped sections to form continuous motor control center lineups as indicated on the Drawings:
 - a. Identify any deviations from the Drawings in writing and submit for approval.
 - 3. Provide wire markers at each end of every wire as specified in Section 26_05_53 - Identification for Electrical Systems.
 - 4. Provide complete and functional motor control centers.
 - 5. Provide devices or accessories not specified in this Section but necessary for the proper installation and operation of the equipment.
- B. Design and construct motor control center to operate at the voltage level and configuration indicated on the Drawings.
- C. Bus system:
 - 1. Material:
 - a. Tin-plated copper.
 - b. Short-circuit rating:
 - 1) As indicated on the Drawings.
 - c. Bus bar supports:
 - 1) High impact strength, non-tracking glass-polyester material that is impervious to moisture and gases.
 - 2. Horizontal power bus:
 - a. Current-carrying capacity as indicated on the Drawings.
 - b. Mounting:
 - 1) Mount horizontal bus bars edgewise, one above the other, and fully isolated from wireways and units.
 - c. Temperature rise:
 - 1) In accordance with UL 845.
 - 2) De-rate the temperature rating of the bus for the specified conditions of ambient temperature and altitude as specified in Section 01_81_50 - Design Criteria.
 - 3. Vertical power bus:
 - a. Current-carrying capacity of not less than 600 amps.
 - b. Mounting:
 - 1) Enclose the vertical bus in a polyester-glass cover with small openings to permit unit stabs to mate with the bus:
 - a) Provide a shutter mechanism to cover the stab openings when plug-in units are removed.
 - 2) Provide top and bottom bus covers for insulation and isolation of the ends of the bus.
 - c. Isolated from the unit compartments by a full height barrier.
 - 4. Ground bus:
 - a. Horizontal ground bus:
 - 1) Current-carrying capacity:
 - a) 300 amps when the horizontal bus is 2,000 amps or less.
 - b) 600 amps when the horizontal bus is greater than 2,000 amps.

- 2) Mounting:
 - a) Full width, firmly secured to each vertical section structure:
 - (1) Located in the top or bottom wireway.
 - b) Pre-drilled and furnished with lugs for connection to equipment ground wires:
 - (1) Furnish a minimum of 10 lugs per vertical section of MCC.
 - b. Vertical ground bus:
 - 1) Mounting:
 - a) Furnish in each vertical section.
 - b) Bolted to the horizontal ground bus.
 - c) Install parallel to the vertical power bus.
 - d) Mount vertical ground bus such that plug-in units engage the ground bus before any connection to the power bus is made. Upon removal of plug-in units, ground stabs are disconnected from the ground bus after the power stabs have been disconnected.
 5. Bus splice bars:
 - a. Provided to join the bus at the splits.
 - b. Connected to each horizontal bus bar with a minimum of 2 bolts.
 - c. Employ conical or spring washers at connections, designed to maintain constant pressure against the splice joint.
 - d. Same ampacity rating as the horizontal bus.
 6. Provide bus system configured for back-to-back MCCs, where required.
- D. Enclosures:
1. Each motor control center shall consist of one or more vertical sections bolted together:
 - a. Freestanding.
 - b. Totally enclosed.
 - c. Dead-front assembly.
 - d. Designed for modification and/or addition of future vertical sections.
 - e. Form each vertical section of heavy gauge steel.
 - f. Designed for back-to-back arrangement installation, where required and/or as indicated on the Drawings.
 2. Enclosure rating:
 - a. Indoor:
 3. NEMA Type 1 gasketed. Standard section dimensions:
 - a. Nominal height: 90 inches.
 - b. Nominal depth: 20 inches.
 - c. Vertical section width as indicated on the Drawings.
 4. Wireways:
 - a. Provide each vertical section with a horizontal wireway at the top and bottom of the section:
 - 1) Arranged to provide a full-width metal enclosed wiring trough across the entire motor control center assembly.
 - b. Provide each vertical section with a full-height vertical wireway.
 - c. Completely isolated from the vertical and horizontal bus bars.
 - d. Provide a removable, hinged door.
 5. Shipping splits:
 - a. No more than 3 vertical sections and not more than 60 inches in width.
 - b. Solid busing between vertical sections in a shipping split is not acceptable.

6. Lifting angles:
 - a. Furnish each vertical section and/or shipping split with a removable lifting angle mounted to the top of the enclosure:
 - 1) Extending the entire width of the shipping split.
 7. Mounting channels:
 - a. Mount each vertical section and/or shipping split on an external 1.5-inch by 3-inch mounting channel.
- E. Units:
1. A plug-in unit consists of:
 - a. Assembly.
 - b. Support pan.
 - c. Door assembly.
 2. Completely enclosed and isolated from adjacent units, buses, and wireways, except for conductor entries into the unit, by a metal enclosure.
 3. Supported and guided by a removable unit support pan:
 - a. Re-arrangement of units and the removal of a unit so that a new and possibly larger unit can be added without the removal of an in-service unit to gain access to the unit support pan.
 4. Held in place by screws or other positive locking means after insertion.
 5. Provide a test position with the unit supported in the structure but disengaged from the bus.
 6. Integral plug-in ground stab.
 7. Stabs:
 - a. Free floating.
 - b. Self-aligning.
 - c. Backed by spring steel clips to ensure high pressure contacts.
 - d. Electrolytically tin-plated copper.
 8. Handle:
 - a. Provide a flange mounted handle mechanism to operate each disconnect switch or circuit breaker.
 - b. Door mounted operators or operator handles are not acceptable.
 - c. Engaged with the disconnect device at all times as an integral part of the unit independent of the door position.
 - d. Lockable in the "OFF" position with up to 3 padlocks.
 - e. Mechanically interlocked so that the door cannot be opened with the handle in the "ON" position:
 - 1) Provide a means for qualified personnel to defeat this interlock.
 - f. Interlocked so the unit cannot be inserted or withdrawn with the handle in the "ON" position.
 - g. Lockable in the "ON" position:
 - 1) This shall not prevent the circuit breaker from operating and opening the contacts in the event of a faulty condition.
 - h. Color-coded to indicate position.
 - i. Located so the center of the grip when it is in its highest position is not more than 6 feet-7 inches above the finished floor, including the height of the housekeeping pad and mounting channels.
 9. Space for future devices:
 - a. Provide spaces as indicated on the Drawings.
 - b. As specified in Section 26_05_00 - Common Work Requirements for Electrical.

2.07 COMPONENTS

- A. Provide components contained within the motor control center as specified in:
 - 1. Section 26_05_53 - Identification for Electrical Systems.
 - 2. Section 26_05_18 - 600-Volt or Less Wires and Cables.
 - 3. Section 26_05_21 - Low Voltage Wire Connections.
 - 4. Section 26_43_14 - Surge Protective Devices.
 - 5. Section 26_28_01 - Low Voltage Molded Case Circuit Breakers.
 - 6. Section 26_29_05 - Motor Starters.

2.08 ACCESSORIES

- A. Wiring:
 - 1. Wire the motor control center in accordance with the following NEMA class and type as defined by NEMA ICS 18-2001:
 - a. NEMA Class II-S:
 - 1) Furnish wiring diagrams for individual units consisting of drawings that identify electrical devices, electrical connections, and indicate terminal numbering designations.
 - 2) Furnish individual unit diagrams with each unit and include inter-wiring between units, i.e., electrical interlocking, etc., as specifically specified in the Contract Documents.
 - 3) Provide custom drawings with unique terminal numbering designations in lieu of standard manufacturer drawings.
 - b. NEMA Type B wiring:
 - 1) Control wiring:
 - a) Type B-T pull-apart terminal blocks.
 - 2) Power wiring:
 - a) Type B-T for Size 1 starters.
 - b) Type B-T or B-D for Size 2 and 3 starters.
 - c) Type B for Size 4 and larger starters and feeder units.
- B. Lugs and terminals:
 - 1. For external connections of No. 6 AWG wire or larger:
 - a. UL listed for copper or aluminum conductors.
 - 2. Compression type, requiring a hydraulic press and die for installation.
 - 3. Provide additional terminal blocks as needed for control conductors passing through the MCC.
 - 4. Provide 30 percent spare control block terminals.
- C. Nameplates:
 - 1. Provide nameplates as specified in Section 26_05_53 - Identification for Electrical Systems:
 - a. Identifying the motor control center designation as indicated on the Drawings.
 - 2. Furnish individual nameplates for each unit indicated on the Drawings:
 - a. 1 nameplate to identify the unit designation.
 - b. 1 nameplate to identify the load served.
 - c. Furnish space units with blank nameplates.

3. Manufacturer's labels:
 - a. Furnish each vertical section with a label identifying:
 - 1) Serial number.
 - 2) Bus rating.
 - 3) Vertical section reference number.
 - 4) Date of manufacture.
 - 5) Catalog number of section.

2.09 FINISHES

- A. Finish metal surfaces and structural parts with phosphatizing, or equal, treatment before painting.
- B. Finish interior surfaces, including bus support angles, control unit back plates, and top and bottom barrier plates with baked white enamel.
- C. Finish exterior of enclosure with the manufacturer's standard gray.
 1. Finish NEMA Type 3R exterior cabinets with ultraviolet resistant enamel paint that is UL recognized for outdoor use.

2.10 SOURCE QUALITY CONTROL

- A. Source Testing (Factory Acceptance Tests):
 1. Witnessed, in-person:
 - a. Number of Owner and Engineer representatives in person: 2.
 2. Test the complete motor control center at the manufacturer's establishment. Completely assemble, wire and test the motor control center:
 - a. Detailed inspections before and after assembly to ensure correctness of design and workmanship.
 3. Provide groups of wires leaving the shipping-assembled equipment with terminal blocks with suitable numbering strips.
 4. Furnish test reports and Manufacturer's Certificate of Source Testing.

PART 3 EXECUTION

3.01 PREPARATION

- A. Anchoring and bracing to structures:
 1. Prepare equipment anchor setting template(s) and use to position anchors during construction of supporting structure(s).
 2. Install anchors of type and material indicated on approved anchoring designs.
 3. Install anchors with embedment indicated on approved anchoring designs.

3.02 INSTALLATION

- A. Install the equipment in accordance with the accepted installation instructions and anchorage details.

- B. General:
1. Furnish cables, conduit, lugs, bolts, and other accessories necessary to completely install the motor control center for the line, load, and control connections.
 2. Assemble and install the motor control center in the locations and with the layouts as indicated on the Drawings.
 3. Make bus splice connections.
 4. Perform Work in accordance with the manufacturer's instruction and Shop Drawings.
 5. Furnish components and equipment necessary to complete the installation.
 6. Replace hardware, lost or damaged during installation or handling, in order to provide a complete installation.
 7. Install the MCC on a raised concrete housekeeping pad:
 - a. Provide structural leveling channels in accordance with the manufacturer's recommendations to provide proper alignment of the units:
 - 1) Remove the manufacturer's supplied mounting channels as required by the manufacturer's installation instructions.
 - b. Weld and/or bolt the motor control center frame to leveling channels.
- C. Provide openings in the top or bottom of the motor control center for conduit only:
1. No additional openings will be accepted:
 - a. Miscut holes will require that the entire vertical section or removable panel be replaced.
 - b. No hole closers or patches will be accepted.
- D. Bundle circuits together and terminate in each unit:
1. Tie with nylon wire ties as specified in Section 26_05_18 - 600-Volt or Less Wires and Cables.
 2. Label wires at each end with wire markers as specified in Section 26_05_53 - Identification for Electrical Systems as shown on the approved elementary schematics.
- E. Furnish Manufacturer's Certificate of Installation Verification.

3.03 FIELD QUALITY CONTROL

- A. Functional Testing:
1. As specified in Section 26_08_50 - Field Electrical Acceptance Tests.
- B. Manufacturer's services:
1. Provide the services of a manufacturer's representative to:
 - a. Inspect, verify, and certify that the motor control center installation meets the manufacturer's requirements.

3.04 OWNER TRAINING

- A. Perform Owner Training as specified in Section 01_75_17 - Commissioning.

3.05 ADJUSTING

- A. Make adjustments as necessary and recommended by the manufacturer, Engineer, or testing firm.

END OF SECTION

SECTION 26_27_26

WIRING DEVICES

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Switches.
 - 2. Receptacles.
 - 3. Device cover wall plates.

1.02 REFERENCES

- A. Federal Specifications (FS):
 - 1. W-C-596 - Connector, Electrical, Power, General Specification for.
 - 2. W-S-896/2 - Switches, Toggle (Toggle and Lock), Flush Mounted (General Specification).
- B. National Electrical Manufacturers Association (NEMA):
 - 1. 250 - Enclosures for Electrical Equipment (1,000 V Maximum).
- C. National Fire Protection Association (NFPA):
 - 1. 70 - National Electrical Code (NEC).
- D. Telecommunications Industry Association (TIA):
 - 1. T568A - Eight-position jack pin/pair assignment.
 - 2. T568B - Optional eight-position jack pin/pair assignment.
- E. Underwriters Laboratories, Inc. (UL):
 - 1. 20 - General Use Snap Switches.
 - 2. 498 - Standard for Attachment Plugs and Receptacles.
 - 3. 943 - Ground-Fault Circuit-Interrupters.

1.03 TERMINOLOGY

- A. The words and terms listed below are not defined terms that require initial capital letters, but, when used in this Section, have the indicated meaning.
 - 1. GFCI: Ground fault circuit interrupter.

1.04 DELEGATED DESIGN (NOT USED)

1.05 SUBMITTALS

- A. Furnish Submittals as specified in Section 01_33_00 - Submittal Procedures.
- B. Product data:
 - 1. Catalog cutsheets.

- C. Shop Drawings:
 - 1. Engraving schedule:
 - a. Furnish complete engraving schedule for engraved nameplates.

1.06 QUALITY ASSURANCE

- A. Wiring devices shall be UL listed and labeled.

1.07 DELIVERY, STORAGE, AND HANDLING (NOT USED)

1.08 PROJECT OR SITE CONDITIONS

- A. As specified in Section 01_81_50 - Design Criteria.

1.09 ADMINISTRATIVE REQUIREMENTS (NOT USED)

1.10 WARRANTY

- A. As specified in Section 01_78_36 - Warranties and Bonds.

PART 2 PRODUCTS

2.01 GENERAL (NOT USED)

2.02 DESIGN AND PERFORMANCE CRITERIA

- A. Switches, receptacles, and device cover wall plates as indicated on the Drawings, wired and operable to form a complete system.

2.03 MANUFACTURERS

- A. Switches:
 - 1. One of the following or equal:
 - a. Cooper Wiring Devices.
 - b. Hubbell.
 - c. Leviton.
 - 2. Occupancy sensor switches:
 - a. One of the following or equal:
 - 1) Cooper Wiring Devices.
 - 2) WattStopper.
 - 3. Dimmer switches:
 - a. One of the following or equal:
 - 1) Cooper Wiring Devices.
 - 2) Lutron.
- B. Receptacles:
 - 1. General purpose:
 - a. One of the following or equal:
 - 1) Cooper Wiring Devices.
 - 2) Hubbell.
 - 3) Leviton.

- C. Device cover wall plates:
 - 1. General location:
 - a. One of the following or equal:
 - 1) Cooper Wiring Devices.
 - 2) Legrand.
 - 2. Wet or corrosive areas:
 - a. One of the following or equal:
 - 1) ABB.
 - 2) Cooper Wiring Devices.
 - 3) Hubbell.
 - 4) Pass and Seymour.
 - 3. In-use covers:
 - a. One of the following or equal:
 - 1) ABB.
 - 2) Cooper Wiring Devices.
 - 3) Pass and Seymour.
 - 4) TayMac.
- D. Data and communications jacks:
 - 1. Network jacks:
 - a. One of the following or equal:
 - 1) Belden, REVConnect Connectivity System.
 - 2) Hubbell.
 - 3) Leviton, Quickport series.
 - 4) Panduit.
 - 2. Wall plates:
 - a. One of the following or equal:
 - 1) Belden, REVConnect Connectivity System.
 - 2) Leviton, Quickport series.
 - 3) Optical Cable Corporation (OCC).
 - 4) Panduit.

2.04 MATERIALS (NOT USED)

2.05 MANUFACTURED UNITS

- A. Switches:
 - 1. General:
 - a. 120 to 277 VAC.
 - b. 20 amp.
 - c. Listed in accordance with UL 20.
 - d. Designed and constructed in accordance with FS W-S-896/2.
 - e. Back and side wired unless otherwise indicated.
 - f. Integral grounding terminal.
 - g. Totally enclosed:
 - 1) Color-coded body with color corresponding to amp rating.
 - h. Provide switches with the operator style and contact arrangement as indicated on the Drawings and as required for proper operation.
 - i. Color:
 - 1) Ivory in finished areas.
 - 2) Brown in all other areas.

2. General purpose switches:
 - a. Toggle type.
 3. Switches for office areas:
 - a. Rocker type.
 - b. Rectangular.
 4. Switches for use with photocell:
 - a. Maintained contact.
 - b. 2 circuit.
 - c. 3 position:
 - 1) Center off.
 5. Occupancy sensor switches:
 - a. Wall switch with dual-technology passive infrared and ultrasonic sensor.
 - 1) Configured such that lights turn on only when both infrared and ultrasonic sensors detect activity, but do not turn off as long as either sensor detects activity.
 - b. Selectable "automatic-on" mode activated by sensors or "manual-on" mode activated by pushbutton.
 - c. Adjustable 5- to 30-minute time delay.
 - d. Selectable audible alert as a warning before lights turn off.
 - e. Rated for fluorescent lighting loads of up to 800 W.
 - f. True multi-way switching allowing identical controls at any location for multi-way switching applications.
 6. Dimmer switches:
 - a. Shall be rectangular design with LED light level indicators.
 - b. Suitable for use with type of lamp switched.
- B. Receptacles:
1. General purpose receptacles:
 - a. Single or duplex as indicated on the Drawings.
 - b. 125 VAC.
 - c. 20 amp or as indicated on the Drawings.
 - d. NEMA Type 5-20R configuration for 20 amp receptacles.
 - e. Other NEMA configurations as indicated on the Drawings.
 - f. Listed in accordance with UL 498.
 - g. Designed and constructed in accordance with FS W-C-596.
 - h. Back and side wired.
 - i. 1-piece, rivet-less mounting strap.
 - j. Color:
 - 1) Ivory in finished areas.
 - 2) Brown in all other areas.
 - 3) Orange when powered by a UPS.
 2. Ground fault interrupter receptacles (GFCI):
 - a. 125 VAC.
 - b. 20 amp.
 - c. Trip level 4 to 6 mA.
 - d. Individual and feed through protection.
 - e. UL 943 and UL 498 listed.
 - f. NEMA Type 5-20R configuration.
 - g. For damp or wet locations:
 - 1) Weather resistant, in accordance with UL 498.

- C. Device cover wall plates:
1. General location:
 - a. Type 302 or 304 stainless steel.
 - b. Brushed satin finish.
 - c. Minimum thickness: 0.032 inches.
 - d. Rectangular or square shape.
 - e. Engraving:
 - 1) Engrave each switch device cover wall plate with the following:
 - a) Area served.
 - b) Panelboard and Circuit.
 - 2) Engrave each receptacle device cover wall plate with the following:
 - a) Panelboard and Circuit.
 - 3) Treat engraving to improve visibility.
 - 4) Characters shall be block letter pantograph engraved with a minimum character height of 1/8-inch.
 - f. Coordinate the number of gangs, number, and type of openings with the specific location.
 2. Outdoor and wet areas requiring NEMA Type 4 or NEMA Type 4X enclosures:
 - a. General:
 - 1) UL listed for wet locations.
 - 2) Gasketed.
 - 3) Die cast metal:
 - a) Match material to box material.
 - b. Switches:
 - 1) Lever operated:
 - a) Provide toggle switch.
 - c. Receptacles:
 - 1) Weatherproof in-use cover:
 - a) Die cast metal construction with electrostatic powder coating for corrosion resistance.
 - b) Gasketed.
 - c) Lockable.
 - d) UL listed and in accordance with the NEC.
 3. Corrosive areas:
 - a. Neoprene.
 - b. Gasketed.
 - c. Weatherproof.
- D. Data and communications jacks:
1. Process network jacks - conduit body mounted:
 - a. Network jacks located in process areas shall have a NEMA Type 4 rating (with closure cap).
 - b. Mounting of network jacks in conduit bodies adapter (with minifast connector) shall be accomplished using conduit body insert and environmental enclosure caps.
 - c. PC board connections are not to be allowed.
 - d. Furnish 10 RJ-45 to minifast connector patch cable 3 feet in length.
 - e. Manufacturers: The following or equal:
 - 1) InterlinkBT.

2. Network/phone jacks:
 - a. Meets or exceeds TIA standards for the category of Ethernet cable connected.
 - b. Accommodates TIA T568A and TIA T568B wiring schemes.
 - c. UL listed or rated.
 - d. Provide different colors for each network unless otherwise indicated on the Drawings.
 - e. Power over Ethernet up to 100 watts.
 - f. Interchangeable icons to identify function.
 - g. In accordance with NEC requirements.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

- A. Mounting heights:
 1. Process and production areas:
 - a. Switches and receptacles: 48 inches from finished floor to top of device cover wall plate.
 2. Offices and finished areas:
 - a. Switches: 48 inches from finished floor to top of device cover wall plate.
 - b. Receptacles: 18 inches from finished floor to center of device cover wall plate.
- B. Switches:
 1. Over 300 volts:
 - a. Where switches used in systems of more than 300 volts between conductors, are to be ganged in outlet boxes, provide switches having no exposed live parts or use barriers between the individual switches.
- C. Receptacles:
 1. Provide GFCI receptacles as indicated on the Drawings.
 - a. Provide weather resistant GFCI receptacles in wet or damp areas.
 2. Mount receptacles vertically:
 - a. Ground slot down.
 3. 3-phase receptacles shall be consistent with respect to phase connection at the receptacle terminals. Correct errors in phasing at the source and not the receptacle.
- D. Ensure device cover wall plates make a firm seal with wall for recessed mounted devices:
 1. Outside edges of device cover wall plates parallel with building lines.

END OF SECTION

SECTION 26_28_01

LOW VOLTAGE MOLDED CASE CIRCUIT BREAKERS

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Low voltage molded case circuit breakers.

1.02 REFERENCES

- A. National Fire Protection Association (NFPA):
 - 1. 70 - National Electrical Code (NEC).
- B. Underwriters Laboratories (UL):
 - 1. 489 - Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit-Breaker Enclosures.

1.03 DELEGATED DESIGN

- A. As specified in Section 01_35_73 - Delegated Design Procedures.
- B. Anchoring and bracing.

1.04 SUBMITTALS

- A. Furnish Submittals as specified in Section 01_33_00 - Submittal Procedures.
- B. Product data:
 - 1. Catalog cutsheets.
 - 2. Manufacturer's time-current curves for molded case circuit breakers furnished.
- C. Delegated Design Submittals:
 - 1. Anchoring and bracing: Provide project-specific calculations based on support conditions and requirements to resist loads specified in Section 01_81_50 - Design Criteria.
 - a. To structures for equipment installed in structures designated as seismic design category C, D, E, or F.
 - b. For equipment installed outdoors.
 - c. For wall mounted equipment weighing 125 pounds or more.
- D. Owner Training Submittals:
 - 1. As specified in Section 01_75_17 - Commissioning.

1.05 QUALITY ASSURANCE

- A. Low voltage molded case circuit breakers shall be UL listed and labeled.

1.06 DELIVERY, STORAGE, AND HANDLING (NOT USED)

1.07 PROJECT OR SITE CONDITIONS

- A. As specified in Section 01_81_50 - Design Criteria.

1.08 ADMINISTRATIVE REQUIREMENTS (NOT USED)

1.09 WARRANTY

- A. As specified in Section 01_78_36 - Warranties and Bonds.

PART 2 PRODUCTS

2.01 GENERAL

- A. Molded case thermal magnetic, solid-state, or motor circuit protector type circuit breakers as indicated on the Drawings and connected to form a completed system.

2.02 DESIGN AND PERFORMANCE CRITERIA (NOT USED)

2.03 MANUFACTURERS

- A. One of the following or equal:
 - 1. ABB.
 - 2. Eaton.
 - 3. Schneider Electric.

2.04 MATERIALS (NOT USED)

2.05 MANUFACTURED UNITS

- A. General:
 - 1. In accordance with UL 489.
 - 2. Operating mechanism:
 - a. Quick-make, quick-break, non-welding silver alloy contacts.
 - b. Common Trip, Open and Close for multi-pole breakers such that all poles open and close simultaneously.
 - c. Mechanically trip free from the handle.
 - d. Trip indicating handle - automatically assumes a position midway between the manual ON and OFF positions to clearly indicate the circuit breaker has tripped.
 - e. Lockable in the OFF position.
 - 3. Arc extinction:
 - a. In arc chutes.
 - 4. Voltage and current ratings:
 - a. Minimum ratings as indicated on the Drawings.
 - b. Minimum frame size 100 A.

5. Interrupting ratings:
 - a. Minimum ratings as indicated on the Drawings.
 - b. Modify as required to meet requirements of the short circuit fault analysis as specified in Section 26_05_74 - Electrical System Studies.
 - c. Not less than the rating of the assembly (panelboard, switchboard, motor control center, etc.).
- B. Motor circuit protectors:
 1. Instantaneous only circuit breaker as part of a listed combination motor controller.
 2. Each pole continuously adjustable in a linear scale with "LO" and "HI" settings factory calibrated.

2.06 EQUIPMENT (NOT USED)

2.07 COMPONENTS

- A. Terminals:
 1. Line and load terminals suitable for the conductor type, size, and number of conductors indicated on the Drawings and in accordance with UL 489.
- B. Case:
 1. Molded polyester glass reinforced.
 2. Ratings clearly marked.
- C. Trip units:
 1. Provide thermal magnetic or solid-state trip units as indicated on the Drawings.
 2. Thermal magnetic:
 - a. Instantaneous short circuit protection.
 - b. Inverse time delay overload.
 - c. Ambient or enclosure compensated by means of a bimetallic element.
 3. Solid state:
 - a. With the following settings as indicated on the Drawings:
 - 1) Adjustable long time current setting.
 - 2) Adjustable long time delay.
 - 3) Adjustable short time pickup.
 - 4) Adjustable short time delay.
 - 5) Adjustable instantaneous pickup.
 - 6) Adjustable ground fault pickup as indicated on the Drawings.
 - 7) Adjustable ground fault delay as indicated on the Drawings.
 - b. Energy reducing maintenance switch on breakers 1,200 amps and above and on additional breakers as indicated on the Drawings.
 - 1) Indication on the breaker.
- D. Provide ground fault trip devices as indicated on the Drawings.
- E. Molded case circuit breakers for use in panelboards:
 1. Bolt-on type:
 - a. Plug-in type breakers are not acceptable.
 2. Ground fault trip devices as indicated on the Drawings.

2.08 ACCESSORIES

- A. Lockable handle:
 - 1. Provide assembly to lock operating handle in "OPEN" position.
 - 2. Where a molded case circuit breaker is located in a dedicated enclosure, provide a lockable handle. Reference the Electrical Specifications for additional locking requirements associated with other mounting installations.
- B. Key interlocks:
 - 1. Provide key operated interlocks to ensure safe switching procedures as indicated on the Drawings.

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL

- A. Test breakers in accordance with:
 - 1. UL 489.
 - 2. Manufacturer's standard testing procedures.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION

- A. Anchoring and bracing to structures:
 - 1. Prepare equipment anchor setting template(s) and use to position anchors during construction of supporting structure(s).
 - 2. Install anchors of type and material indicated on approved anchoring designs.
 - 3. Install anchors with embedment indicated on approved anchoring designs.

3.03 INSTALLATION

- A. Install breakers to correspond with the accepted Shop Drawings.

3.04 FIELD QUALITY CONTROL

- A. Field electrical acceptance testing:
 - 1. As specified in Section 26_08_50 - Field Electrical Acceptance Tests.

3.05 OWNER TRAINING

- A. Perform Owner Training as specified in Section 01_75_17 - Commissioning.

3.06 ADJUSTING

- A. Adjust trip settings in accordance with the protective device coordination study as accepted by the Engineer and in accordance with the manufacturer's recommendations.
- B. Adjust motor circuit protectors in accordance with the NEC and the manufacturer's recommendation based on the nameplate values of the installed motor.

END OF SECTION

SECTION 26_28_17
DISCONNECT SWITCHES

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Knife blade fusible and non-fusible disconnect switches.
 - 2. Switch-rated plugs and receptacles.

1.02 REFERENCES

- A. National Electric Manufacturers Association (NEMA):
 - 1. 250 - Enclosures for Electrical Equipment (1,000 V Maximum).
 - 2. KS 1-2001 - Enclosed and Miscellaneous Distribution Equipment Switches (600 Volts Maximum).
- B. Underwriters Laboratories Inc. (UL):
 - 1. 98 - Enclosed and Dead-Front Switches.

1.03 TERMINOLOGY

- A. The words and terms listed below are not defined terms that require initial capital letters, but, when used in this Section, have the indicated meaning.
 - 1. Safety switches and disconnect switches are to be considered synonymous.

1.04 DELEGATED DESIGN (NOT USED)

1.05 SUBMITTALS

- A. Furnish Submittals as specified in Section 01_33_00 - Submittal Procedures.
- B. Product data:
 - 1. Manufacturer.
 - 2. Manufacturer's specifications and description.
 - 3. Ratings:
 - a. Voltage.
 - b. Current.
 - c. Horsepower.
 - d. Short circuit rating.
 - 4. Fused or non-fused.
 - 5. NEMA enclosure type.
 - 6. Dimensions:
 - a. Height.
 - b. Width.
 - c. Depth.

7. Weight.
 8. Cross-referenced to the disconnect schedule indicated on the Drawings.
- C. Shop Drawings:
1. Manufacturer's installation instructions:
 - a. Indicate application conditions and limitations of use stipulated by product testing agency specified under Quality Assurance, Regulatory Requirements below.
 - b. Include instructions for storage, handling, protection, examination, preparation, installation, and operation of product.
 2. For each switch, indicate nameplate inscription, including voltage, circuit, fuse size (if applicable), and equipment served.
- D. Installation instructions:
1. Provide manufacturer's installation instructions.

1.06 QUALITY ASSURANCE

- A. Regulatory requirements:
1. NEMA Type KS 1- Enclosed and Miscellaneous Distribution Switches (600 V Maximum).
 2. UL 98 - Enclosed and Dead-Front Switches.
- B. Disconnect switches shall be UL listed and labeled.

1.07 DELIVERY, STORAGE, AND HANDLING (NOT USED)

1.08 PROJECT OR SITE CONDITIONS

- A. As specified in Section 01_81_50 - Design Criteria.

1.09 ADMINISTRATIVE REQUIREMENTS

- A. Sequencing:
1. After successful review of the initial fault current study, submit complete equipment Submittal.

1.10 WARRANTY

- A. As specified in Section 01_78_36 - Warranties and Bonds.

PART 2 PRODUCTS

2.01 GENERAL (NOT USED)

2.02 DESIGN AND PERFORMANCE CRITERIA

- A. Provide knife blade disconnect switches and switch-rated plugs and receptacles as indicated on the Drawings and specified in the Contract Documents.
- B. Provide equipment with the number of poles, voltage, current, short circuit, and horsepower ratings as required by the load and the power system.
- C. Provide a local horsepower rated disconnect switch as indicated on the Drawings.

2.03 MANUFACTURERS

- A. Knife-blade disconnect switches:
 - 1. One of the following or equal:
 - a. ABB.
 - b. Appleton.
 - c. Crouse-Hinds.
 - d. Eaton.
 - e. Schneider Electric.
 - f. Siemens.

2.04 MATERIALS (NOT USED)

2.05 MANUFACTURED UNITS (NOT USED)

2.06 EQUIPMENT

- A. Knife-blade style switch disconnects:
 - 1. Switch mechanism:
 - a. Quick-make, quick-break heavy-duty operating mechanisms:
 - 1) Provisions for padlocking the switch in the Off position.
 - 2) A minimum of 90-degree handle travel position between Off and On positions:
 - a) Provide handle position indicators to identify the handle position.
 - 3) Full cover interlock to prevent opening of the switch door in the On position and to prevent closing the switch mechanism with the door open:
 - a) With an externally operated override.
 - 2. Switch interior:
 - a. Switch blades visible when the switch is Off and the cover is open.
 - b. Lugs:
 - 1) Front accessible.
 - 2) Removable.
 - 3) UL listed for 60/75-degree Celsius copper conductors.
 - c. Current carrying parts completely plated to resist corrosion.
 - d. Removable arc suppressors to facilitate easy access to line side lugs.
 - e. Furnish equipment ground kits for every switch.

3. Fused switches:
 - a. Furnish with fuses as indicated on the Drawings:
 - b. UL approved for field conversion from standard Class H fuse spacing to Class J fuse spacing:
 - 1) Ratings 100 amps through 600 amps at 240 volts.
 - 2) Ratings 30 amps through 600 amps at 600 volts.
 - 3) Provide spring reinforced and plated fuse clips.
 4. Ratings:
 - a. UL horsepower rated for AC or DC with the rating not less than the load served.
 - b. Current:
 - 1) 30 to 1,200 amps.
 - c. Voltage:
 - 1) 250 volts AC, DC.
 - 2) 600 volts (30 A to 200 A, 600 volts DC).
 - d. Poles:
 - 1) 2, 3, 4, and 6 poles.
 - e. UL listed short circuit ratings:
 - 1) 10,000 RMS symmetrical amps when used with or protected by Class H or K fuses (30 to 600 amps).
 - 2) 200,000 RMS symmetrical amps when used with or protected by Class R or J fuses (30 to 600 amps employing appropriate fuse rejection).
 - 3) 200,000 RMS symmetrical amps when used with or protected by Class L fuses (800 to 1,200 amps).
- B. Where not indicated on the Drawings, provide switches with the NEMA ratings specified in Section 26_05_00 - Common Work Results for Electrical for the installed location.
- C. Size, fusing and number poles as indicated on the Drawings or as required:
1. Provide solid neutral where indicated on the Drawings.

2.07 COMPONENTS (NOT USED)

2.08 ACCESSORIES

- A. Disconnect switches to have provisions for a field installable "B" type electrical interlock for position indication as indicated on the Drawings.
- B. Disconnect switches to have provisions for a field installed insulated groundable neutral kit as indicated on the Drawings.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION

- A. Anchoring and bracing to structures:
 - 1. Prepare equipment anchor setting template(s) and use to position anchors during construction of supporting structure(s).
 - 2. Install anchors of type and material indicated on approved anchoring designs.
 - 3. Install anchors with embedment indicated on approved anchoring designs.

3.03 INSTALLATION

- A. Install the equipment in accordance with the accepted installation instructions and anchorage details.
- B. General:
 - 1. Use Myers hubs or bolt-on hubs for conduit penetrations on NEMA Type 12, Type 4, and Type 4X enclosures.
 - 2. Provide mounting brackets, stands, supports and hardware as required:
 - a. Match finish and materials for brackets, stands, and hardware with the switch installed.
 - b. Provide adequate supporting pillar(s) for disconnect switches in accordance with the approved seismic calculations, and locate aboveground or above decks, where there is no structural wall or surface for box.
 - 3. When possible, mount switches rigidly to exposed building structure or equipment structural members:
 - a. For NEMA Type 4 and Type 4X locations, maintain a minimum of 7/8 inch air space between the enclosure and supporting surface.
 - b. When mounting on preformed channel, position channel vertically so that water may freely run behind the enclosure.
 - 4. Provide a nameplate for each disconnect switch:
 - a. As specified in Section 26_05_53 - Identification for Electrical Systems.

3.04 FIELD QUALITY CONTROL

- A. As specified in Section 26_05_00 - Common Work Results for Electrical.
- B. Field electrical acceptance testing:
 - 1. As specified in Section 26_08_50 - Field Electrical Acceptance Tests.

END OF SECTION

SECTION 26_29_05

MOTOR STARTERS

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Motor starters and contactors.

1.02 REFERENCES

- A. Abbreviations:
 - 1. FVNR: Full voltage non-reversing.
 - 2. FVR: Full voltage reversing.
 - 3. PWS: Part winding start.
 - 4. RVAT: Reduced voltage auto transformer.
 - 5. RVSS: Reduced voltage solid state.
 - 6. TS1W: 2 speed 1 winding (consequent pole).
 - 7. TS2W: 2 speed 2 winding.
- B. Standards:
 - 1. Institute of Electrical and Electronics Engineers (IEEE).
 - 2. International Electrotechnical Commission (IEC):
 - a. 801-1 - Electromagnetic Compatibility for Industrial-Process Measurement and Control Equipment - Part 1: General Information.
 - b. 947-4 - Low-Voltage Switchgear and Control Gear.
 - 3. National Electrical Manufacturer's Association (NEMA):
 - a. 250 - Enclosures for Electrical Equipment (1,000 V Maximum).
 - b. ICS 2-230 - Industrial Control and Systems: Controllers, Contactors, and Overload Relays Rated 600 V.
 - 4. Underwriters Laboratories, Inc. (UL):
 - a. 508 - Standard for Industrial Control Equipment.
 - b. 508A - Standard for Industrial Control Panels.

1.03 TERMINOLOGY

- A. The words and terms listed below are not defined terms that require initial capital letters, but, when used in this Section, have the indicated meaning.
 - 1. Overload relay class: A classification of an overload relay time current characteristic by means of a number which designates the maximum time in seconds at which it will operate when carrying a current equal to 600 percent of its current rating.

1.04 DELEGATED DESIGN

- A. As specified in Section 01_35_73 - Delegated Design Procedures.
- B. Anchoring and bracing for individually enclosed starters.

1.05 SUBMITTALS

- A. Furnish Submittals as specified in Section 01_33_00 - Submittal Procedures:
 - 1. Submit motor starter data with equipment Submittal.
- B. Product data:
 - 1. Manufacturer.
 - 2. Catalog cutsheets.
 - 3. Technical information.
 - 4. Complete nameplate schedule.
 - 5. Complete bill of material.
 - 6. List of recommended spare parts.
 - 7. Confirmation that the overload relay class for each starter meets the requirements of the equipment and motor supplier.
 - 8. Electrical ratings:
 - a. Phase.
 - b. Wire.
 - c. Voltage.
 - d. Ampacity.
 - e. Horsepower.
 - 9. Furnish circuit breaker submittals as specified in Section 26_28_01 - Low Voltage Molded Case Circuit Breakers.
- C. Shop Drawings:
 - 1. Elementary and schematic diagrams:
 - a. Provide 1 diagram for every starter and contactor.
 - b. Indicate wire numbers for control wires on the diagrams:
 - 1) Wire numbering as specified in Section 26_05_53 - Identification for Electrical Systems.
 - c. Indicate interfaces with other equipment on the Drawings.
- D. Delegated Design Submittals:
 - 1. Anchoring and bracing: Provide project-specific calculations based on support conditions and requirements to resist loads specified in Section 01_81_50 - Design Criteria:
 - a. To structures for equipment installed in structures designated as seismic design category C, D, E, or F.
 - b. For equipment installed outdoors.
 - c. For wall mounted equipment weighing 125 pounds or more.
- E. Quality Control Submittals:
 - 1. Manufacturer's representative qualifications.
 - 2. Manufacturer's Certificate of Source Testing as specified in Section 01_75_17 - Commissioning.
 - 3. Test reports.

- F. Owner Training Submittals:
 - 1. As specified in Section 01_75_17 - Commissioning.
- G. Operation and maintenance manuals:
 - 1. As specified in Section 01_78_24 - Operation and Maintenance Manuals.
 - 2. Submit complete operating and maintenance instructions presenting full details for care and maintenance of equipment furnished or installed under this Section, including, but not limited to:
 - a. Electrical ratings:
 - 1) Phase.
 - 2) Wire.
 - 3) Voltage.
 - 4) Ampacity.
 - b. Complete bill of material.
 - c. Manufacturer's operating and maintenance instructions starter and/or contactor component parts, including:
 - 1) Protective devices (fuses, breakers, overload relays, heater elements, etc.).
 - 2) Pilot devices.
 - d. Recommended spare parts list.
 - e. As-built drawings:
 - 1) Furnish as-built drawings for each starter and contactor indicating final:
 - a) Wire numbers.
 - b) Interfaces with other equipment.
 - 2) 11-inch by 17-inch format.

1.06 QUALITY ASSURANCE

- A. Regulatory requirements:
 - 1. Starters and components shall be UL listed and labeled:
 - a. UL 508 - Industrial Control Equipment.
 - b. UL 508A - Industrial Control Panels.
 - 2. NEMA ICS 2 - Industrial Control and System Controllers; Contactors and Overload Relays Rated: 600 Volts.
 - 3. Combination starters shall be UL listed and labeled.

1.07 DELIVERY, STORAGE, AND HANDLING (NOT USED)

1.08 PROJECT OR SITE CONDITIONS

- A. As specified in Section 01_81_50 - Design Criteria.

1.09 ADMINISTRATIVE REQUIREMENTS

1.10 WARRANTY

- A. As specified in Section 01_78_36 - Warranties and Bonds.

1.11 MAINTENANCE

- A. Provide the following spare parts, suitably packaged and labeled with the corresponding equipment number:
 - 1. 1 spare fuse of each size and type per starter.

PART 2 PRODUCTS

2.01 GENERAL

- A. Starters for motor control centers, individual enclosed starters, or control panels.

2.02 DESIGN AND PERFORMANCE CRITERIA

- A. Provide equipment and components that are fully rated for the Site elevation and operating environment where the equipment will be installed as specified in Section 01_81_50 - Design Criteria and as indicated on the Drawings.
- B. Non-conditioned spaces:
 - 1. For equipment located in non-conditioned spaces, provide additional temperature conditioning equipment to maintain the equipment temperature within a band of 10 degrees Fahrenheit above the minimum operating temperature and 10 degrees Fahrenheit below maximum operating temperature.
- C. Outdoor installations:
 - 1. Provide conditioning equipment incorporated into the equipment to maintain the enclosures within the equipment manufacturer's specified operating ranges.

2.03 MANUFACTURERS

- A. One of the following or equal:
 - 1. NEMA starters and contactors:
 - a. ABB.
 - b. Allen-Bradley.
 - c. Eaton.
 - d. Schneider Electric.

2.04 MATERIALS (NOT USED)

2.05 MANUFACTURED UNITS

- A. General:
 - 1. Provide combination type starters with motor circuit protector or thermal-magnetic circuit breaker and control power transformer with ratings as indicated on the Drawings.
 - 2. NEMA size, design, and rated:
 - a. NEMA Size 1 minimum.

3. Coordinate motor circuit protector, thermal magnetic circuit breaker, or fusible disconnect, and overload trip ratings with nameplate horsepower and current ratings of the installed motor.
 - a. If motors provided are different in horsepower rating than those specified or indicated on the Drawings, provide starters coordinated to the actual motors furnished.
 4. Mount extended overload reset buttons to be accessible for operation without opening starter enclosure door.
- B. Full voltage starters (FVNR, FVR):
1. Across-the-line full voltage magnetic starters.
 2. Rated for 600 volts.
 3. Electrical characteristics as indicated on the Drawings.
 4. Provide positive, quick-make, quick-break mechanisms, padlockable enclosure doors.
 5. Furnish starter with solid state electronic overload relays.
 6. Double-break silver alloy contacts.
 7. Reversing starters provided with both mechanical and electrical interlocks to prevent line shorts and energizing both contactors simultaneously.

2.06 EQUIPMENT (NOT USED)

2.07 COMPONENTS

- A. Molded case circuit breakers:
1. Circuit breaker type and ratings as indicated on the Drawings.
 2. Provide as specified in Section 26_28_01 - Low Voltage Molded Case Circuit Breakers.
- B. Contactors:
1. NEMA size as indicated on the Drawings.
 2. Electrically held:
 - a. For lighting loads designed to withstand the initial inrush currents of ballast and lamp loads.
 3. Factory adjusted and chatter free.
 4. Auxiliary contacts:
 - a. Contact ratings in accordance with NEMA A600 rating:
 - 1) Auxiliary contacts rated 10 amps at 600 volts.
 - b. Provide contacts indicated on the Drawings and any additional contacts required for proper operation.
 - c. Provide at least 1 normally open and 1 normally closed spare auxiliary contact.
 5. Constructed in accordance with the following standards:
 - a. UL 508.
 - b. IEC 947-4:
 - 1) Type 1 coordination when protected by a circuit breaker.
 - 2) Type 2 coordination when protected by a suitable UL listed fuse.
 - c. IEC 801-1 parts 2 through 6.

- C. Overloads:
 - 1. Solid state electronic:
 - a. Selectable Class 10, 20, 30 protection.
 - b. Ambient insensitive:
 - 1) Operating temperature: -20 to 70 degrees Celsius.
 - c. Thermal memory.
 - d. Protective functions:
 - 1) Motor overcurrent.
 - 2) Phase unbalance (adjustable).
 - 3) Phase loss.
 - 4) Ground fault protection.
 - e. Self-powered.
 - f. Provide current transformers for metering of motor current.
 - g. Visible trip indicator.
 - h. Push-to-trip test.
 - i. Isolated normally open alarm contact.
 - j. Normally closed trip contact.
 - k. Automatic reset.
- D. Control power transformer:
 - 1. Furnish integral control power transformer capacity to power:
 - a. Motor controls: Motor and starter accessories indicated on the Drawings or specified.
 - 2. Primary and secondary fusing as indicated on the Drawings:
 - a. Fusing sized by the manufacturer for the rating of the transformer furnished.
 - 3. Control power transformer secondary voltage:
 - a. As indicated on the Drawings.

2.08 ACCESSORIES

- A. Lugs and terminals:
 - 1. For external connections of No. 6 AWG and larger.
 - 2. UL listed for either copper or aluminum conductors.
- B. Surge protective devices:
 - 1. Furnish surge protection devices across the coil of each starter, contactor, and relay.
- C. Pilot devices:
 - 1. Provide pilot lights, switches, elapsed time meters, and other devices as specified or as indicated on the Drawings.
 - 2. As specified in Section 40_67_01 - Control Systems: Panels, Enclosures, and Panel Components.
- D. Nameplates and wire markers:
 - 1. As specified in Section 26_05_53 - Identification for Electrical Systems.
- E. Conformal coating:
 - 1. Provide conformal coating material applied to electronic circuitry and printed circuit boards to act as protection against moisture, dust, temperature extremes, and chemicals such as H₂S and chlorine.

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL

- A. Source Testing:
 - 1. Not witnessed.
 - 2. Furnish test reports and Manufacturer's Certificate of Source Testing.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION

- A. Anchoring and bracing to structures:
 - 1. Prepare equipment anchor setting template(s) and use to position anchors during construction of supporting structure(s).
 - 2. Install anchors of type and material indicated on approved anchoring designs.
 - 3. Install anchors with embedment indicated on approved anchoring designs.

3.03 INSTALLATION

- A. Install the equipment in accordance with the accepted installation instructions and anchorage details.
- B. Starters in motor control centers:
 - 1. As specified in Section 26_24_20 - Low Voltage Motor Control Centers.
- C. Starters in control panels:
 - 1. As specified in Section 40_67_01 - Control Systems: Panels, Enclosures, and Panel Components.

3.04 FIELD QUALITY CONTROL

- A. Field electrical acceptance testing:
 - 1. As specified in Section 26_08_50 - Field Electrical Acceptance Tests.

3.05 OWNER TRAINING

- A. Perform Owner Training as specified in Section 01_75_17 - Commissioning.

3.06 ADJUSTING

- A. Provide the services of a qualified manufacturer's representative for start-up assistance:
 - 1. Inspection and field adjustment:
 - a. Supervise equipment installation and confirm controls have been properly installed, aligned, adjusted, and readied for operation.

2. Starter parameter and protection settings:
 - a. Program protection settings coordinated with the driven equipment supplier.
 3. Provide documentation of starter settings, including, but not limited to:
 - a. Motor nameplate information.
 - b. All protection settings.
- B. Make adjustments as necessary and as recommended by the manufacturer, Engineer, or testing firm.
- C. Set overloads and motor circuit protectors based on the nameplate values of the installed motor.

END OF SECTION

SECTION 26_33_01

BATTERY SYSTEMS

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Nickel-cadmium battery systems.

1.02 REFERENCES

- A. Fire Code:
 - 1. As specified in Section 01_41_00 - Regulatory Requirements.
- B. Institute of Electrical and Electronics Engineers (IEEE):
 - 1. 693 - IEEE Recommended Practice for the Seismic Design of Substations.
 - 2. 1115 - IEEE Recommended Practice for Sizing Nickel-Cadmium Batteries for Stationary Applications.
- C. Occupational Health and Safety Administration (OSHA):
 - 1. 1926.441 - Batteries and Battery Charging.
- D. Underwriters Laboratories, Inc. (UL):
 - 1. 94 - Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances.

1.03 DELEGATED DESIGN

- A. As specified in Section 01_35_73 - Delegated Design Procedures.
- B. Anchoring and bracing.

1.04 SUBMITTALS

- A. Furnish Submittals as specified in Section 01_33_00 - Submittal Procedures.
- B. Product data:
 - 1. Complete bill of material, including quantity, description, manufacturer, and part number.
 - 2. Battery cells:
 - a. Manufacturer.
 - b. Type.
 - c. Amp-hour rating.
 - d. Volts per cell/volts per string.
 - e. Hydrogen off-gassing rate per amp of charging current.
 - f. Volume of electrolyte.

3. Battery charger:
 - a. Input power requirements.
 - b. Output voltage.
 - c. Maximum output current.
 - d. Enclosure type.
 - e. Alarm and status contacts.
 4. Anchorage hardware.
 5. Spill containment hardware.
 6. Chemical neutralization.
 7. Panelboard.
 8. Warning signs.
 9. Warranty.
- C. Shop Drawings:
1. Plan, elevation, and section drawings for:
 - a. Battery cells.
 - b. Racks.
 - c. Spill containment.
 2. Point-to-point wiring diagrams, including all components of the battery system, with each component and terminal number labeled.
- D. Calculations:
1. Complete calculations used to size the battery system in accordance with IEEE 1115.
 - a. Use manufacturer's load data for the actual equipment provided, including the actual demand for protective relays, lights, etc., and the trip, close, and spring charge currents for the circuit breakers provided:
 - 1) Provide a table showing the load for each piece of equipment used in the calculations (including trip, close, and spring charge actions for circuit breakers).
- E. Delegated Design Submittals:
1. Anchoring and bracing: Provide project-specific calculations based on support conditions and requirements to resist loads specified in Section 01_81_50 - Design Criteria:
 - a. To structures for equipment installed in structures designated as seismic design category C, D, E, or F.
- F. Installation instructions:
1. Detail the complete installation of the equipment, including rigging, moving, and setting into place.
 2. Provide manufacturer's installation instructions.
- G. Quality Control Submittals:
1. Manufacturer's representative qualifications.
 2. Manufacturer's Certificate of Source Testing as specified in Section 01_75_17 - Commissioning.
 3. Manufacturer's Certificate of Installation Verification as specified in Section 01_75_17 - Commissioning.
 4. Test reports.

- H. Operation and maintenance manuals:
 - 1. As specified in Section 01_78_24 - Operation and Maintenance Manuals.
 - 2. Furnish the manufacturer's standard shop manual for troubleshooting and maintenance tasks.
 - 3. Include a table listing each maintenance task and the recommended interval for the task.
- I. Certification letter:
 - 1. Provide a certificate indicating that the battery rack(s) supplied are in accordance with the seismic requirements of IEEE 693 under the criteria specified in Section 01_81_50 - Design Criteria.

1.05 QUALITY ASSURANCE (NOT USED)

1.06 DELIVERY, STORAGE, AND HANDLING

- A. Store batteries in a climate-controlled environment until installation in their final location.

1.07 PROJECT OR SITE CONDITIONS

- A. Equipment shall be de-rated in accordance with the manufacturer's guidelines for the Project altitude and ambient temperature as specified in Section 01_81_50 - Design Criteria.

1.08 ADMINISTRATIVE REQUIREMENTS (NOT USED)

1.09 WARRANTY

- A. As specified in Section 01_78_36 - Warranties and Bonds.
- B. Special warranty:
 - 1. Provide 20-year pro-rata warranty on the battery units. An individual unit shall be considered defective if its capacity degrades to less than 80 percent of its published capacity within 20 years of acceptance.

PART 2 PRODUCTS

2.01 GENERAL (NOT USED)

2.02 DESIGN AND PERFORMANCE CRITERIA

- A. Design requirements:
 - 1. Battery systems to provide DC power to electrical equipment under normal and emergency conditions as specified in the Contract Documents or indicated on the Drawings.
 - 2. Switchgear battery systems:
 - a. As specified in the equipment specification.
 - b. Battery type nickel-cadmium.

- B. Performance requirements:
 - 1. Size battery system to meet the functional requirements of the equipment in accordance with IEEE 1115 using the following factors:
 - a. Design margin: 1.15.
 - b. Aging factor: 1.25.
 - c. Temperature correction factor:
 - 1) Select the temperature correction factor from the IEEE table based on the temperature range specified in Section 01_81_50 - Design Criteria.
 - 2. Size the switchgear battery system to meet the following criteria for the actual equipment provided:
 - a. Operate continuous loads for a period of 4 hours.
 - b. After a period of 4 hours:
 - 1) Operate main, tie, and generator breakers through 2 complete cycles of close, trip, and spring charge.
 - 2) Trip feeder breakers on one side of the tie breaker simultaneously.

2.03 MANUFACTURERS

- A. Nickel-cadmium batteries:
 - 1. One of the following or equal:
 - a. Alcad.
 - b. HBL Power Systems.
 - c. SENS.
- B. Battery chargers:
 - 1. One of the following or equal:
 - a. EnerSys.
 - b. SAFT.
 - c. SENS.

2.04 MATERIALS (NOT USED)

2.05 MANUFACTURED UNITS (NOT USED)

2.06 EQUIPMENT (NOT USED)

2.07 COMPONENTS

- A. Nickel-cadmium batteries:
 - 1. Plates:
 - a. Sealed pocket plates.
 - b. Welded connections to plates.
 - c. Plastic grid plate separators.
 - 2. Jar and cover:
 - a. Constructed of flame-retardant, translucent material, marked on the sides to indicate electrolyte levels.
 - b. Safety venting cap:
 - 1) Flame arresting type.

2.08 ACCESSORIES

- A. Battery racks:
 - 1. Designed and certified to conform to IEEE 693.
 - 2. Welded steel support frames and rails.
 - 3. Provisions for attachment of a grounding lug.
 - 4. Flame-retardant spacers between each unit.
 - 5. Seismic anchoring hardware.
- B. Spill containment:
 - 1. Sealed acid-resistant PVC or epoxy-coated steel floor pan and vertical barrier:
 - a. Designed to contain the entire electrolyte volume of the largest battery unit contained in the rack.
 - b. Containing electrolyte-neutralizing chemical packets covering the entire floor of the containment area plus 10 percent spare, designed to control and neutralize a spill from the largest battery unit contained in the rack to a pH of between 7.0 and 9.0.
- C. Battery charger:
 - 1. Designed to float and equalize the batteries in accordance with the manufacturer's requirements and recommendations.
 - 2. Sized to recharge the batteries from a fully discharged state to a fully charged state in a period of 8 hours, while operating all continuous DC loads.
 - 3. Input voltage as indicated on the Drawings.
 - 4. AC input circuit breaker.
 - 5. DC output circuit breaker.
 - 6. DC output ammeter and voltmeter.
 - 7. Voltage surge suppressors.
 - 8. Contacts rated 5 A at 120 VAC for remote monitoring of the following signals:
 - a. Low battery voltage.
 - b. Battery charger fail.
 - 9. Enclosure rating as specified in Section 26_05_00 - Common Work Results for Electrical for the area of installation.
- D. Signage:
 - 1. Provide warning signs meeting the requirements of IFC 1207.4.8 and OSHA 1926.441 at entrances to spaces containing batteries or battery chargers.
- E. DC panelboard:
 - 1. As specified in Section 26_24_16 - Panelboards.
 - 2. Size circuit breakers based on the DC load of the actual equipment provided.

2.09 FABRICATION (NOT USED)

2.10 FINISHES

- A. Finish battery racks with an acid-resistant, electrostatically applied epoxy powder coat, ANSI 61 gray in color.

2.11 SOURCE QUALITY CONTROL

- A. Source Testing:
 - 1. Factory test each unit shipped to verify initial system capacity and performance of electrical connections:
 - a. "Lot" testing or testing of a typical unit is not acceptable.
 - 2. Furnish test reports and Manufacturer's Certificate of Source Testing.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION

- A. Anchoring and bracing to structures:
 - 1. Prepare equipment anchor setting template(s) and use to position anchors during construction of supporting structure(s).
 - 2. Install anchors of type and material indicated on approved anchoring designs.
 - 3. Install anchors with embedment indicated on approved anchoring designs.

3.03 INSTALLATION

- A. In accordance with the manufacturer's guidelines and submitted installation instructions.
- B. Installation Verification:
 - 1. Furnish Manufacturer's Certificate of Installation Verification.

3.04 FIELD QUALITY CONTROL

- A. Field electrical acceptance testing:
 - 1. As specified in Section 26_08_50 - Field Electrical Acceptance Tests.
- B. Provide the services of a qualified manufacturer's representative to inspect the battery system and verify that the installation complies with the manufacturer's guidelines and written installation instructions.

END OF SECTION

SECTION 26_33_54

UNINTERRUPTIBLE POWER SUPPLIES 10 - 30 KVA

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. 3-phase double conversion uninterruptible power supplies rated 10 to 30 kVA.

1.02 REFERENCES

- A. Code of Federal Regulations (CFR) Title 47:
 - 1. Part 15, Subpart B - Unintentional Radiators.
- B. Institute of Electrical and Electronic Engineers (IEEE):
 - 1. C62.41 - IEEE Recommended Practice for Surge Voltages in Low-Voltage AC Power Circuits.
- C. International Organization for Standardization (ISO):
 - 1. ISO 9001 Quality management systems - Requirements.
- D. National Electrical Manufacturers Association (NEMA).
- E. National Fire Protection Association (NFPA):
 - a. 70 - National Electrical Code (NEC).
- F. Underwriters Laboratories, Inc. (UL):
 - 1. 1778 - Uninterruptible Power Systems.

1.03 TERMINOLOGY

- A. The words and terms listed below are not defined terms that require initial capital letters, but, when used in this Section, have the indicated meaning.
 - 1. Critical load: Loads requiring uninterrupted power supplied by the UPS.
 - 2. MOV: Metal Oxide Varistor.
 - 3. Point of common coupling (PCC): MCC bus, panelboard, or power source from which the UPS derives power.
 - 4. Static transfer switch: A typically solid state device, which serves to route the UPS input power directly to the output of the UPS, effectively bypassing the UPS rectifier/charger, batteries, and inverter. Also termed "Automatic Bypass Switch" and "Dynamic Bypass Switch" in some literature.

1.04 DELEGATED DESIGN

- A. As specified in Section 01_35_73 - Delegated Design Procedures.
- B. Anchoring and bracing.

1.05 SUBMITTALS

- A. Furnish Submittals as specified in Section 01_33_00 - Submittal Procedures.
- B. Product data:
 - 1. Manufacturer and model number.
 - 2. Catalog data.
 - 3. Dimensions:
 - a. Height.
 - b. Width.
 - c. Depth.
 - d. Weight.
 - 4. Ratings:
 - a. Input voltage.
 - b. Output voltage.
 - c. Power factor.
 - d. Efficiency.
 - e. Harmonic distortion.
 - f. Run times.
 - 5. Noise specifications.
 - 6. Heat dissipation.
 - 7. Warranties and maintenance contracts.
 - 8. Isolation transformer specifications.
 - 9. All communications requirements such as software, cards, etc.
 - 10. Communications bus protocol.
 - 11. Alarms and status available for remote monitoring and system health.
 - 12. Recommended spare parts.
 - 13. For equipment installed in structures designated as seismic design category C, D, E, or F, submit the following as specified in Section 01_81_50 - Design Criteria:
 - a. Manufacturer's statement of seismic qualification with substantiating test data.
 - b. Manufacturer's special seismic certification with substantiating test data.
- C. Shop Drawings:
 - 1. Power distribution block diagrams.
 - 2. Single-line diagrams, including input and output voltage.
 - 3. Front and side views of equipment enclosures with overall dimensions:
 - a. Front elevation, including control and indicating devices.
 - 4. Support points and weight of overall equipment.
 - 5. Schematic and control wiring diagrams, including, but not limited to:
 - a. Line and load terminals.
 - b. Alarm and status terminals.
 - c. Automatic or maintenance switch terminals.
 - d. External wiring requirements for communication signals.
 - 6. Switching and overcurrent protective devices.
 - 7. Conduit entrance locations and requirements.
 - 8. Isolation transformer wiring.

- D. Calculations:
 - 1. Derating for temperature and elevation as necessary and safety factors as specified in this Section.
 - 2. UPS sizing computation:
 - a. Add safety factors as specified in this Section.
 - b. Provide itemized list of critical loads, including individual VA and watt ratings.
 - 3. Battery time calculation based on specified run time.
 - 4. Total battery recharge time as a function of capacity utilized.
- E. Delegated Design Submittals:
 - 1. Anchoring and bracing: Provide project-specific calculations based on support conditions and requirements to resist loads specified in Section 01_81_50 - Design Criteria:
 - a. To structures for equipment installed in structures designated as seismic design category C, D, E, or F.
- F. Installation instructions:
 - 1. Detail the complete installation of the equipment, including rigging, moving, and setting into place.
 - 2. Provide manufacturer's installation instructions.
- G. Quality Control Submittals:
 - 1. Manufacturer's representative qualifications.
 - 2. Manufacturer's Certificate of Source Testing as specified in Section 01_75_17 - Commissioning.
 - 3. Manufacturer's Certificate of Installation Verification as specified in Section 01_75_17 - Commissioning.
 - 4. Test reports.
- H. Owner Training Submittals:
 - 1. As specified in Section 01_75_17 - Commissioning.
- I. Record Drawings:
 - 1. Provide Record Drawings of installed unit(s), including layout and wiring.
- J. Manufacturer's field reports.
- K. Operation and maintenance manuals:
 - 1. As specified in Section 01_78_24 - Operation and Maintenance Manuals.
 - 2. System instruction manuals that describe troubleshooting, installation, operations, and safety procedures.
 - 3. Recommendations for maintenance procedures and intervals.
 - 4. Battery data/replacement information.
 - 5. Parts list.

1.06 QUALITY ASSURANCE

- A. Manufacturer qualifications:
 - 1. A minimum of 10 years of experience in the design, manufacture, and testing of solid-state UPS systems.
 - 2. ISO 9001 certified.
- B. Regulatory requirements for complete UPS system:
 - 1. UL listed in accordance with UL 1778.
 - 2. IEEE C62.41, Categories A & B.
 - 3. CFR Title 47, Part 15, Subpart B:
 - a. Greater than 2,000 VA - Class A.

1.07 DELIVERY, STORAGE, AND HANDLING (NOT USED)

1.08 PROJECT OR SITE CONDITIONS

- A. As specified in Section 01_81_50 - Design Criteria.

1.09 ADMINISTRATIVE REQUIREMENTS (NOT USED)

1.10 WARRANTY

- A. As specified in Section 01_78_36 - Warranties and Bonds.

1.11 MAINTENANCE

- A. Provide a list of recommended spare parts, in addition to those listed below:
 - 1. If the Project is outside of a 150-mile radius of a certified factory technician then provide:
 - a. Spare fuses.
 - b. Spare circuit boards.
 - c. All other components for maximizing parts accessibility and maximizing uptime.

PART 2 PRODUCTS

2.01 GENERAL (NOT USED)

2.02 DESIGN AND PERFORMANCE CRITERIA

- A. Provide equipment and components that are fully rated for the Site elevation and operating environment where the equipment will be installed as specified in Section 01_81_50 - Design Criteria and as indicated on the Drawings.
- B. Complete, factory-assembled, wired, and tested, double conversion UPS equipment, including, but not limited to, rectifier/charger, DC bus, inverter, batteries, automatic bypass and manual maintenance bypass, and ancillary components as specified in this Section.
- C. Supply power to loads as indicated on the Drawings.

- D. Modes of operation:
1. Normal AC power:
 - a. Inverter supplies critical load(s).
 - b. Rectifier continually supplies power to the inverter.
 - c. Rectifier/charger supplies float charging current to the DC batteries.
 2. Abnormal AC power:
 - a. Inverter supplies critical load(s).
 - b. DC batteries supply power to the inverter for the rated time.
 - c. No switching or delay between normal and battery power.
 - d. Critical loads do not experience power interruption upon loss of AC source.
 3. Return of normal AC power:
 - a. Rectifier rectifier/charger is automatically re-started.
 - b. Transition to normal power:
 - 1) Power is restored gradually via rectifier "walk in."
 4. Loss of rectifier/charger, battery, or inverter:
 - a. Static transfer switch routes power from the normal AC source to critical loads upon reaching preset voltage and frequency parameters:
 - 1) Voltage sensing provided at input terminals of static bypass to prevent disturbance in excess of 1/4 cycle.
 - 2) Return critical load back to inverter upon restoration of normal inverter operation. Restoration occurs after a preset timing interval and automatic re-synchronization to AC power line.
 - 3) Synchronizing check prevents return if the inverter and line voltage are not within 5 electrical degrees.
 5. Maintenance bypass:
 - a. Normal AC power routes directly to the critical loads.

2.03 MANUFACTURERS

- A. One of the following or equal:
1. Liebert.
 2. Mitsubishi.
 3. Powerware.
- B. Manufacturers of batteries:
1. As specified in this Section.

2.04 MATERIALS (NOT USED)

2.05 MANUFACTURED UNITS

- A. System characteristics:
1. Safety factor:
 - a. Minimum kW and kVA ratings of the UPS shall be 1.5 times the connected load for both kW and kVA ratings.
 2. For UPS units which are possibly powered from backup generators:
 - a. Suitably rated for operation while on generator power.
 3. Battery run time at full load and Site ambient temperature as indicated in Attachment A - UPS Schedule.

4. Efficiency:
 - a. Greater than 89 percent AC-AC, no input transformer.
 - b. Greater than 83 percent when input transformer implemented.
5. Acoustical noise:
 - a. Less than 58 dBA at 1 meter after installation.
6. Input connections:
 - a. As indicated in Attachment A - UPS Schedule.
7. Output connections:
 - a. Hardwired connection as indicated on the Drawings.
8. UPS power quality abnormalities:
 - a. Undervoltage:
 - 1) Operate on battery power if incoming source voltage drops below UPS system limits.
 - b. Overvoltage:
 - 1) Operate on battery power if incoming source voltage rises above UPS system limits.
 - c. Overcurrent:
 - 1) Input and output current-limiting protection to ensure adequate overcurrent protection for UPS.
 - 2) 125 percent of full load current for 30 seconds.
 - 3) Sub-cycle fault clearing for currents in excess of 300 percent of full load current.
 - d. Surge protection:
 - 1) MOV-based.

B. Electrical characteristics:

1. AC input:
 - a. Voltage:
 - 1) As specified in Attachment A - UPS Schedule:
 - a) Fully functional within +10 percent, -15 percent of nominal voltage.
 - b. Current:
 - 1) Reflected total harmonic distortion (THD) less than 5 percent at rated load.
 - 2) Maximum inrush current 800 percent of full load.
 - 3) Rectifier walk-in:
 - a) 20 seconds to full rated input current maximum.
 - b) Field selectable 5 to 20 seconds.
 - c. Frequency range of operation:
 - 1) 60 hertz within 5 percent.
 - d. Power factor:
 - 1) Not less than 0.96 at nominal voltage and full rated load.
 - e. Rectifier current limiting to 125 percent of the rated input.
2. Output:
 - a. Voltage:
 - 1) As indicated in Attachment A - UPS Schedule.
 - 2) Voltage regulation:
 - a) Within 2 percent 3-phase RMS average for a 100 percent unbalanced load for the combined effects of input voltage, connected load, battery voltage, ambient temperature, and load power factor.

- 3) Total harmonic distortion (THD):
 - a) 1 percent THD for linear loads.
 - b) Less than 4 percent for 100 percent non-linear loads without derating at a crest factor of 3:1.
 - 4) Transient recovery time:
 - a) Within 1 percent of nominal voltage within 1 cycle.
 - 5) Voltage unbalance:
 - b. Within 1 percent for 100 percent unbalanced load.
 - c. Load power factor:
 - 1) 0.7 lagging to 0.95 leading.
 - d. Frequency regulation:
 - 1) Within 0.1 hertz when synchronized to source.
 - e. Frequency slew rate:
 - 1) Maximum 1.0 hertz/s.
 - 2) User selectable 0.1 to 1.0 hertz/s.
 - f. Phase displacement:
 - 1) Within 0.5 degree for balanced load.
 - 3. Within 1.0 degree for 100 percent unbalanced load.
- C. Environmental requirements:
- 1. Operating ambient temperature:
 - a. UPS module: 32 degrees Fahrenheit to 104 degrees Fahrenheit (0 degrees Celsius to 40 degrees Celsius).
 - b. Battery: 68 degrees Fahrenheit to 86 degrees Fahrenheit (20 degrees Celsius to 30 degrees Celsius).

2.06 EQUIPMENT (NOT USED)

2.07 COMPONENTS

- A. Surge protective devices:
 - 1. MOV-protection with suitable ratings for installation location and voltage.
- B. Inverter:
 - 1. SCR/IGBT type with constant voltage/current-limiting control circuitry.
 - 2. Pulse-width modulated AC output signal.
- C. Battery rectifier/charger:
 - 1. SCR/IGBT type with constant voltage/current-limiting control circuitry.
 - 2. Sufficient capacity to simultaneously recharge batteries and supply full load current to the inverter.
 - 3. Phase-controlled, self-regulated, and self-protected.
 - 4. Separate battery current limit, adjustable from 0 to 15 percent of the full load input current of the charger.
 - 5. Ability to manually limit the battery recharge current to zero when activated, for instances such as generator operation.
- D. Protection:
 - 1. Provide circuit breakers at the following locations:
 - a. Input to rectifier/charger.
 - b. Manual maintenance bypass switch.

- c. DC output of rectifier/charger.
- d. AC output inverter.
- e. Battery system circuit breaker with under voltage release (UVR) and auxiliary contacts for isolation of the battery pack from the UPS module. Locate disconnect in a separate wall mounted NEMA Type 1 enclosure:
 - 1) Provides manual disconnecting means, short circuit protection, and overcurrent protection for the battery system. When opened, removes battery voltage within the UPS enclosure.
 - 2) Automatically disconnects the UPS from the battery by opening the breaker when the battery reaches the minimum discharge voltage level.
- 2. Short circuit on system output under any condition, including transfer to the AC line, may not cause UPS damage.
- 3. Additional protection:
 - a. Undervoltage relaying.
 - b. Current limiting fuses.
 - c. Single-phase protection.
 - d. Inverter DC protection:
 - 1) DC overvoltage shutdown:
 - a) If the DC voltage rises to the pre-set limit, UPS shut down occurs automatically and initiates an uninterrupted load transfer to the static bypass line.
 - b) Inverter control logic senses and disconnects the inverter from the critical AC load without the requirement to clear protective fuses.
 - 2) DC undervoltage warning (low battery reserve), user adjustable from 1 to 99 minutes.
 - 3) DC undervoltage shutdown (end of discharge).
 - e. Over-discharge protection:
 - 1) Automatically raise the shutdown voltage setpoint as discharge time increases beyond 15 minutes.
 - f. Fuse power semiconductors in the rectifier/charger with fast-acting fuses, so that loss of any power semiconductor cannot cause cascading failures.

E. Batteries:

- 1. VRLA (valve regulated lead acid), sealed, maintenance free.
- 2. Minimum 3-year float service life at 25 degrees Celsius.
- 3. Integral to UPS enclosure or housed in a matching enclosure.
- 4. Provide the capability for additional battery packs for future storage capacity.
- 5. Hot-swappable.
- 6. Recharge to 95 percent within 10 times discharge time.
- 7. Automatically perform routine battery health monitoring and provide visual, audible, and/or serial warnings if abnormal battery conditions exist.
- 8. Manufacturers: One of the following or equal:
 - a. C&D.
 - b. CSB.
 - c. East Penn.
 - d. EnerSys.
 - e. Nife (NiCad).
- 9. Batteries:
 - a. Lead calcium sealed, UL listed, non-gassing, immobilized electrolyte type.

- b. Maintenance free, sealed in plastic containers to form a permanent leak-proof unit. Sealed, valve regulated. Absorbed glass mat (AGM) design.
 - c. Provided with intercell cables and connectors, stainless steel terminal lugs, cell lifter, and lug wrenches.
 - d. Covers fitted with spray-proof vent plugs.
 - e. Cabinet:
 - 1) Rack enclosed in vented metal cabinet with hinged access doors.
 - 2) Finished to match floor standing rectifier and inverter enclosures using acid resistant paint.
 - 3) Casters and leveling feet provided with the battery power pack cabinet for ease of installation. Removable upon installation where seismic design constraints require.
 - 4) Battery accessibility:
 - a) Mount battery cells on slide-out trays for ease of maintenance.
 - 5) Bolt battery cabinet to the UPS cabinet. Interconnecting cables are to be provided, pre-cut, and pre-lugged.
 - 6) Battery monitor capable of monitoring battery failure, charge abnormalities, and emergency inverter operation with display capabilities for remote and local monitoring.
- F. Static bypass switch:
- 1. Integral to UPS system.
 - 2. Maximum detect and transfer time of 4 to 6 milliseconds.
 - 3. Automatic re-transfer without power interruption to critical load.
 - 4. Input shall match input output in phase, voltage, frequency, and grounding.
 - 5. Rated to carry the full input and output current of the UPS.
 - 6. Provide ability for manual operation.
 - 7. Bypass line synch range:
 - a. Within 0.5 hertz.
 - b. Inhibit automatic transfer of the critical load to the bypass source if any of the following conditions are present:
 - 1) Inverter/bypass voltage difference exceeding preset limits.
 - 2) Bypass frequency out of limits.
 - 3) Bypass out-of-synchronization range with inverter output.
 - 4) UPS fault condition present.
- G. Manual maintenance bypass switch:
- 1. Provide isolation of the UPS and power to the critical loads for maintenance purposes, and to prevent personnel exposure during maintenance.
 - 2. Make-before-break design so that UPS can be isolated from the critical loads by placing these loads on source power without interruption of operation:
 - a. Applies to both transfer to UPS and transfer return to the utility.
 - 3. Rated to carry the full current of the UPS.
 - 4. Include transformer in bypass circuit where UPS output does not match voltage of UPS input:
 - a. Match input and output in phase, voltage, frequency, and grounding.
 - 5. Input and output circuit breakers.
 - a. Provide external enclosure so that full isolation can be attained for UPS servicing.

- H. Cooling:
 - 1. Forced air-cooled.
 - 2. Powered by UPS unit.
 - 3. Coordinate thermal and ambient sensors with protective devices such that component or internal temperature limits are not exceeded:
 - a. Automatic bypass On/Off.
 - b. Maintenance bypass On/Off.
 - c. Input power On.
 - d. Battery testing mode.
- I. Monitoring and controls:
 - 1. Front-panel pushbuttons:
 - a. UPS startup, shutdown, manual bypass (for automatic bypass), and maintenance bypass.
 - b. Testing.
 - c. Visual/audible alarms reset.
 - 2. Monitoring:
 - a. Microprocessor-based interface with the display and controls section.
 - b. Provide a graphical display showing a single-line diagram as part of the monitoring and controls sections of the UPS. Display switch positions and power flow.
 - c. Display monitoring functions such as metering, status, and alarms on the graphical LCD display. Additional features of the monitoring system include:
 - 1) Menu-driven display with pushbutton navigation.
 - 2) Real time clock (time and date).
 - 3) Alarm history with time and date stamp.
 - 4) Battery back-up memory.
 - 3. Status indication:
 - a. Normal operation.
 - b. Load on maintenance bypass.
 - c. Load on UPS (loss of rectifier/utility power).
 - d. Load on static bypass.
 - e. Lamp test/reset pushbutton.
 - 4. Metering displays:
 - a. Input AC voltage line-to-line.
 - b. Input AC current for each phase.
 - c. Input frequency.
 - d. Battery voltage.
 - e. Battery charge/discharge current.
 - f. Output AC voltage line-to-line and line-to-neutral for each phase.
 - g. Output AC current for each phase.
 - h. Output frequency.
 - i. Output kVA and kW.
 - j. Battery time left during battery operation.
 - 5. Alarm messages:
 - a. Input power out of tolerance.
 - b. Battery rectifier/charger problem.
 - c. Input phase rotation incorrect.
 - d. Input over/under frequency.
 - e. Input current limit.
 - f. Battery failed test.

- g. Low battery warning.
- h. Low battery shutdown.
- i. DC bus overvoltage.
- j. Bypass frequency out of range.
- k. Excessive retransfers attempted.
- l. Static switch failure.
- m. UPS output not synchronized to bypass power.
- n. Input power phase loss.
- o. Output undervoltage.
- p. Output overvoltage.
- q. Output overcurrent.
- r. System output overloaded.
- s. Load transferred to bypass due to overload.
- t. Static bypass switch overload.
- u. Overload shutdown.
- v. Control error.
- w. Critical power supply failure.
- x. Load transferred due to internal protection.
- y. External shutdown (remote EPO activated).
- z. Ambient overtemperature limit.
- aa. Fan failure.
- bb. Overtemperature shutdown pending.
- cc. Overtemperature timeout shutdown.
- dd. Time and date of alarm events.
- ee. Provide audible alarm with Reset pushbutton.
- 6. On-line battery test:
 - a. Menu-driven.
 - b. If the battery fails the test, the system:
 - 1) Maintains the load through the UPS.
 - 2) Displays a warning message.
 - 3) Sounds an audible alarm.
 - c. Additional test features:
 - 1) DC bus voltage threshold (pass/fail value).
 - 2) Interval between tests (2 to 9 weeks).
 - 3) Date and time of initial test.
 - 4) Enable/disable test.

J. Alarm contacts:

- 1. Isolated contact outputs:
 - a. Contacts rated 5 amps, 120 VAC.
 - b. Programmable relay board configurable such that any of the UPS alarms can be programmed onto any channel of the programmable relay board.
 - c. Provide as a minimum, 8 sets of isolated Form C contacts indicating:
 - 1) Normal mode (UPS is supplying power via utility).
 - 2) Emergency mode (UPS is supplying power via batteries).
 - 3) Bypass mode (Static bypass is supplying power).
 - 4) Low battery.
 - 5) AC low inverter voltage.

- 6) Common (summary) alarm.
 - 7) Provide a 50-foot shielded cable, compliant with NEMA Class 2 for plenum applications, with sub-miniature 9-pin D-type connector.
- d. Interconnect these monitoring points to the PCM as well as provide a SCADA screen reflecting the status of the UPS, whether specifically shown on the P&IDs or not.
- K. Communications requirements:
 - 1. RS-232.
 - 2. Ethernet - allow remote indication of alarms and status signals present in the UPS.
- L. DC filter:
 - 1. Maintain voltage ripple to less than 1 percent RMS on the DC bus.
- M. UPS enclosure:
 - 1. Single freestanding unit to house all components, including rectifier/charger, inverter, automatic bypass, all battery modules, and available space for spare battery modules.
 - 2. Casters and leveling feet.
 - 3. Cleaned, primed, and painted with manufacturer's standard color.
 - 4. NEMA Type 1 lockable construction.
- N. Input filter:
 - 1. Provide if required to ensure the UPS input THD remains below specified values.

2.08 ACCESSORIES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL

- A. Source Testing:
 - 1. Not witnessed.
 - 2. Inspect, functionally test, and endurance load test uninterruptible power supply:
 - a. For endurance test, subject uninterruptible power supply equipment to at least 2 times the rated duration specified for the battery system at full load at an ambient temperature equal to or greater than the maximum full load ambient temperature specified above:
 - 1) Test system in accordance with IEEE C62.41, Categories A and B. Submit test procedures and results.
 - 3. Furnish test reports and Manufacturer's Certificate of Source Testing.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION

- A. Anchoring and bracing to structures:
 - 1. Prepare equipment anchor setting template(s) and use to position anchors during construction of supporting structure(s).
 - 2. Install anchors of type and material indicated on approved anchoring designs.
 - 3. Install anchors with embedment indicated on approved anchoring designs.

3.03 INSTALLATION

- A. Install the equipment in accordance with the accepted installation instructions and anchorage details.
- B. Bond neutral and ground as close as possible to UPS system to attenuate common mode noise:
 - 1. Make bonding connections in accordance with the NEC for separately derived systems.
- C. Installation Verification:
 - 1. Furnish Manufacturer's Certificate of Installation Verification.

3.04 FIELD QUALITY CONTROL

- A. As specified in Section 26_05_00 - Common Work Results for Electrical.
- B. Field electrical acceptance testing:
 - 1. As specified in Section 26_08_50 - Field Electrical Acceptance Tests.
- C. Perform inspections and test procedures by factory-trained field service personnel before UPS startup:
 - 1. Inspect equipment for signs of damage.
 - 2. Verify installation in accordance with Drawings and Contract Documents.
 - 3. Inspect cabinets for foreign objects.
 - 4. Verify neutral and ground conductors are properly sized and terminated.
 - 5. Inspect battery cases.
 - 6. Inspect batteries for proper polarity.
 - 7. Check power and control wiring for tightness.
 - 8. Check terminal connectors for tightness.
 - 9. Ensure connection and voltage of the battery string(s).

3.05 OWNER TRAINING

- A. Perform Owner Training as specified in Section 01_75_17 - Commissioning.

3.06 ADJUSTING (NOT USED)

3.07 SCHEDULES

- A. As specified in Attachment A - UPS Schedule.

END OF SECTION

ATTACHMENT A - UPS SCHEDULE

UPS SCHEDULE

TAG	Min. kVA	Run Time	Input Voltage	Input Phase	Output Voltage	Output Phase
UPS-1	10	30 min	480	3	208	3

SECTION 26_36_24
TRANSFER SWITCHES

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Transfer switches.

1.02 REFERENCES

- A. Abbreviations:
 - 1. MTS: Manually initiated, electrically operated transfer switch.
- B. Standards:
 - 1. National Electrical Manufacturers Association (NEMA):
 - a. 250 - Enclosures for Electrical Equipment (1,000 V Maximum).
 - 2. Underwriters Laboratories (UL):
 - a. 1008 - Transfer Switch Equipment.

1.03 TERMINOLOGY

- A. The words and terms listed below are not defined terms that require initial capital letters, but, when used in this Section, have the indicated meaning.
 - 1. SCCR: Short-circuit current rating, the maximum short-circuit current a component and assembly can safely withstand when protected by a specific overcurrent protective device(s) or for a specified time.
 - 2. WCR: Withstand and closing rating, represents a transfer switch's capability to ride out a fault condition until the overcurrent protective device opens and clears the fault.

1.04 DELEGATED DESIGN

- A. As specified in Section 01_35_73 - Delegated Design Procedures.
- B. Anchoring and bracing.

1.05 SUBMITTALS

- A. Furnish Submittals as specified in Section 01_33_00 - Submittal Procedures.
- B. Product data:
 - 1. Manufacturer of transfer switch.
 - 2. Manufacturer of component parts of the ATS.
 - 3. Dimensions:
 - a. Width.
 - b. Length.

- c. Height.
 - d. Weight.
- 4. Bill of material.
- 5. Description of operation.
- 6. Ratings:
 - a. Voltage.
 - b. Phase.
 - c. Current.
 - d. Number of poles.
 - e. Withstand and closing rating (WCR).
- 7. Overcurrent devices:
 - a. As specified in Section 26_28_01 - Low Voltage Molded Case Circuit Breakers.
- 8. List of recommended spare parts.
- 9. For equipment installed in structures designated as Seismic Design Category C, D, E, or F, submit the following as specified in Section 01_81_50 - Design Criteria:
 - a. Manufacturer's statement of seismic qualification with substantiating test data.
 - b. Manufacturer's special seismic certification with substantiating test data.
- C. Shop Drawings:
 - 1. Layout drawings:
 - a. Furnish full-dimensional and to-scale equipment layout drawings, which include:
 - 1) Plan, front, and side views.
 - 2) Sub-panels.
 - 3) Interior panels.
 - 4) Top and bottom conduit windows.
 - 2. Complete electrical wiring diagrams:
 - a. Point-to-point connections.
 - b. Indicate wire numbers.
 - 3. Complete interface and connection diagrams.
 - 4. Transfer equipment label indicating the short-circuit current rating (SCCR).
- D. Calculations:
 - 1. Detailed calculations or details of the actual physical testing performed on the transfer switch to prove the transfer switch is suitable for the seismic requirements at the Project Site.
- E. Delegated Design Submittals:
 - 1. Anchoring and bracing: Provide project-specific calculations based on support conditions and requirements to resist loads specified in Section 01_81_50 - Design Criteria:
 - a. To structures for equipment installed in structures designated as seismic design category C, D, E, or F.
 - b. For equipment installed outdoors.
 - c. For wall mounted equipment weighing 125 pounds or more.

- F. Installation instructions:
 - 1. Detail the complete installation of the equipment, including rigging, moving, and setting into place.
 - 2. Provide manufacturer's installation instructions.
- G. Quality Control Submittals:
 - 1. Manufacturer's representative qualifications.
 - 2. Manufacturer's Certificate of Source Testing as specified in Section 01_75_17 - Commissioning.
 - 3. Manufacturer's Certificate of Installation Verification as specified in Section 01_75_17 - Commissioning.
 - 4. Test reports.
- H. Owner Training Submittals:
 - 1. As specified in Section 01_75_17 - Commissioning.
- I. Operation and maintenance manuals:
 - 1. As specified in Section 01_78_24 - Operation and Maintenance Manuals.
 - 2. Operating instructions:
 - a. Printed and framed instruction chart suitable for wall hanging.
 - b. Detail the operational functions of transfer switch controls.
 - 3. Maintenance manual:
 - a. Furnish maintenance manuals with instructions covering maintenance of equipment and data identifying all parts.
 - b. Furnish information needed to maintain the transfer switch, including, but not limited to, the following:
 - 1) Instructions for testing, adjustment, and start-up.
 - 2) Detailed control instructions that outline the purpose and operation of every control device used in normal operation.
 - 3) Description of the sequence of operation that outlines the steps that follow normal power failure, transfer to standby power, return to normal power, and fault conditions.
 - 4) Schematics and wiring:
 - a) Furnished in a reduced 11-inch-by-17-inch fully legible format.
 - 5) Report listing the installed setting of adjustable parameters for the automatic transfer system.

1.06 QUALITY ASSURANCE

- A. Where indicated on the Drawings, the transfer switch shall be UL labeled and listed "Suitable for Service Entrance".

1.07 DELIVERY, STORAGE, AND HANDLING

- A. Ship the transfer switch to the job site on a dedicated air-ride vehicle that will allow the Contractor to utilize on-site off-loading equipment.
- B. Furnish temporary equipment heaters within the transfer switch to prevent condensation from forming.

1.08 PROJECT OR SITE CONDITIONS

- A. As specified in Section 01_81_50 - Design Criteria.

1.09 ADMINISTRATIVE REQUIREMENTS (NOT USED)

1.10 WARRANTY

- A. As specified in Section 01_78_36 - Warranties and Bonds.

PART 2 PRODUCTS

2.01 GENERAL

- A. Provide transfer switches capable of transferring load circuits from utility power to standby power and back.

2.02 DESIGN AND PERFORMANCE CRITERIA

- A. Provide equipment and components that are fully rated for the Site elevation and operating environment where the equipment will be installed as specified in Section 01_81_50 - Design Criteria and as indicated on the Drawings.
- B. Non-conditioned spaces:
 - 1. Provide additional temperature conditioning equipment to maintain the equipment temperature within a band of 10 degrees Fahrenheit above the minimum operating temperature and 10 degrees Fahrenheit below maximum operating temperature.

2.03 MANUFACTURERS

- A. One of the following or equal:
 - 1. ABB.
 - 2. ASCO.
 - 3. Eaton.
 - 4. Russelectric, Inc.

2.04 MATERIALS (NOT USED)

2.05 MANUFACTURED UNITS (NOT USED)

2.06 EQUIPMENT

- A. General:
 - 1. Capable of switching all classes of load.
 - 2. Rated for continuous duty when installed in a non-ventilated enclosure.
 - 3. Provide circuit breakers or contactors rated for continuous duty.

4. Capable of transferring successfully in either direction with 70 percent of rated voltage applied to the terminals.
 5. Transfer switch short circuit rating to be coordinated with the overcurrent protective devices at the fault current available on the line side of the transfer switch.
- B. Electrical ratings:
1. Voltage, configuration, and amp ratings as indicated on the Drawings.
 2. WCR in accordance with UL 1008.
- C. Contacts:
1. Mechanically held.
 2. Mechanically interlocked to prevent normal and standby sources from being closed at the same time.
 3. Silver alloy construction.
 4. Neutral contact, when indicated on the Drawings:
 - a. Same ratings as the phase contacts.
 - b. Break last and make first operation.
- D. Controls:
1. MTS shall be manually initiated to transfer from one acceptable source to another acceptable source. MTS shall derive control power from the source from which it is switching.
 2. Control panel:
 - a. Microprocessor based.
 - b. 4-line, 20-character LCD display. Displayed data shall include:
 - 1) Normal and standby source parameters.
 - 2) Diagnostic information.
 - 3) Switch and timer status.
 - c. Keypad for making ATS settings and operating parameters:
 - 1) Settings shall be password protected.
 - d. LED display of the following:
 - 1) Normal source available.
 - 2) Connected to normal source.
 - 3) Standby source available.
 - 4) Connected to standby source.
- E. Enclosure:
1. NEMA 1.

2.07 COMPONENTS (NOT USED)

2.08 ACCESSORIES

- A. Overcurrent device:
1. As specified in Section 26_28_01 - Low Voltage Molded Case Circuit Breakers.

2.09 SOURCE QUALITY CONTROL

- A. Source Testing:
 - 1. Complete factory test to verify proper operation of timers, settings, and operation.
 - 2. Furnish test reports and Manufacturer's Certificate of Source Testing.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION

- A. Anchoring and bracing to structures:
 - 1. Prepare equipment anchor setting template(s) and use to position anchors during construction of supporting structure(s).
 - 2. Install anchors of type and material indicated on approved anchoring designs.
 - 3. Install anchors with embedment indicated on approved anchoring designs.

3.03 INSTALLATION

- A. Install the equipment in accordance with the accepted installation instructions and anchorage details.
- B. General:
 - 1. Furnish components and equipment as required to complete the installation.
 - 2. Replace hardware lost or damaged during the installation or handling to provide a complete installation.
 - 3. Install the transfer switch on a raised concrete housekeeping pad:
 - a. Provide structural leveling channels in accordance with the manufacturer's recommendations to provide proper alignment of the units.
 - b. Weld and/or bolt the transfer switch frame to the leveling channels.
 - 4. Provide openings in top or bottom of the enclosure for conduit only, no additional openings will be allowed:
 - a. Improperly cut holes will require that the entire panel be replaced:
 - 1) No hole closers or patches will be allowed.
- C. Furnish Manufacturer's Certificate of Installation Verification.

3.04 FIELD QUALITY CONTROL

- A. As specified in Section 26_05_00 - Common Work Results for Electrical.
- B. Field electrical acceptance testing:
 - 1. As specified in Section 26_08_50 - Field Electrical Acceptance Tests.

3.05 OWNER TRAINING

- A. Perform Owner Training as specified in Section 01_75_17 - Commissioning.

END OF SECTION

SECTION 26_41_01
LIGHTNING PROTECTION

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Design and installation of a complete lightning protection system.
 - 2. Materials and components for the lightning protection system.

1.02 REFERENCES

- A. Lightning Protection Institute (LPI).
 - 1. 175 - Standard for the Design - Installation - Inspection of Lightning Protection Systems.
 - 2. 177 - Inspection Guide for Certified Systems.
- B. National Fire Protection Association (NFPA):
 - 1. 70 - National Electrical Code (NEC).
 - 2. 780 - Standard for the Installation of Lightning Protection Systems.
- C. Underwriters Laboratories, Inc. (UL):
 - 1. 96 - Standard for Lightning Protection Components.
 - 2. 96A - Standard for Installation Requirements for Lightning Protection Systems.

1.03 DELEGATED DESIGN (NOT USED)

1.04 SUBMITTALS

- A. Furnish Submittals as specified in Section 01_33_00 - Submittal Procedures.
- B. Product data:
 - 1. Provide samples and pertinent catalog data for:
 - a. Air terminals.
 - b. Conductors.
 - c. Connectors.
 - d. Accessories.
 - e. Include dimensions and materials of each component and include indication of listing in accordance with UL 96.
- C. Shop Drawings:
 - 1. Including, but not limited to:
 - a. Layout of air terminals with the respective configuration of the zone of protection.
 - b. Grounding electrodes, and bonding connections to structure and other metal objects.

- c. Type, size and locations for:
 - 1) Terminal.
 - 2) Electrode.
 - 3) Conductor.
 - d. Conductor routing details.
 - e. Connection details.
 - f. Termination details.
 - g. Applicable air terminal and other calculations.
 - 2. Details showing installation of air terminals, conductors, and connectors.
- D. Certificates:
- 1. Submit written confirmation of having obtained UL Master Label or LPI certification for each lightning protection system.
 - 2. Photocopy of UL or LPI Installers' Certificate(s) for installation of lightning protection systems.
 - 3. Proof the manufacturer has been UL listed for at least 5 years.
 - 4. Proof the installer has been UL listed or LPI certified for at least 5 years.
- E. Record Documents:
- 1. Provide as specified in Contract Documents.
 - 2. Accurately record actual locations of air terminals, grounding electrodes, bonding connections, and routing of system conductors.
 - 3. Manufacturer's installation instructions.

1.05 QUALITY ASSURANCE

- A. Conform to the requirements of the UL or LPI and NFPA standards for lightning protection systems:
- 1. Components shall be listed in accordance with UL 96.
- B. Manufacturer's qualifications:
- 1. Company specializing in lightning protection equipment with minimum 5 years of experience:
 - a. Listed in section "Lightning Conductor, Air Terminals and Fittings" of the UL "Electrical Construction Materials Directory" for at least 5 years previous to this Contract's bid opening date.
- C. Installer's qualifications:
- 1. Member of the UL quality control program listed in section "Lightning Protection Installation" of the UL "Electrical Construction Materials Directory" or LPI-certified installer for installation of lightning protection systems for at least 5 years previous to this Contract's bid opening date.
 - a. Lightning protection system shall meet the applicable requirements of NFPA 780 and UL 96 and 96A, or LPI 175 and 177.
- D. Upon completion of installation, the lightning protection contractor to have the building lightning system physically inspected by UL or in accordance with LPI requirements:
- 1. Furnish a UL Master Label or LPI Installer Certificate for the building:
 - a. Application for the UL Master Label without a physical inspection by UL is unacceptable.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. Do not store or install aluminum lightning protection components in contact with concrete.

1.07 PROJECT OR SITE CONDITIONS (NOT USED)

1.08 ADMINISTRATIVE REQUIREMENTS

- A. Sequencing:
 - 1. Pre-installation conference:
 - a. Convene a pre-installation conference 1 week before commencing the Work of this Section, as specified in Section 01_31_19 - Project Meetings.
 - 2. Coordinate Work with other trades to ensure neat, correct, and unobtrusive installation.
 - 3. Coordinate the Work of this Section with roofing and exterior and interior finish installations.

1.09 WARRANTY

- A. As specified in Section 01_78_36 - Warranties and Bonds.

PART 2 PRODUCTS

2.01 GENERAL (NOT USED)

2.02 DESIGN AND PERFORMANCE CRITERIA

- A. Provide the services of a lightning protection contractor to design, furnish, and install complete lightning protection system, connected to the facility grounding system at the following structures:
 - 1. Source Water Pump Station.
 - 2. Outside surge tanks area.
- B. Lightning protection system: NFPA 780; Class I UL 96A master labeled or LPI certified system(s) protecting roofs, consisting of:
 - 1. Air terminals on roof(s).
 - 2. Bonding of structure and other metal objects.
 - 3. Grounding electrodes.
 - 4. Interconnecting conductors.
- C. Connect the lightning protection system to the facility grounding electrode:
 - 1. Provide common ground connections as necessary to the electric service conductors.
- D. Installing contractor is responsible for all costs associated with UL or LPI application/inspection of the lightning protection system, including any costs associated with re-inspection necessary to obtain the UL 96A Master Label or LPI 177 Certification.

2.03 MANUFACTURERS

- A. One of the following or equal:
 - 1. Erico.
 - 2. Harger Lightning and Grounding.
 - 3. Thompson Lightning Protection, Inc.
 - 4. VFC, Inc.

2.04 MATERIALS

- A. Air terminals:
 - 1. Material: Aluminum.
 - a. Aluminum components for aluminum roofing, compatible with aluminum roofing materials.
 - 2. Size: 3/8-inch by 18-inch minimum extending a minimum of 12 inches above the object to be protected.
 - 3. On flat or walkable roofs, provide air terminals with:
 - a. Mushroom type blunt tip incapable of impalement if fallen upon.
 - b. Spring mounted and capable of being pushed flush to the roof.
 - 4. Air terminals on stacks and chimneys:
 - a. Protected from corrosion.
 - b. Sized in accordance with UL and NFPA requirements.
 - c. Lead-coated copper.
 - 5. Air terminal bases:
 - a. Cast bronze with bolt pressure cable connections securely mounted with stainless steel screws and bolts.
- B. Ground rods and below grade connectors:
 - 1. As specified in Section 26_05_26 - Grounding and Bonding.
- C. Ground plate: Copper.
- D. Conductors:
 - 1. Perimeters:
 - a. Aluminum.
 - 1) Aluminum components for aluminum roofing, compatible with aluminum roofing materials.
 - 2. Down conductors:
 - a. Copper.
 - 3. Sized in accordance with UL or LPI and NFPA requirements.
 - 4. UL listed for the application.
- E. Cable fasteners:
 - 1. Electrolytically compatible with conductors and mounting surface:
 - a. Spaced in accordance with LPI or NFPA requirements.
- F. Above grade connectors:
 - 1. Make connections between dissimilar metals with approved bimetallic connectors.
 - 2. Installed by trained personnel.
 - 3. UL listed for the application.

- G. Miscellaneous materials:
 - 1. Copper of type and size recommended by the manufacturer of the lightning protection system.
 - 2. Stainless steel bolts, screws, and other threaded fasteners.

PART 3 EXECUTION

3.01 EXAMINATION

- A. It is the responsibility of the lightning protection subcontractor to review the electrical system design and provide any and all additional equipment and materials needed in order to construct a master labeled UL or LPI certified lightning protection system.
- B. Verify that surfaces are ready to receive Work.
- C. Field verify that measurements are as indicated on the Drawings and as specified elsewhere in this Section.
- D. Protect elements surrounding Work of this Section from damage or disfiguration.

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

- A. In accordance with the manufacturer's instructions unless otherwise specified in this Section.
- B. Installation must be made by a LPI certified master installer or an UL certified installer.
- C. Conductor installations:
 - 1. Install the lightning protection roof system(s) grounding and bending conductors exposed on flat roof areas and concealed at ridge roof areas.
 - 2. Install main downloads completely concealed and sleeved.
 - 3. Other than for the purpose of protecting download conductors from damage up to 6 feet above grade level, do not use exposed conduits to conceal the downloads on the exterior of the building(s) outside walls.
 - 4. Use minimum 1-inch PVC conduits to protect lightning system conductors from damage.
- D. Clearances: Ensure 6-foot minimum distance required by NEC:
 - 1. From lightning rod conductors to non-current-carrying metal parts of electrical equipment unless they are bonded to the rods.
 - 2. From lightning system conductors to open conductors of communication systems.
 - 3. From lightning protection grounding electrodes to electrodes of other grounding systems.
- E. Extend air terminals a minimum of 12 inches above object to be protected.

- F. Maintain horizontal or downward coursing of main conductor and ensure that bends have at least an 8-inch radius and that no bend of a conductor forms an included angle of less than 90 degrees.
- G. Grounding electrode system:
 - 1. Where a grounding electrode system is indicated on the Drawings, modify the installation to meet the applicable lightning protection standards.
 - a. Provide additional electrodes where required.
 - 2. Where a grounding electrode system is not indicated on the Drawings, install grounding electrodes in accordance with the applicable UL or LPI standards.
- H. Interconnection of metals:
 - 1. Bond metal bodies within 6 feet of the conductor to the system with approved fittings and conductor.
 - 2. Connections between dissimilar metals shall be made with approved bimetallic connections.
 - 3. Bond metal bodies of inductance located within 6 feet of a conductor or object with secondary bonds.
- I. Bond isolated metallic bodies at or below the roof subject to inductance and within 6 feet of lightning protection system conductors.
- J. Provide necessary common grounds between the lightning protections system and the electric and telephone service entrance wires, TV and radio antenna grounds.
- K. Ensure that air terminals are installed to withstand calculated wind force due to 100 mile per hour winds or as specified in Section 01_81_50 - Design Criteria, whichever is greater, with a 1.3 gust factor without structural damage and without damage to integrity of the lightning protection system.

3.04 FIELD QUALITY CONTROL

- A. Provide one of the following:
 - 1. Services of UL to physically inspect the entire lightning protection system and issue the UL Master Label:
 - a. Furnish UL Master Label as evidence that the installation has met with UL 96A code requirements.
 - 2. Obtain LPI system certification reports and LPI system certification.

END OF SECTION

SECTION 26_42_13
CATHODIC PROTECTION

PART 1 GENERAL

1.01 SUMMARY

- A. Work under this section is subject to all the requirements of the Contract Documents, including the General Conditions, Special Conditions and all the related sections of the Specifications.

1.02 SCOPE OF WORK

- A. The corrosion control shall consist of monitoring and galvanic anode current cathodic protection (CP) systems which shall include the furnishing and installation of all wiring, test stations, anodes, exothermic welding, coating repairs, joint bonding, and all other work and items required for a complete and functioning system for the specified buried piping, metallic fittings, and other appurtenances.
- B. The CP systems shall be installed as indicated on the Drawings and as specified herein.
- C. The installation and testing of each CP system shall be overseen by a National Association of Corrosion Engineers (NACE) certified Cathodic Protection Specialist (CP4) engaged by the Contractor. Approval of the NACE CP Specialist (CP4) shall be subject to the approval of City of Thornton or Designated Representative.

1.03 REFERENCES

- A. The CP system installations shall comply with applicable requirement codes, laws and ordinances of Federal, State and Local bodies having jurisdiction; the National Association of Corrosion Engineers (NACE), including applicable supplements, bulletins and special rulings.
- B. Where more stringent requirements than code are shown or specified, the more stringent requirements shall apply. All electrical items shall be UL listed or labeled, where such listing or labeling is obtainable.
- C. Applicable Standards:
 - 1. National Association of Corrosion Engineers (NACE):
 - a. Standard Practice SP0169 - Control of External Corrosion on Underground or Submerged Metallic Piping Systems.
 - b. Standard Practice SP0286 - Electrical Isolation of Cathodically Protected Pipelines.
 - 2. National Electrical Code (NEC).
 - 3. Underwriters Laboratory (UL).

1.04 RELATED WORK SPECIFIED ELSEWHERE

- A. Dielectric couplings, protective pipe coating, wrapping, and patching will be provided by the Contractor under other sections of the Specifications.
- B. Backfilling other than specified herein for anodes will be provided by the Contractor under another section of the Specifications.

1.05 DEFINITIONS

- A. Anode Groundbed:
 - 1. Cathodic protection anode(s) that is installed in a drilled or excavated hole at a prescribed depth from the structure being cathodically protected to achieve electrical remoteness.
- B. Cathodic Protection: The electrical method of reducing or eliminating corrosion by making previous anodic areas on the structure surface a cathode by creating a DC current flow to the structure by use of a cathodic protection system.
- C. Cathodic Protection Criteria: Conform to NACE SP0169.
- D. Cathodic Protection Systems:
 - 1. Galvanic anode system: Galvanic anode material, usually magnesium or zinc, which naturally corrodes or sacrifices itself and does not require an outside power source.
 - 2. Impressed current system: Utilizes an outside power source, usually a rectifier (that converts AC to DC current), and forces (impresses) current from a number of anodes (or ground bed) through the environment to the structure to be protected.
- E. Cathodic Protection Station (CPS): An impressed current cathodic protection installation location consisting of rectifier, groundbed, and anode terminal box.
- F. Electrically Continuous Pipeline: Linear electrical resistance equal to or less than the sum of the resistance of the pipe plus the maximum allowable bond resistance for each joint as specified in this Section.
- G. Electrical Isolation: The condition of being electrically isolated from other metallic structures and the environment as defined in NACE RP0286.
- H. Ferrous or Metallic Pipe: Pipe or structure made of steel or iron alloys and pipe or structure containing steel or iron as a principal structural material (such as steel, ductile iron, and cast iron).
- I. Foreign-Owned: Buried pipe or cable not specifically owned or operated by the City of Thornton or Designated Representative.

- J. Functional and Performance Testing:
 - 1. Testing that is necessary to demonstrate that the installed equipment and systems function as specified and operate in the manner intended.
 - 2. Functional testing is a prerequisite to performance testing for equipment and systems that are specified to have a performance test.
- K. Lead, Lead Wires, Joint Bond, and Cable: Insulated copper conductor; the same as wire.
- L. Manufacturer's Representative: An employee of the manufacturer who is factory trained and knowledgeable in the technical aspects of their products and systems.
- M. Raceways: Conduit, plastic or metal pipe, or electrical metallic conduit (EMT) for the casing of electrical or cathodic protection cables.
- N. Structure-to-Reference Electrode Potential (also Structure-to-Reference Electrode Voltage): The difference in voltage (potential) between the subject metallic structure and the electrolyte in which it is buried or submerged, as measured to the standard specified reference electrode placed in contact with the electrolyte.

1.06 PERFORMANCE REQUIREMENTS

- A. Show evidence of UL approval where UL standards exist and product listings are available.
- B. Conform to National Electrical Code (NEC) and applicable federal, state, and local laws, codes, and regulations.
- C. When requirements of specification or drawings exceed those of codes or the manufacturer's instruction, requirements of Specifications or Drawings prevail.

1.07 SUBMITTALS

- A. Products and manufacturers:
 - 1. As soon as practicable and within thirty (30) days after notice to proceed, and before any material or equipment is purchased, the Contractor shall submit for approval a complete list of materials and equipment to be incorporated in the work. The list shall include catalog numbers, cuts, diagrams, drawings and other descriptive data as may be necessary. No consideration will be given to partial lists submitted from time to time. Approval will be based on the manufacturer's published ratings. Any materials and equipment listed, which are not in accordance with the specification requirements, will be rejected. Include manufacturer's name and provide sufficient information to show that materials meet the requirements of the project.
 - 2. As a minimum, submittals for the following items are required:
 - a. Galvanic anode alloy, size, and wire type and length.
 - b. Dielectric insulating fittings.
 - c. Test station enclosures, terminal boards, and shunts.
 - d. Test station wire conductors.
 - e. Reference electrodes and coupons.
 - f. Exothermic welding equipment.

- g. Exothermic weld connection coating systems.
 - h. Wire splice kits.
 - i. Wire marker tags and labels.
 - j. Wire terminals.
- B. As soon as practicable and within thirty (30) days after notice to proceed, and before any material or equipment is purchased, the Contractor shall submit for approval:
 - 1. Qualifications and certification of the Contractor's NACE CP Specialist (CP4).
 - 2. The CP Test Plan as prepared by the Contractor's NACE CP Specialist (CP4).
- C. After completion of the CP installation work, and in compliance with the data submittal requirements of the contract documents, the Contractor shall submit the following:
 - 1. Record drawings of installation and construction of CPS; accurate location and type of anodes, wires, conduits, insulators, pipe connections, and junction boxes.
 - 2. Field test reports.
 - 3. CP system test report and O&M manual.

1.08 QUALITY CONTROL

- A. Contractor's CP Specialist (CP4) Qualifications:
 - 1. Currently certified by NACE as a CP Specialist (CP4).
 - 2. Shall have successfully completed a minimum of ten Contracts of similar nature and scope as that indicated in this Specification.
 - 3. Oversee or perform all installation and testing services during installation of CP system components associated with the project.
 - 4. Visit the site for testing and specification compliance verification a minimum of once every two weeks or more frequent as needed.
 - 5. Ensure the proper installation of the galvanic anode CP systems indicated on the Contract Drawings, verify electrical continuity of the pipeline, verify the effectiveness of insulating fittings, and obtain test results of the CP system.
- B. The Contractor's NACE CP Specialist (CP4) shall prepare a written test program and shall perform or supervise all testing as the work progresses and for the completed work. The testing program shall include:
 - 1. Procedures for measuring the CP potentials, AC potentials, and anode currents for the structure.
 - 2. Methods for determining the effectiveness of dielectric fittings.
- C. Manufacturer's Qualifications:
 - 1. Regularly engaged on a full-time basis in the manufacture of products in this Section for a minimum of 5 years.
 - 2. Provide certification that all materials and components meet the requirement of the Drawings and Specifications and applicable standard details.
- D. Field Supervision:
 - 1. Provide a Superintendent or Foreman to supervise the construction site.
 - 2. Minimum of 2 years of experience in cathodic protection.

1.09 DELIVERY, STORAGE, AND HANDLING

- A. CP Materials:
 - 1. Store off the ground.
 - 2. Protect against weather, condensation, and mechanical damage.
 - 3. Handle with care.
 - 4. Do not sharply bend or tightly coil the wire.
 - 5. Replace equipment or materials damaged in shipment or installation.
- B. Anodes:
 - 1. Coil the anode wires and secure and package the anode in crates as required to prevent damage during shipping.
 - 2. Ensure that the wire is not damaged and that the anodes or lead connection at the anode end are not physically stressed.
 - 3. If anode or wires are damaged, replace the complete anode.
- C. Reference electrodes:
 - 1. Do not allow to freeze.
 - 2. Store in a protected area.
 - 3. Utilize before shelf life expires.

PART 2 PRODUCTS

2.01 STANDARD PRODUCTS

- A. Materials and equipment submitted for approval under this specification shall be product of a manufacturer regularly engaged in the manufacture of the product, shall be of the best quality used for the purpose in commercial service, shall be the respective manufacturers latest standard design and shall meet the requirements of the specifications.
- B. Materials and equipment shall be new and the manufacturer's latest standard design that complies with the specification requirements conforming to NACE Standards.
- C. Use of the manufacturer's name and model or catalog number is for the purpose of establishing a standard quality and the general configuration desired.
- D. Substitutions: As approved by City of Thornton.

2.02 MATERIALS AND EQUIPMENT

A. Test stations:

1. Flush Style:
 - a. Oldcastle Christy, Model G05 with 3-inch diameter Cott Big Fink model test head inside, cast iron cover labeled 'C.P. Test'.
 - 1) Terminal board hardware shall consist of stainless steel or nickel-plated brass and consist of a minimum of seven (7) 1/2-inch diameter by 1.25 inches long studs with double nuts, flat washers, and lock washers.
 - 2) Test station head shall have 3-inch PVC threaded collar and cover.
 - b. Labels: Install label tags on all wires with the following:
 - 1) Pipe Diameter and material, as applicable.
2. Wire Function.
3. Post style:
 - a. Gerome Electric, Model 917, 7 Terminal, Threaded 3-inch Top:
 - 1) Terminal board hardware shall consist of stainless steel or nickel-plated brass and consist of a minimum of 7-1.2-inch diameter by 1.25-inch long studs with double nuts, flat washers, and lock washers.
 - b. Gerome Electric, Model 2015, 10 Terminal, Threaded 3-inch Top:
 - 1) Terminal board hardware shall consist of stainless steel or nickel-plated brass and consist of a minimum of 7-1.2-inch diameter by 1.25-inch long studs with double nuts, flat washers, and lock washers.
 - c. Support Post: 3.5-inch galvanized painted rigid steel, threaded one end, minimum 5 feet long.
 - d. Labels: Install label tags on all wires with the following:
 - 1) Pipe diameter and material, as applicable.
 - 2) Wire function.
 - 3) Posts located at property lines shall include reflective band and labels.

B. Galvanic (magnesium) buried pipeline anodes:

1. Magnesium anodes shall be Hi-Potential, ASTM B843, Grade M1C and conform to the following specifications:

Aluminum (Al)	0.10% maximum
Manganese (Mn)	0.50 to 1.30%
Zinc (Zn)	0.005% maximum
Copper (Cu)	0.02% maximum
Nickel (Ni)	0.001% maximum
Iron (Fe)	0.03% maximum
Other Impurities – each	0.05% maximum
Total	0.30% maximum
Magnesium (Mg)	Balance

2. Circuit Potential and Electrochemical Capacity: Open circuit potential of 1.70 volts or more negative in reference to a copper-copper sulfate reference electrode.

3. Anode Backfill:
 - a. Anodes shall be furnished prepackaged in special backfill material consisting of 75 percent ground hydrated gypsum, 20 percent powdered bentonite and 5 percent anhydrous sodium sulfate.
 - b. The backfill shall have a grain size such that 100 percent is capable of passing through a 20-mesh screen and 50 percent will be retained by a 100-mesh screen. The backfill mixture shall be firmly packaged around the anode within a cotton bag by means of adequate vibration.
 4. Anode Lead Wire:
 - a. No. 12 AWG solid copper conductors with RHW insulation.
 - b. Black insulation.
 - c. Lead wires shall be a minimum of 50 feet in length or as needed to reach test station without splicing. The lead wires shall be connected to the galvanized steel core of the anode by silver soldering and sealed with waterproof epoxy or electrical potting compound.
 - 1) Sufficient length to reach test station without being spliced.
 5. Dimensions: Minimum bare weight of 48 pounds with an ingot length of 31 inches or sized as per detail drawings.
 6. Anodes shall be shipped in waterproof bags or wrapping and shall remain dry until installation.
 7. Acceptable manufacturers:
 - a. Farwest Corrosion Control (Denver, CO) or MESA (Denver, CO).
 - b. Construction Manager or City of Thornton or Designated Representative approved equal.
- C. Galvanic (magnesium) trash rack submerged anodes:
1. Magnesium anodes shall be Hi-Potential, ASTM B843, Grade M1C and conform to the following specifications:

Aluminum (Al)	0.10% maximum
Manganese (Mn)	0.50 to 1.30%
Zinc (Zn)	0.005% maximum
Copper (Cu)	0.02% maximum
Nickel (Ni)	0.001% maximum
Iron (Fe)	0.03% maximum
Other Impurities – each	0.05% maximum
Total	0.30% maximum
Magnesium (Mg)	Balance
 2. Condenser anodes with a diameter of 5 inches and 2 in thickness and a weight of 2.5 pounds.
- D. Stationary reference electrodes:
1. Copper/copper sulfate reference electrode material designed for minimum 20-year useful life as manufactured by GMC Electrical.
 2. Reference electrode to be pre-packaged with a low resistivity backfill formulated to retain moisture and maintain stability.
 3. Reference electrode shall contain one (1) #14 RHW yellow lead wire for connection. Recommend 50 feet minimum or as needed to reach test station without splicing.

- E. Metallic coupons:
 - 1. Suitable sized metallic with a minimum exposed surface area of 1.55 square inches (10 cm²) as manufactured by McMiller Co., Inc.
 - 2. Coupon shall contain two (2) #12 AWG THHN/THWN green cables for connection.
 - 3. Ensure metallic coupon is the same material and composition as the structure under cathodic protection. Recommend 50 feet minimum or as needed to reach test station without splicing.
- F. Exothermic welds:
 - 1. All electrical cable connections to the buried piping shall be made by an exothermic weld.
 - 2. Exothermic type weld materials including the proper size and type of weld cartridges and welder molds for use on ductile-iron or steel pipe.
 - 3. Acceptable Manufacturers:
 - a. Erico Products Inc. "CADWELD PLUS".
 - b. Construction Manager approved equal.
 - 4. Weld materials shall be compatible to the pipe material as recommended by the manufacturer.
 - 5. Copper sleeves specifically designed for the purpose of exothermic welding shall be crimped on all bare wire ends of #8 AWG or smaller gauge wires prior to exothermic welding to improve mechanical strength and thermal capacity.
- G. Di-electric coatings:
 - 1. Denso Protal 7125 repair coating or Construction Manager approved equivalent.
 - 2. All waterline pipe and pipe fittings shall be furnished with a factory applied coating as specified in other sections. The factory applied coatings shall be inspected prior to installation and shall be installed in accordance with the manufacturer's recommendations.
 - 3. All bare line pipe, uncoated flange bolts, uncoated mechanical fitting bolts, and other uncoated bolts, nuts, flanges, or fittings with metallic composition shall be protected with wax-tape primer and #1 wax-tape as manufactured by Trenton Corporation or approved equivalent and applied to a thickness of 20 mils.
- H. Plastic conduit for cathodic protection sheathing (below grade applications):
 - 1. Diameter: Sized to match application.
 - 2. Schedule 40 polyethylene (PE) or polyvinyl chloride (PVC) plastic pipe.
- I. Wire:
 - 1. Insulated stranded or solid copper wire as specified.
 - 2. Wire size, type, and insulation type: As specified in this Section and as indicated on the Drawings:
 - a. Pipe Test Leads: #8 AWG, Stranded, RHW.
 - b. Pipe Test Leads at Isolation Device: #4 AWG, Stranded, RHW
 - c. Galvanic Anode Leads: #12 AWG, Solid, RHW.
 - d. Reference Electrodes: #14 AWG, Stranded, RHW.
 - e. Metallic Coupons: #12 AWG, Stranded, THHN/THWN.

3. Wire insulation color: Indicate the function of each wire as indicated on the Drawings.
 - a. Blue: Test Leads for City of Thornton (Project) Pipe.
 - b. White: Test Leads for Isolated, Future or Foreign Pipelines.
 - c. Black: Anode Leads and Continuity Bonds.
 - d. Yellow: Reference electrode.
 - e. Green: Metallic coupon.
- J. In-line tap slices for cathodic protection cables (use only if approved by City of Thornton or Designated Representative):
 1. "C" taps made of conductive wrought copper.
 2. Sized to fit the wires being spliced.
 3. Apply compression connectors the proper crimp tool and die recommended by the manufacturer for the wire and the tap connector size; in-line.
 4. "Butt" type wire splice connectors are acceptable for #8 AWG or smaller splices.
 5. Electrical splicing tape and coating:
 - a. Acceptable manufacturers:
 - 1) Scotch 130C tape.
 - 2) Scotch Super 88 tape.
 - 3) Scotchkote Electrical Coating as manufactured by 3M Products.
 - 4) Construction Manager-approved equal.
 - b. 30 mil liner-less rubber high voltage splicing tape and 7 mil vinyl electrical tape suitable for moist or wet environments.
 - c. Electrical Connectors: Tin or nickel-plated copper, brass, bronze, or stainless steel for electrical conductivity and atmospheric corrosion resistance.
- K. Wire terminals:
 1. Burndy YAV series.
- L. Test station shunts:
 1. 0.01 ohm, yellow.
 2. Acceptable Manufacturers:
 - a. Cott.
 - b. City of Thornton or Designated Representative-approved equal.
- M. Wax tape:
 1. Design:
 - a. A blend of microcrystalline waxes, plasticizers and corrosion inhibitors saturated into a non-woven, non-stitch bonded synthetic fabric, forming a tape wrapper.
 - b. Shall contain no siliceous mineral fillers.
 - c. Suitable for below ground use.
 - d. Nontoxic, nonflammable, non-carcinogenic, free of all VOCs.
 2. Acceptable manufacturers:
 - a. Trenton, #1 Wax-Tape.
 - b. City of Thornton or Designated Representative-approved equal.
- N. Polyethylene wrap:
 1. High density, cross-laminated polyethylene film, 4-mil thickness.

- O. Wire labeling:
 - 1. Design:
 - a. Wire labeling shall be permanent, heat shrinkable sleeves.
 - b. Shall be weather resistant/UV light resistant with matte finish.
 - c. Install marking sleeve within 6 inches of termination. Marking sleeve shall be clearly visible.
 - 2. Acceptable manufacturers:
 - a. Epson LabelWorks.
 - b. Construction Manager or City of Thornton or Designated Representative approved equal.
- P. CP warning tape:
 - 1. 3-inch plastic, APWA blue, non-detectable, marked "Caution Cathodic Protection Cable Buried Below".
- Q. Electrical isolation devices:
 - 1. Electrical isolation of the buried piping shall be accomplished by flange isolation kits, insulating mechanical couplings, di-electric unions, or a piece of non-metallic piping where specified herein or indicated on the Drawings. In the event an insulating coupling is restrained using harness rods, each rod shall be insulated using a properly sized one-piece insulating sleeve and washer with steel backing washer.
 - 2. Flange isolation kits shall be ordered according to pipe size and pressure rating of the flange and shall be installed per the manufacturer's instructions. Care shall be exercise so as not to damage the insulating bolt sleeves and washers.
 - 3. Required applications of dielectric flange isolation assemblies, couplings, and other devices are not limited to selected locations where new piping is mechanically connect to existing piping. Other such examples include:
 - a. Transfer of ownership locations.
 - b. Connections between dissimilar metals (i.e., welded steel to ductile).
 - c. Cased segments of piping.
 - d. Connections to electrically grounded components such as actuated valves, meters, pump stations, processing facility, and other structures.
 - e. Concrete encased segments of piping such building risers and valve vault penetrations.
 - 4. Materials:
 - a. Di-electric (insulated) unions:
 - 1) Approved manufacturers:
 - a) Hart Industrial Unions with thermo baked epoxy polymer coating of 3 to 6 mils on tailpiece.
 - b) City of Thornton or Designated Representative-approved equal.
 - b. Insulating mechanical couplings:
 - 1) Approved manufacturers:
 - a) Dresser "Style 39".
 - b) Rockwell "416".
 - c) Romac "IC501".
 - d) Baker "Series 216" without pipe stop.
 - e) City of Thornton or Designated Representative-approved equal.

- c. Insulating flange gaskets:
 - 1) Provide G-10 Glass Reinforced Epoxy Retainer with appropriate seal based on type of product, Type 'E' full face gasket as manufactured by GPT Industries, or Construction Manager approved equivalent.
 - d. Insulating sleeves and washers:
 - 1) Provide full length G-10 sleeves with G-10 or Diamond Hyde washers as manufactured by GPT Industries, or Construction Manager approved equivalent.
 - a) For direct buried applications, install single washer sets on the existing or uncathodically protected side of the isolation flange or coupling so that the metallic flange bolts, restraining rods, nuts, and washers are electrically continuous with the new or cathodically protected piping.
 - b) For above grade or vaulted applications, install double washer sets.
 - 5. Coat all bare, buried di-electric components to include nuts, bolts, and washers with wax-tape primer and #1 wax-tape as manufactured by Trenton Corporation or approved equivalent and applied to a thickness of 20 mils.
- R. Concrete Encasement for Corrosion Control:
- 1. Concrete materials:
 - a. Conform to ASTM C94-90, Option A, and ASTM C 150.
 - b. Concrete shall be Type II with a minimum cement content of 564 pounds per cubic yard.
 - 1) Aggregate size; 3/4-inch or smaller
 - c. Minimum compressive strength of 3,000 psi at 28 days with a maximum water-cement ratio of 0.45.
 - d. Air Entrainment:
 - 1) ASTM c 260, nontoxic after 30 days and contain no chlorides.
 - 2) Not less than 5 percent entrained air at the project site.
 - 2. Piping materials:
 - a. Each concrete encased segment of piping shall be bare except for a 12-inch coating overlap at each end of the encasement. The 12-inch coating overlap shall consist of a bonded coating system such as polyurethane or fusion bonded epoxy.

PART 3 EXECUTION

3.01 GENERAL

- A. Complete wire connections, anode placement, and backfill operations during daylight conditions.
- B. Install corrosion protection system components, such as splices, bonds, and wire installation when ambient temperature is above 15 degrees Fahrenheit and rising in order to minimize damage to materials and insulation.
 - 1. Bury all CP wiring, conduits, and other components with a minimum of 24 inches of cover or a minimum of 36 inches for agricultural areas.
 - 2. Do not Cadweld or utilize open flame or torches in areas of flammable vapors or airborne particles where a fire or explosion could result.

3. Install and work around above grade and buried AC power lines and oil and gas pipelines with extreme care; follow the minimum separation distances in accordance with foreign company requirements and regulations. Contractor is required to identify and notify all foreign owners of pending construction and schedule when line crossings will occur.
4. Do not work next to power lines during times of high lightning activity.
5. Changes to the locations of components due to field conditions must be approved in writing by City of Thornton or Designated Representative.

3.02 INSTALLATION

A. Test stations:

1. Determine location of test stations based on actual site conditions and as approved by City of Thornton or Designated Representative.
2. Locate test stations as indicated on the Drawings and/or CP tables.
3. Locate all test stations in a protected location such as near fences, behind curbs, outside of roadways, and in areas that are accessible for personnel. Do not install test stations in open farm areas and that are restrictive to the property owner.
 - a. When routing test stations away from the protected pipe, all test station, anode, reference electrode, coupons, and other wires shall be installed in a minimum 1.5-inch diameter PVC conduit routed from the edge of the pipe trench to the test station location.
4. Make wire connections to test station terminal boards with crimp-on spade lug terminals.
5. Wire labeling:
 - a. Label and marking materials should be suitable for permanent identification, heat shrinkable marking sleeve.
 - b. Position markers in test stations so that they do not interfere with operation and maintenance.
 - c. Include pipe diameter and type, and wire function, as applicable.
 - d. Test station wires shall be color coded as indicated on the Drawings and specified herein and each wire shall be permanently identified using sleeves as indicated on the Drawings and specified herein. Heat shrink label onto each wire within 6 inches of termination. Replace any damaged or illegible labels during heat shrinking. Test station wiring shall have enough extra wire slack to extend a distance of 2 feet above the top of the test station box.

Examples:

36-inch STL	48 lb. Mag	SRE	Coupon
W/L	Anode	CuCuSO4	10 cm2

B. Galvanic (magnesium) anodes:

1. Install anodes as indicated on the Drawings and/or CP tables.
2. Install anodes equally along each side of pipeline spaced 5 feet on center. Anodes should be placed a minimum of 3 feet or (1) pipe diameter (whichever is greater) at or below the invert of the pipe and maintain a minimum of distance of 3 feet from all other buried metallic structures.
3. Anodes should be placed horizontally or vertically at or below the invert of the pipeline.

4. Do not place anode in Engineered backfill (granular pipe embedment, gravel, squeegee, concrete, etc.). Install in native soils only.
 5. Lowering of anodes:
 - a. The Contractor will be responsible for inspecting anodes and lead wires for damage prior to installation. Damage to anodes or lead wires is cause for rejection of that anode assembly.
 - b. Maintain sufficient slack in the anode lead cables to prevent damage during installation and backfilling operations.
 - c. Lower anodes with rope sling or similar methods and do not lower using the anode lead wire.
 - d. During installation, if any anode is damaged or wire insulation is cut, gouged, or scraped, the anode and wire will not be acceptable.
 - e. No wire splices will be allowed except those indicated on the Drawings and approved by the City of Thornton or Designated Representative.
 - f. Elevation and spacing of anodes shall be as indicated on the Drawings unless the Construction Manager modifies the anode depth and spacing in the field based on the drilling geological log and/or soil resistivity log.
 6. Route anode wires along excavation to test station. Bury wires a minimum of 24 inches below grade or a minimum of 36 inches for agricultural areas.
 7. Thoroughly compact native backfill a minimum of 1 foot deep above each anode.
 8. Saturate the anode and backfill with approximately 5 gallons of clean water prior to completion of backfilling.
 9. Obtain anode to soil measurements during backfill to confirm proper anode activation and function. If deficiencies are discovered, replace anode.
 10. Install warning tape 12 inches above all anodes and other CP wires.
- C. Galvanic (magnesium) Trash Rack Anodes:
1. Install anodes along length of L-brackets on all sides of each trash rack. Attach using steel welded studs, nuts and washers. Do not coat the studs.
- D. Stationary reference electrodes:
1. Install reference electrodes as indicated on the Drawings and/or CP tables.
 2. Install reference electrodes a maximum of 6 inches from the structure under cathodic protection and/or 4 inches from any adjacent metallic coupons. Reference electrodes should be placed according to detail drawings at or below the invert of the pipeline but must not come into contact with the piping.
 3. Do not place reference electrodes in engineered backfill (granular pipe embedment, gravel, squeegee, concrete, etc.). Install in native soils only.
 4. Lowering of reference electrodes:
 - a. The Contractor will be responsible for inspecting reference electrodes and lead wires for damage prior to installation. Damage to reference electrodes or lead wires is cause for rejection of that reference electrode assembly.
 - b. Maintain sufficient slack in the reference electrode lead cables to prevent damage during installation and backfilling operations.
 - c. Lower reference electrodes with rope sling or similar methods and do not lower using the reference electrode lead wire.
 - d. During installation, if any reference electrode is damaged or wire insulation is cut, gouged, or scraped, the reference electrode and wire will not be acceptable.

- e. No wire splices will be allowed except those indicated on the Drawings and approved by the City of Thornton or Designated Representative.
 - f. Elevation and spacing of reference electrodes shall be as indicated on the Drawings unless the Construction Manager modifies the electrode depth and spacing in the field based on the drilling geological log and/or soil resistivity log.
 - 5. Route electrode wires along excavation to test station. Bury wires a minimum of 24 inches below grade or a minimum of 36 inches for agricultural areas.
 - 6. Thoroughly compact native backfill a minimum of 1 foot deep above each electrode.
 - 7. Saturate the electrode and backfill with approximately 5 gallons of clean water prior to completion of backfilling.
 - 8. Obtain reference electrode to structure measurements during backfill to confirm proper electrode activation and function. If deficiencies are discovered, replace electrode.
 - 9. Install warning tape 12 inches above all electrodes and wires.
- E. Metallic coupons:
- 1. Install metallic coupons as indicated on the Drawings and/or CP tables.
 - 2. Install coupons a maximum of 6 inches from the structure under cathodic protection and/or 4 inches from any adjacent reference electrodes. Coupons should be placed according to detail drawings at or below the invert of the pipeline but must not come into contact with the piping.
 - 3. Do not place coupons in Engineered backfill (granular pipe embedment, gravel, squeegee, concrete, etc.). Install in native soils only.
 - 4. Lowering of metallic coupons:
 - a. The Contractor will be responsible for inspecting metallic coupons and lead wires for damage prior to installation. Damage to coupons or lead wires is cause for rejection of that coupon assembly.
 - b. Maintain sufficient slack in the metallic coupon lead cables to prevent damage during installation and backfilling operations.
 - c. Lower metallic coupons with rope sling or similar methods and do not lower using the coupon lead wire.
 - d. During installation, if any metallic coupon is damaged or wire insulation is cut, gouged, or scraped, the metallic coupon and wire will not be acceptable.
 - e. No wire splices will be allowed except those indicated on the Drawings and approved by the City of Thornton or Designated Representative.
 - f. Elevation and spacing of metallic coupons shall be as indicated on the Drawings unless the Construction Manager modifies the coupon depth and spacing in the field based on the drilling geological log and/or soil resistivity log.
 - 5. Route coupon wires along excavation to test station. Bury wires a minimum of 24 inches below grade or a minimum of 36 inches for agricultural areas.
 - 6. Thoroughly compact native backfill a minimum of 1 foot deep above each coupon.
 - 7. Saturate the coupon and backfill with approximately 5 gallons of clean water prior to completion of backfilling.
 - 8. Install warning tape 12 inches above all coupons and wires.

- F. Wire connections:
1. Use thermite weld method for electrical connection of copper wire to metallic surfaces. Follow manufacturer's procedures for installation. Assure that the pipe or fitting wall thickness is of sufficient thickness that thermite weld process will not damage the integrity of the pipe or fitting or protective lining. Hold back thermite welds from joints and/or flanges where gaskets may be damaged by the thermite weld heat.
 2. For #8 AWG or smaller wires, install copper sleeves on wire ends prior to thermite welding.
 3. After cooling, remove all weld slag and visually inspect wire connection. Remove and replace any defective connections.
 4. Install Denso Protal 7125 repair coating over each completed connection. Repair exposed metal surfaces in accordance with coating manufacturer's recommendations.
 5. Maintain a minimum of 6 inches of separation between any (2) thermite weld connections.
 6. Attach test wires to pipe via exothermic weld and wrap wires around pipe for strain relief.
- G. Buried conductors:
1. Install test leads to the pipeline and attach by thermite weld method.
 2. Bury CP cables and wires a minimum of 24 inches below finished grade.
 3. Only splices indicated on the Drawings or approved by the Construction Manager are permitted on any wires, cables, or leads.
 4. Insulation on wires shall be free of cut or abraded areas.
 5. Avoid damage to existing structures, pipelines, and utilities during the trenching process.
 6. CP cable trenches:
 - a. In a general location and route as indicated on the Drawings.
 - b. Modify location to minimize possible damage to existing structures; obtain approval for modification.
 - c. Uniform depth and width, level, smooth, and free of any sharp objects.
 - d. Hand trenching may be required in some areas to avoid damage to existing structures.
- H. Warning tape:
1. Bury approximately 12 inches above underground cathodic protection cable.
 2. Align parallel to and within 2 inches of centerline of conduit or cable run.
- I. Conductors in boxes/test stations:
1. Do not damage wire, insulation, or conduit during the installation process.
 2. Route and maintain sufficient slack in cables to prevent the conductor from being unduly stressed, damaged, or broken during backfill operations.
 3. Do not exceed the cable manufacturer's recommendations for maximum pulling tensions and minimum bending radii.
 4. Where a pulling compound is used, use only a UL listed compound compatible with cable outer insulation and the conduit type involved.
 5. Wires:
 - a. Installed in continuous length, free of splices, except those approved by the City of Thornton or Designated Representative.
 - b. Insulation: Free of cut, damaged, or abraded areas.

- c. If field conditions dictate that a splice is required or wire is damaged, repair splices or damage to wire insulation at the discretion of the City of Thornton or Designated Representative.
 - d. Replace wire and insulation with major damage.
 - e. Splice and wire insulation repair must be approved.
 - 6. Arrange wiring neatly in the test station or terminal box; cut to proper length; remove surplus wire; attach the wire terminal, and connect to the terminal board as specified.
 - 7. Install wire label tags on all wires indicating structure type and wire function (e.g., 32 lb anode, 42-inch waterline, 12-inch service outlet, etc.).
 - 8. Provide CP anode, test station, and reference electrode wires with sufficient slack and looped or coiled at the pipeline and the boxes to prevent wire from being unduly stressed or broken during backfilling operations.
- J. Electrical isolation:
- 1. Accomplish electrical isolation using flange isolation kits, insulating mechanical couplings, di-electric fittings, or non-metallic piping where indicated on the Drawings. All electrical and instrumentation, pipe supports, and other appurtenances should be configured to maintain proper electrical isolation at each insulating device location.
- K. Joint / Continuity Bonding
- 1. All buried metallic pressure piping systems, which contain mechanical or non-welded joints, shall be made electrically continuous by bonding with AWG stranded copper wire. The bonding shall be achieved using the exothermic welding process with the bond wire size and quantity, per joint connection, in accordance with the following table:

Pipe Diameter, Inches	Wire Size	# of Wires
12 or less	#8 AWG	2
13 - 36	#4 AWG	2
>36	#2 AWG	3

- 2. Exothermic welding shall be used to attach wire type joint bonds to buried pipe and fittings.
- 3. Electrical continuity shall be provided on all underground metallic piping, valves and fittings and component parts thereof (except bolts) by bonding across every non-welded pipe joint (except for designated dielectric fittings).
- 4. Test each joint/continuity bonds as specified herein prior to backfill via Digital Low Resistance Ohm method and again after backfill using Calculated Resistance Measurement or similar.
- 5. All follower bonds to metallic fittings shall have a single #8 AWG joint bond wire attached as shown on the Drawings. Bonding must be done in a fashion to avoid shorting out mechanical insulating couplings and those with restraining rods.
- 6. Exothermic welding to narrow surfaces such as MJ follower gland rings shall be accomplished using mold sealing material temporarily placed around the base of the exothermic welder to minimize the leakage of molten weld metal.
- 7. Any MJ or flexible coupling follower gland rubber seals or any PVC pipe itself damaged by molten weld metal shall be replaced by and at the Contractor's sole expense.

- L. Electrical Isolation:
 - 1. Accomplish electrical isolation using flange isolation kits, insulating mechanical couplings, di-electric fittings, or non-metallic piping where shown on the Drawings. All electrical and instrumentation, pipe supports, and other appurtenances should be configured to maintain proper electrical isolation at each insulating device location.
- M. Concrete Encasement for Corrosion Control:
 - 1. Position the piping so that movement will not occur during concrete encasement.
 - 2. Set wooden or earthen forms, stakes, tie-downs, and/or anchors prior to installation of concrete encasement.
 - 3. Do not use rebar or allow any other metallic structure to come into contact with the encased metallic piping. Test and inspection each encased pipeline or fittings for electrical isolation prior to pouring concrete.
 - 4. Install the required cathodic protection test leads, joint bonds, anodes, and other components as depicted on Drawings prior to pouring of concrete.
 - 5. Pour concrete encasement in a continuous manner along the piping to avoid any seams or joints.
 - 6. Ensure a 3-inch thick layer of concrete is placed around the piping and no voids, gaps, or un-encased portion of piping exists. The concrete shall be placed to provide direct, intimate contact with the bare embedded piping and fittings.
 - 7. If piping contains insulating flanges or couplings, pour concrete to leading each of insulating device and overlap by 6 inches.
 - 8. Test and inspection each encased pipeline or fittings for electrical isolation again after pouring of concrete
 - 9. Allow concrete to properly cure prior to proceeding with backfilling operations

3.03 QUALITY CONTROL

- A. Installation is not complete until all wiring is complete, and the CP system is capable of operating at the full rated capacity.
- B. Preservation, restoration, and cleanup:
 - 1. Keep the site neat and orderly at all times.
 - 2. Remove excess equipment and cuttings daily when required by prevailing conditions.
 - 3. Contain and remove excess materials, mud, waste, products, and tailings.
 - 4. Confine operations to construction easements and work areas.
 - 5. Restore the site to a condition equivalent to the original condition to the satisfaction of the City of Thornton or Designated Representative, jurisdiction, and the potential landowner(s).
 - 6. Prevent contamination of project area:
 - a. Do not dump or spill oil, fuel, solvents, coatings, rubbish, or similar materials on the ground or in or near streams or wetland areas.
 - b. Use caution to prevent stream or groundwater contamination.
 - c. Conform to federal, state, and local regulations.

- d. Provide containment for and remove excess materials, drilling mud, and waste products from the project site as necessary to meet the local road and highway requirements and the permit and easement conditions.
- e. Contain and cleanup contamination to any aquifer, stream, or soil at the Contractor's sole expense.
- 7. Upon completion of Work, remove materials, scraps, and debris from the premises and from the interior and exterior of devices and equipment.
- 8. Touch up scratches, scrapes, and chips in the interior and exterior surfaces of devices and equipment with finishes matching as nearly as possible the type, color, consistency, and type of surface of the original finish.
- 9. If extensive damage is done to equipment paint surfaces, completely refinish to equal or better than factory finish.
- 10. Promptly correct damage to existing structures or utilities at the Contractor's sole expense.
- 11. Repair damage to concrete and asphalt sidewalks, curbs, roads, and driveways.
- 12. If subsequent trench or undercrossing settlement, cracking, subsidence, or other indication of failure occurs within the warranty period, promptly repair or replace at the Contractor's sole expense.

3.04 TESTS AND MEASUREMENTS

- A. Electrical isolation testing:
 - 1. Piping which is electrically isolated for corrosion control purposes shall be tested prior to and after backfilling to verify electrical isolation from unintended structures.
 - a. Contractor's NACE CP Specialist (CP4) shall develop a test plan and submit to the City of Thornton or Designated Representative for approval prior to completing any testing.
 - b. Acceptable test methods may include but not limited to:
 - 1) Induced current testing.
 - 2) Flange Isolation Tester as per manufacturer's recommendations.
 - 3) IR drop testing.
 - 4) Remote 'Fixed Cell' testing.
 - c. The pipeline shall be tested for electrical isolation at key elements to include but not limited to the following:
 - d. Transfer of City of Thornton ownership locations.
 - e. Connections between dissimilar metals (i.e., welded steel to aluminum).
 - f. Cased segments of piping.
 - g. Connections to electrically grounded components such as actuated valves, meters, pump stations, processing facility, and other structures.
 - h. Concrete encased segments of piping such building risers and valve vault penetrations.
 - 2. Record Tests of each electrical isolation component:
 - a. Description and location of pipeline and electrical isolation component under test.
 - b. Test method(s) utilized.
 - c. Date of test.
 - d. Summary of findings.

3. The Contractor shall assist the City of Thornton or Designated Representative in the performance of such additional tests by providing electrical contacts and physical access to the pipe. This work, and any subsequent repairs and additional testing shall be performed at no additional cost to the City of Thornton.
- B. Joint Bond Electrical Continuity Testing:
1. Piping which is electrically bonded for corrosion control purposes shall be tested prior to and after backfilling to verify electrical continuity.
 2. Pressure piping requiring such testing shall be piping which has mechanical or non-welded joints.
 3. Electrical resistance of the pipe shall be measured in sections for resistance of the pipe shall be measured in sections for which the total length of pipe and the number of mechanical joints is known.
 4. The test station wires shall be used as the electrical contact points to the pipe for such measurements to facilitate repeating such measurements subsequent to backfilling.
 5. The electrical resistance obtained shall be compared with the calculated resistance for each section of piping. The calculated resistance shall be based on the resistance per unit length of pipe. Such resistance shall be a function of the resistivity and the cross sectional area of the metal conductor in the pipe wall, the length of pipe, the number of pipe joints, the resistance of the bond wires installed across the pipe joints, and the number of bond wires within the pipe length being measured.
 6. Measured resistance greater than 120 percent of the corresponding calculated resistance shall be reviewed and additional tests shall be made to determine the reason for the variation and the corrective measures required.
 7. The Contractor shall assist the Owner or Designated Representative in the performance of such additional tests by providing electrical contacts and physical access to the pipe. This work, and any subsequent repairs and additional testing shall be performed at no additional cost to the Owner.
 8. The acceptable resistance value obtained prior to backfill shall be used as the standard for comparison for the resistance values subsequent to backfilling.
 9. Joint Bond Resistance Test
 - a. General:
 - 1) The Contractor shall test completed joint bonds for electrical continuity using a digital low resistance ohmmeter (DLRO).
 - 2) Joint bond quality control test shall be performed on all bonded joints after the bonds are installed but before backfilling.
 - 3) Furnish all equipment and materials as required for test.
 - b. Digital Low Resistance Ohmmeter Test Method:
 - 1) Required Equipment and Materials:
 - a) One Biddle Model 247001 digital low resistance ohmmeter (or equal).
 - b) One set of duplex helical current and potential handspikes, Biddle Model No. 241001, cable length as required.
 - 2) Test Procedure:
 - a) Measure the resistance of joint bonds with the low resistance ohmmeter in accordance with the manufacturer's written instructions.

- b) Use the helical handspikes to contact the pipe on each side of the joint without touching the thermite weld or the bond. The contact area shall be cleaned to bright metal by filing or grinding and without any surface rusting or oxidation.
 - c) Record the measured joint bond resistance on the test form described herein.
 - d) Repair any damaged pipe coating in accordance with these specifications.
- 3) Joint Bond Acceptance:
- a) Joint bond resistance shall be less than or equal to the maximum allowable bond resistance values shown below.

Bond Wire Length	Bond Wire Size	Maximum Allowable Resistance (μ -ohms)		
		One Bond Wire Per Joint	Two Bond Wires Per Joint	Three Bond Wires Per Joint
12 inches	#8	870	435	290
18 inches	#8	1304	652	435
24 inches	#8	1740	870	580
30 inches	#8	2174	1087	725
36 inches	#8	2610	1305	870
12 inches	#4	518	259	172
18 inches	#4	776	388	259
24 inches	#4	1036	518	346
30 inches	#4	1294	647	432
36 inches	#4	1554	777	518
12 inches	#2	325	162	108
18 inches	#2	486	243	162
24 inches	#2	648	324	216
30 inches	#2	810	405	270
36 inches	#2	972	486	324

- b) The Contractor shall remove and replace all joint bonds on a joint that exceeds the maximum allowable resistance.
Replacement joint bonds shall be retested for compliance with the specified bond resistance.
- c. Record Tests of Each Bonded Pipeline:
- 1) Description and location of pipeline under test;
 - 2) Starting location and direction of test;
 - 3) Date of test;
 - 4) Joint type; and
 - 5) Measured joint bond resistance using specified DLRO meter.
- d. Testing After Backfill (Calculated Resistance Method or similar):
- 1) The pipeline shall be tested for electrical continuity along its entire length using the calculated resistance method or similar test plan developed under the direction of the Contractor's NACE CP Specialist (CP4). The test plan shall be submitted to the Owner or Designated Representative for approval prior to completing any testing.

- 2) If calculated resistance method is utilized:
 - a) Apply suitable current (minimum 15 amps) along segments not to exceed 2,000 feet.
 - b) Electrical resistance of the pipe shall be measured in sections for resistance of the pipe in sections for which the total length of pipe and the number of mechanical joints is known.
 - c) The test station wires shall be used as the electrical contact points to the pipe for such measurements to facilitate repeating such measurements subsequent to backfilling.
 - d) The electrical resistance obtained shall be compared with the calculated resistance for each section of piping. The calculated resistance shall be based on the resistance per unit length of pipe. Such resistance shall be a function of the resistivity and the cross sectional area of the metal conductor in the pipe wall, the length of pipe, the number of pipe joints, the resistance of the bond wires installed across the pipe joints, and the number of bond wires within the pipe length being measured.
 - e) Measured resistance greater than 120 percent of the corresponding calculated resistance shall be reviewed and additional tests shall be made to determine the reason for the variation and the corrective measures required.
- 3) Record Tests of Each Bonded Pipeline:
 - a) Utilize the form provided in the CP Testing Plan.
 - b) Description and location of pipeline under test.
 - c) Starting location and direction of test.
 - d) Date of test.
 - e) Joint type and summary of calculated resistances.
 - f) Measured joint bond resistance.
 - g) Results, observations, and comments.
- 4) The Contractor shall assist the Owner or Designated Representative in the performance of such additional tests by providing electrical contacts and physical access to the pipe. This work, and any subsequent repairs and additional testing shall be performed at no additional cost to the Owner.

C. CP Commissioning and Testing:

1. Prior to Initial Acceptance, notify the City of Thornton or Designated Representative and provide a minimum of 2 weeks' notice that the installation is ready to be turned on.
2. Provide a CP commissioning and testing plan to the City of Thornton or Designated Representative for review and approval.
3. Functional and Final Testing to be overseen or performed by the Contractor's NACE CP Specialist (CP4).
4. Energize installation as per the approved testing plan.
5. Operating Test: Conduct a series of tests to demonstrate that equipment and material are installed correctly and operating properly for initial approval.
 - a. Locate, correct, and retest system defects or incomplete work identified during functional and final testing or warranty inspections at no additional cost to the City of Thornton.

- b. Functional testing (to be completed upon completion of pipeline construction):
 - 1) Commission all CP devices and measure native and polarized structure-to-soil potential of pipeline at each test station and CP device using applicable equipment. Include all test stations, isolation devices, bonded segments, above grade appurtenances, surrounding metallic structures, and other identified locations.
- c. Final testing (to be completed 30 days after functional testing and/or connections of all CP devices):
 - 1) Make adjustments in the output of the system; conduct sufficient testing throughout the network of protected structures and piping to ensure proper installation and CP levels.
 - 2) Locate, correct, and retest system defects or incomplete work identified.
 - 3) Warranty Testing (to be completed 30 days prior to end of warranty period or approximately 1 year after installation).
 - 4) Make adjustments in the output of the system; conduct sufficient testing throughout the network of protected structures and piping to ensure proper installation and CP levels.
 - 5) Locate, correct, and retest system defects or incomplete work identified.
- 6. The Contractor shall assist the City of Thornton or Designated Representative in the performance of such additional tests by providing electrical contacts and physical access to the pipe. This work, and any subsequent repairs and additional testing shall be performed at no additional cost to the City of Thornton.
- 7. Provide a final chronological installation and testing report.
 - a. Include:
 - 1) NACE certifications of Contractor's NACE CP Specialist (CP4).
 - 2) Tabulated reports of the following:
 - a) Drilling/excavation log.
 - b) Soil resistance log.
 - c) Backfilled anode resistance log test results.
 - d) Final anode placement, coke breeze, casing, and seal depths.
 - e) Final anode current measurements.
 - f) Native and polarized CP potential measurements.
 - g) Insulated flanges/fittings testing with test methods indicated.
 - h) Electrical continuity testing results.
 - i) Reference electrode and coupon testing results.
 - j) All reports shall contain both stationary reference electrode readings and portable reference electrode readings.
 - 3) Changes, modifications, and alterations from plans.
 - 4) Comments relative to the Project.
 - 5) Failures, defects, and any repairs.
 - 6) Retesting information.
 - 7) Recommendations.

- b. As-Built Records and Documentation:
 - 1) As-Built records shall annotate all CP components and include the following as a minimum:
 - a) Drawings showing location of each test station, reference electrode, anode, and insulated flanges/fittings.
 - b) Provide As-Built drawings to design engineer for inclusion in Record Documentation.
- D. Report should be signed and sealed by the Contractor's NACE CP Specialist (CP4) and submitted for approval by the City of Thornton or Designated Representative.

3.05 CATHODIC PROTECTION CRITERIA

- A. Cathodic protection level shall be considered satisfactory when all pipe-to-soil potential measurements met the -850 mV criteria set forth in NACE SP0169. IR drops in the soil, coating, and measurement circuit shall be compensated for in the measurements.
- B. All "Native State" anode-to-soil potential measurements shall be -1.5 volts or more negative.
- C. Piping with native potential measurements of -0.4 volts or more positive shall be investigated for improper electrical isolation and/or interference.

3.06 INADEQUATE PROTECTION

- A. Inadequate pipe joint continuity, electrical isolation, and/or CP levels due to defective or incorrect installation work shall be corrected by and at the sole expense of the Contractor.
- B. Any anode with a "Native State" anode-to-soil potential less than the specified 1.5 volts (CSE) shall be replaced by and at the sole expense of the Contractor, as required by the City of Thornton or Designated Representative.

3.07 OPERATION AND MAINTENANCE MANUAL

- A. The Contractor's NACE CP Specialist (CP4) shall prepare and furnish an electronic copy (PDF) of Operations and Maintenance (O&M) manual upon completion of the CP system testing. The O&M manual shall contain the following minimum information:
 - 1. Physical description of the protected pipeline including diameter, pipe material, type of pipe joint construction, length, and type of external coating system.
 - 2. CP system description including anode sizes and locations, test station locations, and locations and type of electrical isolation fittings.
 - 3. Schematic drawing of the pipeline showing locations of CP test stations and electrical isolation fittings. The drawing shall also include the approximate alignment of the pipeline, connections to existing piping, and key topographic information such as roads and ditches. The actual locations of the test stations installed out of the roadways should be shown. The drawing does not have to be drawn to scale.
 - 4. Final CP test data.

5. Operations and maintenance procedures and manufacturer manuals or data outlining the routine steps required to operate and maintain the CP system and components. Provide electronic copies of all manuals in .PDF file format.
6. Provide two (2) complete training sessions for City of Thornton personnel for the operations and maintenance of the CP systems.

3.08 SPECIAL WARRANTY

- A. The work under this section shall be guaranteed in accordance with the General Conditions and Special Conditions.

END OF SECTION

SECTION 26_43_14
SURGE PROTECTIVE DEVICES

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
1. High-energy surge protective devices.

1.02 REFERENCES

- A. Institute of Electrical and Electronics Engineers (IEEE):
1. C62.41.1 - Guide on the Surge Environment in Low-Voltage (1,000 V and less) AC Power Circuits.
 2. C62.41.2 - Recommended Practice on Characterization of Surges in Low-Voltage (1,000 V and Less) AC Power Circuits.
 3. C62.45 - Recommended Practice on Surge Testing for Equipment Connected to Low-Voltage (1,000 V and Less) AC Power Circuits.
 4. C62.62- Standard Test Specifications for Surge Protective Devices (SPDs) for Use on the Load Side of the Service Equipment in Low Voltage (1,000 V and less) AC Power Circuits.
- B. International Electrotechnical Commission (IEC):
1. 1000-4 - Electromagnetic Compatibility Standards for Industrial Process Measurement and Control Equipment.
- C. National Electrical Manufacturers Association (NEMA).
- D. National Fire Protection Agency (NFPA):
1. 20 - Standard for the Installation of Stationary Pumps for Fire Protection.
 2. 70 - National Electrical Code (NEC).
 3. 75 - Standard for the Fire Protection of Information Technology Equipment.
 4. 780 - Standard for the Installation of Lightning Protection Systems.
- E. Underwriters Laboratory (UL):
1. 96A - Standard for Installation Requirements for Lightning Protection Systems.
 2. 1283 - Standard for Electromagnetic Interference Filters.
 3. 1449 - Standard for Surge Protective Devices.

1.03 TERMINOLOGY

- A. The words and terms listed below are not defined terms that require initial capital letters, but, when used in this Section, have the indicated meaning.
1. I_n : Nominal discharge current.
 2. MCOV: Maximum continuous operating voltage.
 3. MOV: Metal oxide varistor.
 4. SAD: Silicon avalanche diode.

5. SCCR: Short circuit current rating.
6. SPD: Surge protective device.
7. VPR: Voltage protection rating.

1.04 DELEGATED DESIGN (NOT USED)

1.05 SUBMITTALS

- A. Furnish Submittals as specified in Section 01_33_00 - Submittal Procedures.
- B. Product data:
 1. Furnish complete product data confirming detailed compliance or exception statements to all provisions of this Section.
 2. Manufacturer's catalog cutsheets indicating:
 - a. Manufacturer and model numbers.
 - b. Ratings of each SPD, including, but not limited to:
 - 1) Short circuit current rating.
 - 2) Nominal discharge current.
 - 3) Maximum continuous operating voltage.
 - 4) Voltage protection rating.
 - 5) System voltage.
 - 6) System frequency.
 - 7) Surge current capacity.
 3. Submit independent test data from a nationally recognized testing laboratory verifying the following:
 - a. Overcurrent protection.
 - b. UL 1449.
- C. Shop Drawings:
 1. Provide electrical and mechanical drawings by the manufacturer that detail:
 - a. Unit dimensions.
 - b. Weights.
 - c. Components.
 - d. Field connection locations.
 - e. Mounting provisions.
 - f. Connection details.
 - g. Wiring diagram.
- D. Quality Control Submittals:
 1. Manufacturer's representative qualifications.
 2. Manufacturer's Certificate of Source Testing as specified in Section 01_75_17 - Commissioning.
- E. Owner Training Submittals:
 1. As specified in Section 01_75_17 - Commissioning.
- F. Operation and maintenance manuals:
 1. As specified in Section 01_78_24 - Operation and Maintenance Manuals.
 2. Provide the manufacturer's manual with installation, start-up, and operating instructions for the specified system.

1.06 QUALITY ASSURANCE

- A. Provide SPD units that are designed, manufactured, tested and installed in accordance with the following codes and standards:
 - 1. IEEE C62.41.1, C62.41.2, C62.45, C62.62.
 - 2. Federal Information Processing Standards Publication 94 (FIPS PUB 94).
 - 3. NEMA.
 - 4. NFPA 20, 70, 75, and 780.
 - 5. UL 1449 current edition and UL 1283.
 - 6. IEC 1000-4.
- B. Provide surge protective devices that are suitable for application in IEEE C62.41.1, C62.41.2 Category A, B, and C3 environments, as tested to IEEE C62.45.

1.07 DELIVERY, STORAGE, AND HANDLING (NOT USED)

1.08 PROJECT OR SITE CONDITIONS

- A. As specified in Section 01_81_50 - Design Criteria.

1.09 ADMINISTRATIVE REQUIREMENTS

- A. Sequencing:
 - 1. Coordinate with and provide SPD equipment to the electrical equipment manufacturer before final assembly and factory testing.

1.10 WARRANTY

- A. As specified in Section 01_78_36 - Warranties and Bonds.
- B. Extended warranty:
 - 1. Furnish a manufacturer's standard parts and labor warranty from date of shipment against any part failure when installed in accordance with the manufacturer's instructions, UL listing requirements, and any applicable national, state, or local electrical codes.
 - 2. Warranty shall include:
 - a. Direct, factory-trained employees must be available within 48 hours for assessment of the problem.
 - b. A 24-hour toll-free 800-number for warranty support.

PART 2 PRODUCTS

2.01 GENERAL (NOT USED)

2.02 DESIGN AND PERFORMANCE CRITERIA

- A. Provide surge protection as indicated on the Drawings.

2.03 MANUFACTURERS

- A. One of the following or equal:
1. ABB.
 2. Eaton.
 3. Southern Tier Technologies.
 4. Schneider Electric.

2.04 MATERIALS (NOT USED)

2.05 MANUFACTURED UNITS (NOT USED)

2.06 EQUIPMENT

- A. Provide Type 1 or Type 2 SPD units as required for the locations indicated on the Drawings.
- B. Electrical requirements:
1. SPD ratings are to be consistent with the nominal system operating voltage, phase, and configuration as indicated on the Drawings.
 2. MCOV:
 - a. For the SPD and all components in the suppression path (including all MOVs, SADs, and selenium cells): Greater than 115 percent of the nominal system operating voltage.
 3. Operating frequency:
 - a. 47 to 63 hertz.
 4. SCCR:
 - a. 65 kAIC minimum, but not less than the equipment it is connected to as indicated on the Drawings.
 - b. Marked on the SPD in accordance with UL 1449 and the NEC.
 5. Nominal discharge current I_n :
 - a. 20 kA.
 6. Maximum VPR:

Modes	240/120 3W	208Y/120	480Y/277	480 V
L-N, L-G, N-G	700	700	1,200	1,800
L-L	1,200	1,200	2,000	1,800

7. Peak surge current:
 - a. Service entrance locations:
 - 1) 240 kA per phase minimum.
 - 2) 120 kA per mode minimum.
 - b. Branch locations:
 - 1) 120 kA per phase, minimum.
 - 2) 60 kA per mode minimum.
- C. Protection modes:
1. Provide SPD protection modes as follows:
 - a. Line to neutral (L-N) where applicable.
 - b. Line to ground (L-G).
 - c. Neutral to ground (N-G), where applicable.

- D. Environmental requirements:
 - 1. Storage temperature:
 - a. -40 to 122 degrees Fahrenheit.
 - 2. Operating temperature:
 - a. 32 to 140 degrees Fahrenheit.
 - 3. Relative humidity:
 - a. 5 to 95 percent.
 - 4. Audible noise:
 - a. Less than 45 dBA at 5 feet (1.5 m).
 - 5. Operating altitude:
 - a. Zero to 12,000 feet above sea level.

2.07 COMPONENTS

- A. Enclosure:
 - 1. Located in electrical equipment as indicated on the Drawings.
- B. Internal connections:
 - 1. Provide low impedance copper plates for intra-unit connections:
 - a. Attach surge modules using bolted connections to the plates for low impedance connections.
 - 2. Size connections, conductors, and terminals for the specified surge current capacity.
- C. Surge diversion modules:
 - 1. MOV:
 - a. Where multiple MOVs are used in parallel, utilize computer matched MOVs to within 1 volt variance and tested for manufacturer's defects.
- D. Overcurrent protection:
 - 1. Individually fuse components, including suppression, filtering, and monitoring components:
 - a. Rated to allow maximum specified nominal discharge current capacity.
 - b. Overcurrent protection that limits specified surge currents is not acceptable.
- E. Connections:
 - 1. Provide terminals to accommodate wire sizes up to #2 AWG.

2.08 ACCESSORIES

- A. Unit status indicators:
 - 1. Provide red and green solid-state indicators, with printed labels, on the front cover to redundantly indicate on-line unit status:
 - a. The absence of the green light and the presence of the red light indicate that surge protection is reduced and service is needed to restore full operation.
 - b. Indicates the status of protection on each mode or phase.

- B. Dry contacts for remote monitoring:
 - 1. Electrically isolated Form C dry contacts (1 A/125 VAC, or 2 A/24 VDC) for remote monitoring of system integrity, and indication of under voltage, phase and/or power loss.
- C. Provide an audible alarm which activates under any fault condition:
 - 1. Alarm On/Off switch to silence the alarm.
 - 2. A visible LED will confirm whether alarm is On or Disabled.
 - 3. Locate both switches and the audible alarm on the unit's front cover.

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL

- A. Source Testing:
 - 1. Perform manufacturer's standard factory test:
 - a. Perform testing in accordance with UL 1449.
 - 2. Furnish test reports and Manufacturer's Certificate of Source Testing.
- B. Permanently affix surge rating to the SPD.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

- A. Follow the manufacturer's recommended installation practices and comply with applicable codes.
- B. Special techniques:
 - 1. Install SPDs internal to equipment with as short and straight conductors, including ground conductor as practically possible:
 - a. Twist the input conductors together to reduce input conductor inductance.
 - 2. Do not subject SPD to insulation resistance testing.

3.04 FIELD QUALITY CONTROL

- A. Field electrical acceptance testing:
 - 1. As specified in Section 26_08_50 - Field Electrical Acceptance Tests.

3.05 OWNER TRAINING

- A. Perform Owner Training as specified in Section 01_75_17 - Commissioning.

END OF SECTION

SECTION 26_50_10

LIGHTING: LED LUMINAIRES

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. LED luminaires, drivers, and accessories.

1.02 REFERENCES

- A. Illuminating Engineering Society (IES):
 - 1. LM-79 - Approved Method: Optical and Electrical Measurements of Solid-State Lighting Products.
 - 2. LM-80 - Measuring Luminous Flux and Color Maintenance of LED Packages, Arrays and Modules.
 - 3. RP-7 - Recommended Practice for Lighting Industrial Facilities.
 - 4. TM-21 - Projecting Long Term Lumen, Photon, and Radiant Flux Maintenance of LED Light Sources.
- B. Institute of Electrical and Electronics Engineers (IEEE):
 - 1. C62.41 - IEEE Recommended Practice for Surge Voltages in Low-Voltage AC Power Circuits.
- C. National Electrical Manufacturers Association (NEMA):
 - 1. 410 - Performance Testing for Lighting Controls and Switching Devices with Electronic Drivers and Discharge Ballasts.
- D. National Fire Protection Association (NFPA):
 - 1. 70 - National Electrical Code (NEC).
- E. Underwriters Laboratories (UL):
 - 1. 1598 - Luminaires.
 - 2. 8750 - Light Emitting Diode (LED) Equipment for Use In Lighting Products.

1.03 TERMINOLOGY

- A. The words and terms listed below are not defined terms that require initial capital letters, but, when used in this Section, have the indicated meaning.
 - 1. CCT (correlated color temperature) - Scientific scale to describe how “warm” or how “cool” the light source is, measured in Kelvin. The lower the Kelvin temperature, the warmer the light feels, or appears.
 - 2. CRI (color rendering index) - A quantitative measure of the ability of a light source to reveal the colors of various objects faithfully in comparison with an ideal or natural light source.
 - 3. Driver - Device that manages power and controls the current flow from AC to DC for an LED lighting product.

4. Efficacy - Lumen output of a light source per unit of power supplied to that source (lumens per watt).
5. EMI (electromagnetic interference) - Electrical interference (noise) generated by electrical and electronic devices.
6. FC (foot candles) - Measure of light level on a surface being illuminated.
7. L70 - Extrapolated life in hours of the luminaire when the luminous output depreciates 30 percent from initial values.
8. LED (light emitting diode) - A solid-state semiconductor device that produces light when electrical current flows through it.
9. LED light source - See LED luminaire.
10. LED luminaire - A complete lighting unit consisting of LED-based light emitting elements and a matched driver together with parts to distribute light, to position and protect the light emitting elements, and to connect the unit to a branch circuit.
11. Lumen - International (SI) unit of luminous flux or quantity of light. The amount of light that is spread over a square foot of surface by 1 candle power when all parts of the surface are exactly 1 foot from the light source.
12. Lumen ambient temperature multiplier - LED light source relative lumen output when compared to a standard ambient temperature.
13. Lumen maintenance factor - How well an LED light source is able to retain its intensity when compared to new.
14. Luminaire - Lighting unit.
15. THD (total harmonic distortion) - Combined effect of harmonic Distortion on the AC waveform produced by a driver or other device.

1.04 DELEGATED DESIGN

- A. As specified in Section 01_35_73 - Delegated Design Procedures.
- B. Anchoring and bracing for light poles.

1.05 SUBMITTALS

- A. Furnish Submittals as specified in Section 01_33_00 - Submittal Procedures.
- B. Product data:
 1. LED luminaires:
 - a. Catalog literature for each luminaire specified, cross-referenced to the luminaire type on the Luminaire Schedule, in the Drawings.
 - b. Provide for each luminaire type:
 - 1) Materials.
 - 2) Type of diffuser.
 - 3) Hardware.
 - 4) Gasketing.
 - 5) Reflector.
 - 6) Chassis.
 - 7) Finish and color.
 - 8) Driver type and protection.
 - 9) LED luminaire:
 - a) Initial lumen output at 40 degrees Celsius ambient.
 - b) Correlated color temperature.

- c) Lumen maintenance factors.
 - d) Lumen ambient temperature multipliers.
 - e) Drive current.
 - f) Efficacy.
- 10) Picture of luminaire.
- 11) IES optical distributions.
- 12) Dimensioned drawings:
 - a) Effective projected area rating for pole mounted luminaires.
- 13) Weight.
- 14) Photometric data:
 - a) Coefficient of utilization tables based on the IES zonal cavity system by an approved testing laboratory.
 - b) Luminaire dirt depreciation factor.
 - c) Candlepower distribution curves.
 - d) Average luminaire brightness.
 - e) Lumen output charts.
- 15) Furnish support method for interior luminaires weighing more than 30 pounds and all wall-mounted luminaires:
 - a) Support methods shall be based on seismic requirements at the Project Site as specified in Section 01_81_50 - Design Criteria.
- c. Luminaire substitutions:
 - 1) Provide complete literature for each luminaire substitution:
 - 2) Submittals for substituted luminaires shall be sufficient for competent comparison of the proposed luminaire to the originally specified luminaire:
 - a) Photometric data:
 - (1) IES file in standard IES format.
 - (2) Coefficient of utilization tables based on the IES zonal cavity system by an approved testing laboratory.
 - (3) Candlepower distribution curves.
 - (4) Average luminaire brightness.
 - (5) Lumen output charts.
 - (6) Power requirements in watts and volt-amperes.
 - b) Calculations:
 - (1) Provide software generated calculations showing illuminance levels in footcandles and power usage in watts per square foot for each of the areas in which substitutions are proposed:
 - (a) Use surface reflectance values in accordance with IES RP-7.
 - (b) Use manufacturer projected lumen maintenance factor for minimum of 60,000 hours to perform all calculations.
 - c) Specification sheets:
 - (1) If lacking sufficient detail to indicate compliance with Contract Documents, standard specification sheets will not be accepted. This includes, but is not limited to, luminaire type designation, manufacturer's complete catalog number, voltage, LED type, CCT, CRI, specific driver information, system efficacy, L70 life rating, and any modifications necessary to meet the requirements of the Contract Documents.

- 3) Substitutions for specified luminaires will be evaluated upon quality of construction, light distribution, energy use, appearance, and maintenance.
 - 4) Substitutions shall comply with all applicable building and energy codes.
 2. Driver: Provide for each driver type:
 - a. Catalog number.
 - b. Type of driver.
 - c. Output wattage.
 - d. Input voltage.
 - e. Operating voltage range.
 - f. Maximum input power.
 - g. Efficiency.
 - h. Operating line current.
 - i. Power factor.
 - j. Operating temperature range.
 - k. Current output range in ambient temperatures of 30 to 55 degrees Celsius.
 - l. Surge suppression data.
 3. Photocell:
 - a. Provide for each photocell type:
 - 1) Switching capacity.
 - 2) Life expectancy when used on LED sources.
 - 3) Means of adjusting the lighting pickup level.
 - 4) Enclosure type.
 - 5) Mounting method.
 4. Luminaire poles:
 - a. Submit complete data for each pole type including, but not limited to:
 - 1) Material.
 - 2) Finish and color.
 - 3) Handholes.
 - 4) Anchoring.
 - 5) Luminaire attachment methods and fittings.
 - 6) Pole height.
 - 7) Pole dimensions.
 - 8) Bolt hole circle layout and hardware.
 - 9) Accessories.
 - 10) Provide the EPA wind load rating.
 - 11) Installation instructions for rigging, moving and setting into place.
- C. Delegated Design Submittals:
1. Project-specific calculations with anchoring and bracing details based on support conditions and requirements to resist loads specified in Section 01_81_50 - Design Criteria.
- D. Record documents:
1. Update the Luminaire Schedule in the Drawings to reflect the acceptable substitutions, after the substitution has been reviewed and accepted by the Engineer.

1.06 QUALITY ASSURANCE

- A. Luminaires shall be UL listed and labeled.

1.07 DELIVERY, STORAGE, AND HANDLING (NOT USED)

1.08 PROJECT OR SITE CONDITIONS

- A. As specified in Section 01_81_50 - Design Criteria.

1.09 ADMINISTRATIVE REQUIREMENTS

- A. Scheduling:
 - 1. Exterior and outdoor lighting system operation shall be demonstrated during the hours of darkness.
 - 2. Lighting demonstration shall occur within 2 weeks before substantial completion.

1.10 WARRANTY

- A. As specified in Section 01_78_36 - Warranties and Bonds.
- B. LED luminaire:
 - 1. 5-year warranty from the date of installation including material, workmanship, photometrics, driver, and LED modules.

1.11 MAINTENANCE

- A. Furnish 1 complete spare LED luminaire, with driver, of each type used.

PART 2 PRODUCTS

2.01 GENERAL

- A. Individual luminaire types are indicated on the Drawings and on the Luminaire Schedule.

2.02 DESIGN AND PERFORMANCE CRITERIA

- A. Provide luminaires and accessories for all lighting systems, complete and operable, in accordance with the requirements of the Contract Documents.

2.03 MANUFACTURERS

- A. Luminaires:
 - 1. The following or equal:
 - a. As noted on the Luminaire Schedule.
- B. Drivers:
 - 1. One of the following or equal:
 - a. eldoLED.

- b. Philips Advance.
 - c. Thomas Research.
- C. Photo-electric cells:
 - 1. One of the following or equal:
 - a. Cooper.
 - b. Hubbell-Killark.
 - c. Intermatic.
 - d. Tork.
- D. Substitutions:
 - 1. Lighting design and luminaire selection has been based upon the photometric data of the identified luminaire. It is the Contractor's responsibility to ensure and prove to the Engineer at time of Submittal the substitutions meet the quality and photometric requirements of the original design.

2.04 MATERIALS (NOT USED)

2.05 MANUFACTURED UNITS (NOT USED)

2.06 EQUIPMENT

- A. LED luminaires:
 - 1. General:
 - a. Pre-wired with leads of 18-AWG, minimum, for connection to building circuits.
 - b. Provide the luminaires furnished as indicated on the Luminaire Schedule in the Drawings:
 - 1) Specifications noted in this Section are an addition or supplement to the Luminaire Schedule.
 - c. Individual LEDs connected such that a catastrophic loss or the failure of 1 LED will not result in the loss of the entire luminaire.
 - 2. Minimum ambient temperature range of 0 degrees Celsius to 40 degrees Celsius.
 - 3. Minimum rated life:
 - a. Office areas: 70,000 hours when operated at 25 degrees Celsius.
 - b. Process areas: 100,000 hours when operated at 40 degrees Celsius.
 - c. Hazardous areas: 100,000 hours when operated at 40 degrees Celsius.
 - 4. Minimum efficacy of 70 lumens/watt.
 - a. Hazardous areas: Minimum 60 lumens/watt.
 - 5. Minimum Color Rendering Index of 70.
 - 6. Tested according to IES LM-79 and LM-80.
 - 7. Lumen maintenance projection in accordance with IES TM-21.
 - 8. RoHS compliant.
 - 9. Integral driver.
 - 10. Suitable for dry, damp, or wet locations as indicated on the Drawings or on the Luminaire Schedule.
 - a. Wet or damp locations: UL 1598 listed.
 - 11. Designed as a complete LED assembly. Retrofit LED lamps in luminaires not designed specifically for LED light sources shall not be used.

12. Exterior/outdoor luminaires:
 - a. Luminaires in combination with their mounting pole and bracket shall be capable of withstanding:
 - 1) Wind levels at the Project Site without damage.
 - 2) Seismic levels at the Project Site.
 - b. Corrosion-resistant hardware and hinged doors or lens retainer.
 - c. Luminaires furnished with integral photoelectrical control shall be of the luminaire manufacturer's standard design.
- B. Photo-electric cells:
 1. Weatherproof.
 2. In Class I Division 2 locations:
 - a. Rated for used in Class I Division 2, Groups A, B, C, D locations.
 - b. Factory sealed.
 3. Photoelectric cells for control of multiple luminaires:
 - a. Self-contained.
 - b. Provided with time-delay features.
 - c. Sized to meet switching capacity of the circuit:
 - 1) Based on luminaire VA as indicated on the Drawings.
 4. Photoelectric cell for control of a single luminaire:
 - a. Integral to the luminaire.
- C. Drivers:
 1. Dimmable, with dimming signal protocol of 0-10 VDC or DALI.
 2. Input power source:
 - a. As indicated on the Drawings.
 3. Drive current:
 - a. As indicated in the Luminaire Schedule.
 4. Power factor: Greater than 0.90.
 5. Efficiency: Greater than 80 percent.
 6. Total harmonic distortion (THD) of the input current less than 20 percent.
 7. Rated life of 60,000 hours in an LED luminaire operated at an ambient temperature of 40 degrees Celsius.
 8. Minimum operating temperature of -40 degrees Celsius.
 9. Sound rating: Class A+ or quieter.
 10. UL listed Class 2 Outdoor in accordance with UL 8750.
 11. In accordance with IEEE C62.41 Category A for transient protection.
 12. Driver must limit inrush current:
 - a. Meet or exceed NEMA 410 driver inrush standard:
 - 1) 230 amps per 10-amp load with a maximum of 106 amps squared-seconds at 120-V.
 - 2) 430 amps per 10-amp load with a maximum of 370 amps squared-seconds at 277-V.

2.07 COMPONENTS (NOT USED)

2.08 ACCESSORIES (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION

- A. Anchoring and bracing to structures:
 - 1. Prepare equipment anchor setting template(s) and use to position anchors during construction of supporting structure(s).
 - 2. Install anchors of type and material indicated on approved anchoring designs.
 - 3. Install anchors with embedment indicated on approved anchoring designs.

3.03 INSTALLATION

- A. Install the equipment in accordance with the accepted installation instructions and anchorage details.
- B. Special techniques:
 - 1. Support luminaires from structural elements capable of carrying the total weight.
 - 2. Install luminaires plumb and square with building and wall intersections:
 - a. Suspend pendant-mounted luminaries that are mounted from sloping ceilings with ball hangers, unless otherwise indicated on the Drawings.
 - b. Install luminaires in machinery rooms after machines have been installed, so as to ensure no conflict with machinery, piping, or ductwork.
 - 3. In all cases, coordinate luminaire locations with work of other trades to prevent obstruction of light from the fixtures:
 - a. Locate bottom of luminaire approximately at the bottom of ductwork, unless otherwise specified or indicated on the Drawings.
 - 4. Support luminaires weighing more than 25 pounds independently of the outlet box and the conduit.
 - 5. Provide ceiling or pendent mounted luminaires with a safety chain connecting the lens, driver, and other components to the building structure.
 - 6. Provide recessed luminaires with auxiliary safety supports attached directly to the building structure:
 - a. Safety supports shall consist of number 12 AWG soft drawn galvanized wires.
 - 7. Install luminaires in accordance with the architectural reflected ceiling drawings:
 - a. Center luminaires on ceiling tiles unless otherwise indicated.
 - 8. Support luminaires installed in suspended grid ceilings, independently of the grid:
 - a. Provide seismic restraint clips for luminaires installed in suspended grid ceilings.
 - 9. Provide luminaires equipped with battery backup with an additional unswitched conductor from the power source circuit designated on the Drawing. Wall switches shall be wired to switch luminaires on and off, while maintaining power to the backup batteries.

3.04 FIELD QUALITY CONTROL (NOT USED)

3.05 OWNER TRAINING (NOT USED)

3.06 ADJUSTING

- A. Aim and verify exterior and outdoor luminaires alignment, during dark evening hours, as directed by the Owner or the Engineer.

3.07 CLEANING

- A. Clean lenses, diffusers, and reflectors.
- B. Refinish luminaires' trim, poles, and support brackets, where finish has been damaged.
- C. Clean LED luminaires (new and old), used during construction for construction lighting, before substantial completion.
- D. Clean and re-lamp existing fluorescent and HID luminaires used during construction for construction lighting, before substantial completion.

3.08 SCHEDULES

- A. Refer to the Luminaire Schedule in the Drawings.

END OF SECTION

SECTION 28_10_00

ELECTRONIC ACCESS CONTROL AND INTRUSION DETECTION

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Integrated security management systems hardware, software, and programming.

1.02 REFERENCES

- A. As specified in Sections 26_05_00 - Common Work Results for Electrical.
- B. Institute of Electrical and Electronics Construction Managers (IEEE):
 - 1. 802.3 - Standard for Information Technology-Specific requirements - Part 3: Carrier Sense Multiple Access with Collision Detection (CSMA/CD) Access Method and Physical Layer Specifications.
- C. Underwriters Laboratories, Inc. (UL).

1.03 DEFINITIONS

- A. As specified in Sections 26_05_00 - Common Work Results for Electrical.

1.04 SYSTEM DESCRIPTION

- A. This Section describes the requirements for security access control and intrusion detection systems. The systems shall be user configurable and scalable.
- B. The complete security access system shall include, but not be limited to, the following major components:
 - 1. Security access control and monitoring software.
 - 2. Network Access controllers.
 - 3. Access control panels.
 - 4. Door hardware with integrated strike locks and panic bars shall be as specified in Division 08.
 - 5. Motion sensors.
 - 6. Door contacts.
 - 7. Card readers.
 - 8. Power supplies as required.
- C. The Contractor shall be responsible for providing fully operational security access control/intrusion detection and intercom/video systems as indicated on drawings. All necessary hardware and software required for the fully operational system shall be the responsibility of the Contractor and shall be provided at no additional cost to the City of Thornton.

- D. The City of Thornton has an existing system utilizing Hirsch access control equipment. New equipment must be compatible with existing City of Thornton Hirsch Velocity software. Coordinate with City of Thornton during implementation and configuration.
- E. Coordinate with the door vendor for door lock type and door hardware.
- F. All equipment shall be UL listed.

1.05 SUBMITTALS

- A. Furnish submittals as specified in Sections 01_33_00 - Submittal Procedures.
- B. Product data:
 - 1. Model numbers of all components furnished on the job.
- C. Manufacturer's catalog data sheets for all components.
 - 1. Input power requirements for all components.
 - 2. Warranty information.
- D. Shop drawings:
 - 1. Complete engineered drawings indicating:
 - a. Layout, wiring diagrams, and dimensions.
 - b. Point-to-point wiring diagrams for all devices.
 - c. Termination details for all devices.
 - d. Single-line system architecture drawings representing the entire system.
- E. Installation instructions:
 - 1. Manufacturer's installation instructions.
- F. Operation and maintenance manuals:
 - 1. Complete documentation shall be provided with the system.
 - 2. The documentation shall completely describe all operations, each program, data sets, and the hardware and peripherals.
 - a. All updates, addendum, and adjustments to the documentation shall be provided at no additional charge, in the same quantities as originally required.
 - b. System administrator manual:
 - 1) Overview and step-by-step guide and instructions detailing all system administrator responsibility and authority.
 - c. User manual:
 - 1) Step by step guide and instructions detailing all system user functions and responsibilities.
 - 3. Technical maintenance manual:
 - a. Shall be a comprehensive and detailed document providing all maintenance action, system testing schedules, troubleshooting flowcharts, functional system layout, and block diagrams and schematic diagrams of all system wiring.

1.06 QUALITY ASSURANCE

- A. Access Control System supplier/installer qualifications:
 - 1. Company specializing in the installation of Access Control Systems, design and installation of cabling infrastructures with a minimum of 5 years of documented experience in successful completion of a minimum of 3 projects similar in scope and cost.
 - 2. Minimum of 2 factory-trained and certified technicians on staff for the duration of the project and the warranty period.
- B. Permits and inspections:
 - 1. Material and workmanship will conform to all applicable legal and code requirements, and as specified in the Contract Documents.
 - 2. Perform all tests required to demonstrate conformance with the Contract Documents.
- C. Job conditions:
 - 1. The installation is to be supervised on a regular basis by a person designated by the Contractor. This person will be authorized and will be competent to be in charge of the Project.

1.07 PROJECT OR SITE CONDITIONS

- A. As specified in Section 01_81_50 - Design Criteria.

1.08 WARRANTY

- A. As specified in Section 01_78_36 - Warranties and Bonds.

PART 2 PRODUCTS

2.01 MANUFACTURER

- A. Access Control System (Controllers, control panels, software, and accessories):
 - 1. The following, no equal:
 - a. Identiv, Hirsch Velocity.
- B. Door Contacts:
 - 1. The following or approved equal:
 - a. George Risk Industries, Inc.
 - b. G.E. Interlogix - Sentrol.
 - c. Honeywell.
- C. Request-to-Exit (REX) Motion Detectors:
 - 1. The following or approved equal:
 - a. G.E. Security.
 - b. Honeywell.
 - c. Bosch Security Systems.

- D. Card Readers:
1. The following or approved equal:
 - a. Identiv, TS.
 - b. HID Global
 - c. Honeywell.

2.02 EQUIPMENT

- A. Access control system:
1. The access control system shall include, but is not limited to, access controllers, communications adapters, access control panels, power supplies, and system software.
 2. The access control system shall be based on the Hirsch Velocity Access System utilizing MX access controllers. The access controllers shall be fully compatible with peripheral devices associated with access control and intrusion detection devices.
 3. Each cabinet shall have a single backplane capable of supporting required modules. Module quantities shall be as required to create a fully functional system.
 4. The access control system shall be capable of monitoring any alarm devices with dry contact outputs, such as motion sensors, door contacts, etc. Provide relay modules, as required.
 5. The access control system shall be capable of triggering video recording events when alarm devices are initiated.
 6. Each cabinet or module shall have the following I/O capabilities:
 7. Inputs:
 - a. Front End Readers (IN and OUT).
 - b. Request to Exit (REX): Normally open loop.
 - c. Door Switch: Normally closed loop.
 8. Outputs:
 - a. Main Relay: Form C, SPDT, 12-24VAC/DC, 2A.
 - b. Alarm Shunt: Form C, SPDT, 12-24VAC/DC, 1A.
 - c. Door Ajar: Form C, SPDT, 12-24VAC/DC, 1A.
 - d. Forced Door: Form C, SPDT, 12-24VAC/DC, 1A.
 9. Communications:
 - a. The system shall include an Ethernet network gateway module (SEG-M) for each site and communicate across a TCP/IP network.
 - b. The system shall support serial communication (RS-485) for interconnection of multiple backplanes.
 10. The system shall be expandable for control of up to 64 modules per site and be networked with unlimited sites.
 11. The peripherals, specified in this Section, shall be fully compatible with the specified access control system. The Contractor shall be responsible for integrating the peripherals to the access control system.
 12. The network cabling and all required wiring between peripherals and network components shall be provided as recommended by the equipment manufacturers.
 13. The access control system shall be fully operational with programmed information. The Contractor shall coordinate with the City of Thornton for the programming input data.

14. The access control system components shall be housed in a NEMA 12 lockable enclosure.
 - a. The enclosure shall be ventilated and sized to accommodate all required components and dissipate the heat generated in the panel.
 - b. The interconnecting cables and wires shall be neatly arranged and installed in wiring channels.
 - c. The components shall be DIN rail or shelf mounted inside the enclosure and shall be secured.
 - d. Provide DIN-rail mounted terminal strips, as required, inside the enclosure for all field wiring terminations, excluding communication cables. The terminal strips shall be rated for 300V applications and shall be sized to accommodate field wire sizes.
15. Provide all required power supplies for all components housed in the security panel and all peripheral devices connected to the security panel. Power supplies shall have minimum of 25 percent spare capacity. All power supplies shall be provided with overload and short circuit protection and shall be mounted in the security panel.
16. Each access control panel shall include a 7AH battery with charging system to provide backup in the event of power failure. Battery and charger shall be as recommended by the manufacturer.
17. A tamper switch shall be provided for the enclosure and the switch shall be wired to an input in the Access Control System. Provide Sentrol Model 3012 or equal.
18. Software:
 - a. Provide all required software installed on the indicated workstations for complete system monitoring and management of the access control system.
 - b. The software shall store all system transactions in a common database stored on the existing network server. The database shall be accessible by the existing security access terminal.
 - c. The System Repository folder shall be located on a Windows Server operating system and the System Manager shall operate on Windows operating system.

B. Door contracts:

1. Recessed mounted door contacts shall meet the following requirements:
 - a. Designed for recessed mounting in the door frame.
 - b. 3/4-inch diameter.
 - c. Minimum 1/2-inch gap in steel doors.
 - d. Hermetically sealed reed switch with matching actuating magnet.
 - e. Minimum one foot lead length.
 - f. Normally closed when active (door is closed).
 - g. Compatible with specified access control modules.
2. Surface mounted door contacts shall meet the following requirements:
 - a. Hermetically sealed reed switch with matching actuating magnet.
 - b. Brushed anodized aluminum housing.
 - c. Three-foot stainless steel armored cable.
 - d. Mounting bracket as required.
 - e. Normally closed when active (door is closed).
 - f. Compatible with specified access control modules.

- g. All mounting hardware shall be included for the installation.
 - h. Compatible with the installation environmental conditions.
- C. Manual request to exit:
 - 1. Refer to Division 08 for exit devices integral to door hardware.
 - 2. Where exit device is not integral to door hardware, provide manual request to exit pushbutton as follows:
 - a. Green with "PUSH TO EXIT" lettering.
 - b. Stainless steel cover plate.
 - c. Momentary SPDT contact rated minimum 1A at 24-Vdc.
 - d. FS or FD box mounting.
 - e. Mounting:
 - 1) Finished Spaces: Recessed.
 - 2) Unfinished Spaces: Surface mount.
- D. Card reader:
 - 1. The card reader shall meet the following requirements:
 - a. Read range: Up to 3 inches with compatible card.
 - b. Input voltage: 5 to 16 Vdc at reader.
 - c. Operating temperature: -30 degrees Celsius to 65 degrees Celsius.
 - d. Enclosure: The reader shall be of potted, polycarbonate material, sealed to a NEMA rating of 4X.
 - e. LED indicator with tri-color standard (red, green, amber or blue).
 - f. Audio tone.
 - g. Output format: Wiegand.
 - h. Frequency: 125 kHz (excitation).
 - i. Factory or field programmable.
 - j. Rated for indoor and outdoor installation.
 - k. Compatible with specified access control modules.
 - 2. Provide a minimum of twenty 125 kHz HID Proximity Access Cards compatible with the Owners' existing system.

2.03 SOURCE QUALITY CONTROL (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION

- A. Verify site conditions are suitable for installation of equipment.
- B. Final or temporary HVAC systems shall be in place and operational to maintain the ambient temperatures and humidity conditions at occupancy levels prior to energizing the access control panels and shall be maintained for the remainder of the construction period.

3.02 PREPARATION

- A. Perform a layout check to ensure that adequate access is available for construction, installation, and maintenance of equipment and devices furnished; however, the Contractor is not responsible for furniture. The Contractor shall consult the City of Thornton and Construction Manager in the design of the monitoring workstation area.

3.03 INSTALLATION

- A. Although expected locations are indicated on the Drawings, all equipment locations, including cameras, controllers, I/O boards, servers, workstations, and all alarm and CCTV devices shall be field verified with the Construction Manager.
- B. Installation of the SMS shall include the appropriate equipment and shall be performed by a factory-trained and certified contractor. The installation shall be completed to this Section and Project Drawings as required by the City of Thornton or prime contractors. The installation shall include the following:
 - 1. Site planning and system configuration of field hardware and SMS. The Contractor shall consult with the City of Thornton and Construction Manager for final required camera settings, access level configuration, and other systems programming.
 - 2. Complete system setup at the head end.
 - 3. Setup of specific network software configuration requirements.
 - 4. Complete system diagnostics verification.
 - 5. Complete system operation verification.
 - 6. Problem reporting and tracking.
 - 7. Project specific installation log.
 - 8. Completion of specific City of Thornton acceptance test plans.
 - 9. Formal turnover of the specific project installation documentation to the City of Thornton's water services department.

3.04 PROGRAMMING

- A. Access Control:
 - 1. Access Control.
 - 2. The access control system shall be programmed to allow access to the indicated areas. Coordinate with the City of Thornton for a complete list of employees and access control rights.
 - 3. Forms shall be developed to allow easy entry of new employees and editing of existing employee rights.
 - 4. Program the database tags, descriptions, and alarm reports in a clear and concise manner.
 - 5. The security system shall be programmed to provide the indicated outputs to the process control system.
 - 6. The security access control for a typical man door shall meet the following sequence of operations:
 - a. Normal Request for Entry: The security access control system shall actuate the man door electric strike when the request for entry is made via the man door card reader. The electric strike shall be released and remain released for 10 seconds before the system secures the electric strike.
 - b. Normal Request to Exit: The man door shall be designed for a free exit using a request to exit push bar or a motion sensing device located on the door interior. The request to exit push bar or motion sensing device shall initiate a contact closure to the access control module exit circuit. The access control module shall release the electric strike and give a permissive to the system for a free exit. The system shall incorporate a 10 second time delay after the request to exit is given to complete the exit cycle.

3.05 COMMISSIONING

- A. As specified in Section 01_75_17 - Commissioning.

3.06 FIELD QUALITY CONTROL

- A. Perform acceptance tests to show system is properly installed and that it meets the Specifications and applicable codes. The acceptance tests will include demonstration of the integration to the existing head end, and the capability to be monitored and controlled from other workstations on the Enterprise.
- B. Performance specification requirements:
 - 1. Where Specifications require compliance with performance requirements, provide products that comply with these requirements, and are recommended by the manufacturer for the application indicated.
 - 2. General overall performance of a product is implied where the product is specified for a specific application.
 - 3. All equipment to be installed per applicable UL listing for that device or component.
- C. Comply with manufacturer's instructions and recommendations for installation of product in the applications indicated. Anchor products securely in place, accurately located and aligned with other work.

3.07 ADJUSTING

- A. After field installation and final wiring terminations are completed the access control panel wiring and cables shall be adjusted and neatly secured with tie wraps, hook-and-loop straps, or the like.
- B. Wiring duct covers shall be replaced and secured as required.

3.08 CLEANING

- A. Prior to final acceptance control panel interior and exterior shall be wiped clean and free from dust and debris.

END OF SECTION

SECTION 28_23_29

VIDEO SURVEILLANCE REMOTE DEVICES AND SENSORS

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. IP Cameras.

1.02 REFERENCES

- A. As specified in Sections 26_05_00 - Common Work Results for Electrical.
- B. Institute of Electrical and Electronics Construction Managers (IEEE):
 - 1. 802.3 - Standard for Information Technology - Specific requirements - Part 3: Carrier Sense Multiple Access with Collision Detection (CSMA/CD) Access Method and Physical Layer Specifications.
- C. Underwriters Laboratories, Inc. (UL).

1.03 DEFINITIONS

- A. As specified in Sections 26_05_00 - Common Work Results for Electrical.

1.04 SYSTEM DESCRIPTION

- A. The close circuit television (CCTV) system is comprised of a series of devices including:
 - 1. Pan tilt zoom (PTZ) hi-speed dome or platform cameras monitoring building exterior.
 - 2. Fixed cameras monitoring internal areas.
- B. Where possible, and unless otherwise approved by the Construction Manager and the City of Thornton, all CCTV products shall be from the same manufacturer.

1.05 SUBMITTALS

- A. Furnish submittals as specified in Sections 01_33_00 - Submittal Procedures.
- B. Product data:
 - 1. Manufacturer of all equipment.
 - 2. Model numbers of all components.
 - 3. Bill of material.
 - 4. Electrical requirements:
 - a. Voltage.
 - b. Power.
 - 5. Manufacturer's catalog data sheets for all components.
 - 6. Warranty documentation.

- C. Shop drawings:
 - 1. Complete engineered drawings indicating:
 - a. Layout, wiring diagrams and dimensions.
 - b. Point-to-point wiring diagrams for all devices.
 - c. Termination details for all devices.
 - d. Single-line system architecture drawings representing the entire system.
- D. Installation instructions:
 - 1. Manufacturer's installation instructions.
- E. Operation and maintenance manuals:
 - 1. Complete documentation shall be provided with the system.
 - a. The documentation shall completely describe all operations, each program, data sets, and the hardware and peripherals.
 - b. All updates, addendum, and adjustments to the documentation shall be provided at no additional charge, in the same quantities as originally required.
 - c. Each Division shall define the initial quantities:
 - 1) System administrator manual: Overview and step-by-step guide and instructions detailing all system administrator responsibility and authority.
 - 2) User manual: Step-by-step guide and instructions detailing all system user functions and responsibilities.
 - 3) Technical maintenance manual: Shall be a comprehensive and detailed document providing all maintenance action, system testing schedules, troubleshooting flowcharts, functional system layout and block diagrams, and schematic diagrams of all system wiring.
 - 4) Where appropriate, this documentation may have been provided as part of the head end.
- F. Training documents:
 - 1. Include course outlines for each of the end user training programs.
 - a. The course outlines shall include the course duration, location, prerequisites, a brief description of the subject matter, and the name of the factory-certified instructor who will present the training.

1.06 QUALITY ASSURANCE

- A. IP camera supplier/installer qualifications:
 - 1. Company specializing in the installation of IP cameras, design and installation of cabling and fiber infrastructures with a minimum of 5 years' documented experience in successful completion of a minimum of 3 projects similar in scope and cost.
 - 2. Minimum of 2 factory-trained and certified technicians on staff for the duration of the project and the warranty period.

1.07 DELIVERY HANDLING AND STORAGE

1.08 PROJECT OR SITE CONDITIONS

- A. As specified in Section 01_81_50 - Design Criteria.

1.09 WARRANTY

- A. As specified in Section 01_78_36 - Warranties and Bonds.
- B. Manufacturer's extended warranties will apply if they are longer than 1 year.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Surveillance cameras:
 - 1. The following or approved equal:
 - a. AXIS P3225-VE Mk II (3MP).
 - b. AXIS P3227-LVE (5MP).
 - c. AXIS Q6125-LE (PTZ).
- B. Security switch:
 - 1. The following or approved equal:
 - a. Vigitron Vi3026.

2.02 EQUIPMENT

- A. Video Surveillance System:
 - 1. The video surveillance system shall include, but is not limited to, surveillance cameras, mounting hardware, CAT6 cable, surge suppression, and power supplies (when applicable).
 - a. Provide extension mounting arm for all outdoor cameras.
 - 2. The video surveillance shall be integrated into existing Video Surveillance System at Wes Brown Water Treatment plant. Contractor to provide all necessary equipment and modifications for a fully functional system.
 - 3. Video coverage shall include inside and outside shots of all access control doors, PLC cabinets, Hatches, room shots with motion detection activated on the cameras for large open areas of the plant.
 - 4. Use 3MP cameras for cameras located near its focal point and 5MP cameras for all large open areas, and long-range shots. When selecting the cameras for the areas, coordinate with the City of Thornton to ensure that the network can support the bandwidth, especially for 5MP cameras.
 - 5. The peripherals specified in this Section shall be fully compatible with the specified surveillance cameras.
 - 6. The network cabling and all required wiring between peripherals and network components shall be provided as recommended by the equipment manufacturers.
 - 7. Contractor shall coordinate with the City of Thornton for the programming input data.
 - 8. Provide surge suppression as required to protect system headend equipment from transients.
 - 9. Surveillance Camera shall include infrared or thermal options such that no additional light sources are needed for operation.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Installation shall include the appropriate equipment and shall be performed by a factory-trained and certified contractor. The installation shall be completed to the Contract Documents as required by the City of Thornton or prime Contractors. The installation shall include the following:
 - 1. Site planning and system configuration of field hardware.
 - a. The Contractor shall consult with the City of Thornton and Construction Manager for final required camera settings and placements, home positions, alarm positions, and pan, tilt, and zoom settings.
 - b. Contractor to provide a programming worksheet prior to programming cameras.
 - c. This worksheet will indicate for each camera home position, pre-sets, field of view, security tours, system alarm events to respond to, and associated card reader or input devices. Construction Manager will work with the Contractor to ensure proper completion.
 - 2. Complete system setup at the head end and workstations.
 - 3. Setup of specific network software configuration requirements.
 - 4. Complete system diagnostics verification.
 - 5. Complete system operation verification.
 - 6. Problem reporting and tracking.
 - 7. Project specific installation log.
 - 8. Completion of specific City of Thornton acceptance test plans.
 - 9. Formal turnover of the specific Project installation documentation to the City of Thornton.
- B. All wire and cable will be labeled with an appropriate identification code attached to the cable near the termination. This code will indicate the source camera. Codes will be similarly addressed in the as-built drawings.

3.02 COMMISSIONING

- A. As specified in Section 01_75_17 - Commissioning.

3.03 FIELD QUALITY CONTROL

- A. Install cameras in compliance with the manufacturer's instructions.
 - 1. Anchor products securely in place, accurately located and aligned with other work.

3.04 ADJUSTING

- A. Adjust all cameras to avoid obstructions and provide a clear field of view.

END OF SECTION

SECTION 28_46_13
FIRE ALARM SYSTEMS

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Design and installation of fire alarm systems.

1.02 REFERENCES

- A. Regulations:
 - 1. As specified in Section 01_41_00 - Regulatory Requirements.
- B. Standards:
 - 1. Federal Communications Commission (FCC).
 - 2. National Fire Protection Association (NFPA):
 - a. 1 - Fire Code.
 - b. 70 - National Electrical Code.
 - c. 72 - National Fire Alarm and Signaling Code.
 - d. 75 - Standard for the Protection of Information Technology Equipment.
 - e. 90A - Standard for the installation of Air Conditioning and Ventilation systems.
 - f. 1221 - Standard for the Installation, Maintenance, and Use of Emergency Services Communications Systems.
 - 3. National Institute for Certification in Engineering Technologies (NICET).
 - 4. Underwriters Laboratories, Inc. (UL):
 - a. 864/1730 - Standard for Control Units and Accessories for Fire Alarm Systems.

1.03 DELEGATED DESIGN

- A. As specified in Section 01_35_73 - Delegated Design Procedures.
- B. Fire alarm system design.

1.04 SUBMITTALS

- A. Furnish Submittals as specified in Section 01_33_00 - Submittal Procedures.
- B. Delegated Design Submittals:
 - 1. Product data for fire alarm system components and materials.
 - 2. Shop Drawings:
 - a. Furnish all Shop Drawings required to obtain approval of the fire alarm system by the authority having jurisdiction (AHJ).
 - 3. Calculations.

- C. Installation instructions:
 - 1. Provide manufacturer's installation instructions.
- D. Designer and installer qualifications.
- E. Quality Control Submittals:
 - 1. Manufacturer's representative qualifications.
 - 2. Manufacturer's Certificate of Installation Verification as specified in Section 01_75_17 - Commissioning.
 - 3. Manufacturer's Certificate of Functional Compliance as specified in Section 01_75_17 - Commissioning.
- F. Owner Training Submittals:
 - 1. As specified in Section 01_75_17 - Commissioning.
- G. Operation and maintenance manuals:
 - 1. As specified in Section 01_78_24 - Operation and Maintenance Manuals.

1.05 QUALITY ASSURANCE

- A. Installer qualifications:
 - 1. NICET Level II Fire Alarm System Technician.
 - 2. Installation to be supervised by NICET Level III Technician.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. As specified in Section 01_60_01 - Product Requirements and the manufacturer's instructions.

1.07 PROJECT OR SITE CONDITIONS

- A. As specified in Section 01_81_50 - Design Criteria.

1.08 ADMINISTRATIVE REQUIREMENTS

- A. Sequencing:
 - 1. Furnish Submittals to the local authority having jurisdiction (AHJ), for review and approval of the proposed system.
 - a. Pay all plan check, permit, and inspection fees.
 - b. Submit AHJ's approval to the Engineer.
 - c. Contractor to meet Poudre Fire Authority requirements/checklists/guides. See <https://www.poudre-fire.org/online-services/contractors-plan-reviews-and-permits>

1.09 WARRANTY

- A. As specified in Section 01_78_36 - Warranties and Bonds.

1.10 MAINTENANCE

- A. Furnish service and maintenance of fire alarm system for 1 year from date of Substantial Completion.

PART 2 PRODUCTS

2.01 GENERAL

- A. Design, furnish, and install fire alarm systems in the following locations:
 - 1. Source Water Pump Station.

2.02 MANUFACTURERS

- A. One of the following or equal:
 - 1. Edwards Signaling Solutions.
 - 2. Honeywell.
 - 3. Siemens Fire Safety Solutions.

2.03 DESIGN AND PERFORMANCE CRITERIA

- A. Provide a complete, non-coded, microprocessor-based fire alarm system with initiating devices, notification appliances, controls, and supervisory devices.
- B. Fire alarm control panel (FACP):
 - 1. Power requirements:
 - a. 120 VAC input power via a dedicated circuit.
 - b. Battery system:
 - 1) Provided with sufficient battery capacity to operate the entire system upon loss of normal 120 VAC power in a normal supervisory mode for a period of 24 hours with 5 minutes of alarm operation at the end of this period.
- C. HVAC shutdown:
 - 1. Shutdown all HVAC equipment serving an area in the event of an alarm.
 - 2. Related HVAC equipment as indicated on the Drawings.
- D. Alarms from the fire alarm system shall be routed to:
 - 1. Poudre Fire Authority and City of Thornton vendor.

2.04 EQUIPMENT

- A. All fire alarm system equipment and materials shall be UL listed.
- B. Fire alarm equipment shall be rated for the installed location as specified in Section 26_05_00 - Common Work Requirements for Electrical.

2.05 COMPONENTS

- A. Conduit:
 - 1. Use the conduit type for the installed location as specified in Section 26_05_00 - Common Work Results for Electrical.
 - 2. Provide conduit as specified in Section 26_05_33 - Conduits.
- B. Boxes:
 - 1. Provide boxes as specified in Section 26_05_34 - Boxes.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

- A. Install system components and associated devices in accordance with applicable NFPA Standards and manufacturer's recommendations.
- B. Smoke detectors shall not be installed until after construction cleanup on all trades is complete and final in accordance with NFPA 70, NFPA 72, NFPA 75, NFPA 90A, FCC, and other codes applicable to the individual installation location.
- C. Locate the fire alarm control panel as indicated on the Drawings.
- D. Wiring:
 - 1. Conduit and wiring systems:
 - a. Size, provide, and install necessary conduits and wiring systems necessary to meet the requirements of the approved fire alarm system design.
 - b. Installed in accordance with the NEC, state, and local codes.
- E. Furnish Manufacturer's Certificate of Installation Verification.

3.04 FIELD QUALITY CONTROL

- A. Provide services of a factory-authorized service representative to:
 - 1. Supervise the field assembly and connection of components and the pre-testing, testing, and adjustment of the system.
 - 2. Verify proper installation, correct deficiencies, and be present at the job site during final inspection by the Engineer.
- B. Functional Testing:
 - 1. Witnessed.
 - 2. Notify the Engineer and the AHJ in writing a minimum of 2 weeks before the scheduled day for the field acceptance tests.
 - 3. Furnish the services of a field service engineer, and any special tools, equipment and labor to perform the tests.
 - 4. Each device and control function shall be individually witness tested and recorded:
 - a. Acceptance tests shall be witnessed by and signed off by the Engineer, the FASS's field engineer, the installing Subcontractor, and a representative of the AHJ.
 - 5. Furnish test reports and the Manufacturer's Certificate of Functional Compliance.

3.05 OWNER TRAINING

- A. Perform Owner Training as specified in Section 01_75_17 - Commissioning.

END OF SECTION

SECTION 31_00_00

EARTHWORK

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Loosening, excavating, filling, grading, borrow, hauling, preparing subgrade, compacting in final location, wetting and drying, and operations pertaining to Site grading for buildings, basins, reservoirs, boxes, roads, and other facilities.
 - 2. Backfilling and compacting under and around structures.

1.02 REFERENCES

- A. American Association of State Highway and Transportation Officials (AASHTO):
 - 1. Standard Specifications for Highway Bridges.
- B. ASTM International (ASTM):
 - 1. D698 - Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft³).
 - 2. D6938 - Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth).

1.03 TERMINOLOGY

- A. The words and terms listed below are not defined terms that require initial capital letters, but, when used in this Section, have the indicated meaning.
 - 1. Backfill adjacent to structure: Backfill within volume bounded by the exterior surfaces of structure, the surface of undisturbed soil in the excavation around structure, and finish grade around structure.
 - 2. Embankments: Dikes, levees, berms, and similar facilities.
 - 3. Excavation: Consists of loosening, removing, loading, transporting, depositing, and compacting in final location, wet and dry materials, necessary to be removed for purposes of construction of structures, ditches, grading, roads, and such other purposes as are indicated on the Drawings.

1.04 SUBMITTALS

- A. Copy of Property Owner's Agreement allowing placement of surplus soil material on their property.
- B. Excavation plan:
 - 1. Describe/show planned conformance with excavation limits, dimensions, depths, and other constraints put forth in the Contract documents and/or Geotechnical report(s).
 - 2. Describe/show proposed shoring and excavation methods.
 - 3. Describe/show how excavation process will be sequenced and coordinated.

4. If confined site, describe/show how access will be maintained to necessary areas during excavation process.
 5. Describe/show proposed equipment and location of equipment placement, if critical to excavation stability.
- C. Testing lab: Submit Contractor's proposed testing laboratory capabilities and equipment.
- D. Test reports:
1. Submit certified test reports of tests specified to be performed by the Contractor.
 2. Sign and seal test reports by a registered Civil Engineer who practices geotechnical engineering registered in Colorado.

1.05 QUALITY CONTROL

- A. Initial compaction demonstration:
1. Adequacy of compaction equipment and procedures: Demonstrate adequacy of compaction equipment and procedures before exceeding any of following amounts of earthwork quantities:
 - a. 50 cubic yards of backfill adjacent to structures.
 - b. 100 cubic yards of embankment work.
 - c. 100 cubic yards of fill.
 - d. 50 cubic yards of roadway base material.
 - e. 100 cubic yards of road fill.
 2. Compaction sequence requirements: Until specified degree of compaction on previously specified amounts of earthwork is achieved, do not perform additional earthwork of the same kind.
 3. After satisfactory conclusion of initial compaction demonstration and at any time during construction, provide confirmation tests as specified under "FIELD QUALITY CONTROL".
- B. Contractor shall perform work related to this Section in accordance with the approved Stormwater Pollution Prevention Plan (SWPPP).

1.06 SEQUENCING AND SCHEDULING

- A. Schedule earthwork operations to meet requirements specified in this Section for excavation and uses of excavated material.
- B. If necessary, stockpile excavated material in order to use it at specified locations.
- C. Excavation, backfilling, and filling: Perform excavation, backfilling, and filling during construction in manner and sequence that provides drainage at all times.

PART 2 PRODUCTS

2.01 DESIGN AND PERFORMANCE CRITERIA

- A. Performance requirements:
 - 1. Where mud or other soft or unstable material is encountered, remove such material and refill space with stabilization material. Wrap stabilization material with stabilization fabric.
 - 2. Obtain acceptable import material from other sources if surplus obtained within Project site does not conform to specified requirements or are not sufficient in quantity.
 - 3. No extra compensation will be made for hauling of fill materials nor for water required for compaction.

2.02 MATERIALS

- A. Water for compacting: Use water from source acceptable to the Engineer.
- B. Soil and rock materials:
 - 1. General:
 - a. Provide materials referenced in Specification Section 31_05_15 - Soils and Aggregates for Earthwork where specified or indicated on the Drawings.
 - b. If suitable surplus materials are available, obtain native material and select fill material from cut sections or excavations or imported materials.
 - 2. Aggregate base course materials: As specified in Section 31_05_15 - Soils.
 - 3. Class 1 structural fill materials: As specified in Section 31_05_15 - Soils.
 - 4. Native material: As specified in Section 31_05_15 - Soils and Aggregates for Earthwork.
 - 5. Stabilization material: As specified in Section 31_05_15 - Soils and Aggregates for Earthwork.
- C. Controlled low-strength material: As specified in Section 31_23_24 - Controlled Low Strength Materials (CLSM).
- D. Geotextile fabrics:
 - 1. Stabilization fabric: As specified in Section 31_32_18.04 - Stabilization Fabric.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Verification of conditions:
 - 1. Character and quantity of material:
 - a. Verify character and quantity of rock, gravel, sand, silt, water, and other inorganic or organic materials to be encountered in Work to be performed.
 - b. Determine gradation, shrinkage, and swelling of soil, and suitability of material for use intended in Work to be performed.

- c. Determine quantity of material, and cost thereof, required for construction of backfills, cuts, embankments, excavations, fills, and roadway fills, whether from on-site excavations or imported materials. Include in cost of Work to be performed.
- d. Include wasting of excess material, if required, in the cost of Work to be performed.

3.02 PREPARATION

A. Backfills:

- 1. After clearing and excavation are completed, scarify entire areas that underlie backfills or structures to a depth of 6 inches and until surface is free of ruts, hummocks, and other features that would prevent uniform compaction by equipment to be used.
- 2. Recompect scarified areas to density specified before placing backfill material or concrete.
- 3. Do not place backfill against walls until:
 - a. Walls have been cast full height of structure and concrete has reached the specified strength.
 - b. Connecting slabs and beams have been cast, and concrete has reached the specified strength.
- 4. Prior to backfilling:
 - a. Remove forms.
 - b. Clean trash and debris from the excavation site.
- 5. After inspection of foundation, walls, and pipes, place backfill symmetrically around structures to prevent eccentric loading of structures.

B. Embankments:

- 1. After clearing is completed, scarify entire areas that underlie embankments to a depth of 6 inches and until surface is free of ruts, hummocks, and other features that would prevent uniform compaction by equipment to be used.
- 2. Recompect scarified areas to density specified for embankments before placing of embankment material.

C. Fills:

- 1. After clearing is completed, scarify entire areas that underlie fill sections or structures to a depth of 6 inches and until surface is free of ruts, hummocks, and other features that would prevent uniform compaction by equipment to be used.
- 2. Recompect scarified areas to density specified for compacted fills before placing of fill material or concrete.

D. Sloped surfaces for fill or foundations:

- 1. Foundations for fill having slopes in excess of 1 vertical to 4 horizontal:
 - a. Bench or terrace to adequately key existing ground and fill built thereon.
- 2. Slopes of original hillsides and old fills: Bench minimum of 10 feet horizontally as fill is placed.
- 3. Provision of new benches:
 - a. Start new bench wherever vertical cut of next lower bench intersects existing grade.
 - b. Recompect material thus cut out along with new embankment material at no additional cost to the Owner.

3.03 INSTALLATION

A. General:

1. Dispose of excavated materials that are not required or are unsuitable for fill and backfill in lawful manner.
2. Dispose of surplus material on private property only when written permission agreement is furnished by the owner of the property. Submit copies of such agreements.
3. Rocks, broken concrete, or other solid materials larger than 4 inches in greatest dimension: Remove from the Project Site at no additional cost to the Owner.
4. Stabilization of subgrade: Provide materials used, or perform Work required, to stabilize subgrade so it can withstand loads that may be placed upon it by the Contractor's equipment.

B. Offsite soil disposal:

1. Additional fill within the project site that is different than finished grade shown on drawings is not allowed. Contractor shall acquire offsite soil disposal locations at the Contractor's expense.

C. Borrow area: There is no borrow area on the Project Site.

1. Where material is required, import material from source located off Project Site selected by the Contractor and subject to acceptance by the Engineer.
2. There will be no additional cost to the Owner for use of imported material.

D. Compaction:

1. Provide specified compaction for backfills, cuts, embankments, fills, roadway fills, and other earthwork.
2. Perform confirmation tests to verify and confirm that work has complied, and is complying at all times, with compaction requirements specified in this Section for initial compaction demonstration and field quality control testing.
3. In-place density of compacted backfills, cuts, embankments, fills, and roadway fills determined in accordance with ASTM D1556, or with ASTM D6938.
4. Maximum density, laboratory compaction for: Soil maximum density and optimum water content when tested in accordance with ASTM D698.
5. To prevent damage to structures due to backfilling operations, place backfill with equipment that does not exceed AASHTO Standard Specifications for Highway Bridges, H-20 vehicle loading, within a distance from the face of the structure of not less than 1/2 the depth of backfill. The depth of backfill is the distance between the level being compacted and the bottom of the excavation. Outside this distance, heavier compaction equipment may be used.
6. Compact to percentage of maximum density as follows:
 - a. Backfill adjacent to structures: 95 percent.
 - b. Backfilling voids: 95 percent.
 - c. Other areas: 90 percent.
 - d. Under present and future structures: 95 percent.
 - e. Under roadways, parking and storage areas, curbs, and sidewalks: 95 percent.
 - f. Upper 6 inches of cuts: 95 percent.
 - g. Fills: 95 percent.
 - h. Topsoil: 70 percent.

- E. Dewatering: As specified in Section 31_23_19 - Dewatering.
- F. Excavation:
1. Blasting: Not permitted.
 2. Excavations for trenching: As specified in Section 31_23_35 - Trenching.
 3. Excavations for structures:
 - a. Provide excavations conforming to dimensions and elevations indicated on the Drawings for each structure.
 - b. After clearing is complete, excavate for the structure, down to the elevation indicated on the Drawings. Unless directed by Construction Manager, do not carry excavations below elevation indicated on the Drawings.
 - c. Where soil is encountered having unsuitable bearing value, Construction Manager may direct in writing that excavation be carried to elevations below those indicated on the Drawings.
 - d. Where excavations are made below elevations indicated on the Drawings, adjust elevations of excavations in accordance with the following requirements:
 - 1) Under slabs: Restore to proper elevation in accordance with procedure specified for backfill in this Section.
 - 2) Under footings: Restore to the proper elevation using one of the following:
 - a) Aggregate base course.
 - b) Controlled low-strength material.
 - e. Excavation width:
 - 1) Extend excavations at least 2 feet clear from walls and foundations of structures to allow for placing and removal of forms, installation of services, and inspection.
 - 2) Do not undercut slopes.
 - f. Difficulty of excavation: No extra compensation will be made for removal of rock or any other material due to difficulty of excavation.
 4. Excavation of unlined channels and basins:
 - a. Excavate to lines and grades indicated on the Drawings.
 - b. Perform excavation and grading so that finish surfaces are in uniform planes with no abrupt breaks in surface.
 5. Excavation of ditches and gutters:
 - a. Cut ditches and gutters accurately to cross sections and grades indicated on the Drawings.
 - b. Take care not to excavate ditches and gutters below grades indicated on the Drawings.
 - c. Backfill excessive ditch and gutter excavations to grade with suitable material acceptable to the Construction Manager.
 - d. Do not deposit any material within 3 feet of edge of ditch unless otherwise indicated on the Drawings.
 6. Necessary over excavation:
 - a. Where it becomes necessary to excavate beyond normal lines of excavation in order to remove boulders or other interfering objects, backfill voids remaining after removal as specified in backfilling of voids below, or as acceptable to the Construction Manager.

- b. Backfill voids with material acceptable to the Construction Manager:
 - 1) With acceptance of the Construction Manager, backfill with one of the following:
 - a) Aggregate base course.
 - b) Controlled low-strength material.
- G. Materials for backfills, embankments, fills, and roadway fills:
 - 1. General:
 - a. Obtain import material from other sources if surplus materials from cuts and excavations obtained from within Project site do not conform to specified requirements or are not sufficient in quantity for construction of Project. Imported soils must be certified as clean.
 - 2. Backfills:
 - a. Backfill around structures shall not overlap with trench backfill. Where there is overlap in extents of backfill, the more stringent material requirement shall govern.
 - b. Backfill adjacent to structures, slabs, or walls: Class 1 structural fill, unless otherwise specified or indicated on the Drawings.
 - c. Backfill material under concrete structures: Class 1 structural fill, except in areas where controlled low-strength material or concrete encasement are indicated on the Drawings.
 - d. Extend backfill in any area under concrete structures from undisturbed soil or rock to the bottom of topsoil or road base material layer.
 - 3. Embankments:
 - a. Native material or imported material meeting the requirements of native material, unless otherwise specified or indicated on the Drawings.
 - 4. Fills:
 - a. Native material or imported material meeting the requirements of native material, unless otherwise specified or indicated on the Drawings.
 - b. Native material may be used for backfill in areas outside of structure or trench backfill areas.
- H. Placement:
 - 1. General:
 - a. Lines and grades:
 - 1) Construct backfills, embankments, fills, and road fills, at locations and to lines and grades indicated on the Drawings.
 - 2) Overbuild permanent fill slopes by at least 1 foot and then cut to final grade to provide adequate compaction of the remaining fill.
 - 2. Backfills:
 - a. Place loose material in successive layers that do not exceed 8 inches in depth after compaction.
 - b. Native material:
 - 1) Bring each layer to a moisture content between 1 percent below optimum moisture content and 3 percent above optimum moisture content before compacting.
 - c. Class 1 structural fill:
 - 1) Bring each layer to a moisture content between 2 percent below optimum moisture content and 2 percent above optimum moisture content before compacting.
 - d. Defective compacted backfills: Remove and recompact.

3. Fills:
 - a. Place loose material in successive layers that do not exceed 8 inches in depth after compaction.
 - b. Native material:
 - 1) Bring each layer to a moisture content between 1 percent below optimum moisture content and 3 percent above optimum moisture content before compacting.
 - c. Class 1 structural fill:
 - 1) Bring each layer to a moisture content between 2 percent below optimum moisture content and 2 percent above optimum moisture content before compacting.
 - d. Defective compacted fills: Remove and recompact.
4. Embankments:
 - a. Place loose material in successive layers that do not exceed 8 inches in depth after compaction.
 - b. Native material:
 - 1) Bring each layer to a moisture content between 1 percent below optimum moisture content and 3 percent above optimum moisture content before compacting.
 - c. Class 1 structural fill:
 - 1) Bring each layer to a moisture content between 2 percent below optimum moisture content and 2 percent above optimum moisture content before compacting.
 - d. Defective compacted embankments: Remove and recompact.

3.04 FIELD QUALITY CONTROL

- A. Tests:
 1. Quality control confirmation tests:
 - a. Confirmation tests:
 - 1) Contractor's responsibilities:
 - a) Adequacy of compaction equipment and procedures:
 - (1) Demonstrate adequacy of compaction equipment and procedures.
 - (2) At each test location include tests for each type or class of backfill from bedding to finish grade.
 - b) Compaction sequence requirements:
 - (1) Do not perform additional earthwork of the same kind until specified degree of compaction has been demonstrated.
 - c) Cost of confirmation tests: Paid for by the Contractor.
 - d) Qualifications of Contractor's testing laboratory: Acceptable to Engineer.
 - e) Copies of confirmation test reports: Submit promptly to the Engineer.
 - b. Frequency of confirmation tests:
 - 1) In-place density testing:
 - a) Backfill: Minimum of 1 test per 900 square feet (or fraction thereof) per lift.

- b) Fill material maximum dry density versus moisture relationship testing:
 - (1) For each fill material, minimum of 1 test at intervals not greater than the least of the following:
 - (a) Every 90 days;
 - (b) Every 5000 cubic yard placed; or
 - (c) Whenever the type of characteristics of the material change.
 - 2. Compliance tests:
 - a. Periodic compliance tests will be made by the City of Thornton to verify that compaction is meeting requirements previously specified.
 - b. Remove overburden above level at which the City of Thornton wishes to test. Backfill and recompact excavation after testing is completed.
 - c. If compaction fails to meet specified requirements, perform remedial work by one of the following methods:
 - 1) Remove and replace materials at proper density.
 - 2) Bring density up to specified level by other means acceptable to the Construction Manager.
 - d. Retesting:
 - 1) Contractor bears the costs of retesting required to confirm and verify that remedial work has brought compaction within specified requirements.
 - 2) Contractor's confirmation tests during performance of remedial work: Double the normal rate specified.
- B. Tolerances:
 - 1. Finish grading of backfills, cuts, embankments, fills, and roadway fills:
 - a. Perform fine grading under concrete structures such that finish surfaces are never above the grade or cross section indicated on the Drawings and are never more than 0.10 feet below.
 - b. Provide finish surface for areas outside of structures that are within 0.10 feet of grade or cross section indicated on the Drawings.
 - 2. Unlined channels and basins:
 - a. In both cut and fill, and levee and access road side slopes in cut: Vertical tolerance of none above and 3 inches below grade indicated on the Drawings on bottom and side slopes.
 - b. On top surface of levee and access road in both cut and fill, and levee and access road side slopes in fill: Vertical tolerance of none below and 3 inches above grade indicated on the Drawings.
 - 3. Areas which are not under structures, concrete, asphalt, roads, pavements, sidewalks, dikes, and similar facilities:
 - a. Provide finish graded surfaces of either undisturbed soil, or cohesive material not less than 6 inches deep.
 - b. Intent of proceeding is to avoid sandy or gravelly areas.
 - 4. Finish grading of surfaces:
 - a. Reasonably smooth, compacted, and free from irregular surface changes.
 - b. Provide degree of finish that is ordinarily obtainable from blade grader operations, except as otherwise specified.
 - c. Uniformly grade areas that are not under concrete.
 - d. Finish ditches and gutters so that they drain readily.

3.05 ADJUSTING

- A. Finish grades of excavations, backfills, and fills:
 - 1. Repair and reestablish grades to required elevations and slopes due to any settlement or erosion that may occur from action of the elements or any other cause prior to final acceptance.

3.06 PROTECTION

- A. Finish grades of backfills, cuts, excavations, and fills:
 - 1. Protect newly graded areas from erosion and deterioration by action of the elements.
- B. Ditches and gutters:
 - 1. Maintain ditches and gutters free from detrimental quantities of debris that might inhibit drainage until final acceptance.

END OF SECTION

SECTION 31_05_15

SOILS AND AGGREGATES FOR EARTHWORK

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Material requirements for soils and aggregates.

1.02 REFERENCES

- A. ASTM International (ASTM):
 - 1. C117 - Standard Test Method for Materials Finer than 75- μ m (No. 200) Sieve in Mineral Aggregates by Washing.
 - 2. C131 - Standard Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine.
 - 3. C136 - Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates.
 - 4. D2419 - Standard Test Method for Sand Equivalent Value of Soils and Fine Aggregate.
 - 5. D2844 - Standard Test Method for Resistance R-Value and Expansion Pressure of Compacted Soils.
 - 6. D4318 - Standard Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils.
 - 7. D4829 - Standard Test Method for Expansion Index of Soils.
 - 8. D5821 - Standard Test Method for Determining the Percentage of Fractured Particles in Coarse Aggregate.
- B. Colorado Department of Transportation (CDOT):
 - 1. Standard Specifications for Road and Bridge Construction (Standard Specifications).

1.03 SUBMITTALS

- A. Product data:
 - 1. Material source.
 - 2. Gradation.
 - 3. Testing data.
- B. Quality control for aggregate base course:
 - 1. Test reports: As required by Sections of Standard Specifications.
 - 2. Certificates of compliance: As required by Sections of Standard Specifications.

1.04 DELIVERY, STORAGE, AND HANDLING

- A. Storage and protection: Protect from segregation and excessive moisture during delivery, storage, and handling.
- B. Comply with Standard Specifications storage requirements, if applicable.

PART 2 PRODUCTS

2.01 MATERIALS - GENERAL

- A. Provide material having maximum particle size not exceeding 4 inches and that is free of trash, lumber, debris, leaves, grass, roots, stumps, and other organic matter.
- B. Comply with soil and aggregate material requirements in the Standard Specifications, unless specified otherwise.

2.02 NATIVE MATERIAL

- A. Native soil-select:
 - 1. Processed native material is acceptable under the following conditions:
 - a. Lean clay consisting of a minimum fines content of 50 percent and a minimum plasticity index of 8.
 - b. Processing onsite materials shall include removing expansive materials, frozen chunks, wood, trash, organic material, and cobbles and boulders larger than 3 inches in any dimension. Bedrock of any type shall be removed.

2.03 GRANULAR BEDDING MATERIAL

- A. Clean, coarse, granular squeegee material conforming to size and grade within the limits as follows when tested in accordance with ASTM C117 and C136.

Well-Graded Sand	
Sieve Size (Square Openings)	Percent By Weight Passing Sieve
3/4-inch	100
Number 200	Less than 5

2.04 AGGREGATE BASE COURSE

- A. Consist of hard, durable particles or fragments of stone or gravel, screened or crushed to required size and grading and free from vegetable matter, lumps or balls of clay, alkali, adobe, or other deleterious matter.
- B. Materials derived from crushed reclaimed concrete or asphalt:
 - 1. Shall not be used for aggregate base course under structures or around pipes.
 - 2. May be used as base course under asphaltic concrete or concrete paving when accepted by the Construction Manager.

- C. Conform to CDOT Standard Specifications, "Class 6 Aggregate Base Course" (CDOT Section 703.03). Gradation as shown in the following table, and liquid limit of 30 or less.

Sieve Size (Square Openings)	Percent By Weight Passing Sieve
3/4-inch	100
No. 4	30 - 65
No. 8	25 - 55
No. 200	3 - 12

2.05 CDOT CLASS 1 STRUCTURAL FILL

- A. A plasticity index less than 6.
- B. A liquid limit less than 35.
- C. Conform to CDOT Standard Specifications, "Class 1 Structural Backfill" (CDOT Section 703.08). Gradation as shown in the following table.

Sieve Size (Square Openings)	Percent By Weight Passing Sieve
2-inch	100
No. 4	30 - 100
No. 50	10 - 60
No. 200	5 - 20

2.06 STABILIZATION MATERIAL

- A. Consists of clean, hard, durable particles of crushed rock or gravel; screened or crushed to the specified sizes and gradations; and free of any detrimental quantity of soft, friable, thin, elongated, or laminated pieces, disintegrated material, organic matter, oil, alkali, or other deleterious substance.
- B. Shall be free of slaking or decomposition under the action of alternate wetting and drying.
- C. The portion of material retained on the 3/8-inch sieve shall contain at least 50 percent of particles having 3 or more fractured faces. Not over 5 percent shall be pieces that show no such faces resulting from crushing. Of that portion which passes the 3/8-inch sieve but is retained on the Number 4 sieve, not more than 10 percent shall be pieces that show no faces resulting from crushing.

- D. Conforms to size and grade when tested in accordance with ASTM C117 and ASTM C136.

Sieve Size (Square Openings)	Percent by Weight Passing Sieve
2 1/2-inch	100
2-inch	95-100
Number 4	30-60
Number 200	5-15
Liquid Limit	35 (Max)
Plasticity Index	6 (Max)

- E. Provide stabilization fabric as specified in Section 31_32_18.04 - Stabilization Fabric.

2.07 RECYCLED ASPHALT PAVEMENT (RAP)

- A. Material from millings of asphalt pavement is acceptable under the following conditions:
1. The millings do not contain soil.
 2. The millings have a maximum size of 1.5 inches.

2.08 1-1/2-INCH LANDSCAPE ROCK

- A. Provide 1-1/2-inch washed landscape rock.

PART 3 EXECUTION (NOT USED)

END OF SECTION

SECTION 31_10_00

SITE CLEARING

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Clearing, grubbing, and stripping project site.

1.02 DEFINITIONS

- A. Clearing: Consists of removal of natural obstructions and existing foundations, buildings, fences, lumber, walls, stumps, brush, weeds, rubbish, trees, boulders, utility lines, and any other items which interfere with construction operations or are designated for removal.
- B. Grubbing: Consists of the removal and disposal of wood or root matter below the ground surface remaining after clearing and includes stumps, trunks, roots, or root systems greater than 1 inch in diameter or thickness to a depth of 6 inches below the ground surface.
- C. Stripping: Includes the removal and disposal of all organic sod, topsoil, grass and grass roots, and other objectionable material remaining after clearing and grubbing from the areas designated to be stripped. The depth of stripping is estimated to be 8 to 10 inches, but the required depth of stripping will be determined by the Construction Manager.

1.03 QUALITY ASSURANCE

- A. Regulatory requirements: Verify and comply with applicable regulations regarding those governing noise, dust, nuisance, drainage and runoff, fire protection, and disposal.
- B. Pre-construction conference: Meet with Engineer to discuss order and method of work.

1.04 SEQUENCING AND SCHEDULING

- A. Clearing and grubbing: Perform clearing and grubbing in advance of grading operations.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION

- A. Verification of conditions: Examine site and verify existing conditions for beginning work.

3.02 PREPARATION

- A. Protect existing improvements from damage by site preparation work.
- B. See Section 32_92_19 - Seeding for additional clearing and grubbing requirements.

3.03 INSTALLATION

- A. Clearing:
 - 1. Clear areas where construction is to be performed and other areas as indicated on the Drawings, or specified in this Section, of fences, lumber, walls, stumps, brush, roots, weeds, trees, shrubs, rubbish, and other objectionable material of any kind which, if left in place, would interfere with proper performance or completion of the work, would impair its subsequent use, or form obstructions.
 - 2. Do not incorporate organic material from clearing and grubbing operations in fills and backfills.
 - 3. Contractor's temporary construction facilities: Fill or remove pits, fill, and other earthwork required for erection of facilities, upon completion of the work, and level to meet existing contours of adjacent ground.
- B. Grubbing:
 - 1. From excavated areas: Grub stumps, roots, and other obstructions 3 inches or over in diameter to depth of not less than 18 inches below finish grade.
 - 2. In embankment areas or other areas to be cleared outside construction area: Do not leave stumps, roots, and other obstructions higher than the following requirements:

Height of Embankment over Stump	Depth of Clearing and Grubbing
0 feet to 2 feet	Grub stumps or roots 3 inches or over in diameter to 18 inches below original grade. Cut others flush with ground.
2 feet to 3 feet	Grub stumps 1 foot and over in diameter to 18 inches below original grade. Cut others flush with ground.
Over 3 feet	Leave no stumps higher than stump top diameter, and in no case more than 18 inches.

- 3. Backfill and compact cavities left below subgrade elevation by removal of stumps or roots to density of adjacent undisturbed soil.

- C. Stripping:
1. Remove soil material containing sod, grass, or other vegetation to depth of 8 to 10 inches from areas to receive fill or pavement and from area within 5 feet outside foundation walls.
 2. Deposit stripped material in accordance with following requirements:
 - a. Topsoil to be stockpiled separately from other materials.
 - b. Wetland topsoil to be stockpiled separately from other topsoil.
 - c. At locations acceptable to Construction Manager.
 - d. Use accepted material in top 8 to 10 inches of areas to be used for future planting.
 3. Replace topsoil where reseeding is indicated on the Drawings.

END OF SECTION

SECTION 31_23_18

ROCK REMOVAL

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes: Removal of rock during excavation and trenching by mechanical methods.

1.02 REFERENCES

- A. Associated General Contractors (AGS):
 - 1. Manual of Accident Prevention for Construction.
- B. Institute of Makers of Explosives (IME):
 - 1. Safety Library Publications.
- C. Occupational Safety and Health Administration (OSHA).

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 INSPECTION

- A. Verify site conditions and note irregularities affecting work. Beginning work as specified in Section means acceptance of existing condition.
- B. Determine best method of rock removal.

3.02 ROCK REMOVAL BY MECHANICAL METHOD

- A. Excavate for and remove rock by mechanical methods.
- B. Cut away rock at excavation bottom to form level bearing.
- C. Remove shaled layers to provide sound and unshattered base for foundations.
- D. In utility trenches, excavate to 6 inches below invert elevation of pipe and 24 inches wider than pipe diameter. At dedicated easements or rights of way, excavate 18 inches wider than pipe diameter.

- E. Remove excavated material unsuitable for fill or backfill from site.
- F. Correct unauthorized rock removal in accordance with backfilling and compaction requirements as specified in Section 31_00_00 - Earthwork, 31_23_35 - Trenching, and as otherwise required.

3.03 FIELD QUALITY CONTROL

- A. Visual inspection of bearing surfaces and cavities formed by removed rock.

3.04 ADJUSTING

- A. Correct unauthorized rock removal or overbreak in accordance with backfilling and compaction requirements as specified in Section 31_00_00 - Earthwork.

END OF SECTION

SECTION 31_23_19

DEWATERING

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Installation and maintenance of dewatering systems.
 - 2. Disposal of water entering excavation or other parts of the work.

1.02 REFERENCES

- A. National Electrical Manufacturers Association (NEMA):
 - 1. 250 - Enclosures for Electrical Equipment (1,000 V Maximum).

1.03 SUBMITTALS

- A. Dewatering plan:
 - 1. Dewatering design analysis.
 - 2. Required permits.
 - 3. Arrangement, location, and depths of dewatering system components.
 - 4. Type and sizes of filters.
 - 5. Identify proposed alignment, support, and protection for discharge pipe. Identify location of discharge and provide details for that location. Well construction logs. Include:
 - a. Descriptions of actual materials encountered, categorized in accordance with Unified Soil Classification System.
 - b. Construction details.
 - c. Well development procedures and results.
 - d. Deviations from original design.
- B. Flowmeter:
 - 1. Product information on flowmeter and chart recorder.
 - 2. Recent flowmeter calibration documentation.
 - 3. Chart(s) from flowmeter chart recorder.
- C. Qualifications:
 - 1. Dewatering contractor.
 - 2. Dewatering design engineer.
 - 3. Testing laboratory.

1.04 QUALITY ASSURANCE

- A. Dewatering plan and dewatering system analysis:
 - 1. Prepared by a qualified Civil Engineer, licensed in the state where the Project is located.
 - a. The dewatering design engineer shall have at least 8 years of experience in designing similar systems.
- B. Dewatering Contractor shall have at least 8 years of experience in installing similar systems.
- C. Testing laboratory shall meet discharge permit testing laboratory qualifications.
- D. Regulatory requirements:
 - 1. Obtain required water discharge permits.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Flowmeter and chart recorder: The following or equal:
 - 1. Badger Turbo Series Meter with totalizer.

2.02 DESIGN AND PERFORMANCE CRITERIA

- A. Design requirements:
 - 1. Keep excavations reasonably free from water. Draw down static groundwater level to minimum of 3 feet below anticipated bottom of excavations before the excavation reaches bottom elevation.
 - 2. Dewatering design analysis. Include the following:
 - a. Evaluation of anticipated subsurface conditions.
 - b. Required well spacing.
 - c. Diameter of wells.
 - d. Depth to screen, screen height, and mesh size.
 - e. Backfill and filter pack.
 - f. Pump size.
 - g. Drawdown duration.
 - h. Drawdown and steady state flow rates.
 - i. Plans for de-silting of groundwater before discharge.
 - j. Anticipated area influenced by dewatering system and potential impacts to adjacent structures, existing and proposed. Mitigation measures needed to prevent any expected settlements. Contingency plan for restoring nearby structures if settlement is observed as result of dewatering operations.
 - k. Expected settlements.
 - 3. Include water drawdown curves in dewatering calculations.
 - 4. Coordinate dewatering design with excavation and shoring design. Excavation and shoring design shall consider changes in groundwater conditions and associated earth pressures.

5. Do not place concrete or masonry foundations or concrete slabs in water. Do not allow water to rise over these elements until concrete or mortar has set for at least 24 hours.
 6. Maintain operation of dewatering system until complete structure -- including walls, slabs, beams, struts, and other structural elements -- has been constructed; concrete has attained its specified compressive strength; and backfill has been completed to finished grade.
 7. Provide standby power to ensure continuous dewatering in case of power failure.
- B. Dewatering shored excavations:
1. Dewater from within shoring.
 2. Use impermeable shoring system to minimize lowering of groundwater outside shoring.
 3. Extend impermeable shoring below bottom of excavation sufficient amount to:
 - a. Minimize lowering of groundwater outside shoring.
 - b. Prevent unstable excavation due to piping and heave.
 4. To minimize settlement outside shoring due to dewatering, do not lower groundwater outside shoring more than 1 foot. Provide groundwater recharge if required to maintain this groundwater elevation outside of shoring.
 5. Provide monitoring wells located outside shoring for monitoring groundwater elevation.
- C. Obtain written permission from Engineer before locating wells, well points, or drain lines for dewatering within the limits of a structure's foundation.
- D. Locate dewatering facilities where they will not interfere with utilities and construction work to be performed by others.

PART 3 EXECUTION

3.01 INSTALLATION

- A. The responsibility for conducting the dewatering operation in a manner which will protect adjacent structures and facilities rests solely with Contractor.
- B. During construction, provide and maintain ample means and devices to promptly remove and properly dispose of water entering excavation or other parts of the work, whether water is surface water or underground water.
- C. Keep excavations reasonably free of water.
- D. Make provisions to maintain continuous dewatering:
1. Provide standby power to maintain dewatering during power outages and interruptions.
 2. Provide 24-hour monitoring by personnel skilled in operation and maintenance of the system, and capable of providing or obtaining work required to maintain system operation.

- E. Intercept and divert precipitation and surface water away from excavations. Use dikes, curb walls, ditches, pipes, sumps, or other means acceptable to Engineer.
- F. Disposal of water:
 - 1. Dispose of water from the work in suitable manner without damage to adjacent property.
 - 2. Do not drain water into work built or under construction.
 - 3. Properly dispose of discharge water in accordance with Federal, State, and local requirements and permits and in such manner that it will not be a menace to public health or safety.
 - 4. For discharge of water into holding tanks or infiltration ponds, include a means of overflow protection that is acceptable to Engineer.
- G. Wells, well points, and drain lines for dewatering:
 - 1. Provide after receiving Engineer's written acceptance.
 - 2. Fill dewatering wells, pipes, and French drains to be left in place within structure foundation limits with Class "C" concrete as specified in Section 03_30_00 - Cast-in-Place Concrete or grout as specified in Section 03_60_00 - Grouting.

3.02 CONSTRUCTION

- A. Prior to release of groundwater to its static level: Confirm that:
 - 1. All groundwater pressure relief devices for structure are fully operational.
 - 2. Construction of structure is complete and concrete has reached its specified compressive strength.
 - 3. Backfill of structure is complete.
- B. Control release of groundwater to its static level to prevent disturbance of natural foundation soils or compacted backfills and fills and to prevent flotation or movement of structures, pipelines, or other facilities.

3.03 FIELD QUALITY CONTROL

- A. Flowmeter and chart recorder:
 - 1. Provide flowmeter and continuous 24-hour chart recorder for recording dewatering flow.
 - 1. Maintain meter recorder and provide continuous reading charts with minimum capacity of 24 hours each.
 - 2. Calibrate flowmeter and recorder device to provide accuracy within 5 percent.
 - 3. Submit written evidence of calibration of meter and recorder signed by a Professional Engineer registered in the state where Project is located.
 - 4. Portable recorder (bench mount), dual scale, and mounted in NEMA Type 4X enclosure with transparent plastic door and latch. Operate unit off 115-volts, 60-Hertz power supply.
 - 5. Submit readings to the Engineer on a weekly basis.

END OF SECTION

SECTION 31_23_24

CONTROLLED LOW STRENGTH MATERIAL (CLSM)

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes: Controlled low strength material (CLSM), also known as "flowable fill".
- B. CLSM shall be per CDOT standard for removable flow fill.

1.02 REFERENCES

- A. American Concrete Institute (ACI):
 - 1. 229R - Report on Controlled Low-Strength Materials.
 - 2. 301 - Specifications for Structural Concrete.
- B. ASTM International (ASTM):
 - 1. C94 - Standard Specification for Ready Mix Concrete.
 - 2. C143 - Standard Test Method for Slump of Hydraulic Cement Concrete.
 - 3. C150 - Standard Specification for Portland Cement.
 - 4. C260 - Standard Specification for Air-Entraining Admixtures for Concrete.
 - 5. C494 - Standard Specification for Chemical Admixtures for Concrete.
 - 6. C618 - Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete.
 - 7. D1557 - Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft³(2,700 kN-m/m³)).
 - 8. D4832 - Standard Test Method of Preparation and Testing of Controlled Low Strength Material (CLSM) Test Cylinders.
 - 9. D5971 - Standard Practice for Sampling Freshly Mixed Controlled Low Strength Material.
 - 10. D6023 - Standard Test Method for Density (Unit Weight), Yield, Cement Content, and Air Content (Gravimetric) of Controlled Low-Strength Material.
- C. Colorado Department of Transportation (CDOT): Standard Specifications Book.

1.03 SUBMITTALS

- A. Product data: Submit data completely describing materials in the mix and demonstrating compliance with the requirements of this Section.
 - 1. Cement: Mill tests. Indicate alkali content representative of each shipment.
 - 2. Fly ash: Identify source and type of fly ash.
 - 3. Water: Identify source and quality if not from a municipal treatment source.
 - 4. Admixtures: Manufacturer's product data indicating suitability for use in CLSM mixes and recommended dosage rates.

5. Aggregate:
 - a. Submit source, type, and sieve analyses. Resubmit at any time there is a significant change in grading of materials.
- B. Mix design:
 1. Submit full details, including mix design calculations for mix proposed for use.
 2. Trial batch test data:
 - a. Submit data for each test cylinder.
 - b. Submit data that identifies mix and slump for each test cylinder.

PART 2 PRODUCTS

2.01 DESIGN AND PERFORMANCE CRITERIA

- A. Mixture of portland cement, water, pozzolan, fine aggregate and admixtures, proportioned in accordance with CDOT Standard Specification Section 206.02(a)2 to produce a homogeneous mixture that is flowable, that will readily work into corners and angles; that will not segregate in the plastic state; and that is self-compacting at the time of placement without the use of mechanical vibration.
- B. Performance requirements:
 1. Compressive strength, measured in accordance with ASTM D4832 at 28 days: Not less than 50 pounds per square inch, nor greater than 150 pounds per square inch.
 2. Slump, measured in accordance with ASTM C143 at the point of placement: 7 to 10 inches, or a minimum flow consistency of 6 inches when tested in accordance with ASTM D6103 and that allows CLSM to flow freely and to be self-compacting during placement.
 3. Shall have a Removability Modulus (RM) of 1.5 or less.
 - a. Removability Modulus, RM, is calculated as follows:

$$RM = \frac{W^{1.5} \times 104 \times C^{0.5}}{10^6}$$

where: W = unit weight (pcf)

C = 28-day compressive strength (psi)

2.02 MATERIALS

- A. Fine Aggregate: Per CDOT Standard Specification Section 703.01.
- B. Coarse Aggregate: Per CDOT Standard Specification Section 703.02.
- C. Portland Cement: Per CDOT Standard Specification Section 701.01.
- D. Fly Ash: Per CDOT Standard Specification Section 701.02.
- E. Water: Per CDOT Standard Specification Section 712.01.

- F. Air-Entraining Admixture: Per CDOT Standard Specification Section 711.02.
- G. Chemical Admixtures: Per CDOT Standard Specification Section 711.03.

2.03 MIXES

- A. See System Description for performance requirements of the plastic and hardened mix.

PART 3 EXECUTION

3.01 MEASURING, BATCHING, MIXING AND TRANSPORTING

- A. All CLSM shall be mixed at the batch plant.
- B. Measure, batch, mix and transport CLSM in accordance with the requirements of ASTM C94 and this Section.
- C. After trial batch testing and mix acceptance at the batch plant, maintain slump during construction within plus or minus 1 inch of the design slump.

3.02 PREPARATION

- A. Do not place CLSM until preparation and condition of surfaces receiving the fill have been observed and accepted by the Construction Manager.
- B. Remove debris, foreign matter, and standing or running water from excavations and areas receiving CLSM before placement.

3.03 INSTALLATION

- A. Pipes and trenches.
 - 1. Install CLSM as indicated on the Drawings and specified.
 - 2. Where CLSM is placed around and over pipes, secure pipes in place, or place CLSM in lifts to prevent pipe flotation.
 - 3. Where CLSM is placed in long, open trenches, confine material using bulkheads of sandbags, earth dams, or stiffer concrete at open ends of placement.

3.04 PLACING

- A. Place controlled low strength material by method that preserves the quality of the material in terms of compressive strength and density.
- B. Maintain fluid properties of the mix during placement.
 - 1. At point of placement, provide material that flows easily around, beneath, or through walls, pipes, conduits, or other structures.
 - 2. Do not place CLSM that has partially hardened or that has been contaminated by foreign materials.
 - 3. Handle and place CLSM using methods that minimize segregation of the mix.

4. Deposit mix as near its final position as possible to avoid segregation due to rehandling or flowing.
 5. Contain and confine mix while it is fluid. Design containment structures and bracing at walls and forms to withstand lateral pressures of wet mix.
- C. Lifts:
1. Limit lift heights of CLSM placed against structures and other facilities that could be damaged due to the pressure from the CLSM, to the lesser of 3 feet or the lift height indicated on the Drawings.
 2. Do not place another lift of CLSM until the last lift of CLSM has set and gained sufficient strength to prevent additional lateral load against the forms or structure due to the weight of the next lift of CLSM.
- D. Water conditions:
1. Do not place CLSM in standing or flowing water.
 2. Do not permit water to flow over the surface of freshly placed or un-hardened CLSM.
 3. Do not submerge CLSM in water within 24 hours after placement.
- E. Manage CLSM bleed water.
1. Grade top surface of CLSM to drain away from the fill.
 2. Provide side containment that permits bleed water to drain to a contained management area away from the fill.

3.05 CURING AND PROTECTION

- A. Curing:
1. Prior to and during curing, install barriers to prevent equipment or personnel from falling into or becoming entrapped in CLSM.
- B. Protect CLSM from:
1. Damage from the elements.
 2. Damage of any nature during surrounding construction operations.
 3. Freezing: Do not use salt, manure, or other chemicals to provide protection from cold temperatures.

3.06 QUALITY CONTROL

- A. Provide quality control over the Work of this Section as specified in Section 01_45_17 - Contractor Quality Control Plan and as specified in this Section.
- B. General:
1. Construction Manager inspection and acceptance required prior to placement.
 2. Make provisions for and furnish all material for the test specimens.

3.07 FIELD QUALITY CONTROL

- A. Provide quality control over the work of this Section as specified in Section 01_45_17 - Contractor Quality Control Plan.

- B. Field inspections:
1. Construction Manager shall provide on-site inspection for the Work of this Section.
 2. Advise Construction Manager of readiness to proceed at least 24 hours prior to each placement of CLSM.
 3. Required inspections:
 - a. Construction Manager will observe the prepared areas. Do not place CLSM until Construction Manager has observed and accepted preparations.
 4. Record of inspections.
- C. Field sampling and testing:
1. During construction, Contractor shall provide sampling and testing to determine whether the CLSM, as produced and placed, complies with the requirements specified.
 - a. Make provisions for and furnish material for test specimens. Provide assistance in obtaining and preparing said specimens.
 2. Sample CLSM for testing in accordance with ASTM D5971.
 3. Required tests:
 - a. Air content: Prepare sample and test in accordance with ASTM D6023.
 - b. Compressive strength: Prepare and test cylinder specimens in accordance with ASTM D4832.
 - 1) Prepare 6-inch diameter by 12-inch high specimens for testing.
 - a) Provide one set of specimens for each 150 cubic yards of CLSM placed, but not less than 1 set for each half day's placement.
 - b) Prepare and test not less than 3 cylinders for each set.
 - c) Place CLSM in the molds in accordance with ASTM D4832. Do not rod or otherwise consolidate the material in the mold.
 - d) In accordance with ASTM D4832 recommendations for displacing bleed water at the top of the molds and refilling the molds before covering with a lid. Do not use air-tight lids.
 - 2) Place the cylinders in a safe location away from construction activities.
 - a) Protect cylinders from bumping and impact.
 - b) Maintain temperature surrounding cylinders between 60 and 80 degrees Fahrenheit until delivery to the laboratory for testing.
 - c) After the first day, surround molds with a high humidity environment by covering with wet burlap, or equivalent highly absorptive material. Maintain saturation of the cover. Do not sprinkle water directly on the cylinders.
 - 3) After 4 days, place the cylinders in a protective container for transport to the laboratory for testing.
 - a) Exercise caution in moving and transporting the cylinders since they are fragile and will withstand only minimal bumping, banging, or jolting without damage.
 - b) Transport container may be a box with a Styrofoam or similar lining that will limit jarring and bumping of the cylinders.
 - 4) Upon receipt at the testing laboratory, place test cylinders in a moist curing room until dates for testing.
 - 5) Do not remove test cylinders from molds until the day that cylinders are to be capped and tested.

- 6) Cap and test for compressive strength in accordance with ASTM D4832.
 - a) Do not perform initial compression test until the cylinders reach an age of at least 4 days.
 - b) Test 1 cylinder at 7 days and 2 at 28 days.
- 7) Compressive strength of the cylinders tested at 28 days shall be equal to or greater than the minimum required compression strength but shall not exceed maximum compression strength specified.

3.08 NON-CONFORMING WORK

- A. When testing or observation indicates CLSM with properties outside the specified and accepted range, Construction Manager will issue instructions regarding disposition of nonconforming materials.
- B. Construction Manager may:
 1. Reject CLSM represented by those test specimens and require its removal and replacement.
 2. Require modification of the mix design to provide CLSM with the properties specified.
- C. Make such modifications at no additional expense to the City of Thornton and with no adjustment to the schedule.

END OF SECTION

SECTION 31_23_35

TRENCHING

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Trench excavation and trench backfill for pipelines, manholes, vaults, and appurtenances.

1.02 REFERENCES

- A. ASTM International (ASTM):
 - 1. D1556 - Standard Test Method for Density and Unit Weight of Soil in Place by the Sand Cone Method.
 - 2. D1557 - Standard Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft³).
 - 3. D4254 - Standard Test Methods for Minimum Index Density and Unit Weight of Soils and Calculation of Relative Density.
 - 4. D6938 - Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth).

1.03 TERMINOLOGY

- A. The words and terms listed below are not defined terms that require initial capital letters, but, when used in this Section, have the indicated meaning.
 - 1. Backfill: Material placed in trench above the pipe embedment zone.
 - 2. Bedding: Material placed under, around, and over pipes or ducts in trenches.
 - 3. Fine grading: Bedding material placed directly below pipes or ducts to provide support at the bottom of the trench and to bring those elements to required grades and elevations.
 - 4. Flexible pipe: Includes steel, ductile iron, thermoplastics such as polyvinyl chloride (PVC) and high-density polyethylene (HDPE), thermosetting plastics such as fiberglass-reinforced polymer (FRP), bar-wrapped concrete cylinder pipe, and corrugated steel pipes.
 - 5. Haunch zone: Material placed below and beside the pipe up to the pipe springline.
 - 6. Lift: A layer of soil or aggregate material, measured before compaction.
 - 7. Maximum density, Field Compaction: Soil density and water content when tested in accordance with ASTM D1556.
 - 8. Maximum density, Laboratory Compaction: Soil maximum density and optimum water content when tested in accordance with ASTM D1557.
 - 9. Pavement section: Includes pavement plus underlying courses such as base course and subgrade.
 - 10. Pipe embedment zone: Includes bedding, fine grading, and haunch zone.
 - 11. Pipe foundation: Material placed at the bottom of trench to provide support.

12. Pipe springline: A horizontal reference line located at mid-height, or halfway point, of a circular conduit, pipe, or tunnel. It is the maximum horizontal dimension or diameter of a circular conduit, pipe, or tunnel.
13. Rigid pipe: Includes reinforced non-cylinder concrete, reinforced concrete cylinder, prestressed concrete cylinder, vitrified clay, polymer concrete, cast iron, asbestos cement and cast-in-place pipes.

1.04 SUBMITTALS

- A. As specified in Section 01_33_00 - Submittal Procedures.
- B. Product data on soils and aggregates.
 1. Material source.
 2. Gradation.
 3. Test data to demonstrate compliance with requirements as specified in this Section.
- C. Samples:
 1. Provide 50-pound sample of materials when requested by the Construction Manager.
- D. Confirmation testing:
 1. Certification of Contractor's testing laboratory.
 2. Record copy report for tests performed by the Contractor's testing laboratory.

PART 2 PRODUCTS

2.01 MATERIALS

- A. As specified in Section 31_05_15 - Soils and Aggregates for Earthwork.
- B. Class C concrete: As specified in Section 03_30_00 - Cast-in-Place Concrete.
- C. Controlled low-strength material: As specified in Section 31_23_24 - Controlled Low Strength Material (CLSM).

PART 3 EXECUTION

3.01 PREPARATION

- A. Stabilize excavations as specified in Section 31_50_00 - Excavation Support and Protection.

3.02 DEWATERING

- A. As specified in Section 31_23_19 - Dewatering.

3.03 TRENCH EXCAVATION

- A. Excavate bottom of trench to depth indicated on the Drawings.
- B. Areas of new fill or embankment:
 - 1. Prior to laying pipes or electrical service, place fill and compact as specified to not less than 2 feet above top of pipe, conduit, or duct bank.
 - 2. Excavate through fill for pipe trench.
- C. Trench widths as specified in the following table:

Buried Pipe or Accessory	Minimum Trench Width	Maximum Trench Width
Nominal Pipe Diameter: 4-inch to 24-inch	OD + 18 inches	OD + 24 inches
Nominal Pipe Diameter: Greater than 24-inch	OD + 24 inches	OD + 36 inches
Manholes, vaults, valves, or other accessories	12 inches between outer surface and trench side or shoring	Not applicable

- D. Potable water pipe and appurtenances:
 - 1. Lay in trenches separate from those used for sewers and recycled water.
 - 2. Unless otherwise specified or indicated on the Drawings, lay in trenches having cover of not less than 3 feet below surface of ground located at distance of not less than 10 feet clear horizontally from any parallel sewer and 1 foot clear vertically above any parallel sewer.

3.04 TRENCH BACKFILL - GENERAL

- A. Trench area terminology and locations as indicated on the Drawings.
- B. Place material, except CLSM and concrete, in maximum 6-inch lifts, measured before compaction.
- C. Backfilling of manhole excavation: In accordance with backfilling requirements for trenches as specified in this Section.

3.05 PIPE FOUNDATION

- A. Provide trench bottom with firm, dry, uniform bearing surface at the grade indicated on the Drawings.
- B. Excess excavation below elevation indicated on the Drawings will require installation of pipe foundation material to bring the trench bottom back to the elevation indicated on the Drawings at no additional cost to the Owner.
 - 1. Materials and placement:
 - a. Stabilization material:
 - 1) Wrap stabilization material as specified in Section 31_32_18.04 - Stabilization Fabric.

- C. If bottom of trench excavation consists of soil:
 - 1. Scarify bottom of trench to a depth of 6 inches below the grade indicated on the Drawings.
 - 2. Materials and placement:
 - a. Recompact scarified material to 95 percent of maximum density and within minus 1 to plus 3 percent of optimum moisture content.
- D. If bottom of trench excavation consists of rock or any material that, by reason of its hardness, cannot be excavated to provide uniform bearing surface:
 - 1. Remove such rock or other material to a depth of not less than 4 inches below pipe embedment zone.
 - 2. Materials:
 - a. CLSM.
 - b. Class C concrete.
- E. If bottom of trench excavation consists of mud or other soft unstable material:
 - 1. Remove such unacceptable material to a depth of not less than 18 inches below pipe embedment zone.
 - 2. Material and placement:
 - a. Stabilization material:
 - 1) Wrap stabilization material as specified in Section 31_32_18.04 - Stabilization Fabric.

3.06 PIPE EMBEDMENT ZONE

- A. Pipe displacement:
 - 1. Take necessary precautions in placement and compaction of bedding material to prevent displacement of piping.
 - 2. In event there is movement or floating of the piping, re-excavate, re-lay, and backfill the pipe.
- B. Fine grading:
 - 1. Place 6 inches of approved haunch zone bedding material from the trench bottom to the bottom of the pipe or duct to provide support at the bottom of the trench and to bring those elements to required line and grade.
- C. Depressions for joints or couplings:
 - 1. Excavate holes in the fine grading material at the bottom of the trench.
 - 2. Provide holes of sufficient width to provide ample room for grouting, banding, or welding as necessary for making joints and to ensure that pipe rests upon prepared trench bottom and not supported by any portion of the joint.
- D. Rigid pipe:
 - 1. Pipe embedment zone: Below pipe springline:
 - a. Materials and placement:
 - 1) Granular pipe bedding material compacted to a minimum relative density of 65 percent in accordance with ASTM D4253 and ASTM D4254.
 - 2. Pipe embedment zone: Above pipe springline:
 - a. Compacted to a depth above pipe: 12 inches minimum.

- b. Materials and placement:
 - 1) Granular pipe bedding material compacted to a minimum relative density of 65 percent in accordance with ASTM D4253 and ASTM D4254.
- E. Flexible pipe:
 - 1. Pipe embedment zone:
 - a. Compacted to a depth above pipe: 12 inches minimum.
 - b. Materials and placement:
 - 1) Granular pipe bedding material compacted to a minimum relative density of 65 percent in accordance with ASTM D4253 and ASTM D4254.

3.07 BACKFILL

- A. Trenches:
 - 1. Materials and placement:
 - a. Native material compacted to 95 percent maximum dry density and within minus 1 to plus 3 percent of optimum moisture content.
 - b. Imported fill compacted to 95 percent maximum dry density and within minus 1 to plus 3 percent of optimum moisture content.
- B. Trenches in rock:
 - 1. Backfill to top of rock.
 - a. Materials and placement:
 - 1) CLSM.
 - 2) Class C concrete.
 - 2. Backfill from top of rock to grade, if applicable:
 - a. Materials and placement:
 - 1) Native material compacted to 95 percent maximum dry density and within minus 1 to plus 3 percent of optimum moisture content.
- C. Trenches below or within 10 feet of the outside perimeter of structures:
 - 1. Backfill to underside of structure.
 - 2. Materials and placement:
 - a. Aggregate base course compacted to 95 percent of maximum density and within minus 1 to plus 3 percent of optimum moisture content.
 - b. CLSM.
- D. Trenches in areas outside the improved section of roadways or in open country:
 - 1. Backfill to underside of topsoil layer.
 - 2. Materials and placement:
 - a. Native material compacted to 95 percent of maximum density and within minus 1 to plus 3 percent of optimum moisture content.

- E. Trenches under existing intersecting pipes, duct banks, or conduits larger than 3 inches in diameter:
 - 1. Backfill from above top of new pipe embedment zone to springline of intersecting pipe or conduit.
 - a. Extend backfill at least 2 feet on either side of intersecting pipe or conduit to ensure backfill material remains in place while other backfill is being placed.
 - b. Materials and placement:
 - 1) CLSM, unless otherwise indicated on the Drawings.
 - 2. Backfill remainder of trench:
 - a. Materials and placement:
 - 1) Native material compacted to 95 percent of maximum density and within minus 1 to plus 3 percent of optimum moisture content.

3.08 EXCESS MATERIAL

- A. Remove excess excavated material from the Project Site as specified in Section 31_00_00 - Earthwork.

3.09 FIELD QUALITY CONTROL

- A. Provide field quality control for the Work as specified in Section 01_45_17 - Contractor Quality Control Plan.
- A. Confirmation tests by Contractor: As specified in Section 31_00_00 - Earthwork.
 - 1. Minimum frequency of confirmation testing:
 - a. At each test location, include tests for each type or class of backfill from bedding to finished grade, at a maximum of 5 feet vertically between each test.
 - b. For trenches: 1 location every 200 linear feet.
 - c. In open fields: 2 locations every 1,000 linear feet or 1 location every 200 cubic yards.
 - d. Along dirt or gravel road or off traveled right-of-way: 1 location at every 500 linear feet.
 - e. Crossing paved roads: 1 location at each crossing.
 - f. Under pavement cuts or within 2 feet of pavement edges: 1 location every 400 linear feet.
- B. Compliance tests by Owner:
 - 1. Make periodic compliance tests to verify that compaction is meeting requirements as specified in this Section.
 - 2. Contractor shall perform remedial work if compaction test fails to meet specified requirements using one of the following methods:
 - a. Remove and replace backfill at the proper density.
 - b. Other means acceptable to the Construction Manager.
 - 3. Retesting:
 - a. Costs of retesting: Contractor is responsible for the costs of retesting required to confirm and verify that remedial work has brought compaction within specified requirements.

- b. Contractor's confirmation tests during performance of remedial work:
 - 1) Performance: Perform tests in manner acceptable to the Construction Manager.
 - 2) Frequency: Double amount specified for initial confirmation tests.
- C. Piping system testing:
 - 1. As specified in Section 40_05_00.09 - Piping Systems Testing.

END OF SECTION

SECTION 31_32_18.04
STABILIZATION FABRIC

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes: Woven stabilization fabric used for subgrade enhancement.

1.02 REFERENCES

- A. ASTM International (ASTM):
1. D4355 - Standard Test Method for Deterioration of Geotextiles by Exposure to Light, Moisture and Heat in a Xenon Arc Type Apparatus.
 2. D4491 - Standard Test Methods for Water Permeability of Geotextiles by Permittivity.
 3. D4533 - Standard Test Method for Trapezoid Tearing Strength of Geotextiles.
 4. D4632 - Standard Test Method for Grab Breaking Load and Elongation of Geotextiles.
 5. D4751 - Standard Test Method for Determining Apparent Opening Size of a Geotextile.
 6. D6241 - Standard Test Method for the Static Puncture Strength of Geotextiles and Geotextile-Related Products Using a 50-mm Probe.

1.03 DEFINITIONS

- A. Stabilization fabric: Woven geotextile fabric manufactured from polypropylene yarns.

1.04 SUBMITTALS

- A. Product data.
- B. Samples.
- C. Quality control submittals:
1. Certificates of Compliance.
 2. Manufacturer's Installation Instructions.

1.05 DELIVERY, STORAGE, AND HANDLING

- A. Storage and protection:
1. Furnish stabilization fabric in protective covers capable of protecting the fabric from ultraviolet rays, abrasion, and water.

1.06 PROJECT CONDITIONS

- A. Field measurements:
1. Take field measurements to determine the exact lengths and dimensions of the surfaces to receive the fabric.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. One of the following or equal:
1. Propex, Geotex 200ST.
 2. Ten Cate Geosynthetics, Mirafi 500X.

2.02 MATERIAL REQUIREMENTS

- A. Physical properties: Meet the following minimum requirements:

Property ⁽¹⁾	Test Method	Unit	Requirements ⁽¹⁾
Grab Tensile Strength	ASTM D4632	lbs	200
Grab Elongation	ASTM D4632	%	15
Trapezoid Tear Strength	ASTM D4533	lbs	75
CBR Puncture Resistance	ASTM D6241	lbs	700
UV Resistance (strength retained at 500 hours)	ASTM D4355	%	70
Apparent Opening Size (AOS)	ASTM D4751	US sieve	40
Permittivity	ASTM D4491	sec ⁻¹	0.05
Flow Rate	ASTM D4491	gpm/ft ²	4
Notes: (1) Minimum average roll values.			

PART 3 EXECUTION

3.01 EXAMINATION

- A. Verification of conditions: Verify that conditions are satisfactory for the installation of stabilization fabric.

3.02 PREPARATION

- A. Surface preparation: During grading operations, take care not to disturb the subgrade. This may require use of lightweight dozers for low strength soils such as saturated, cohesionless, or low cohesion soils.
- B. Prior to placement of fabric: Prepare surface to smooth condition free of debris, depressions, or obstructions that may damage the fabric.

3.03 INSTALLATION

- A. Follow manufacturer's installation instructions and as complimented in this Section.
- B. Place the stabilization fabric smoothly without folds or wrinkles.
- C. Use special care when placing the stabilization fabric in contact with the soil so that no void spaces occur between the stabilization fabric and the prepared surface.
- D. Overlap the parallel rolls and ends of rolls a minimum of 24 inches and not less than recommended by manufacturer.
- E. Do not drag stabilization fabric across subgrade.
- F. Make overlaps at ends of rolls in the direction of the aggregate placement with the previous roll-on top.
- G. Use lightweight dozers, if necessary. Do not allow equipment directly on stabilization fabric.

3.04 FIELD QUALITY CONTROL

- A. Inspection: Before covering, the condition of the fabric will be observed by the Construction Manager to determine that no holes or rips exist in the fabric. Repair all holes or rips by placing a new layer of fabric extending beyond the defect in all directions, a distance equal to the minimum overlap required for adjacent rolls.

END OF SECTION

SECTION 31_36_02

RIPRAP AND GABIONS EROSION AND SEDIMENTATION CONTROL

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes: Plain and grouted riprap.

1.02 REFERENCES

- A. ASTM International (ASTM):
 - 1. A90 - Standard Test Method for Weight of Coating on Iron and Steel Articles with Zinc or Zinc-Alloy Coatings.
 - 2. C150 - Standard Specification for Portland Cement.

1.03 SUBMITTALS

- A. Product data.
- B. Installation instructions.

PART 2 PRODUCTS

2.01 PLAIN RIPRAP

- A. Material: Rock, broken concrete from site preparations, or wasted concrete from project pours.
- B. Size and weight: 1/8 cubic to 1 cubic foot and 20 to 150 pounds, except small stones and spalls used to chink interstices shall weigh not less than 10 pounds and at least 50 percent of pieces shall weigh not less than 100 pounds.
- C. Material shapes:
 - 1. Capable of forming stable protection structure of required depth.
 - 2. Rounded boulders or cobbles on 2:1 slopes and less.
 - 3. Angular.
 - 4. Flat or needle shapes with thickness more than 1/3 length.

PART 3 EXECUTION

3.01 PREPARATION

- A. Shape and trim bed for riprap as required to provide even surface which at no point is higher than design surface.

3.02 PLACING PLAIN RIPRAP

- A. When required riprap is less than 20 inches in depth, place material by hand.
- B. When riprap is 20 inches or more in depth, place material by dumping and spreading in layers by bulldozers or other suitable equipment.
- C. Place material to provide minimum of voids.
- D. Place larger pieces in toe of trench, foundation course, and on outer surface of riprap.
- E. Place pieces with their longitudinal axis normal to face of embankment and so arranged that each piece above the foundation course has minimum 3-point bearing on underlying stones.
 - 1. Bearing on smaller pieces used to fill voids will not be acceptable.
- F. Fill interstices between pieces with small pieces and spalls.

3.03 TOLERANCES

- A. Finished surfaces of riprap for plain or grouted riprap: Within 3 inches per foot of depth.

END OF SECTION

SECTION 31_50_00

EXCAVATION SUPPORT AND PROTECTION

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Designing, providing, maintaining, and removing excavation support and protection.

1.02 REFERENCES

- A. American Society of Civil Engineers (ASCE):
 - 1. Guidelines of Engineering Practice for Braced and Tied-Back Excavations.
- B. Department of the Navy Naval Facilities Engineering Command (NAVFAC):
 - 1. Design Manual 7.2 - Foundations and Earth Structures.
 - 2. Design Manual 7.3 - Soil Dynamics and Special Design Aspects.
- C. United States Steel Corporation (USS):
 - 1. Steel Sheet Piling Design Manual.

1.03 TERMINOLOGY

- A. The words and terms listed below are not defined terms that require initial capital letters, but, when used in this Section, have the indicated meaning.
 - 1. General engineering design practice: In area of the Project, performed in accordance with recent engineering literature on subject of shoring and stability of excavations.
 - 2. Shoring: A temporary structural system designed to support vertical faces, or nearly vertical faces, of soil or rock for purposes of excavation. Shoring includes cantilevered sheet piling, internally braced sheet piling, slurry walls, soldier piles and lagging, and other similar shoring systems. Sloping of the soil is not shoring.
 - 3. Support levels: Level of tiebacks, wales, rakers, bottom of excavation, and other types of support.

1.04 SUBMITTALS

- A. Shop Drawings and calculations:
 - 1. Calculations for different load, support, and other conditions that occur during the sequence of installation of shoring, construction of facilities protected by shoring, and sequence of removal of shoring.
 - 2. Sketches showing the condition at various stages of installation and removal of shoring.
 - 3. Show on plan shoring, structures, pipelines, and other improvements located near shoring.

4. When utilities penetrate shoring, show location of penetrations on elevation of sides of shoring.
 5. Show details for ground support and sealing around utility penetrations.
 6. Indicate method used for installing driven shoring.
- B. Control points and schedule of measurements:
1. Submit location and details of control points and method and schedule of measurements.
 2. Survey data.
- C. Detailed sequence of installation and removal of shoring:
1. Consider effects of ground settlement in sequence of installation and removal of shoring.
 2. Provide sketches showing conditions at various stages in sequence of installation and removal of shoring.
- D. Furnish Submittals for excavation support and protection as complete package and include items required in this Section:
1. Incomplete Submittals will not be reviewed and will be returned for resubmittal as a complete package.
- E. Furnish dewatering Submittals as specified in Section 31_23_19 - Dewatering with Submittals for excavation support and protection.
- F. Project environmental requirements:
1. Sound control:
 - a. Muffle equipment for excavation support and protection installation as necessary to comply with federal, state, and local community noise regulations.
Perform installation operations in manner such that noise levels do not exceed 80 dB(A) during the day, 7:00 a.m. to 7:00 p.m, per Larimer County noise ordinances, at any residential property boundary.
 - b. Monitor and record noise levels from installation operations, as required for compliance with worker safety regulations:
 - 1) Monitoring costs and any costs associated with related construction and project shutdown delays necessitated while bringing noise levels in compliance with the preceding provisions shall be the responsibility of and be borne by the Contractor.
 - c. Perform installation construction operations such that they occur only on weekdays and only between the hours of 7a.m. and 7 p.m.

1.05 SEQUENCING

- A. Do not begin construction of any shoring or excavation operations until:
 - 1. Submittals for shoring and dewatering have been accepted.
 - 2. Control points as specified in this Section and on existing structures and other improvements as indicated on the Drawings have been established and surveyed to document initial elevations and locations.
 - 3. Materials necessary for installation are on site.
- B. Furnish Submittals a minimum of 60 days prior to scheduled date to begin excavation work.

PART 2 PRODUCTS

2.01 DESIGN AND PERFORMANCE CRITERIA

- A. Where general engineering design practice is specified, provide Drawings and calculations that are performed and signed by civil or structural engineer registered in the state where the Project is located:
 - 1. Clearly disclose assumptions made, criteria followed, and stress values used for materials being used in design calculations.
 - 2. Submit list of references acceptable to the Engineer that substantiate appropriateness of design assumptions, criteria, and stress values.
- B. Design requirements:
 - 1. General:
 - a. Dewatering:
 - 1) Dewater soil inside shoring as specified in Section 31_23_19 - Dewatering.
 - 2) Do not lower groundwater outside of shoring more than 1 foot.
 - 3) Recharge groundwater outside shoring to limit groundwater draw down outside of shoring to amount specified above.
 - b. When electing to design with material stresses for temporary construction higher than allowable stresses prescribed in building code as specified in Section 01_41_00 - Regulatory Requirements, increase in such stresses shall not exceed 10 percent of value of prescribed stresses.
 - c. Minimum safety factor used for design shall not be less than 1.5.
 - d. Calculated minimum depth of penetration of shoring below bottom of excavation shall be increased not less than 30 percent if full value of allowable passive pressure is used in design.
 - e. Maximum height of cantilever shoring above bottom of excavation shall not exceed 15 feet. Use braced shoring when height of shoring above bottom of excavation exceeds 15 feet.
 - f. Location of point of fixity for shoring shall not be less than half calculated minimum embedment depth below bottom of excavation.
 - g. Generally acceptable references for design of shoring and excavations are as follows:
 - 1) ASCE Guidelines of Engineering Practice for Braced and Tied-Back Excavations.
 - 2) NAVFAC Design Manual 7.2.

- 3) NAVFAC Design Manual 7.3.
 - 4) USS Steel Sheet Piling Design Manual.
- h. Maximum total deflection of shoring at any point on shoring shall not be more than 1/2 inch.
- 2. Soldier piles and lagging:
 - a. Provide lagging over full face of excavation. Joints between pieces of lagging shall be tight to prevent loss of soil.
 - b. Provide full face lagging around penetrations through lagging.
 - c. If the soldier piles are installed in predrilled holes and are not concrete encased, fill predrilled holes with controlled low strength material as specified in Section 31_23_24 - Controlled Low Strength Material (CLSM) after soldier piles are installed.
 - d. Assumed effective width for passive soil resistance:
 - 1) Effective width of driven soldier piles shall not exceed 2 times width of pile.
 - 2) Effective width of CLSM encased soldier piles in drilled holes shall not exceed 2 times width of pile.
 - 3) Effective width of concrete encased soldier piles shall not exceed 2 times width of concrete encasement.
 - e. Fill voids behind lagging with gravel or other material acceptable to the Engineer.
 - f. Apply loads from tie back soil, rock, or deadman anchors concentrically to soldier piles or wales spanning between soldier piles:
 - 1) Wales shall be back-to-back double channels or other members acceptable to the Engineer.
 - 2) Do not eccentrically load structural section of soldier piles or wales.
 - g. Design soldier piles for downward loads, including vertical loads from tieback anchors.
- 3. Soil anchors, rock anchors, and deadman anchors:
 - a. Design tieback anchors for a safety factor of not less than 2 times calculated load from shoring.
 - b. Proof load production anchors to 125 percent of calculated load from shoring.
 - c. Lock off production anchors at calculated load from shoring.
 - d. Length of soil anchors used to calculate resistance to load from shoring shall not include any length within potential active pressure soil failure zone behind face of shoring.
 - e. Design tie rods for tieback anchors for 130 percent of calculated load from shoring.
 - f. Design tie rods for tieback anchors for 150 percent of the calculated load from shoring when tie rod couplers are used and for other conditions where stress concentrations can develop.
- 4. Set inside face of shoring back from structure not less than greater of following:
 - a. 5 feet from face of wall.
 - b. 2 foot-6 inches from edge of foundation.
 - c. Depth of excavation below bottom of foundation.

C. Performance requirements:

1. General:
 - a. Support faces of excavations and protect structures and improvements in vicinity of excavations from damage and loss of function due to settlement or movement of soils, alterations in ground water level caused by such excavations, and related operations.
 - b. Specified provisions:
 - 1) Complement, but do not substitute or diminish, obligations of the Contractor for furnishing of safe place of work pursuant to provisions of the Occupational Safety and Health Act of 1970 and its subsequent amendments and regulations and for protection of work, structures, and other improvements.
 - 2) Represent minimum requirement for:
 - a) Number and types of means needed to maintain soil stability.
 - b) Strength of such required means.
 - c) Methods and frequency of maintenance and observation of means used for maintaining soil stability.
2. Provide safe and stable excavations by means of sheeting, shoring, bracing, sloping, and other means and procedures, such as draining and recharging groundwater and routing and disposing of surface runoff, required to maintain stability of soils and rock.
3. Provide support for trench excavations for protection of workers from hazard of caving ground.
4. Provide shoring:
 - a. Where, as result of excavation work and analysis performed pursuant to general engineering design practice, as defined in this Section:
 - 1) Excavated face or surrounding soil mass may be subject to slides, caving, or other types of failures.
 - 2) Stability and integrity of structures and other improvements may be compromised by settlement or movement of soils, or changes in soil load on structures and other improvements.
 - b. For trenches 5 feet and deeper.
 - c. For trenches less than 5 feet in depth, when there is potential for cave-in.
 - d. Where indicated on the Drawings.
5. For safe and stable excavations, use appropriate design, construction, and maintenance procedures to minimize settlement of supported ground and to prevent damage to structures and other improvements, including:
 - a. Using stiff shoring systems.
 - b. Following appropriate construction sequence.
 - c. Using shoring system that is tight enough to prevent soil loss through the shoring.
 - d. Using shoring system that extends far enough below bottom of excavation to prevent piping, heave, or flow of soil under shoring.
 - e. Design for safety factor of not less than 1.50.
 - f. Providing surface runoff routing and discharge away from excavations.
 - g. Where dewatering inside shoring is necessary, recharge groundwater outside shoring as necessary to prevent settlement in area surrounding shored excavation.

- h. Where sheet piling is used, use interlocking type sheets:
 - 1) Sheet piles shall be continuous and driven in interlock.
 - 2) If bottom of the excavation is located below the water table, use “ball and socket” or “thumb and finger” type interlock.
- i. Not applying shoring loads to existing structures and other improvements.
- j. Not changing existing soil loading on existing structures and other improvements.
- k. Provide welded steel packing between soil retaining members such as sheet piles and wales and similar members when gap exceeds 1/2 inch before wales are loaded.

PART 3 EXECUTION

3.01 CONSTRUCTION

- A. Installation of shoring:
 - 1. Install means for providing safe and stable excavations as indicated in Submittals.
- B. Removal of shoring:
 - 1. Except for concrete encased soldier piles, slurry walls, and similar shoring systems, remove shoring by completion of the Work.
 - 2. Select shoring system and method of removal, which will minimize soil that sticks to shoring from creating voids and causing settlement.
 - 3. To prevent settlement caused by pulling shoring, fill voids with pressure injected grout:
 - a. Inject grout starting at bottom of void and progressively fill void to grade.
 - b. Minimize length of shoring removed ahead of grouting operation and limit time void is left ungrouted to prevent void from closing up before being grouted.
 - 4. Pressure preservative treated wood lagging may be left in place if acceptable to the Engineer.
- C. Sound monitoring:
 - 1. Measure sound due to installation and removal of shoring.
 - 2. Perform installation and removal operations in manner such that noise levels do not exceed 80 dB(A) during the day, 7:00 a.m. to 7:00 p.m, per Larimer County noise ordinances, at any residential property boundary.
 - 3. Monitor and record noise levels from installation operations, as required for compliance with local noise ordinance and worker safety regulations.
- D. Maintenance:
 - 1. Where loss of soil occurs, plug gap in shoring and replace lost soil with fill material acceptable to the Engineer.
 - 2. Where measurements and observations indicate possibility of failure or excessive movement of excavation support, determined in accordance with general engineering design practice, take appropriate action immediately.

END OF SECTION

SECTION 31_63_30
DRILLED CONCRETE PIERS

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Drilled concrete piers.
- B. See the project Geotechnical Design Memorandum (GDM) and Geotechnical Data Report (GDR), as referenced in Section 01_11_00 - Summary of Work, for more information.
- C. Payment procedures:
 - 1. Basis of payment:
 - a. See Section 01_20_20 - Measurement and Payment.

1.02 TERMINOLOGY

- A. The words and terms listed below are not defined terms that require initial capital letters, but, when used in this Section, have the indicated meaning.
 - 1. Cementitious Materials: Defined as Portland cement and pozzolan admixture.

1.03 SUBMITTALS

- A. Unless otherwise specified, the Contractor shall submit the information specified herein to the Engineer not less than 30 days before the start of Work of this Section.
- B. Reinforcing bar placement drawings.
- C. Method of securing and maintaining position of steel reinforcing.
- D. Bar lists and bending details.
- E. Concrete mix design report as specified in Section 03_30_00 - Cast-in-Place Concrete.
- F. Aggregate tests.
- G. Trial batch results.
- H. Concrete testing requirements as specified in Section 03_30_00 - Cast-in-Place Concrete.
- I. Method and materials necessary to complete corrections for out-of-tolerance drilled shaft foundations.

- J. Drilled Pier Installation Plan. The Contractor must submit a drilled pier installation narrative for approval. The Engineer will evaluate the pile installation plan for conformance with the Contract. Do not begin drilled pile installation until the installation plan is approved. This narrative must provide at least the following information:
1. The drilled pier construction sequence.
 2. The drilled pier contractor's understanding of the site subsurface conditions. The drilled pier contractor must reference the available subsurface data provided in the contract test hole boring logs and the geotechnical report(s) prepared for this project.
 3. List, proposed equipment descriptions and capacities, including but not limited to cranes, drilling related equipment and appurtenant parts, bailing and cleanout buckets, final cleaning equipment and drilling unit. The narrative must describe why the equipment was selected and describe equipment suitability to the anticipated site and subsurface conditions. The narrative must include a drilling equipment project history demonstrating the equipment's successful use for drilled piles of equal or greater size in similar soil/rock conditions.
 4. Drilling excavation method details, including proposed drilling methods, methods for drilled pile cleanout, and an excavated material and drilling water/slurry disposal plan. This must include a method suitability review for the anticipated site and subsurface conditions.
 5. Detail the method(s) to be used to ensure pile excavation stability (i.e. caving). This must include a method suitability review for the anticipated site and subsurface conditions.
 6. Concrete placement details, including proposed tremie or pumping methods.
- K. Drilled pier Preconstruction Conference. A drilled pier preconstruction conference must be held at least five working days before beginning any drilled pier construction work at the site to discuss scheduling, construction procedures, personnel, and equipment to be used, and other approved pile installation plan elements as specified in these Special Provisions. Those attending must include: the superintendent; on site supervisors; all foremen in charge of excavating material from inside the pile, placing the casing and slurry as applicable, placing the steel reinforcing bars, and placing the concrete; the Engineer; and key inspection personnel.
- L. Qualifications of crew for review at bid time. Substitution of approved personnel will not be allowed without written authorization by the Owner.
- M. Pier location plan and location information:
1. Pier plan showing location indicated on the Drawings, including:
 - a. Assigned number for each pier as identification for use in pier installation record.
 - b. Pier tip elevation.
- N. Pier installation record including: pier identification, subsurface materials, concrete volume, and any deviations from the Construction Drawings.
- O. Pier location survey.

1.04 QUALITY ASSURANCE

- A. Contractor qualifications:
1. Regularly engaged in the installation of drilled piers foundation systems.
 2. Have a minimum of 10 years previous experience on projects of similar or larger size, complexity, and subsurface conditions.
 3. Job supervisor directly responsible for pier installation shall have continuous experience on drilled pier installation throughout the last 10 years.
 4. The drilled pier Contractor must submit at least three projects in similar or more difficult subsurface conditions on which the drilled pier contractor has previously been engaged in drilled pier construction with satisfactory results using the proposed means and methods. These projects shall have been completed within the previous 5 years. A brief description of each project including the following shall be provided:
 - a. Brief description of methods and approaches.
 - b. Owner's contact person's name and current phone number and email address.
 - c. A description of the project including awarded and completed dates, number and diameter of drilled piers, and subsurface conditions.
 - d. Drilled pier project value and a description of any submitted claims during construction.
 5. Provide resumes for the following individuals, employed by the drilled pier contractor for a minimum of 2 years:
 - a. The drilled pier on-site supervisor(s) must have a minimum of five years of experience in drilled pier construction and shall have completed at least two comparable projects with equal to or greater number, diameter, and length of drilled piers though equal to or more challenging subsurface conditions.
 - b. The drilled pier rig operator(s) must have a minimum of five years of experience in drilled pier construction and shall have completed at least two comparable projects with equal to or greater number, diameter, and length of drilled piers though equal to or more challenging subsurface conditions.
 6. Provide resumes for the following individuals, employed by the drilled pier contractor for a minimum of 2 years:
 - a. The drilled pier on-site supervisor(s) must have a minimum of five years of experience in drilled pier construction and shall have completed at least two comparable projects with equal to or greater number, diameter, and length of drilled piers though equal to or more challenging subsurface conditions.
 - b. The drilled pier rig operator(s) must have a minimum of five years of experience in drilled pier construction and shall have completed at least two comparable projects with equal to or greater number, diameter, and length of drilled piers though equal to or more challenging subsurface conditions.

- c. The Engineer will approve or reject the drilled pier contractor's qualifications and field personnel prior to the start of drilled pier construction. The Engineer reserves the right to suspend the drilled pier construction if the drilled pile contractor substitutes unqualified or undocumented personnel. The Contractor will be fully liable for the additional costs resulting from the work suspension and no adjustments in contract time resulting from the work suspension will be allowed.

1.05 PROJECT CONDITIONS

- A. Project environmental requirements:
 - 1. Sound control:
 - a. Muffle equipment for pier installation as necessary to comply with federal, state, and local community noise regulations.
 - b. Perform drilling and pier installation operations in manner such that noise levels do not exceed 80 dBA between 7:00 a.m. to 7:00 p.m. at any residential property boundary as provided by local ordinances.
 - c. Monitor and record noise levels from pier installation operations, as required for compliance with worker safety regulations:
 - 1) Monitoring costs and any costs associated with related construction and project shutdown delays necessitated while bringing noise levels in compliance with the preceding provisions shall be the responsibility of and be borne by the Contractor.
 - d. Perform drilling and pier installation construction operations such that they occur only on weekdays and only between the hours of 7 a.m. and 7 p.m.

PART 2 PRODUCTS

2.01 MATERIALS

- A. Reinforcing steel: Use reinforcing steel as specified in Section 03_20_00 - Concrete Reinforcing.
- B. Tie wire: Use Number 18 double annealed iron wire, tie wire.
- C. Concrete:
 - 1. Use concrete materials as specified in Section 03_30_00 - Cast-in-Place Concrete.
 - 2. Use Class P concrete as specified in Section 03_30_00 - Cast-in-Place Concrete.

PART 3 EXECUTION

3.01 INSTALLATION

- A. General:
 - 1. Monitoring and evaluation of the shafts at each stage will be by the Engineer. Do not place concrete in the shaft until the shaft excavation has been accepted by the Engineer. Install piers only in the presence of the Engineer.

2. Piers that fail to meet the requirements of these Specifications for alignment and piers which for other reasons are unacceptable will be rejected.
 3. Correct drilled shafts not constructed within the specified tolerances. Remedial measures, including engineering analysis and redesign, to correct for out-of-tolerance drilled shaft foundations, shall be performed at no additional cost to the Owner.
 4. Correct damaged or rejected piers by methods acceptable to the Engineer.
- B. Drilling:
1. Drill holes by means of a power driven, rotary bucket, rotary auger type, or core barrel foundation drilling machine designed to excavate a cylindrical shaft:
 - a. Have sufficient power and cutting capacity to excavate the pier holes to the required depths into the soil or rock at the site.
 2. Use drilling method which prevents the shaft sidewalls from caving in or sloughing into the excavated hole, except that dewatering will not be permitted.
 3. Proceed with the work in the "wet" if the groundwater level is found above pier tip elevation.
 4. Do not drill holes within 4 pier diameters (center-to-center) of a previously drilled hole until after the concrete in the previous hole has set up, but in no case until the concrete has been placed for at least 15 hours.
 5. Do not drill holes until the excavation or fill in the area in which the shafts are to be located has been completed to the elevations indicated on the Drawings.
 6. Clean out the hole until no more than 1/4 inch of loose or soft material is left in the bottom of the hole. Make all bottom surfaces of shaft level.
 7. Clean and protect top of holes to prevent soil from falling into hole.
 8. Drill piers from the ground surface to tip elevations as indicated on the Drawings.
 - a. Maintain a record of each drilled hole during installation
 - b. Engineer will determine the final bottom of hole elevation.
 - c. The bottom elevations may be adjusted to obtain the required design capacity based on the elevation and quality of the bearing material encountered during installation of each drilled shaft. The Engineer shall be the sole judge as to the classification of the material encountered during drilled shaft excavation.
 - d. Sound and measure the final depth to the bottom of shaft excavation in the presence of the Engineer at the following times to verify that soil from the sides of the shaft has not fallen into the shaft and sediment has not collected on the shaft bottom.
- C. Reinforcing steel:
1. Upon completion of drilling, position the reinforcing steel cage in the pier shaft as indicated on the Drawings and suspend it above the bottom of excavation before any concrete is placed in the shaft.
 2. Support the reinforcing steel cage so that it rotates freely just prior to final suspension.
 3. If soil caving occurs after reinforcing steel is placed and before placement of concrete, remove the reinforcing steel and ream the hole to permit repositioning of the cage.

4. Support the cage in a manner that will ensure that it remains centered in the pier shaft during placement of concrete.
 - a. Use plastic roller type centering devices attached to spiral reinforcing bars.
 - b. Centering device shall position reinforcing cages in center of hole and provide proper cover for reinforcing bars.
 5. Tolerances:
 - a. Normal to drilled shaft wall: plus or minus 1 inch. Maintain minimum 3-inch cover.
 - b. Vertical: 1 inch.
 - c. Dowels: 3 inches from indicated position with respect to wall.
 - d. Top of steel and bottom of steel: plus or minus 1 inch from elevation shown on Drawings.
- D. Concrete placement:
1. Placement of concrete shall be as specified for dry or wet conditions as may be applicable for the conditions found at the time of the work.
 2. During concrete placement, take care to prevent concrete from hitting the sides of the steel reinforcing bar cage which will cause segregation.
 3. To prevent segregation, do not allow concrete to fall more than 5 feet.
 4. Proceed with concrete placement that starts underwater, using underwater placement requirements until the hole is completely filled.
 - a. Do not dewater the shaft after partial concrete placement.
 5. Provide for a supply of concrete that is adequate to complete placement on any given drilled pier in one continuous uninterrupted operation without cold joints.
 6. Construct concrete work in a manner that dense, monolithic concrete is provided throughout the full length and diameter of the drilled pier.
 7. Immediately after acceptance of the excavation, place the concrete. Do not leave uncased excavations unfilled overnight.
 8. Water in excavation:
 - a. Excavations containing more than 3 inches of water shall be pumped dry prior to concrete placement.
 - 1) Except for the bottom 3 inches, do not drop concrete through water.
 - b. In a dry excavation, place concrete with a concrete chute or pumping method acceptable to the Engineer.
 - c. Direct the flow of concrete down the center of the pier shaft in order to minimize sloughing of the sides of the hole and segregation of the concrete on the reinforcing steel.
 9. Water seepage:
 - a. If seepage occurs at such a rate that the concrete cannot be properly placed, even if the pier hole is cased, place concrete using the "tremie" method.
 - b. Use a tremie pipe having a disposable plug that keeps the tremie free of fluid until the plug is blown out by the concrete pressure.
 - c. Preferably, use a tremie pipe which is 12 inches, but not less than 8 inches in diameter.
 - d. Alternatively, use pumped concrete discharging through a pipe at least 5 inches in diameter.
 - e. Use a tremie or pump pipe having watertight joints.
 - f. Provide for no more than 3 inches of height between the bottom of the tremie pipe and the bottom of excavation during initial concrete placement.

- g. Provide positive control to make certain that the bottom of the tremie or pump pipe is at all times below the concrete surface.
 - h. At least a 1 foot head of concrete shall be maintained above the top of the water.
- E. Temporary casing:
 - 1. Use temporary casing.
 - a. Withdraw casing as the concrete is placed.
 - 2. Provide steel casing onsite in various appropriate lengths.
 - 3. Case the drilled pier holes through any fill and native soil or rock as required to maintain a stable excavation.
 - 4. Withdraw casing as concrete placement proceeds while maintaining at least 3 feet of concrete depth over the bottom of the casing pipe.
 - 5. Use steel casing with an inside diameter at least as large as the design pier diameter.
 - 6. Use a casing wall thickness such that it is not damaged by water or ground pressures or by the stresses of installation.
 - 7. Attach cutting teeth to the casing, if required to penetrate to the planned depth.
 - 8. Use casing length so that at the end of drilling, the top of the casing projects above the ground surface and any adjacent mound of drill cuttings.
 - 9. Provide positive control to make certain that the bottom of the casing is at least 3 feet below the top of the concrete being placed to prevent a reduction in the diameter of the pier shaft due to earth pressure and to prevent in situ materials from falling into and mixing with the concrete.
- F. Cave-ins:
 - 1. Remove soil which sloughs into the excavated pier shaft prior to concrete placement.
 - 2. During concrete placement, if the Engineer has reasons to suspect that concrete was breached by the soil or that the pier, for any other reason, may contain extraneous material, or otherwise is not in conformance with Drawings and Specifications, the Engineer may order testing of the pier by coring or other methods:
 - a. Pay for testing and additional construction as required by the Engineer if the work is found defective.
 - b. If work is found to be not defective, testing cost will be paid by the Owner.
- G. Where required due to pier being constructed too high, cut off piers to the butt elevations indicated on the Drawings.
- H. Site tolerances:
 - 1. Pier installation tolerances:
 - a. Deviation of center of pier butts: Not deviate from locations indicated on the Drawings more than 3 inches in any direction.
 - b. Deviation of elevation of pier butts: Not more than 1 inch higher nor more than 3 inches lower than elevation indicated on the Drawings.
 - c. Deviation of piers from vertical: Not more than 1/4 inch per foot of length.
 - d. After installation, a line from center of butt to center of tip shall be wholly within body of pier.

3.02 FIELD QUALITY CONTROL

- A. Field records:
 - 1. For each drilled shaft foundation installed, record on drilled shaft installation logs the location, alignment, dimensions, elevations of top and bottom, depth of bearing stratum of materials encountered at all elevations, elevations of water table during excavation, condition of bottom of excavation, slurry test data, concrete data, verticality and deviation from plan location, and other data called for on the report form or pertinent to the drilled shaft.
 - 2. Record the theoretical volume of excavation, volume of concrete placed vs. depth, and total volume of concrete placed.
 - 3. Report observed irregularities to the Engineer within 24 hours of discovery.
- B. Inspection of drilled hole:
 - 1. If inspection of hole is required by the Engineer, dewater holes to make the holes accessible to inspection and construction personnel.
 - 2. Provide fresh air and adequate light for workmen and Engineer during such time that they occupy the shafts.
 - 3. Test each drilled hole for toxic or explosive gas prior to entry into the hole.
- C. Field measurements:
 - 1. Pier location survey:
 - a. After piers are installed and prior to placing reinforcing steel, formwork, or concrete for the structure, prepare pier location survey showing coordinates of final location of butt of piers and elevations of butt of piers to accuracy of plus or minus 0.01 feet.
 - b. Pier location survey shall be performed by Surveyor licensed in the state where the Project is located.
 - c. Provide survey that includes as minimum following information:
 - 1) Location coordinates of:
 - a) Location of pier butts as indicated on the Drawings.
 - b) Location of pier butts as installed.
 - c) Calculate distance between location coordinates of pier butts as indicated on the Drawings and actual location coordinates of pier butts as installed.
 - 2) Elevation of pier butts:
 - a) Elevation of pier butts as indicated on the Drawings.
 - b) Elevation of pier butts as installed.
 - c) Calculate difference in elevations of pier butts as indicated on the Drawings and actual elevation of pier butts as installed.
 - 3) Highlight piers that are not within specified tolerances for location in plan and butt elevation.
 - 4) Provide preceding information in tabular form and keyed to a pier plan by pier number:
 - a) Submit pier plan that shows each pier for each structure.
 - d. Engineer will utilize pier location survey information to evaluate acceptability of pier locations and elevations.

3.03 ADJUSTING

- A. If a drilled shaft is determined to be unacceptable, submit a plan for remedial action to the Engineer. Labor and materials necessary to perform the remediation shall be furnished without cost to the Owner and without an extension of the Contract time.
- B. Correction of defective pier work:
 - 1. Pier work not in accordance with the requirements indicated on the Drawings and specified in the Specifications is considered defective.
 - 2. Take corrective measures acceptable to the Engineer, if piers are damaged, out of tolerance, mislocated, or otherwise defective:
 - a. Cost of redesign of foundation elements by the Engineer required by reason of defective pier work shall be paid by the Contractor.
 - b. Allow 15 working days from submittal of pier location survey, for design of corrections for defective pier work.
 - 3. Measures to be used to correct defective pier work will be selected by the Engineer. Corrective measures that may be acceptable to the Engineer include:
 - a. Installing additional piers at locations selected by the Engineer.
 - b. Pier caps will be redesigned by the Engineer and required details of modifications to pier caps will be given to the Contractor to accommodate piers that were installed out of tolerance.
 - 4. Leave piers which are not accepted in the ground. Cut off such piers at least 2 feet below bottom of pier cap and fill such holes with compacted aggregate base course material.
 - 5. Fill holes drilled for piers that are not used with Class C concrete.

END OF SECTION

SECTION 32_16_14

CONCRETE CURBS, GUTTERS, AND SIDEWALKS

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes: Concrete curbs, gutters, sidewalks, driveways, access ramps, and alley intersections.

1.02 SUBMITTALS

- A. Product data: Submit data completely describing products.
- B. Samples: Submit samples when requested.

PART 2 PRODUCTS

2.01 DESIGN AND PERFORMANCE CRITERIA

- A. Performance requirements: Construct various types of concrete curb, gutter, sidewalk, driveways and alley intersections to dimensions and details indicated on the Drawings.

2.02 MATERIALS

- A. Concrete: Class A, as specified in Section 03_30_00 - Cast-In-Place Concrete.
- B. Curb finishing mortar: 1 part portland cement to 2 parts sand.
- C. Form release material: Light oil or other releasing agent of type which does not discolor concrete or interfere with the application of finishing mortar to curb tops and faces.
- D. Joint materials:
 - 1. Expansion: As specified in Section 03_15_00 - Concrete Accessories.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Verification of Conditions:
 - 1. Verify field conditions, including subgrade condition and interferences, before beginning construction.

3.02 PREPARATION

- A. Surface preparation:
 - 1. Subgrade:
 - a. Construct and compact true to grades and lines indicated on the Drawings and requirements as specified Section 31_05_15 - Soils and Aggregates for Earthwork.
 - b. Remove soft or unsuitable material to depth of not less than 6 inches below subgrade elevation and replace with satisfactory material.
 - 2. Forms and subgrade: Water immediately in advance of placing concrete.

3.03 INSTALLATION

- A. Special techniques:
 - 1. Contractor's option:
 - a. Construct concrete curbs and gutters by conventional use of forms, or by means of curb and gutter machine when acceptable to the Construction Manager.
 - b. When use of machines designed specifically for work of this Section are accepted by the Construction Manager, results must be equal to or better than those produced by use of forms.
 - c. Applicable requirements of construction that apply to use of forms also apply to use of machines.
 - d. Discontinue use of machines when results are not satisfactory to the Construction Manager.
- B. Forms:
 - 1. Carefully set to line and grade and securely stake in position forms conforming to dimensions of items to be constructed.
 - 2. Thoroughly clean prior to each use and coat with form releasing material.
- C. Expansion and weakened-plane joints:
 - 1. Expansion joints:
 - a. Construct vertically, and at right angles to centerline of street and match joints in adjacent pavement or sidewalks.
 - b. Constructed at radius points, driveways, alley entrances, and at adjoining structures.
 - c. Fill joints with expansion joint filler material.
 - 2. Weakened-plane joints:
 - a. Construct as indicated on the Drawings.
 - b. Match joint locations and details in adjacent curbs, gutters, and sidewalks.
- D. Concrete:
 - 1. Placing:
 - a. Thoroughly spade concrete away from forms so that no rock pockets exist next to forms and so that no coarse aggregate will show when forms are removed.
 - 2. Compacting:
 - a. Compact by mechanical vibrators accepted by the Construction Manager.
 - b. Continue tamping or vibrating until mortar flushes to surface and coarse aggregate is below concrete surface.

3. Form removal:
 - a. Front form faces: Do not remove before concrete has taken initial set and has sufficient strength to carry its own weight.
 - b. Gutter and rear forms: Do not remove until concrete has hardened sufficiently to prevent damage to edges. Take special care to prevent damage.
 4. Finishing and curing: Comply with requirements as specified in Section 03_35_29 - Tooled Concrete Finishing except as modified here:
 - a. As soon as curb face forms are stripped, apply finishing mortar to the top and face of curb and trowel to a smooth, even finish. Finish with fine haired broom in direction of work.
 - b. Where curb is installed without integral gutter, extend finish 2 inches below grade.
 - c. Edge concrete at expansion joints to 1/4-inch radius.
 - d. Flow lines of gutters shall be troweled smooth 4 inches out from curb face for integral curb and gutter and 4 inches on both sides of flowline for gutters without curbs.
 - e. Sidewalks and ramps: Broom finish.
- E. Backfilling:
1. Unless otherwise specified, backfill behind curbs, gutters, or sidewalks with soil native to area and to lines and grades indicated on the Drawings.

3.04 FIELD QUALITY CONTROL

- A. Tests:
1. Curbs and gutters:
 - a. Test face, top, back, and flow line with 10-foot straightedge or curve template longitudinally along surface.
 - b. Correct deviations in excess of 1/4 inch.
 2. Gutters:
 - a. Frequency of testing: When required by the Construction Manager, where gutters have slope of 0.8 foot per 100 feet or less, or where unusual or special conditions cast doubt on capability of gutters to drain.
 - b. Test method: Establish flow in length of gutter to be tested by supplying water from hydrant, tank truck, or other source.
 - c. Required results:
 - 1) 1 hour after supply of water is shut off, inspect gutter for evidence of ponding or improper shape.
 - 2) In event water is found ponded in gutter to depth greater than 1/2 inch, or on adjacent asphalt pavement, correct defect or defects in manner acceptable to the Construction Manager without additional cost to the Contract.

3.05 ADJUSTING

- A. Repair portions of concrete damaged while stripping forms or, when damage is severe, replace such work at no additional cost to the Contract. Evidence of repairs shall not be noticeable in the finished product.
- B. Remove and replace sections of work deficient in depth or not conforming to requirements indicated on the Drawings and specified in the Specifications at no additional cost to the Contract. Removal and replacement shall be the complete section between 2 joints.

END OF SECTION

SECTION 32_17_23
PAVEMENT MARKINGS

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes: Pavement marking requirements for striping, text, and graphics; traffic signs.

1.02 SUBMITTALS

- A. Product data.
- B. Manufacturer's instructions.

1.03 QUALITY ASSURANCE

- A. Applicator qualifications: Minimum 5 years of experience of applying traffic markings with satisfactory performance record.
- B. Regulatory requirements: Comply with applicable requirements of governmental agencies having jurisdiction, including airborne emissions and industrial waste disposal requirements.

1.04 PROJECT CONDITIONS

- A. Apply pavement marking paint when:
 - 1. Pavement is clean and thoroughly dry.
 - 2. Ambient temperature is above 40 degrees Fahrenheit.
 - 3. Precipitation is not expected within 12 hours of completion of application.

PART 2 PRODUCTS

2.01 PAVEMENT MARKING PAINT

- A. Manufacturers: One of the following or equal:
 - 1. Dunn-Edwards Corp.
 - 2. Glidden Co.
 - 3. Sherwin Williams Co.
- B. Materials:
 - 1. Pavement marking paint, latex based: One of the following or equal:
 - a. Dunn-Edwards: No. W 801, Vin-L-Stripe, epoxy-modified acrylic-latex based paint.
 - b. Glidden: 63240 Series, UltraHide Latex Traffic Paint.
 - c. Sherwin Williams: Set fast acrylic water borne traffic marking paint.

2. Masonry conditioner: The following or equal:
 - a. Sherwin Williams: B46WZ1000, Masonry Conditioner.
3. Colors:
 - a. Text: White.
 - b. Parking dividers: White.
 - c. No parking zone markings: Yellow.
 - d. No parking curb: Red.
 - e. Handicap zone markings: Blue and white.
 - f. Accessible parking dividers and accessible route: Yellow.
 - g. Directional arrows: White.
 - h. Driving lane dividers: White.

2.02 TRAFFIC SIGNS

- A. Manufacturers: One of the following or equal:
 1. Seton Name Plate Co.
 2. Emedco.
- B. Material, shapes, and graphics: Post mounted baked enamel on steel sheet, reflectorized to show the same shape and color both day and night, with mounting holes, in accordance with the Uniform Traffic Control Devices manual. Fasten sign to post with stainless steel bolts.

PART 3 EXECUTION

3.01 PREPARATION

- A. Remove dirt, oil, grease, and other materials which may affect paint adhesion.
- B. Apply masonry conditioner on weathered or sandblasted surfaces, brick, or stucco.

3.02 APPLICATION

- A. Apply paint at package consistency whenever possible. Thin paint as little as possible.
- B. Apply paint with specifically designed and manufactured equipment for pavement marking. Provide:
 1. Uniform straight edges without overspray.
 2. 4-inch-wide lines, unless indicated otherwise.
 3. Hatching in handicap parking areas.
- C. Provide striping between parking stalls as indicated on the Drawings:
 1. Identify parking spaces with text as indicated on the Drawings:
 - a. Compact spaces: COMPACT.
 - b. Carpool spaces: CARPOOL.
 - c. Motorcycle spaces: MOTORCYCLE.
 - d. Visitor spaces: VISITOR.

- D. Apply paint to obtain thickness recommended by paint manufacturer.
- E. Paint traffic control markings, including striping, directional arrows, cross walks and lettering, and handicap striping and symbols as indicated on the Drawings and in accordance with local governing agency's standards. Use stencils for arrows, lettering, and symbols.
- F. Apply 700 square inch international handicap symbol on pavement surface where indicated on the Drawings:
 - 1. On asphalt surfaces, paint blue symbol on white square.
 - 2. On concrete surfaces, paint white symbol on blue square.
- G. Install traffic signs where indicated on the Drawings. Set post in concrete to depth to resist sign damage from wind speed of 100 miles per hour.

END OF SECTION

SECTION 32_31_00

FENCES AND GATES

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Fence, framework, fabric, and accessories.
 - 2. Excavation for post bases and concrete foundation for posts.
 - 3. Manual gates and related hardware.

1.02 REFERENCES

- A. ASTM International (ASTM):
 - 1. A121 - Standard Specification for Metallic-Coated Carbon Steel Barbed Wire.
 - 2. A123 - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
 - 3. A153 - Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
 - 4. A385 - Standard Practice for Providing High-Quality Zinc Coatings (Hot-Dip).
 - 5. A392 - Standard Specification for Zinc-Coated Steel Chain-Link Fence Fabric.
 - 6. A702 - Standard Specification for Steel Fence Posts and Assemblies, Hot-Wrought.
 - 7. F626 - Standard Specification for Fence Fittings.
 - 8. F668 - Standard Specification for Polyvinyl Chloride (PVC) and Other Organic Polymer-Coated Steel Chain-Link Fence Fabric.
 - 9. F1043 - Standard Specification for Strength and Protective Coatings on Steel Industrial Chain Link Fence Framework.
 - 10. F1184 - Standard Specification for Industrial and Commercial Horizontal Slide Gates.

1.03 SUBMITTALS

- A. Product data: Submit data completely describing products, including manufacturer's catalog cuts indicating material compliance and specified options. Manufacturer shall provide certification of compliance with material specifications. Actual samples of the material may be requested.
- B. Shop drawings:
 - 1. Manufacturer to include a list of all elements of fencing including but not limited to gate post foundations, gate posts, fence fabric, barb arms, barb wire, gates, and gate hardware. The shop drawings shall indicate all member sizes, wall thickness and gauges. Complete details of all components of the enclosure construction to include, but not be limited to:
 - a. Fence height, post spacing, dimensions.

- C. Quality control submittals:
 - 1. Certificates of compliance: Provide certification that materials conform to referenced specifications.
 - 2. Qualifications: Provide installer's references and list of local references.

1.04 QUALITY ASSURANCE

- A. Pre-installation conference: Participate in conference, if required.

1.05 DELIVERY, STORAGE, AND HANDLING

- A. Storage and handling: Unload, store, and protect materials such that they are not damaged.

1.06 PROJECT CONDITIONS

- A. Field measurements:
 - 1. Verify actual field distances so that post spacing can be made uniform.
 - 2. Verify and coordinate gate opening and column distances for driveway.

1.07 SEQUENCING AND SCHEDULING

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Chain link fence and gates: One of the following or equal:
 - 1. Allied Tube and Conduit.
 - 2. Master-Halco.
- B. Card reader pedestals: The following or equal:
 - 1. American Access Systems, Inc.

2.02 MATERIALS

- A. Chain link fence:
 - 1. Fabric:
 - a. Height:
 - 1) Fence: 7 feet 0 inch.
 - b. Mesh: 2 inches.
 - c. Size wire: 9 gauge:
 - 1) Coating: 1.2-ounce zinc coating, ASTM A392, Class 1.
 - 2) Tensile strength: 80,000 pounds per square inch minimum.

2. Edges shall be knuckled bottom and twisted top finished selvages.
Framework: Posts and rails shall be tubular round steel, self-draining shapes meeting strength requirement of ASTM F669, sizing per the post schedule below, and with 2-ounce zinc coating per square foot of surface area conforming to ASTM A123. The following steel post schedule shall be applied unless specified otherwise in the drawings:

Steel Post Schedule			
Post Use	Min. Outside Dimensions (Nominal)		
	Fabric less than 72 inches	Fabric 72-96 inches	Fabric Over 96 inches
Line Post - Tubular Round	1.90 inches O.D.	2.375 inches O.D.	2.875 inches O.D.
Corner, End and Pull - Tubular Round	2.375 inches O.D.	2.875 inches O.D.	4.00 inches O.D.
Bottom and Brace Rails - Tubular Round	1.66 inches O.D.	1.66 inches O.D.	1.66 inches O.D.

- a. Top rail:
 - 1) Size: 1-5/8 inches outside diameter.
- b. Bottom rail:
 - 1) Tension wire: 7-gauge galvanized coil spring wire.
3. Post Setting Concrete and Grout:
 - a. Class A concrete as specified in Section 03_30_00 - Cast in Place Concrete and non-shrink grout as specified in Section 03_60_00 - Grouting.
4. Accessories:
 - a. Outrigger:
 - 1) The top guard outrigger will face outward at a 45-degree angle increasing the height of the fence by a total of 12 inches, and will consist of 3 strands of barbed wire mounted on barb arms.
 - 2) Barbed wire strands shall be 12-gauge galvanized wires, 2 wires per strand, with 4-point galvanized barbs (at not more than 4 inches on center spacing).
 - 3) The barb arms shall be constructed of 12-gauge pressed steel or malleable iron hot-dip galvanized per ASTM A153. The barb arms shall be permanently affixed to the top of fence posts by riveting or welding.
 - 4) The outrigger shall be constructed to withstand a vertical load of not less than 250 pounds without sagging or bending.
 - 5) Barbed wire shall be stretched taut between barb arms in conformance with ASTM A121, Class I.
 - b. Fence fittings: In accordance with ASTM F626 and ASTM A153.
 - 1) Post top fittings:
 - a) Pressed steel or malleable iron, hot-dip galvanized.
 - b) Provide post caps that fit snugly over posts to exclude moisture. Provide dome style caps for terminal posts and loop style caps for line posts.
 - 2) Rail and brace ends: Provide pressed steel or malleable castings that are cup shaped to receive rail and brace ends.

- c. Fabric accessories:
 - 1) Wire clips: Minimum 6 gauge hot-dip galvanized.
 - 2) Tension bars: 1/4 inch by 3/4 inch, galvanized.
 - 3) Steel bands: 11-gauge, 1 inch wide, hot-dip galvanized.
 - 4) Bolts and nuts: 3/8-inch diameter.
 - 5) Hog rings: 11 gauge.
 - 6) Tie wires: 9-gauge minimum galvanized steel with 6 tie wires per post, evenly spaced.

B. Chain link gates:

- 1. Gate posts and concrete foundations for gate posts: Except where differently indicated on the Drawings, determine gate posts and concrete foundations for gate posts in accordance with following schedule:
 - a. Gate posts shall be galvanized in accordance with ASTM F1083-04 and shall conform to the requirements indicated on the Drawings.

Gate Leaf Widths (feet)	Gate Posts	Foundations		Weight (lb/ft)
	Post O.D. ASTM F1043 Group IA or IC (inches)	Diameter (inches)	Depth (feet)	
0 to 6	2-7/8	12	4	
Over 6 to 13	4	18	3	9.11
Over 13 to 18	6-5/8 (Group IA)	18	4	18.97
Over 18 to 25	8-5/8 (Group IA)	18	4.5	28.55

- 2. Chain link gate frames:
 - a. Assemble frames by welding for rigid connections, providing security against removal and breakage of connections.
 - 1) The gate size shall be as indicated on the Drawings. Frames and center supports: 1 7/8 inches outside diameter galvanized steel, Schedule 40 pipe that in accordance with ASTM F1043 Group IA or IC. All members shall be welded and cold galvanized after welding.
 - 2) Top and bottom rails: 2-inch standard weight pipe (O.D. = 2 3/8 inches, wall thickness = 0.154 inch, weight = 3.65 pounds per lineal foot).
 - 3) Vertical members: 1 1/2-inch standard weight pipe (O.D. = 1.90 inches, wall thickness = 0.140 inch, weight = 2.72 pounds per lineal foot).
 - 4) Diagonal members: 1 1/4-inch standard weight pipe (O.D. = 1.66 inches, wall thickness = 0.140 inch, weight = 2.27 pounds per lineal foot).
 - b. Install diagonal cross-bracing consisting of 3/8-inch diameter adjustable length truss rods to ensure frame rigidity without sag or twist on gate leaves wider than 6 feet.
- 3. Gate accessories:
 - a. Post top fittings:
 - 1) Same as described above for the chain link fence.
 - b. Corner fittings: Heavy pressed steel or malleable castings.

- c. Gate tensioning:
 - 1) Cross tensioning rods: 3/8 inch, galvanized. Pressed steel or malleable iron, hot-dip galvanized conforming to ASTM A153.
 - 2) Turnbuckles: Heavy duty.
 - 3) Tension bands: Pressed steel or malleable iron, hot-dip galvanized conforming to ASTM A153.
 - 4) Tension rods for 4-foot gates: 3/8 inch, easily adjustable, galvanized.
 - 5) Tension Wire: 7-gauge hardened spring steel wire galvanized.
 - a) Intermediate tension wire is required for gates ≥ 10 feet.
- d. Gate frame corner fittings: Fitting designed for purpose, Manufacturer's standard.
- e. Outriggers:
 - 1) Transition from outward facing 45-degree outrigger to vertical type outrigger at posts where gate and fence meet.
 - 2) Provide vertical type outriggers for all gates:
 - a) "L" shaped vertical barb arms, provide an additional 12 inches to fence height.
 - b) Vertical portion shall be 1 1/2-inch standard weight pipe (O.D. = 1.90 inches, wall thickness = 0.145 inch, weight = 2.72 pounds per lineal foot).
 - c) Horizontal portion shall be 1 1/4-inch standard pipe (O.D. = 1.66 inches, wall thickness = 0.149 inch, weight = 2.27 pounds per lineal foot).
 - 3) Barbed wire strands shall be 12-gauge galvanized wires, 2 wires per strand, with 4-point galvanized barbs (at not more than 4 inches on center spacing).
 - 4) The barb arms shall be constructed of 12-gauge pressed steel or malleable iron hot-dip galvanized per ASTM A153. The barb arms shall be permanently affixed to the top of fence posts by riveting or welding.
 - 5) Barbed Wire: Stretched taut between barb arms in conformance with ASTM A121, Class I.
 - 6) The outrigger shall be constructed to withstand a vertical load of not less than 250 pounds without sagging or bending.
 - 7) No barb arms on the counterbalance of gate.
- f. Horizontal gate stiffeners: 1 5/8-inch outside diameter galvanized steel pipe that in accordance with ASTM F1043 Group IA or IC.
- g. Fabric:
 - 1) Provide same fabric as for fence described previously. Install fabric with stretcher bars at vertical edges and at top and bottom edges for gate leaves wider than 6 feet. Attach stretcher bars to frame at 15 inches on center maximum.
 - 2) Only the opening portion of the gate is stretched with chain link fabric. The counterbalance slides behind the fence line and does not need fence fabric. It is designed for structural integrity only.
 - 3) Where needed add pickets or screening to match existing gates or fencing.

- h. Gate hardware: Provide hardware and accessories for each gate, galvanized per ASTM A153, and in accordance with the following:
 - 1) Hinges: Provide 1 1/2 pair of hinges for each leaf over 6-foot nominal height.
 - a) Non-lift-off type, size, and material to suit gate size.
 - b) Offset to permit 108-degree gate opening.
 - 2) Truck assemblies for Square aluminum frame.
- i. Catch and locking attachment: Combination steel or malleable iron catch and locking attachment of acceptable design.
- j. Latch at Paving: Provide Slide Series GL-100 type to permit operation from either side of gate.
 - 1) Padlock eye as integral part of latch.
- k. Stops:
 - 1) Type 1: Capable of holding gates open.
 - 2) Type 2: Center rest with catch.
- l. Square Aluminum gate Framework:
 - 1) Total number strands: 6.

2.03 FABRICATION

- A. Shop finishing:
 - 1. Galvanizing: For items not fabricated of galvanized materials hot-dip galvanize products after fabrication in accordance with following as applicable:
 - a. ASTM A123.
 - b. ASTM A153.
 - c. ASTM A385.
 - 2. Mark galvanized products with name of galvanize, applicable ASTM designation, and weight of zinc coating.
 - 3. Galvanize fabricated items complete, or in largest practicable sections.
 - 4. Provide galvanizing at rate of 2.0 ounces per square foot, minimum.
 - 5. Hardware:
 - a. Padlocks: Cadmium plated.
 - b. Chain: Galvanized.
- B. Finish schedule:
 - 1. Ferrous metal:
 - a. Typical: Clean, then hot-dip galvanize in accordance with galvanizing standards.
- C. Field finish touch-up painting:
 - 1. Galvanized repair paint: Apply paint having minimum dry film thickness of 2.0 to 3.5 mils.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Verification of conditions: Verify field conditions prior to construction.

3.02 PREPARATION

A. Surface preparation:

1. Before locating fence posts grade ground to permit grade of fence to remain constant over any local elevations or depressions in ground line.

3.03 INSTALLATION

A. Chain link fences and gates:

1. General:

- a. Gates shall be installed by a properly trained crew, skilled and experienced in erecting gates of this type in accordance with the Contract Documents and Design Drawings.
- b. Install chain link fence and gates as indicated on the Drawings and specified in this Section.
- c. Provide fence systems that are plumb, taut, true to line and grade, and complete in all details.
- d. Install fencing to generally follow finish grade of ground and provide pull posts at points where required to conform to change in grade.
- e. When general ground contour is to be followed, make changes in gradual, rolling manner.
- f. Install fencing such that space between bottom of fence and finish ground line does not exceed 4 inches.
- g. Weld gate frames and provide for free and easy operation. All welding shall be with E70 electrodes and shall consist of 3/16-inch fillet welds around the entire perimeter of connected member. The distance between the gates and gateposts shall not exceed 5 inches when the gate is closed.
- h. Gates and gate posts shall be grounded.
- i. Evenly space posts in line of fence a maximum of 10 feet center to center.
- j. Join bottom rail with 6-inch minimum couplings.

2. Concrete foundation for fence posts:

- a. Set fence posts in concrete foundations, that extend at least 3 feet into ground, and space posts not over 10 feet apart.
- b. Provide concrete foundations having minimum of 10 inches in diameter for line posts and 12 inches in diameter for corners and gates.
- c. Except for gate posts as described previously, set posts with concrete post foundations as specified below:
- d. Provide foundations that extend minimum of 1 inch above finish grade and have tops that are shaped to slope to drain away from posts. Concrete foundations shall be cured for at least 72 hours before further work is done on the post.
- e. Trowel finish tops of footings, and slope or dome to direct water away from posts.
- f. Set keepers, stops, sleeves, tracks, eye bolts, and other accessories into concrete as required.
- g. Wheel rolling area for sliding gates shall be steel-trowel smooth finish concrete.
- h. At mow strips, set top of post foundation below grade sufficient to allow for placing of mow strip. Measure post foundation depth from top of mow strip.

- i. Where fences are incorporated into slabs, measure post foundation depth from top of slab. Extend bottom of slab footing sufficient to allow specified amount of concrete around post. At existing slabs, install fence posts with sleeves as detailed.
 - j. For fences on retaining walls, provide 12-inch long sleeves to be cast into retaining wall. Set pipe in sleeve and grout space in between sleeve and post full.
 - k. Where posts are set in earth, concrete foundations 36 inches deep shall be provided. If bedrock is encountered, post excavation shall be continued to the 36-inch depth or 18 inches into the rock, whichever is less. Concrete foundation shall be circular in horizontal section, not less than 10 inches in diameter for line posts, and with a diameter not less than the post O.D. plus 10 inches for terminal and gate posts.
3. Post bracing:
- a. End corner, pull, and gate posts: Brace with same material as top rail and trussed to line posts with 3/8-inch rods and tighteners.
 - b. Bracing end, corner, slope, and gate posts:
 - 1) Brace to midpoint of nearest line post or posts with horizontal braces used as compression members.
 - 2) Then from such line posts truss from brace back to bottom of end, corner, slope, or gate post with 3/8-inch steel truss rods with turnbuckles or other suitable tightening devices used as tension members.
 - c. Brace and truss assemblies are required to counteract lateral forces. The vertical and diagonal brace posts shall be spaced as shown on the fencing typical details and welded into place.
4. Top rail:
- a. Unless otherwise specified or indicated on the Drawings, install fencing with top rail and bottom tension wire. Connect tension wires with tension band to corner terminal or pull posts.
5. Tension wire:
- a. Fasten at each end of the gate opening with tension bands and at each intermediate vertical member with a wire wrap.
 - b. Place on the same side as the chain link fabric between the brace posts and the chain link fabric.
 - c. Install as specified in RR-F-191/4.
6. Fabric:
- a. Place fabric on outward facing side of the posts and install so that top edge projects over top rail of fence. For rolling and slide gates, install so that fabric extends from mid-height of the bottom rail to mid-height of the top rail, so as not to interfere with the rollers.
 - b. Stretch fabric taut and securely fasten to posts, top rail, and bottom tension wire. Stretch fabric by attaching one end to terminal post and supplying sufficient tension to other end to stretch so slack is removed.
 - c. Install tension wire parallel to line of fabric.
 - d. Install fabric with tension bars at vertical edges of the chain link fabric.
 - 1) Attach tension bars to the vertical members with tension bands.
 - a) Place one band within 3 inches of the bottom rail and another within 3 inches of the top rail.

- b) Provide additional tension bands spaced approximately equal between the top and bottom bands.
 - c) Tension bands spacing shall not exceed 14 inches on center, 6 bands minimum.
 - e. Fabric: Connect fabric to:
 - 1) Line posts: Place one tie as close to bottom of fabric as is possible with additional ties equally spaced between top and bottom band on approximately equal spacing not to exceed 14 inches on center, 6 ties minimum.
 - 2) Terminal, corner, and gate posts with tension bars tied to posts minimum 14 inches on center and with steel bands and bolts and nuts.
 - 3) Bottom rail: tie wires at no more than 24 inches on center.
 - 4) Tension wires with hog rings minimum 18 inches on center.
 - 5) Intermediate vertical and diagonal members: 6 tie wires minimum per member.
- 7. Gates:
 - a. Weld gate frames and provide for free and easy operation.
 - b. Provide gate latching devices with padlocking capabilities.
 - c. Align top bar of gates with tension wire of fence.
 - d. Gates shall be plumb and on the same plane as fence, both vertically and horizontally.
 - e. Gates must reach within 5 inches of paved surface and must be designed to prevent lifting to any greater height.
 - f. Where gates extend over other than paved surface the fabric must come within 2 inches of grade.
 - g. Set gate stops and other catches in concrete.
- B. Swing gates:
 - 1. Provide gates with 2 leaves at each gate location.
 - 2. Hang gates by at least 2 hinges.
- C. Weld Galvanizing:
 - 1. All welds shall be coated with cold galvanizing compound after welding in accordance with ASTM A780.
- D. Gate Hardware:
 - 1. All fence bolted hardware with threaded ends shall be on the interior fence side to prevent tampering.
 - 2. Tack weld all U-bolts to the gate post to keep them from turning.

3.04 FIELD QUALITY CONTROL

- A. Fence Fabric Deflection Test:
 - 1. All panels shall be capable of withstanding a 50-pound force applied to the fabric at mid-height of the gate and at the center of the gate frame members.
 - 2. The force shall be applied to "pull" the fabric and then "push" the fabric.

3. After exercising the fabric, a 30-pound “pull” force shall be applied at the same point. The “pulling action shall be toward the post side of the fence.
 - a. Deflection shall not exceed 1-1/4 inches from the “at-rest” position.
 4. The number of fabric panels to be tested will be determined by City of Thornton.
- B. Post Rigidity Test:
1. All posts shall withstand a 50-pound force to the post at a height of 5 feet above the ground from the base of the post.
 - a. Deflection shall not exceed 3/4 inch.
 - 1) Posts that exceed 3/4-inch deflection shall be removed and a new post installed.
 2. The number of posts to be tested will be determined by City of Thornton.

3.05 ADJUSTING

- A. Adjust gate travel, stops, and operator position to meet field conditions.

3.06 CLEANING

- A. Clean up surplus dirt, concrete, and other waste material and dress grade up upon completion of the work.
- B. Spread dirt/rock from foundation excavations evenly around surrounding area unless otherwise directed. Leave area free of excess dribbles of concrete, pieces of wire, and other scrap materials.

3.07 PROTECTION

- A. Protect installed fences and gates against damage and, if damaged, repair prior to final acceptance.

END OF SECTION

SECTION 32_92_19

SEEDING

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Guidelines for Noxious Weed Management Plan.
 - 2. Guidelines for native upland seed grassland and shrubland restoration areas.
 - 3. Guidelines for native riparian seed restoration areas.
 - 4. Installation, Maintenance, Acceptance, and preferred mixes.

1.02 SUBMITTALS

- A. Noxious weed management plan.
- B. Test Reports: Results of seed purity and germination tests.
- C. Certificates: Manufacturer's certification that materials meet specification requirements.
- D. Supplier's or manufacturer's signed statement certifying that the seed furnished is from a lot that has been tested by recognized laboratory for seed testing within 6 months prior to the date of delivery.
 - 1. Subject to the testing provisions of the Association of Official Seed Analysis.

1.03 GENERAL REQUIREMENTS

- A. Take all practical precautions to minimize disturbances to streams, vegetation, trees, and crop lands. Wherever practical, existing trees and vegetated areas should be undisturbed. Additionally, where possible, blading and grubbing of woody vegetation in areas of temporary disturbance should be minimized. If necessary, woody vegetation should be pruned to ground level without removing the root mass so that it may grow back following construction. Unnecessary removal of trees or shrubs should be avoided (e.g., the aerial portions of trees and shrubs should be pruned only if they hang over the work limits and interfere with equipment).

1.04 NOXIOUS WEED MANAGEMENT PLAN

- A. Noxious weeds within the work limits will be controlled using the following Integrated Pest Management (IPM) methods as described by the Colorado Department of Agriculture (CDOA). The following methods have been developed to control noxious weeds in a manner that prevents harm to human health and to environmentally sensitive areas such as waterways and desirable vegetation including native trees.
 - 1. Major equipment (e.g., truck equipment and backhoes) will be cleaned by high-pressure air or water spray before being delivered to the Project area to avoid introducing undesirable plants and noxious weeds. Proof of cleaning must be provided to Larimer County Planning Department or their representative.
 - 2. If practicable, topsoil should not be salvaged in any area densely infested with noxious weeds. See the SWPS parcel specific Restoration Plan that has been prepared by the Owner's ecologist for more details.
 - 3. For areas where removal is not practicable or only a small area of noxious weeds is present, pre-treat all noxious weed populations in the topsoil.
 - 4. After construction is complete, all disturbed areas will be properly revegetated as quickly as possible. Prompt revegetation with appropriate species is essential for preventing the spread of noxious weeds.
 - 5. Certified weed-free seed and mulch will be used for revegetation. Weed-free straw bales will be used for sediment barriers.
 - 6. If stands of noxious weeds become established, weed control would be implemented following an integrated approach specific to the weed species present.
 - 7. Because new control methods are continually being developed, particularly for herbicide applications, any control methods used will follow the CDOA and Larimer County recommendations at the time of implementation.

1.05 REQUIREMENTS – NATIVE UPLAND SEED RESTORATION AREAS

- A. Before any work is started in native seed areas, scrape the top 12 inches of topsoil in the area with a front-end loader and stockpile the topsoil for later use in restoring site conditions. Segregate native topsoil from other topsoil stockpiles. See the SWPS parcel specific Restoration Plan that has been prepared by the Owner's ecologist for more details.
- B. Seed bed preparation:
 - 1. After Owner approval of weed eradication (herbicide application as appropriate), the seedbed shall be ripped (plow, chisel, disc/harrow) and worked to minimum 12-inch depth, and all rocks greater than 3 inches, debris, and large roots would be removed. This can be accomplished by disking, ripping, plowing, and rototilling, made more effective by ripping in two directions perpendicular to each other. On steeper slopes, a track hoe with a ripper tooth can be used to decompact soil to the proper depth.
 - 2. Seedbed shall be smooth and free of large clumps, fluffy yet firm, moist but not wet. When walking across the bed, a shoe imprint in the soil should not be deeper than 1 inch. Owner will approve results of seedbed preparation before addition of soil amendment and may approve a "no till" seed bed preparation.
 - 3. Replace 12 inches of stockpiled native area topsoil.
 - 4. Take representative soil samples.

5. Soil Amendment: Submit representative soil tests to Owner before ordering amendment. Soil amendment shall be based on soil test recommendations. See the SWPS parcel specific Restoration Plan that has been prepared by the Owner's ecologist for more details. Submit all load tickets and seed tags.
6. Preparing the seedbed should be timed with planting dates to conserve soil moisture and prevent wind and water erosion. Seeding, soil preparation, blanketing, or mulching shall not occur when the soil is wet, snow covered, or frozen. Seed shall be applied at the specified rates within a week of topsoil placement. If a rain event occurs that compacts or erodes the seedbed prior to performing seeding, the seedbed shall be re-prepared. Seeding data shall include a timeline that incorporates control of weed emergence and growth, including after incorporation of amendment to the bed. Provide amended weed free seeding bed for Owner approval by April 15, to incorporate a final weed kill. Dryland seeding of non-irrigated warm and cool season grasses should occur between December 1 and May 1. If seeding occurs outside this timeframe, an alternative maintenance plan must be approved by the Owner.
7. After amending topsoil, till the soil to 6 inches, leaving no clod greater than 3 inches in diameter.

C. Planting:

1. A site survey shall be provided showing finished grades installed as designed, prior to seeding operations.
 - a. Slopes of 3:1 or steeper shall be covered with biodegradable erosion control blankets.
 - b. Coir mats shall be installed along the toe of slope using wooden stakes.
 - c. Prior to seeding, the project will be inspected for appropriate weed control, tilled/ripping of compacted areas, proper mixing of amendments, the finish rake for proper height at hard surfaces (walks, valve boxes, heads), hi/low areas, debris removal, etc.
 - d. Before planting, Owner will approve results of incorporation of amendment into seedbed.
2. Provide the seed mix for Owner approval. Seed tags, certified copy of seed analysis and load tickets for soil amendment are required. Seed which has become wet, moldy, or otherwise damaged in transit or storage, will not be acceptable.
3. Drill seeding would be applied to native seed zones with dry soils and slopes less than 4:1. Drill seeding should occur to 1/2 inch deep. Native grass drills should also be equipped with Coulter wheels, adjustable depth bands, and drill row spacing of 7 inches or less. Drilling the seed in two directions perpendicular to one another would improve coverage and establishment. If seeded in only one direction, drilling will follow the contour to reduce a tendency for drilling down furrows. Partial broadcasting with some of the seed prior to or during drilling operations can also improve results, especially for finer-seeded species.
4. For broadcast seeding instead of the drill seeding method, the specified application rate should be doubled. Refer to the appropriate native seed mixes below for species and application rates.
5. See the SWPS parcel specific Restoration Plan that has been prepared by the Owner's ecologist for details on where the upland grassland native seed mix, upland shrubland native seed mix, and upland woody container species for planting in upland shrubland areas shall be used.

D. Upland Grassland Native Restoration Seed Mix:

Scientific Name	Common Name	Lbs/ac (PLS)	Variety
Graminoids			
Achnatherum hymenoides	Indian ricegrass	2.00	Paloma
Andropogon hallii	Sand bluestem	2.00	CO Ecotype
Bouteloua curtipendifolia	Sideoats grama	2.50	Vaughn
Bouteloua gracilis	Blue grama	1.00	Hachita
Buchloe dactyloides	Buffalograss	4.00	Bowie
Elymus trachycaulus	Slender wheatgrass	2.00	San Luis
Hesperostipa comata ssp. comata	Needle and thread grass	2.00	CO Ecotype
Hilaria jamesii	Galleta grass	2.00	Viva
Nassella viridula	Green needle grass	3.50	Cucharas
Panicum virgatum	Switchgrass	0.75	Blackwell
Pascopyrum smithii	Western wheatgrass	7.00	Arriba
Schizachyrium scoparium	Little bluestem	1.00	Cimarron
Sporobolus cryptandrus	Sand dropseed	0.1	CO Ecotype
Forbs and Shrubs			
Artemisia ludoviciana	Prairie sage	0.02	CO Ecotype
Dalea purpurea	Purple prairie clover	0.30	CO Ecotype
Ericameria nauseosa	Rubber rabbitbrush	0.15	
Galliardia aristata	Blanket flower	1.00	CO Ecotype
Heterotheca villosa	Hairy goldenaster	0.15	CO Ecotype
Liatris punctata	Dotted gayfeather	0.70	CO Ecotype
Linum lewisii	Lewis flax	0.75	CO Ecotype
Ratibida columnifera	Prairie coneflower	0.20	CO Ecotype
Rhus aromatica	Aromatic sumac	3.00	CO Ecotype
Ribes cereum	Wax current	0.15	CO Ecotype
Rosa woodsii	Wood's rose	1.00	CO Ecotype
Sphaeralcea coccinea	Scarlet globemallow	0.15	CO Ecotype
Yucca glauca	Soapweed yucca	2.00	CO Ecotype
Total PLS Pounds/Acre		37.42	
Notes:			
Lbs/ac - pounds per acre; PLS - pure live seed (if broadcasting, double the rate).			

E. Upland Shrubland Native Restoration Seed Mix:

Scientific Name	Common Name	Lbs/ac (PLS)	Variety
Graminoids			
Achnatherum hymenoides	Indian ricegrass	3.00	Paloma
Andropogon hallii	Sand bluestem	2.00	CO Ecotype
Bouteloua curtipendifolia	Sideoats grama	3.00	Vaughn
Bouteloua gracilis	Blue grama	1.00	Hachita
Buchloe dactyloides	Buffalograss	5.00	Bowie
Elymus trachycaulus	Slender wheatgrass	2.00	San Luis
Hesperostipa comata ssp. comata	Needle and thread grass	0.00	CO Ecotype
Hilaria jamesii	Galleta grass	2.00	Viva

Nassella viridula	Green needle grass	4.00	Cucharas
Panicum virgatum	Switchgrass	1.00	Blackwell
Pascopyrum smithii	Western wheatgrass	6.00	Arriba
Schizachyrium scoparium	Little bluestem	1.50	Cimarron
Sporobolus cryptandrus	Sand dropseed	0.1	CO Ecotype
Forbs and Shrubs			
Artemisia frigida	Prairie sagewort	0.01	CO Ecotype
Artemisia ludoviciana	Prairie sage	0.01	CO Ecotype
Dalea purpurea	Purple prairie clover	0.25	CO Ecotype
Ericameria nauseosa	Rubber rabbitbrush	0.15	
Galliardia aristata	Blanket flower	1.00	CO Ecotype
Heterotheca villosa	Hairy goldenaster	0.20	CO Ecotype
Liatris punctata	Dotted gayfeather	0.25	CO Ecotype
Linum lewisii	Lewis flax	0.50	CO Ecotype
Ratibida columnifera	Prairie coneflower	0.10	CO Ecotype
Rhus aromatica	Aromatic sumac	3.00	CO Ecotype
Ribes cereum	Wax current	0.20	CO Ecotype
Rosa woodsii	Wood's rose	1.30	CO Ecotype
Sphaeralcea coccinea	Scarlet globemallow	0.15	CO Ecotype
Yucca glauca	Soapweed yucca	2.00	CO Ecotype
Total PLS Pounds/Acre		39.72	
<u>Notes:</u>			
Lbs/ac - pounds per acre; PLS - pure live seed (if broadcasting, double the rate).			

F. Upland Woody Container Species for Planting in Upland Shrubland Areas

Scientific Name	Common Name	Quantity
Artemisia frigida	Fringed sagebrush	20
Ericameria nauseosa	Rubber rabbitbrush	30
Heterotheca villosa	Hairy goldenaster	20
Rhus trilobata	Three-leaf sumac	10
Ribes cereum	Wax currant	10
Rosa woodsia	Woods' rose	10
Yucca glauca	Soapweed yucca	30

G. Acceptance Criteria for seeded area:

1. Mitigation would be considered successful and self-sustaining when the following conditions have been met:
 - a. The areas will be considered established when 70 percent vegetative cover is reached.
 - b. The restoration areas have less than 10 percent of state-listed noxious weed cover.
 - c. No bare spots larger than 1 foot square and no rill or erosion concerns are observed.
2. The construction contractor's state stormwater discharge permit shall not be closed until 70 percent vegetation cover of pre-construction condition is achieved and Larimer County Community Development staff have deemed the landscape restoration complete.

1.06 REQUIREMENTS – NATIVE RIPARIAN SEED RESTORATION AREAS

- A. Before any work is started in native seed areas, scrape the top 12 inches of topsoil in the area with a front-end loader and stockpile the topsoil for later use in restoring site conditions. Segregate native topsoil from other topsoil stockpiles. See the SWPS parcel specific Restoration Plan that has been prepared by the Owner's ecologist for more details.
- B. Seed bed preparation:
 - 1. After Owner approval of weed eradication (herbicide application as appropriate), the seedbed shall be ripped (plow, chisel, disc/harrow) and worked to minimum 12-inch depth, and all rocks greater than 3 inches, debris, and large roots would be removed. This can be accomplished by disking, ripping, plowing, and rototilling, made more effective by ripping in two directions perpendicular to each other. On steeper slopes, a track hoe with a ripper tooth can be used to decompact soil to the proper depth.
 - 2. Seedbed shall be smooth and free of large clumps, fluffy yet firm, moist but not wet. When walking across the bed, a shoe imprint in the soil should not be deeper than 1 inch. Owner will approve results of seedbed preparation before addition of soil amendment and may approve a "no till" seed bed preparation.
 - 3. Replace 12 inches of stockpiled native area topsoil.
 - 4. Take representative soil samples.
 - 5. Soil Amendment: Submit representative soil tests to Owner before ordering amendment. Soil amendment shall be based on soil test recommendations. See the SWPS parcel specific Restoration Plan that has been prepared by the Owner's ecologist for more details. Submit all load tickets and seed tags.
 - 6. Preparing the seedbed should be timed with planting dates to conserve soil moisture and prevent wind and water erosion. Seeding, soil preparation, blanketing, or mulching shall not occur when the soil is wet, snow covered, or frozen. Seed shall be applied at the specified rates within a week of topsoil placement. If a rain event occurs that compacts or erodes the seedbed prior to performing seeding, the seedbed shall be re-prepared. Seeding data shall include a timeline that incorporates control of weed emergence and growth, including after incorporation of amendment to the bed. Provide amended weed free seeding bed for Owner approval by April 15, to incorporate a final weed kill. Dryland seeding of non-irrigated warm and cool season grasses should occur between December 1 and May 1. If seeding occurs outside this timeframe, an alternative maintenance plan must be approved by the Owner.
 - 7. After amending topsoil, till the soil to 6 inches, leaving no clod greater than 3 inches in diameter.
- C. Planting:
 - 1. A site survey shall be provided showing finished grades installed as designed, prior to seeding operations.
 - a. Slopes of 3:1 or steeper shall be covered with biodegradable erosion control blankets.
 - b. Coir mats shall be installed along the toe of slope using wooden stakes.

- c. Prior to seeding, the project will be inspected for appropriate weed control, tilled/ripping of compacted areas, proper mixing of amendments, the finish rake for proper height at hard surfaces (walks, valve boxes, heads), hi/low areas, debris removal, etc.
 - d. Before planting, Owner will approve results of incorporation of amendment into seedbed.
2. Provide the seed mix for Owner approval. Seed tags, certified copy of seed analysis and load tickets for soil amendment are required. Seed which has become wet, moldy, or otherwise damaged in transit or storage, will not be acceptable.
 3. Drill seeding would be applied to native seed zones with dry soils and slopes less than 4:1. Drill seeding should occur to 1/2 inch deep. Native grass drills should also be equipped with Coulter wheels, adjustable depth bands, and drill row spacing of 7 inches or less. Drilling the seed in two directions perpendicular to one another would improve coverage and establishment. If seeded in only one direction, drilling will follow the contour to reduce a tendency for drilling down furrows. Partial broadcasting with some of the seed prior to or during drilling operations can also improve results, especially for finer-seeded species.
 4. For broadcast seeding instead of the drill seeding method, the specified application rate should be doubled. Refer to the appropriate native seed mixes below for species, percentages, and application rates.
 5. See the SWPS parcel specific Restoration Plan that has been prepared by the Owner's ecologist for details on where the riparian native seed mix, and riparian woody container species for planting in riparian forested areas shall be used.

D. Riparian Native Restoration Seed Mix:

Scientific Name	Common Name	Lbs/ac (PLS)	Variety
Graminoids			
<i>Achnatherum hymenoides</i>	Indian ricegrass	1.50	Rimrock
<i>Bouteloua gracilis</i>	Blue grama	0.30	Hachita
<i>Calamovilfa longifolia</i>	Prairie sandreed	0.75	Goshen
<i>Distichlis spicata</i>	Inland saltgrass	0.30	CO Ecotype
<i>Elymus canadensis</i>	Canada wildrye	2.50	Mandan
<i>Elymus trachycaulus</i>	Slender wheatgrass	2.00	San Luis
<i>Hordeum jubatum</i>	Foxtail barley	0.05	CO Ecotype
<i>Juncus arcticus</i>	Mountain rush	0.01	CO Ecotype
<i>Muhlenbergia asperifolia</i>	Alkali muhly	0.1	CO Ecotype
<i>Nassella viridula</i>	Green needle grass	2.00	Cucharas
<i>Panicum virgatum</i>	Switchgrass	2.00	Blackwell
<i>Pascopyrum smithii</i>	Western wheatgrass	4.00	Arriba
<i>Schizachyrium scoparium</i>	Little bluestem	1.00	CO Ecotype
<i>Sorghastrum nutans</i>	Indiangrass	1.00	Holt
<i>Spartina pectinata</i>	Prairie cordgrass	2.00	Red River
<i>Sporobolus cryptandrus</i>	Sand dropseed	0.10	CO Ecotype

Forbs and Shrubs			
Achillea millefolium var. occidentalis	Western yarrow	0.03	CO Ecotype
Artemisia ludoviciana	Prairie sage	0.02	CO Ecotype
Asclepias speciosa	Showy milkweed	2.00	CO Ecotype
Coreopsis tinctoria	Plains Coreopsis	0.08	CO Ecotype
Ericameria nauseosa	Rubber rabbitbrush	0.15	CO Ecotype
Galliardia aristata	Blanket flower	0.75	CO Ecotype
Heliomeris multiflora	Showy goldeneye	0.10	CO Ecotype
Monarda fistulosa	Wild bergamot	0.05	CO Ecotype
Rhus aromatica	Aromatic sumac	3.00	CO Ecotype
Ribes cereum	Wax current	0.15	CO Ecotype
Rosa woodsii	Wood's rose	1.30	CO Ecotype
Total PLS Pounds/Acre		22.79	
Notes:			
Lbs/ac - pounds per acre; PLS - pure live seed (if broadcasting, double the rate).			

E. Riparian Woody Container Species for Planting in Riparian Forested Areas

Scientific Name	Common Name	Quantity
Ericameria nauseosa	Rubber rabbitbrush	15
Rhus trilobata	Three-leaf sumac	15
Ribes cereum	Wax currant	20
Yucca glauca	Soapweed yucca	20

F. Acceptance Criteria for seeded area:

1. Mitigation would be considered successful and self-sustaining when the following conditions have been met:
 - a. The areas will be considered established when 70 percent vegetative cover is reached.
 - b. The restoration areas have less than 10 percent of state-listed noxious weed cover.
 - c. No bare spots larger than 1 foot square and no rill or erosion concerns are observed.
2. The construction contractor's state stormwater discharge permit shall not be closed until 70 percent vegetation cover of pre-construction condition is achieved and Larimer County Community Development staff have deemed the landscape restoration complete.

1.07 WARRANTY

- A. Guarantee that restoration areas are alive, healthy, and meet acceptance criteria for a minimum of 1 year after Initial Acceptance.
- B. Replace seeding in restoration areas when it is no longer in a satisfactory condition or does not meet the preceding standard as determined by the Construction Manager for the duration of the Warranty Period.
 - 1. Make replacements as soon as possible within the recommended seeding schedule.
 - 2. Repairs and replacements shall be made at no expense to the Owner.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION (NOT USED)

END OF SECTION

SECTION 33_05_01.01

WELDED STEEL PIPE AND FITTINGS

PART 1 GENERAL

1.01 REFERENCES

- A. The following is a list of standards which may be referenced in this section:
1. American Society of Mechanical Engineers (ASME):
 - a. B16.9 - Factory-Made Wrought Buttwelding Fittings.
 - b. B36.10M - Welded and Seamless Wrought Steel Pipe.
 - c. BPVC SEC VIII, Div. 1, Rules for Construction of Pressure Vessels.
 - d. BPVC SEC IX, Welding and Brazing Qualifications.
 2. American Society for Nondestructive Testing Inc. (ASNT):
 - a. SNT-TC-1A - Recommended Practice for Personnel Qualification and Certification in Nondestructive Testing.
 3. American Water Works Association (AWWA):
 - a. C200 - Steel Water Pipe - 6 Inches (150 mm) and Larger.
 - b. C205 - Cement-Mortar Protective Lining and Coating for Steel Water Pipe - 4 Inches (100 mm) and Larger - Shop Applied.
 - c. C206 - Field Welding of Steel Water Pipe.
 - d. C207 - Steel Pipe Flanges for Waterworks Service - Sizes 4 Inches Through 144 Inches (100 mm through 3,600 mm).
 - e. C208 - Dimensions for Fabricated Steel Water Pipe Fittings.
 - f. C602 - Cement-Mortar Lining of Water Pipelines in Place - 4 Inches (100 mm) and Larger.
 - g. M11 - Steel Pipe - A Guide for Design and Installation.
 4. American Welding Society (AWS):
 - a. A2.4 - Standard Symbols for Welding, Brazing, and Nondestructive Examination.
 - b. A3.0M/A3.0 - Standard Welding Terms and Definitions Including Terms for Adhesive Bonding, Brazing, Soldering, Thermal Cutting, and Thermal Spraying.
 - c. D1.1/D1.1M - Structural Welding Code - Steel.
 - d. QC 1 - Standard for AWS Certification of Welding Inspectors.
 5. ASTM International (ASTM):
 - a. A20/A20M - Standard Specification for General Requirements for Steel Plates for Pressure Vessels.
 - b. A53/A53M - Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless.
 - c. A106/A106M - Standard Specification for Seamless Carbon Steel Pipe for High-Temperature Service.
 - d. A234/A234M - Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service.
 - e. A370 - Standard Test Methods and Definitions for Mechanical Testing of Steel Products.

- f. A435/A435M - Standard Specification for Straight-Beam Ultrasonic Examination of Steel Plates.
- g. A516/A516M - Standard Specification for Pressure Vessel Plates, Carbon Steel, for Moderate- and Lower-Temperature Service.
- h. A770/A770M - Standard Specification for Through-Thickness Tension Testing of Steel Plates for Special Applications.
- i. A1018/A1018M - Standard Specification for Steel, Sheet and Strip, Heavy-Thickness Coils, Hot-Rolled, Carbon, Commercial, Drawing, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, and Ultra-High Strength.
- j. E329 - Standard Specification for Agencies Engaged in Construction Inspection, Testing, or Special Inspection.
- k. E1255 - Standard Practice for Radioscopy.
- 6. International Organization for Standardization (ISO): 9001:2000, Quality Management Systems - Requirements.
- 7. Lloyd's Registry.
- 8. NSF International (NSF): 61 - Drinking Water System Components - Health Effects.
- 9. Steel Pipe Fabricators Association (SFPA).

1.02 DEFINITIONS

- A. Fittings: Including, but not limited to fittings, closure pieces, bends, reducers, tees, wyes, bifurcations, crosses, outlets, manifolds, nozzles, wall sleeves, bulkheads, and other piping and appurtenances fabricated from steel plate, sheet, or coils as required to provide the Work, complete. Fittings shall include piping above ground or inside structures.
- B. Acronyms:
 - 1. CJP: Complete Joint Penetration.
 - 2. CWI: Certified Welding Inspector.
 - 3. MT: Magnetic Particle Testing.
 - 4. NDE: Nondestructive Examination.
 - 5. NDT: Nondestructive Testing.
 - 6. PJP: Partial Joint Penetration.
 - 7. PQR: Procedure Qualification Record.
 - 8. PT: Liquid Penetrant Testing.
 - 9. RT: Radiographic Testing.
 - 10. UT: Ultrasonic Testing.
 - 11. VT: Visual Testing.
 - 12. WPQ: Welder/Welding Operator Performance Qualification.
 - 13. WPS: Welding Procedure Specification.

1.03 DESIGN REQUIREMENTS

- A. Fittings:
 - 1. Design reinforcement, unless otherwise shown.
 - 2. Design in accordance with AWWA M11, AWWA C200, and AWWA C208 as modified herein, and this specification.

B. Pipe Layout:

1. Design in accordance with AWWA M11:

a. General:

- 1) Base stationing and elevation convention as indicated on the Drawings.
- 2) Maximum Laying Lengths:
 - a) Not limited, unless specifically indicated on the Drawings.
 - b) Select lengths to accommodate installation operation.

b. Include, as minimum:

- 1) Specific number, location, and direction of each pipe, joint, and fitting. Number each pipe in installation sequence.
- 2) Station and centerline elevation at changes in grade or horizontal alignment.
- 3) Station and centerline elevation to which bell end of each pipe will be laid.
- 4) Elements of curves and bends, both in horizontal and vertical alignment.
- 5) Location of mitered pipe sections, beveled ends for alignment conformance, butt straps, and deep bell lap joints for temperature stress control.
- 6) Location of closures, cutoff sections for length adjustment, temporary access manways, vents, and weld lead outlets for construction convenience.
 - a) Provide for adjustment in pipe laying headings and to conform to indicated stationing.
 - b) Changes in location or number will require Engineer approval.
- 7) Location of bulkheads, both those shown and as required, for hydrostatic testing of pipeline.

C. Welding Procedure Specification (WPS):

1. Qualified by testing in accordance with ASME BPVC SEC IX for shop welds and AWS D1.1/D1.1M for field welds.
2. PQRs conducted on unlisted base metal (most coil products are unlisted base metals) to be production welded as required in the referenced welding Code shall be traceable to heat lots.
3. Written WPS required for welds, both shop and field.
4. Notch-tough welding procedures that require heat input control shall be required:
 - a. AWS D1.1/D1.1M prequalified welding procedures are not allowed.
 - b. WPS used to shop fabricate pipe shall be qualified in accordance with ASME BPVC SEC IX and shall include Supplementary Essential Variables.
 - c. WPS used to field install pipe shall be qualified for heat input control in accordance with AWS D1.1/D1.1M.
 - d. PQRs shall be qualified for notch tough welding with consideration for thickness of steel, test temperature, and Charpy V-notch CVN values. Refer to AWS D1.1/D1.1M, Table 4.6 PQR Supplementary Essential Variable Changes for CVN Testing Applications Requiring WPS Requalification for SMAW, SAW, GMAW, FCAW, and GTAW and Section 4, Part D Requirements for CVN Testing, Option A (three

specimens). CVN test temperature and acceptance shall be same as pipe base metal specified herein.

- D. Stulling (Strutting): Design for pipe and fittings such that over-deflection and damage is avoided during handling, storage, and installation, including backfill and compaction.

1.04 SUBMITTALS

A. Action submittals:

1. Shop drawings showing pipe layout.
2. Material list and steel reinforcement schedules for materials specified.
3. Fabrication information:
 - a. Pipe and fitting details for temporary and permanent facilities indicating:
 - 1) Cylinder thickness.
 - 2) Manufacturing tolerances.
 - 3) Maximum angular deflection limitations of field joints.
 - 4) Closure sections and cutoffs for field length adjustment.
 - 5) Bulkheads, including details for removal of test bulkheads and repair of lining.
 - 6) Weld lead outlets and plugs.
 - 7) Stulling size, spacing, and layout.
 - b. Welded joint details including:
 - 1) Butt joints.
 - 2) Miter-cut ends for alignment conformance.
 - 3) Lap joints.
 - 4) Special thermal control joints required for control of temperature stresses.
 - 5) Butt strap joints.
4. Welding data (shop and field welding):
 - a. Show on a weld map, complete information regarding base metal specification designation location, type, size, and extent of welds with reference called out for WPS and NDE numbers in tail of welding symbol.
 - b. Distinguish between shop and field welds.
 - c. Indicate, by welding symbols or sketches, details of welded joints and preparation of base metal. Provide complete joint welding details showing bevels, groove angles, and root openings for all welds.
 - d. Welding and NDE symbols shall be in accordance with AWS A2.4.
 - e. Welding terms and definitions shall be in accordance with AWS A3.0M/A3.0.
 - f. Submit welding data together with Shop Drawings as a complete package.
5. Product data for the following:
 - a. Welded steel pipe and fittings:
 - 1) Mill certificates, including chemical and physical test reports showing data consistent with specified requirements for each heat of steel proposed for use.

B. Informational submittals:

1. Certificates:
 - a. Manufacturer's Certificate of Compliance.
 - b. Lining Materials: Certificate that lining system is currently approved for potable water contact in accordance with NSF 61 and satisfies current applicable governmental health and safety requirements for use in potable water.
2. Pipe Manufacturer's written Quality Assurance/Control Plan.
3. Statements of qualification:
 - a. Pipe manufacturer.
 - b. Fittings fabricator.
 - c. Contractor's Shop Inspector.
 - d. Contractor's Field Inspector.
 - e. NDT Quality Control Personnel.
4. Procedures:
 - a. Shop and field welding information; at a minimum include complete welding code paper trail with linkage to Shop Drawings.
 - b. Welder Qualifications and Welding Procedure Specifications as specified below:
 - 1) Provide complete joint dimensions and details showing bevels, groove angles, root face, and root openings for all welds.
 - 2) Notch-tough welding procedures required. For shop welding, address supplementary essential variables in addition to essential variables as indicated in ASME Section IX, QW-251.2. For field welding, heat-input, control PQR essential variables as indicated in AWS D1.1/ D1.1M, Table 4.6 shall be included. For shop and field welding, provide heat-input table on WPSs for welder guidance.
 - 3) PQRs for notch-tough welding shall document heat- input control by monitoring volts, amps, and travel speed or time-rate of change of weld metal volume as calculated by measuring change in electrode length over a period of time. Charpy V-notch tests shall be conducted on weld metal and heat affected zone. Test coupons shall be oriented transverse to final direction of rolling. Full size Charpy specimen test acceptance shall be same as base metal specified herein.
 - 4) Written NDT procedures.
 - 5) Written description of proposed sequencing of events or special techniques such as:
 - a) Controlling pipe wall temperature stress during installation.
 - b) Minimizing distortion of steel.
 - c) Shop-Applied Cement-Mortar Lining: Include description of machine to be used and list of similar projects where machine was used. Identify pipe size and total footage.
 - d) Monitoring pipeline temperatures during installation.
 - e) Written weld repair procedures for the Work.
 - f) Field coating application and repair.
 - g) Field lining application and repair.
5. Reports:
 - a. Source Quality Control Test Reports:
 - 1) Nondestructive weld testing.
 - 2) Steel impact testing using Charpy V-notch method.

- 3) Letter from independent testing agency certifying pipe shipped meets requirements of this specification.
- b. Field Quality Control Test Reports:
 - 1) Weld tests, including re-examination of repaired welds, on each weld joint for the following tests, as applicable:
 - a) RT.
 - b) UT.
 - c. Cement-mortar lining compressive strength tests in accordance with AWWA C205.
6. Field Testing Plan: Submit at least 15 days prior to testing and include following information at a minimum:
 - a. Testing dates.
 - b. Piping system and sections to be tested.
 - c. Method of isolation.
 - d. Method of conveying water from source to system being tested.
 - e. Calculation of maximum allowable leakage for piping sections to be tested.
7. Design calculations prepared by a licensed professional engineer for fittings, including opening reinforcement details of collars, increased cylinder thickness, crotch plates; and harnessed joint assemblies.
8. Temperature Stress Control Plan: Submit at least 45 days prior to installing pipe and include at least the following information:
 - a. Step by step installation procedures and sequencing to demonstrate compliance with temperature control requirements, including:
 - 1) Pipe installation.
 - 2) Joint welding of standard joints and temperature control joints.
 - 3) Pipe bedding and backfill.
 - b. Methods to ensure compliance with procedures by installation personnel.
 - c. Equipment to be used to monitor pipe wall temperature.
 - d. Time of day, climatic, or seasonal installation limits to be used to achieve compliance with temperature control requirements.
9. Pipe manufacturer's certification of training of Contractor's pipe installation crews.

1.05 QUALITY ASSURANCE

- A. Qualifications:
 1. Pipe manufacturer:
 - a. Experienced in fabricating pipe of similar diameters, lengths, and wall thickness required for the Work.
 - b. Steel Pipe Fabricators Association (SPFA), Lloyd's Registry Certification, or ISO 9001:2000 Certification.
 - c. Demonstrate current production capability for volume of work required for Project.
 - d. Experience shall include successful fabrication to AWWA C200 standards of at least 25,000 linear feet of 36-inch diameter or larger pipe, with wall thickness of 0.2 inches or greater, within past 5-year period.
 - e. Experience shall be applicable to fabrication plant facilities and personnel, not company or corporation that currently owns fabrication facility or employs personnel.

2. Fittings fabricator:
 - a. Experienced in fabricating fittings of similar diameters and wall thickness required for the Work.
 - b. Steel Pipe Fabricators Association (SPFA), Lloyd's Registry Certification, or ISO 9001:2000 Certification.
 - c. Demonstrate current production capability for volume of work required for this Project.
 - d. Experience shall include successful fabrication to AWWA C200 and AWWA C208 standards of at least 25 fittings of 36-inch or larger pipe, with wall thickness 0.2 inch or greater, within past 5-year period.
 3. Welders and welding operators:
 - a. Shop Welders: In accordance with ASME BPVC SEC IX.
 - b. Field Welders: In accordance with AWS D1.1/D1.1M.
 4. Contractor's inspector for shop and field welding:
 - a. In accordance with AWS QC 1, with knowledge of welding code for the Work.
 - b. After receiving CWI qualification, at least one Shop CWI and one Field CWI shall have 5 years' minimum professional experience related to welding inspection similar to the Work. Other CWIs may work under the supervision of 5-year CWI, provided they have 1 year of related professional experience after receiving CWI qualification.
 5. NDT quality control personnel:
 - a. In accordance with requirements of ASNT SNT-TC-1A, NDT Level II.
 - b. After receiving NDT qualification, at least one NDT person shall have 5 years minimum professional experience related to NDT inspection similar to the Work. Other NDT personnel may work under the supervision of 5-year NDT, provided they have 1 year of related professional experience after receiving NDT qualification.
- B. Contractor's shop inspector:
1. In accordance with AWWA C200.
 2. Responsibilities:
 - a. Verify conformance to use of specified materials and their proper storage.
 - b. Monitor conformance to approved WPS.
 - c. Monitor conformance to approved NDT procedure specifications.
 - d. Monitor conformance of WPQ.
 - e. Provide 100 percent visual inspection before, during, and after shop welding.
 - f. Coordinate NDT work and review test results.
 - g. Maintain records and prepare report confirming results of inspection and testing.
- C. Contractor's field inspector:
1. In accordance with AWWA C206 and AWS D1.1/D1.1M.
 2. Responsibilities:
 - a. Verify conformance to use of specified materials and their proper storage.
 - b. Monitor conformance to approved WPS.
 - c. Monitor conformance to approved NDT procedure specifications.
 - d. Monitor conformance of WPQ.
 - e. Provide 100 percent VT before, during, and after field welding.

- f. Coordinate NDT work and review test results.
 - g. Maintain records and prepare report confirming results of inspection and testing.
- D. Prefabrication meeting:
 - 1. Hold prior to fabrication of pipe and fittings between representatives of the Owner, Construction Manager, Contractor, Engineer, and pipe fabricator to review following:
 - a. Project scope.
 - b. Submittal requirements.
 - c. Testing.
 - d. Inspection responsibilities.
 - e. Shop welding requirements.
 - f. Field welding requirements.
 - g. Shop and field coating and lining requirements.
 - h. Production and delivery schedule.
 - i. Other issues pertinent to the Work.
- E. Inspection of Coating and Lining Application: Qualified manufacturer's technical representative shall visit pipe coating and lining shop and Site at beginning of application process to verify proper workmanship associated with coating and lining application and as may be required to resolve shop or field problems. Submit written report of visit to Engineer.
- F. Warranties:
 - 1. Provide warranty as specified in Section 01_78_36 - Warranties and Bonds.
 - 2. Special Warranty:
 - a. Pipe will be free from defects in materials and workmanship for a period of 1 year from the date of Substantial Completion of this Contract.
 - b. Repair or replace with parts manufactured by the manufacture of the original component.
 - c. Repair or replace work found to be defective, at the sole option of, and not at cost to, the Owner.
 - d. Such repair or replacement shall include removal and reinstallation, inspection, and acceptance testing.

1.06 DELIVERY, HANDLING, AND STORAGE

- A. Pipe marking:
 - 1. Legibly mark installation sequence number on pipe and fittings in accordance with piping layout. Standard pipe sections do not need sequence number labeled provided wall thickness is clearly marked.
 - 2. Fittings shall be marked at each end with notation "TOP FIELD CENTERLINE".
 - 3. The word "TOP" shall be painted or marked on outside top spigot of each fitting.
 - 4. Mark "TOP MATCH POINT" for compound bends per AWWA C208 so end rotations can be easily oriented in field.

- B. Delivery:
 - 1. Securely bulkhead or otherwise seal ends of pipe and fittings prior to loading at manufacturing site.
 - 2. Pipe ends shall remain sealed until installation.
 - 3. Damage to pipe and fittings, including linings and coatings, found upon delivery to Site shall be repaired to Engineer's satisfaction or removed from Site and replaced.
- C. Storage:
 - 1. Support pipe securely to prevent accidental rolling and to avoid contact with mud, water, or other deleterious materials.
 - 2. Support on sand or earth berms free of rock exceeding 3 inches in diameter.
- D. Acceptance at Site: Contractor shall inspect all deliveries for acceptance of material on site.

1.07 SEQUENCING AND SCHEDULING

- A. Notify Engineer in writing of the following:
 - 1. Pipe manufacturing: Not less than 14 days prior to starting.
 - 2. Not less than 5 days prior to start of each of the following:
 - a. Welding.
 - b. Coating application. Lining application.
 - c. Shop hydrostatic testing.

PART 2 PRODUCTS

2.01 GENERAL

- A. Pipe manufacturer:
 - 1. Manufactures: The following or equal:
 - a. Northwest Pipe.
 - b. American Spiral Weld Pipe Co., LLC.
 - c. Thompson Pipe Group.
 - 2. Pipe and fabricated fittings shall be responsibility of one main Supplier.
 - 3. If pipe and fabricated fittings are manufactured by separate Suppliers, one main Supplier shall be responsible for formally managing other Supplier. The one main Supplier is responsible for coordination and management of production of all pipe and fittings work of both Suppliers, including, but not limited to:
 - a. Qualifications.
 - b. Submittals.
 - c. Dimensional consistency between pipe and fittings.
 - d. Fabrication.
 - e. Quality assurance.
 - f. Quality control.
 - g. Reporting.
 - h. Shop lining.
 - i. Shop coating.
 - j. Shop testing.

- k. Field services.
 - l. Delivery schedule.
 - m. Warranties or guarantees.
- B. Pipe size:
 - 1. Unless shown otherwise for pipe over 30 inches in diameter, diameter shown shall be considered finished inside diameter after lining.
 - 2. For pipe 30 inches in diameter and less, diameter shown shall be per ASME B36.10M.
- C. Steel pipe and fittings shall be manufactured, tested, inspected, and marked to comply with AWWA C200 and additional requirements of these Contract Documents.
- D. Materials furnished shall be NSF 61 approved for use with potable water.

2.02 FABRICATION

- A. Shop fabricate steel piping fittings and specials in units as long as practicable for safe hauling and installation.
 - 1. No field fabrication will be allowed, unless approved by Engineer.
 - 2. Do not exceed 50 feet for pipe lengths.
- B. Fabricate fittings and specials to uniform lengths with proper end clearance for the specified types of joint or attachment.
- C. Flanges.
 - 1. Do not weld flanges to nozzles until the nozzles and reinforcements are completely welded to the header.
 - 2. Accurately space and align flanges so that when connections have been made there will be no stress on the header, piping, or equipment.
- D. Identification marks: Stenciled or otherwise shown at the top of the piping items exterior, and include the following information:
 - 1. As specified in Section 01_60_01 - Product Requirements.
 - 2. Date of manufacture of the item.
 - 3. Name or trademark of the manufacturer.
 - 4. Internal diameter in inches.
 - 5. Number of the item, sequential from initial to end station.
 - 6. NSF approval, if applicable for potable water service.

2.03 PIPE BARREL

- A. Steel: Provide steel coils for spiral welded steel pipe or steel plate for straight seam welded steel pipe per AWWA C200 and as follows:
 - 1. Specified Minimum Yield Strength: 42,000 psi.
 - 2. Specified Minimum Tensile Strength: 53,000 psi.
 - 3. Steel modulus of elasticity (E): 30×10^6 psi.
 - 4. Cement mortar modulus of elasticity: 4×10^6 psi.
 - 5. Unit weight of fill (W): 125 pounds per cubic foot.
 - 6. Live Load: AASHTO HS-20, all locations.

7. Trench Depth: As indicated on the Drawings.
8. Deflection Lag Factor (DL): 1.5.
9. Coefficient K: 0.10.
10. Maximum allowable calculated deflection: 3 percent for cement mortar lined and flexible coated pipe.
11. Minimum Elongation in 2-inch Gauge Length: 21 percent.
12. Design Temperature: 40 degrees Fahrenheit (F).
13. Soil Reaction Modulus (E'): 1,000 psi (0-5 feet of bury depth) 1,400 psi (>5 feet of bury depth).
14. Design Pressure: As indicated on the Drawings.
15. Test Pressure: As indicated on the Drawings.
16. Steel Quality as follows:
 - a. Coils:
 - 1) Continuous cast process, fully-killed, fine grained practice conforming to physical, manufacturing and testing requirements of ASTM A1018/A1018M.
 - 2) SS Grade 36, Type 1.
 - 3) Continuous cast process, fully-killed, fine grained practice conforming to physical, manufacturing and testing requirements of ASTM A1018/A1018M, HSLAS Grade 50, Class 2 (modified). Measured yield strength shall not exceed 85 percent of measured tensile strength.
 - b. Plate:
 - 1) Fully-killed, conforming to ASTM A20/A20M, fine grained practice conforming to physical, manufacturing and testing requirements of ASTM A516/A516M, Grade 70.
 - 2) Steel Chemistry: Conform to ASTM A516/A516M, Grade 70. Steel plates that are 3/4-inch thick or greater shall be normalized.
 - c. Toughness:
 - 1) Charpy V-notch Acceptance Criteria: Transverse specimen orientation, full size specimens, 25 foot-pounds energy at test temperature of 30 degrees F.
 - 2) Frequency: See Paragraph Steel Toughness Testing for Thickness Equal to or Greater than 7/16 Inches.
17. Minimum nominal wall thickness as indicated on the Drawings. Maximum allowable thickness variation for plate, sheet, or coil shall be 0.010 inch less than ordered thickness.

2.04 FITTINGS

- A. Fabrication:
 1. Shop fabricate. No field fabrication will be allowed, unless approved by Engineer.
 2. Fabricate from materials or straight pipe in conformance with specified requirements and dimensions of AWWA C208, unless otherwise indicated.
- B. Crotch plate: Fabricate from fully-killed, fine grain, pressure vessel steel conforming to ASTM A516/A516M, Grade 70, and as follows:
 1. Plates shall be normalized.
 2. Perform through-thickness tension testing of plates in accordance with ASTM A770/A770M.

3. Charpy V-notch tests in direction transverse to final rolling shall be performed per ASTM A370 on full size specimens of coupons taken from each plate. Acceptance shall be 25 foot-pounds at 30 degrees F.

C. Wall thickness:

1. General:
 - a. Refer to ASME B36.10M for definitions of wall thickness for standard weight pipe and nominal pipe size (NPS).
 - b. Reinforce to withstand either internal pressures, both circumferential and longitudinal, or external loading conditions, whichever is greater.
 - c. Minimum plate thickness: The greater of adjacent mainline pipe, thickness shown, thickness calculated as hereinafter specified, or as shown in Table 1.

Table 1		
Nominal Pipe Diameter (inches)	Pipe Manifolds Piping Above Ground Piping in Structures	Bends Reducers
24 and Under	Standard Weight	Standard Weight
Over 24	Adjacent Pipe Thickness	Adjacent Pipe Thickness

D. Bends, unless otherwise indicated:

1. Minimum Radius: 2.5 times pipe diameter or as indicated on the Drawings.
2. Minimum Bend Wall Thickness: Greater of Table 1 above or, if radius is less than 2.5 times pipe diameter, as calculated using equation in Chapter 7 of AWWA M11.
3. Maximum Miter Angle: 11-1/4 degrees on each section resulting in a maximum deflection angle of 22.5 degrees per miter weld as recommended in AWWA C208.
4. Bevels: Vary bevels on miters to provide a constant weld groove angle. For 11-1/4-degree miter, (22.5-degree miter weld) bevels must vary from 18.75 degrees on OD of bend to 41.25 degrees on ID of bend to provide a constant 60-degree groove angle for CJP welding.
5. Complete joint penetration (CJP) welds on miter welds.

E. Outlets:

1. 24 Inches and Smaller: Fabricate from ASTM A53/A53M, Type E or S, Grade B, standard weight steel pipe.
2. Larger than 24 Inches: Fabricate from ASTM A106/A106M, Grade B, standard weight pipe.
3. Fabricate collar reinforcement using same steel as specified for main pipe barrel.

F. Steel butt-weld fittings:

1. 24 Inches and Smaller: In accordance with ASME B16.9 conforming to ASTM A234/A234M.
2. Standard weight.

3. Taper pipe wall at welds at 4:1 for connection to pipe of different wall thickness.
4. Coordinate difference in diameter convention between fittings and AWWA C200 and AWWA C208 pipe and fittings to provide complete piping system as shown.

2.05 JOINTS

- A. Shop welded:
 1. Fabricate in accordance with AWWA C200 as modified herein.
 2. Complete joint penetration (CJP) butt joints shall be used for longitudinal, girth, and spiral welds, unless otherwise indicated.
 3. Lengths of pipe shall not be shop-joined using lap joints.
- B. Preparation of joints for field welding:
 1. Butt joint welded:
 - a. Plain ends beveled as required by AWWA C200 and Contractor's field WPS.
 - b. Provide protection for factory beveled pipe ends so ends are not damaged during transport.
 2. Lap joint welded:
 - a. Single fillet lap joints in preparation for field welding shall be in accordance with AWWA C200.
 - b. Double welded lap joints and butt-strap joints shall be tapped and drilled for testing in accordance with AWWA C206.
- C. Miter-end cuts:
 1. Lap joints:
 - a. As indicated on the Drawings.
 - b. Moderate deflections and long radius curves may be made using miter-end cuts.
 - c. Use only with lap welded joints, unless specifically approved in writing by Engineer.
 - d. Maximum Total Allowable Angle: 5 degrees per pipe joint.
 - e. Provide miter-cut that is cold expanded square with face of miter-cut on bell ends only.
 - f. Mitering of spigot ends will not be permitted.
 2. Welded butt joints:
 - a. Maximum Total Allowable Angle: 2.5 degrees per pipe joint.
 - b. Minimum Pipe Wall Thickness: 3/8 inch.
 - c. Welded Butt joints shall be CJP.
- D. Special Temperature control joint:
 1. Temperature control joints will not be required for pipe installed using weld after backfill.
 2. Provide a special longer bell end (Special Temperature Control Joint) at a maximum spacing as indicated herein to account for movement on installed pipe as a result of temperature changes. The longer bell end lap shall be 4-inch minimum or as recommended by the manufacturer.

3. Location:
 - a. At intervals not exceeding 300 feet along welded reaches of the pipeline.
 - b. The first regular lap-welded joint outside each concrete encasement or structure.
 - c. Where special temperature control joints occur in a travelled roadway or other inconvenient location, the location of the joint may be relocated to a more convenient location.

2.06 FLANGES

- A. In accordance with AWWA C207:
 1. Up to 150 psi working pressure: Class D steel ring flange in accordance with AWWA C207 compatible with ANSI Class 125 and 150 bolt circles.
 2. Up to 275 psi working pressure: Class E steel ring flange in accordance with AWWA C207 compatible with ANSI Class 125 and 150 bolt circles.
 3. Up to 300 psi working pressure: Class F steel ring flange in accordance with AWWA C207 compatible with ANSI Class 250 and 300 bolt circles.

2.07 STULLING (STRUTTING)

- A. Materials:
 1. Shop-Lined Pipe: Wood stulls and wedges.
 2. Unlined Pipe: Steel or wood.
- B. Install stulling for pipe and fittings in accordance with approved submittal and as soon as practical after pipe is fabricated or, for shop-lined pipe, after lining has been applied.
- C. Install stulling in manner that will not harm lining.

2.08 COATING

- A. General:
 1. See Division 9 for technical coating requirements.
 2. Notify Engineer at least 3 days prior to application of coating products.
 3. Holdback of and coating from field-welded shall be as determined by designer for coating system specified.
 4. Unless otherwise indicated, coat exterior surfaces of pipe and fittings passing through structure walls from center of wall or from wall flange to end of underground portion.
 5. 54-inch pipe and above shall be lined with the same material as the coating.
- B. Shop-applied:
 1. As determined by Engineer for requirements of coating specified.

2.09 CEMENT-MORTAR LINING

- A. General:
 - 1. Notify Engineer at least 3 days prior to application of lining products.
 - 2. Holdback of lining from field-welded joints shall be as follows:
 - a. For lap-welded joints and flex couplings, 8 inches.
 - b. For butt-weld and butt-strap joints, 6 inches.
- B. Shop-applied:
 - 1. Applied centrifugally in conformance with AWWA C205. Thickness shall be in accordance with AWWA C205.
 - 2. Lining machine type that has been used successfully for similar work and approved by Engineer.
 - 3. Maintain pipe in round condition during lining operation and thereafter by suitable bracing or strutting.
 - 4. Provide polyethylene or other suitable bulkhead on ends of pipe and on special openings to prevent drying out of lining. Bulkheads shall be substantial enough to remain intact during shipping and storage until pipe is installed.
 - 5. Pipe shall be left bare where field joints occur.
 - 6. Ends of lining shall be left square and uniform. Feathered or uneven edges will not be permitted.
- C. Field-applied:
 - 1. Materials conforming to AWWA C602.
 - 2. Do not use pozzolanic material in mortar mix.
 - 3. Admixtures shall contain no calcium chloride.
 - 4. Wire mesh conforming to AWWA C205.

2.10 CATHODIC PROTECTION

- A. Provide as shown and as specified in applicable specification.

2.11 SOURCE QUALITY CONTROL

- A. Steel toughness testing for thickness equal to or greater than 7/16 inches:
 - 1. Include three impact specimens; conduct test in direction transverse to final direction of the coil rolling.
 - 2. Coils:
 - a. Conduct Charpy Testing per ASTM A370 on an initial coil of each heat to establish uniformity of steel.
 - b. Take test coupons from an initial coil of each heat at locations of outer and inner wrap of coil.
 - c. For each coil that fails to meet acceptance criteria, conduct Charpy Testing on next two coils in that heat.
 - d. Do not use coils that do not qualify in production of pipe.
 - 3. Plate:
 - a. Conduct Charpy Tests on each plate in accordance with ASTM A20/A20M.
 - b. Conduct on full-size (10 mm by 10 mm) specimens from each plate in accordance with ASTM A20/A20M.
 - c. Do not use plates that do not qualify in production of pipe.

- B. Crotch plate:
 - 1. Perform through-thickness tension testing with acceptance criteria per Article 5 of ASTM A770/A770M on each plate.
 - 2. Conduct straight-beam ultrasonic examination with acceptance criteria per Article 6 of ASTM A435/A435M on each plate.
 - 3. Plates that do not qualify shall not be used.
- C. Shop Hydrostatic Pressure Test: In accordance with AWWA C200 Section 5.2, except as follows:
 - 1. General: Hydrostatically test 100 percent of straight pipe prior to application of lining or coating and prior to fabrication of fittings.
 - 2. Pipe: Maintain test pressure for minimum of 2 minutes.
 - 3. Fittings:
 - a. Except as otherwise specified herein, no additional shop hydrostatic test will be required on fittings fabricated from successfully tested straight pipe.
 - b. Test with crotch plates, regardless of whether or not straight pipe sections used were previously tested.
 - c. Test Pressure: Design Pressure of fitting.
 - d. Maintain test pressure for a length of time as required to perform a visual inspection of welds.
 - e. No leakage is allowed.
- D. Joints, lap-welded:
 - 1. Fit test minimum of 5 joints, selected by Engineer, of each pipe size used:
 - a. Join pipe ends with proposed adjacent pipe end.
 - b. Match-mark pipe ends.
 - c. Record Actual Annular Space:
 - 1) Maximum space at a point.
 - 2) Minimum space at a point.
 - 3) Space at 90-degree intervals; top, bottom, and spring line on both sides.
- E. Shop nondestructive testing:
 - 1. Welds on straight pipe and fittings: Visually examine 100 percent of welds by Contractor's Shop Inspector to criteria in ASME BPVC SEC VIII, Division 1.
 - 2. CJP welds on fittings: Perform radiographic or radioscopy spot examination of welds in accordance with ASME BPVC SEC VIII, Division 1, Paragraph UW-52 or perform ultrasonic examination of 100 percent of welds in accordance with either ASME BPVC SEC VIII, Div. 1, paragraph UW-53 or API5L Annex E as outlined in AWWA C200.
 - 3. Fillet Welds: 100 percent examine using magnetic particle inspection method in accordance with ASME BPVC SEC VIII, Division 1, Appendix 6.

PART 3 EXECUTION

3.01 INSTALLATION

A. General:

1. Joints and related work for field assembly of fittings shall conform to requirements for straight pipe, unless otherwise shown.
2. Inspect pipe and fittings before installation. Clean ends thoroughly, remove foreign matter and dirt from inside.
3. Make minor field adjustments by pulling standard joints.
 - a. Maximum Allowable Angle: 75 percent of manufacturer's recommended or angle which results from 3/4-inch pull out from normal joint closure, whichever is less.
 - b. Maximum Allowable Gap: 1/8 inch between bell and spigot at weld location.
4. Horizontal deflections or fabricated angles shall fall on alignment, as shown within tolerances below.
5. Vertical deflections shall fall on alignment, and pipe angle point locations shall match those indicated on the Drawings within tolerances below.
6. For field-welded joints, pipe 30 Inches in Diameter and Larger:
 - a. Ensure maximum penetration of spigot end into bell end is achieved through use of shop-welded tabs on inside circumference of bell end or by use of a paint stripe.
 - b. If welded metal tabs are used, remove tabs prior to welding inside of joint.
7. Stulling:
 - a. Maintain stulling in place until pipe is completely backfilled and compacted.
 - b. Reinstall stulls that were temporarily removed to facilitate interior welding prior to backfilling.
8. Pipeline alignment tolerances:
 - a. Plan: 3 inches.
 - b. Elevation: 3 inches.

B. Control of temperature stresses:

1. In accordance with AWWA C206, approved Temperature Stress Control Plan submittal, and this specification.
2. To control temperature stresses, shade unbackfilled special temperature control joint area of pipe from direct rays of sun by use of properly supported awnings, umbrellas, tarpaulins or other suitable materials until pipe is backfilled at least 1 foot over top of pipe. The special temperature control joint area is defined as the entire length of pipe left exposed. Shading materials shall not rest directly on pipe, but shall be supported to allow air circulation around pipe. Shading of special temperature control joints is not required when ambient air temperature is below 50 degrees F.
3. Locate special temperature control joints at 300-foot intervals.
4. Install special temperature control joints as indicated on the Drawings.

5. Design, furnish and install a pipeline temperature monitoring system consisting of thermocouple temperature gauges to monitor temperature of steel pipe wall in trench. Gauges shall be located at top inside surface of pipe at intervals not exceeding 50 feet. Handheld portable temperature sensor devices may be used, provided temperature readings are taken at top of pipe at a frequency and spacing that demonstrates compliance with temperature control requirements.
6. Temperature control requirements:
 - a. Prior to and during placement of pipe backfill, pipeline steel temperature shall be at or below 90 degrees F. Monitor specified temperature and control for at least 3 hours after placement of pipe backfill. Provide supplemental cooling as required.
 - b. Place pipe backfill from a single heading starting at one special temperature control joint and proceed toward next special temperature control joint.
 - c. During period of pipe backfill placement, pipeline section that is partially backfilled shall be shaded as indicated in above. Temperature of partially backfilled pipe shall not be allowed to exceed 110 degrees F. Provide supplemental cooling as required.
 - d. Prior to welding special temperature control joints, pipeline extending 300 feet each direction from joint shall be maintained at or below 85 degrees F. Additionally, pipeline extending 300 feet each direction from joint shall be backfilled to at least 1 foot over top of pipe. Weld special temperature control joint at specified temperature of 90 degrees or below. Begin and complete weld during coolest time interval of the 24-hour day. Use pipeline temperature monitoring system data to demonstrate to Engineer coolest interval of the day. After field welding of special temperature control joint, pipe temperature for 150 feet in each direction shall be maintained below 110 degrees F for a minimum of 24 hours after special temperature control joint area has been backfilled to at least 1 foot over top of pipe.

3.02 WELDING

- A. Perform welding only in presence of Contractor's Field Inspector.
- B. Conform to AWS D1.1/D1.1M, AWWA C206, approved welding procedures, and referenced welding codes. In case of conflict AWS D1.1/D1.1M shall govern.
- C. Preheat and Interpass temperature requirements for unlisted base metals shall be determined according to AWS D1.1/D1.1M, Annex XI Guideline on Alternative Methods for Determining Preheat.
- D. Rejectable weld defects shall be repaired or redone, and retested until sound weld metal has been deposited in accordance with appropriate welding codes.

3.03 REPAIR OF SHOP-APPLIED COATINGS

- A. Exterior surfaces of steel pipe and fittings shall be inspected upon delivery to Site and just prior to backfilling trench.
- B. Repair of coating: Field repairs shall be made in accordance with requirements of coating system specified.

3.04 COATING OF FIELD-WELDED JOINTS

- A. As required for coating system specified.

3.05 FIELD-APPLIED CEMENT-MORTAR LINING

- A. General:
 - 1. Except for requirements specified in this section, lining of steel pipe shall be in accordance with AWWA C602.
 - 2. After joints are welded, tested, and coated, and bedding and backfill have been placed, begin cleaning and lining operation with approval of Engineer.
 - a. Access for cleaning and lining operations shall be at pipe access manholes or pipe ends. No cutting of openings in pipe will be allowed, unless approved in writing by Engineer.
 - b. Upon approval by Engineer, openings may be cut into pipe in order to gain entry for placing lining. Repair of openings, welding, repair of coatings, and backfilling shall conform to other portions of these Specifications.
 - 3. Internal cleaning:
 - a. Prior to placing lining, pipe shall be thoroughly cleaned of foreign matter, including water.
 - b. Cleaning may be by hand or mechanical method that is approved by Engineer.
 - c. Waste materials and water from cleaning operations shall not be passed through sections of existing pipe or pipe that has already been lined.
 - d. No pipe shall be lined until inspected and approved by Engineer.
 - 4. Protection of appurtenances:
 - a. Prevent mortar from being thrown into pipe openings in accordance with AWWA C602.
 - b. Outlet openings shall be trimmed, smoothed, and beveled.
 - c. Damaged or defective areas shall be repaired to satisfaction of Engineer.

3.06 CEMENT-MORTAR LINING APPLICATION AT JOINTS

- A. Cement-mortar lining: For pipe with shop-applied cement-mortar lining, place lining at joints in accordance with AWWA C205.

3.07 CATHODIC PROTECTION

- A. Apply to pipe as shown and as specified in applicable specification.

3.08 FIELD QUALITY CONTROL

A. Field welding:

1. All welds, 100 percent inspection, shall be VT inspected by Contractor's Field Inspector and marked to indicate acceptance or rejection.
2. Test butt-strap or double-welded lap joint welds by pressurizing connection between the two fillet welds in accordance with AWWA C206.
 - a. Apply air or other Engineer-approved gas into connection between the two fillet welds.
 - b. Paint welds with soap solution.
 - c. Mark leaks indicated by escaping gas bubbles.
 - d. Close threaded openings with flush pipe plugs or by welding them.
3. CJP welds:
 - a. Inspect 10 percent of butt joint welds with full circumference RT.
 - b. Inspect 10 percent of other groove welds with UT.
4. Inspect 10 percent of lap joint welds with PT or MT
5. Weld acceptance:
 - a. If, in the opinion of Engineer, inspections indicate inadequate quality of welds, percentage of welds inspected shall be increased.
 - b. Welds to be inspected, if less than 100 percent rate, shall be selected at random by Engineer.
 - c. VT: Perform VT per AWS D1.1/D1.1M Paragraph 6.9, Visual Inspection, Statically Loaded Nontubular Connections.
 - d. UT: Perform UT of CJP groove welds in accordance with AWS D1.1/D1.1M, Paragraph 6.13.1.
 - e. RT: Perform RT of CJP butt joint welds in accordance with AWS D1.1/D1.1M, Paragraph 6.12.1.
 - f. PT or MT:
 - 1) Perform on fillet and PJP groove welds in accordance with AWS D1.1/D1.1M, Paragraph 6.10.
 - 2) Acceptance shall be in accordance with VT standards specified above.
 - g. Remove in manner that permits proper and complete repair by welding.
 - h. Caulking or peening of defective welds is not permitted.
 - i. Retest unsatisfactory welds.
6. Verification acceptance: Owner may conduct random nondestructive inspections of field-welded joints. Inspections will be of an appropriate type for weld being evaluated. Possible types of inspection include, but are not limited to, RT, UT, PT, and VT. Testing will be performed and evaluated per AWS D1.1/D1.1M. Provide access to the Work to the Owner's Verification Inspector.

B. Hydrostatic testing:

1. Pipeline:
 - a. General:
 - 1) Notify Engineer in writing 5 days prior to testing. Perform testing in presence of Engineer.
 - 2) Test newly installed pipelines. Using water as test medium, pipes shall successfully pass a leakage test prior to acceptance.

- 3) Furnish testing equipment and perform tests in manner satisfactory to Engineer. Testing equipment shall provide observable and accurate measurements of make-up water under specified conditions.
 - 4) Isolate new pipelines that are connected to existing pipelines.
 - 5) Conduct field hydrostatic test on buried piping after trench has been completely backfilled. Testing may, as approved by Engineer, be done prior to placement of asphaltic concrete or roadway structural section.
 - 6) Contractor may, if field conditions permit and as determined by Engineer, partially backfill trench and leave joints open for inspection and conduct an initial service leak test. Final field hydrostatic test shall not, however, be conducted until backfilling has been completed as specified above.
 - 7) Supply of temporary water shall be determined by the Contractor.
 - 8) Dispose of water used in testing in accordance with federal, state, and local requirements.
- b. Procedure:
- 1) Maximum filling velocity shall not exceed 0.25 foot per second, calculated based on the full area of pipe.
 - 2) Expel air from pipe system during filling. Expel air through air release valve or through corporation stop installed at high points and other strategic points.
 - 3) Test Pressure: 125 percent of system operating pressure based on pressure as measured at lowest point in a given test section.
 - 4) Apply and maintain specified test pressure with hydraulic force pump. Valve off piping system when test pressure is reached.
 - 5) Maintain hydrostatic test pressure continuously for 2 hours minimum, adding additional make-up water only as necessary to restore test pressure.
 - 6) Determine actual make-up water by measuring quantity of water necessary to maintain specified test pressure for duration of test.
 - 7) If measured make-up water exceeds allowable or if leaks are visible, repair defective pipe section and repeat hydrostatic test.
- c. Allowable make-up water:
- 1) For pipe with welded joints, no make-up water is allowed.

3.09 MANUFACTURER'S SERVICES

- A. Manufacturer's representative available at Site for installation assistance and training of pipe installation crews.
1. Coordinate pipe manufacturer's representative services.
 2. Pipe manufacturer's representative shall visit Site and instruct, guide, and provide procedures for pipe handling, laying, and jointing at start of pipe installation by each crew.

END OF SECTION

SECTION 40_05_00.01

COMMON WORK RESULTS FOR GENERAL PIPING

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:

1. Basic materials and methods for metallic and plastic piping systems.

1.02 REFERENCES

A. American Society of Mechanical Engineers (ASME):

1. B1.1 - Unified Inch Screw Threads (UN, UNR, and UNJ Thread Forms).
2. B18.2.1 - Square, Hex, Heavy Hex, and Askew Head Bolts and Hex, Heavy Hex, Hex Flange, Lobed Head, and Lag Screws (Inch Series).
3. B18.2.2 - Nuts for General Applications: Machine Screw Nuts; and Hex, Square, Hex Flange, and Coupling Nuts (Inch Series).
4. PCC-1 - Pressure Boundary Bolted Flange Joint Assembly.

B. American Water Work Association (AWWA):

1. C105 - Polyethylene Encasement for Ductile-Iron Pipe Systems.
2. C110 - Ductile-Iron and Gray-Iron Fittings.
3. C111 - Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings.
4. C115 - Flanged Ductile-Iron Pipe with Ductile-Iron or Gray-Iron Threaded Flanges.
5. C151 - Ductile-Iron Pipe, Centrifugally Cast.

C. ASTM International (ASTM):

1. A193 - Standard Specification for Alloy-Steel and Stainless Steel Bolting for High Temperature or High Pressure Service and Other Special Purpose Applications.
2. A194 - Standard Specification for Carbon Steel, Alloy Steel, and Stainless Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both.
3. A307 - Standard Specification for Carbon Steel Bolts, Studs, and Threaded Rod 60,000 PSI Tensile Strength.
4. A563 - Standard Specification for Carbon and Alloy Steel Nuts.
5. B88 - Standard Specification for Seamless Copper Water Tube.
6. D395 - Standard Test Methods for Rubber Property—Compression Set.
7. D412 - Standard Test Methods for Vulcanized Rubber and Thermoplastic Elastomers—Tension.
8. D573 - Standard Test Method for Rubber—Deterioration in an Air Oven.
9. D1149 - Standard Test Methods for Rubber Deterioration—Cracking in an Ozone Controlled Environment.
10. D1330 - Standard Specification for Rubber Sheet Gaskets.
11. D2513 - Standard Specification for Polyethylene (PE) Gas Pressure Pipe, Tubing and Fittings.
12. F37 - Standard Test Methods for Sealability of Gasket Materials.

13. F593 - Standard Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs.
 14. F594 - Standard Specification for Stainless Steel Nuts.
 15. F2329 - Standard Specification for Zinc Coating, Hot-Dip, Requirements of Application to Carbon and Alloy Steel Bolts, Screws, Washers, Nuts, and Special Threaded Fasteners.
- D. NSF International (NSF):
1. 61 - Drinking Water System Components - Health Effects.

1.03 TERMINOLOGY

- A. The words and terms listed below are not defined terms that require initial capital letters, but, when used in this Section, have the indicated meaning.
1. Buried pipes:
 - a. Pipes that are buried in the soil, with or without a concrete pipe encasement.
 - b. Pipes within buried structures, such as manholes or buried vaults.
 2. Exposed pipe: Pipes that are located above ground, or located inside a structure, supported by a structure, or cast into a concrete structure.
 3. Pipes adjacent to a wet wall: Pipe centerline within 10 inches of the wet wall.
 4. Underground pipes: Buried pipes - see 1. above.
 5. Underwater pipes: Pipes below the top of walls in basins or tanks containing water.
 6. Wet wall: A wall with water on at least one side.

1.04 SUBMITTALS

- A. Shop Drawings:
1. Detailed/tabulated layout drawings showing alignment of pipes, actual piping lengths, location of valves, fittings, piping taps, and appurtenances, types of joints, and connections to pipelines or structures.
 2. Cut sheets for fabricated, bolted couplings, flange adapters, and other commercially available accessories for use with the piping system.
 3. Thrust restraint systems.
 4. Provide new lay drawings developed by the Contractor/piping supplier.
 - a. Drawings shall be scalable, completed in AutoCAD, and submitted as 11x17 PDFs for review.
 - b. Annotation of the contract design drawings is not permitted.
 5. Provide flange bolt stress and torque calculations based on the recommended gasket stress from the manufacturer.

PART 2 PRODUCTS

2.01 GENERAL

- A. Pipes:
 - 1. Provide new pipe.
 - 2. Piping provided from manufacturers'/distributors' inventory is subject to the following condition:
 - a. Provide proof pipe manufactured more than 6 months prior to delivery was stored properly and the material and/or coating was not subjected to ultraviolet (UV) degradation.
 - 3. Mark each piece of pipe in accordance with applicable standards.
- B. Coatings and linings requirements shown in the Pipe Schedule, as modified in the individual pipe Technical Sections, and as specified in Section 09_96_01 - High-Performance Coatings.

2.02 LINK TYPE SEALS

- A. Characteristics:
 - 1. Modular mechanical type, consisting of interlocking neoprene or synthetic rubber links shaped to continuously fill the annular space between the pipe and wall opening.
 - 2. Links to form a continuous rubber belt around the pipe.
 - 3. Provide a nylon polymer pressure plate with Type 316 stainless steel hardware. Isolate pressure plate from contact with wall sleeve.
 - 4. Hardware to be Type 316 stainless steel.
 - a. Provide anti-galling lubricant for threads.
- B. One of the following or equal:
 - 1. Link-Seal.
 - 2. Pipe Linx.

2.03 FLANGE BOLTS AND NUTS

- A. General:
 - 1. Washer: Provide for each nut.
 - a. Shall be of the same material as the nut.
 - 2. Nuts: Heavy hex-head.
 - 3. Cut and finish flange bolts to project:
 - a. Face of the bolt shall exceed face of nut by 1/8-inch minimum.
 - b. A maximum of 1/4 inch beyond outside face of nut after assembly.
 - 4. Tap holes for cap screws or stud bolts when used.
 - 5. Lubricant for stainless steel bolts and nuts:
 - a. Chloride-free.
 - b. Manufacturers: One of the following or equal:
 - 1) Huskey, FG-1800 Anti-Seize.
 - 2) Weicon, Anti-Seize High-Tech.

- B. Ductile iron pipe:
 - 1. On exposed pipes with pressures equal to or less than 150 pounds per square inch gauge (psig):
 - a. Bolts: In accordance with ASTM A307, Grade B.
 - b. Nuts: In accordance with 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: In accordance with ASTM A193, Grade B7.
 - b. Nuts: In accordance with 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: In accordance with ASTM A193, Grade B8M.
 - b. Nuts: In accordance with ASTM A194, Grade 8M.
- C. Plastic pipe:
 - 1. On exposed pipes:
 - a. Bolts: In accordance with ASTM A307, Grade B.
 - b. Nuts: In accordance with 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: In accordance with ASTM A193, Grade B8M.
 - b. Nuts: In accordance with ASTM A194, Grade 8M.
- D. Steel pipe:
 - 1. On all steel pipe flanges:
 - a. Bolts: ASTM F593, Alloy Group 7 (630), ASME B1.1 Class 2A Threads, with dimensions in accordance with ASME B18.2.1.
 - b. Nuts: ASTM F594, Alloy Group 7, Alloy 630, ASME B1.1 Class 2A Fit, with square or heavy hex dimensions in accordance with ASME B18.2.2.
 - c. Washers: In accordance with ASME PCC-1, Appendix M, Type 7.

2.04 MECHANICAL JOINTS BOLTS AND NUTS

- A. Bolts, including T-bolts:
 - 1. High strength low alloy steel in accordance with AWWA C111.
 - a. Fluoropolymer coated.
- B. Heavy hex nuts:
 - 1. High strength low alloy steel in accordance with AWWA C111.
 - a. Fluoropolymer coated.

2.05 GASKETS

- A. General:
 - 1. Suitable for the specific fluids, pressure, and temperature conditions.
 - 2. Capable of being applied on surface of piping with cavities to provide for an improved seal with the internal piping pressure.
- B. Type FLG1 - Aramid fibers with Neoprene Binder:
 - 1. Gasket material: Aramid fibers with a neoprene binder.
 - a. Temperature range: -10 to 400 degrees Fahrenheit.

- b. Operating pressure: 1,200 psig.
- c. ASTM F36 Compressibility, average: 10 percent.
- d. ASTM F36 Recovery: 55 percent.
- e. ASTM F38 Creep Relaxation: 20 percent.
- f. ASTM F152 Tensile Strength, across grain: 1800 psi.
- g. ASTM F1315 Density: 110 lbs/ft³.
- 2. Thickness: 1/16 inch, minimum and maximum.
- 3. Manufacturers: One of the following or equal:
 - a. Garlock, Blue-Gard Style 3300.
 - b. John Crane.

PART 3 EXECUTION

3.01 INSTALLATION

- A. General:
 - 1. Piping drawings:
 - a. Except in details, piping is indicated diagrammatically. Not every offset and fitting, or structural difficulty that may be encountered has been indicated on the Drawings. Sizes and locations are indicated on the Drawings.
 - b. Perform minor modifications to piping alignment where necessary to avoid structural, mechanical, or other type of obstructions that cannot be removed or changed.
 - 1) Modifications are intended to be of minor scope, not involving a change to the design concept or a change to the Contract Price or Contract Times.
 - 2. Piping alternatives:
 - a. Provide piping as specified in this Section, unless indicated on the Drawings or specified otherwise.
 - b. Alternative pipe ratings:
 - 1) Piping with greater pressure rating than specified may be substituted in lieu of specified piping without changes to the Contract Price.
 - 2) Piping of different material may not be substituted in lieu of specified piping.
 - c. Valves in piping sections: Capable of withstanding specified test pressures for piping sections and fabricated with ends to fit piping.
 - d. Grooved joints: Use couplings, flange adapters, and fittings of the same manufacturer.
 - 1) Manufacturer's factory trained representative:
 - a) Provide on-site training for the Contractor's field personnel.
 - b) Periodically visit the jobsite to verify the Contractor is following best recommended practices.
 - 2) Distributor's representative is not considered qualified to conduct the training or jobsite visits.
 - e. Flanged joints: Where one of the joining flanges is raised face type, provide a matching raised face type flange for the other joining flange.
 - 3. Unless otherwise indicated on the Drawings, piping at pipe joints, fittings, couplings, and equipment shall be installed without rotation, angular deflection, vertical offset, or horizontal offset.

- B. Wall and slab penetrations:
1. Provide sleeves for piping penetrations through aboveground masonry and concrete walls, floors, ceilings, roofs, unless specified or otherwise indicated on the Drawings.
 2. Provide flexibility in piping connecting to structures to accommodate movement due to soil settlement and earthquakes. Provide flexibility using details indicated on the Drawings.
 3. Core drilled openings:
 - a. Do not damage or cut existing reinforcing bars, electrical conduits, or other items embedded in the existing concrete without acceptance by the Engineer.
 - b. Determine location of reinforcing bars or other obstructions with a non-destructive indicator device.
 - c. Remove dust and debris from hole using compressed air.
- C. Exposed piping:
1. Install in straight runs parallel to the axes of structures, unless otherwise indicated on the Drawings.
 - a. Install piping runs plumb and level, unless otherwise indicated on the Drawings.
 - 1) Slope plumbing drain piping with a minimum of 1/4 inch per foot downward in the direction of flow.
 2. Install after installing equipment and after piping and fitting locations have been determined.
 3. Route piping to preserve headroom, access space and workspace, and to prevent tripping hazards and clearance problems:
 - a. Install piping so it does not interfere with the proper and safe operation of equipment and does not block or interfere with ingress or egress, including hatches.
 4. Support piping: As specified in Section 40_05_07.01 - Pipe Supports and Section 40_05_07.03 - Preformed Channel Pipe Support System:
 - a. Do not transfer pipe loads and strain to equipment.
 5. In addition to the joints indicated on the Drawings, provide unions, flexible couplings, flanged joints, flanged coupling adapters, and other types of joints or means which are compatible with and suitable for the piping system, and necessary to allow ready assembly and disassembly of the piping.
 6. Assemble piping without distortion or stresses caused by misalignment:
 - a. Match and properly orient flanges, unions, flexible couplings, and other connections.
 - b. Do not subject piping to bending or other undue stresses when fitting piping.
 - c. Do not correct defective orientation or alignment by distorting flanged joints or subjecting flange bolts to bending or other undue stresses.
 - d. Flange bolts, union halves, flexible connectors, and other connection elements shall slip freely into place.
 - e. Alter piping assembly to fit when proper fit is not obtained.
 - f. Install eccentric reducers or increasers with the top horizontal for pump suction piping.

- D. Buried piping:
1. Bury piping with minimum 3-foot cover without air traps, unless otherwise indicated on the Drawings.
 2. Where 2 similar services run parallel to each other, piping for such services may be laid in the same trench.
 - a. Lay piping with sufficient room for assembly and disassembly of joints, for thrust blocks, for other structures, and to meet separation requirements of public health authorities having jurisdiction.
 3. Laying piping:
 - a. In finished trenches free from water or debris. Begin at the lowest point with bell ends up slope.
 - b. Place piping with top or bottom markings with markings in proper position.
 - c. On an unyielding foundation with uniform bearing under the full length of barrels.
 - d. Where joints require external grouting, banding, or pointing, provide space under and immediately in front of the bell end of each section laid with sufficient shape and size for grouting, banding, or pointing of joints.
 - e. At the end of each day's construction, plug open ends of piping temporarily to prevent entrance of debris or animals.
 4. Concrete encase buried pipe installed under concrete slabs or structures.
- E. Venting piping under pressure:
1. Lay piping under pressure flat or at a continuous slope without air traps, unless otherwise indicated on the Drawings.
 2. Install plug valves as air bleeder cocks at high points in piping.
 - a. Provide 1-inch plug valves for water lines and 2-inch plug valves for sewage and sludge lines, unless otherwise indicated on the Drawings.
 3. Provide additional pipe taps with plug cocks and riser pipes along piping as required for venting during initial filling, disinfecting, and sampling.
 4. Before piping is placed into service, close plug valves and install plugs. Protect plugs and plug valves from corrosion as specified in Section 09_96_01 - High-Performance Coatings.
- F. Restraining buried piping:
1. At valves and at fittings where piping changes direction, changes size, and at ends:
 - a. When piping is underground, use concrete thrust blocks, mechanical restraints, or push-on restraints.
 - b. Determine thrust forces by multiplying the nominal cross-sectional area of the piping by design test pressure of the piping.
 2. Provide restraints with ample size to withstand thrust forces resulting from test pressures:
 - a. During testing, provide suitable temporary restraints where piping does not require permanent restraints.
 3. Place concrete thrust blocks against undisturbed soil.
 4. Place concrete so piping joints, fittings, and other appurtenances are accessible for assembly and disassembly.
 5. Provide underground mechanical restraints where specified in Attachment A - Pipe Schedule.

- G. Restraining above ground piping:
 - 1. At valves and fittings where piping changes direction, changes size, and at ends:
 - a. When piping is aboveground or underwater, use mechanical or structural restraints.
 - b. Determine thrust forces by multiplying the nominal cross-sectional area of the piping by design test pressure of the piping.
 - 2. Provide restraints with ample size to withstand thrust forces resulting from test pressures:
 - a. During testing, provide suitable temporary restraints where piping does not require permanent restraints.
- H. Connections to existing piping:
 - 1. Expose existing piping to which connections are to be made with sufficient time to permit, where necessary, field adjustments in line, grade, or fittings:
 - a. Protect domestic water/potable water supplies from contamination:
 - 1) Make connections between domestic water supply and other water systems in accordance with requirements of public health authorities.
 - 2) Provide devices approved by the owner of the domestic water supply system to prevent flow from other sources into the domestic supply system.
 - 2. Make connections to existing piping and valves after sections of new piping to be connected have been tested and found satisfactory.
 - 3. Provide sleeves, flanges, nipples, couplings, adapters, and other fittings needed to install or attach new fittings to existing piping and to make connections to existing piping.
 - 4. For flanged connections, provide stainless steel bolts with isolation bushings and washers, and full-face flange gaskets.
- I. Connections between ferrous and nonferrous metals:
 - 1. Connect ferrous and nonferrous metal piping, tubing, and fittings with dielectric couplings, especially designed for the prevention of chemical reactions between dissimilar metals.
 - 2. Nonferrous metals include aluminum, copper, and copper alloys.
- J. Flanged connections between dissimilar metals such as ductile iron pipe and steel pipe:
 - 1. Provide stainless steel bolts with isolation bushings and washers, and full-face flange gaskets.

3.02 CLEANING

- A. Piping cleaning:
 - 1. Upon completion of installation, clean piping interior of foreign matter and debris.
 - 2. Perform special cleaning when required by the Contract Documents.
- B. Conduct pressure and leak test, as specified.

3.03 PIPE SCHEDULE

- A. As indicated on the Drawings.

END OF SECTION

SECTION 40_05_00.03

PIPE IDENTIFICATION

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Pipe identification markers, flow direction arrows, tags, and bands.
 - 2. Underground warning tape.
 - 3. Tracer wire.
 - 4. Witness markers.

1.02 REFERENCES

- A. American Society of Mechanical Engineers (ASME):
 - 1. A13.1 - Scheme for the Identification of Piping Systems.

1.03 SUBMITTALS

- A. Furnish Submittals as specified in Section 01_33_00 - Submittal Procedures.
- B. Product Submittals:
 - 1. As specified in Section 01_60_01 - Product Requirements.
 - 2. Product data.
 - 3. Samples.
 - 4. Manufacturer's installation instructions.
 - 5. Submit the following as specified in the Contract Documents:
 - a. Operation and maintenance data.
 - b. Warranty.
 - 6. Tracer wire access plan.

PART 2 PRODUCTS

2.01 EXPOSED AND IN-CHASE PIPE IDENTIFICATION

- A. For piping with outer diameter greater than or equal to 3/4 inch, provide lettered pipe markers and flow direction arrows:
 - 1. General requirements:
 - a. Pipe markers shall include the following, at a minimum:
 - 1) Printed text identifying the pipe fluid.
 - a) Text shall be all capital letters matching the text listed in the "Service" column of the Pipe Schedule for the corresponding piping system.

- 2) An arrow identifying the direction of fluid flow.
 - a) Arrow can either be integral to the text marker or provided separately. If provided separately, the arrow must be placed immediately adjacent to each text marker, with the arrow aligned with the text such that the text and arrow are both visible from the same viewpoint.
 - b) Arrow color shall match the text color, and the arrow background color shall match the text background color.
- b. Suitable for outdoor application from -40 degrees to 180 degrees Fahrenheit; in accordance with ASME A13.1 requirements.
- c. Lettering:

Outside Pipe Diameter, including Covering	Lettering Height
Less than 0.75 inches	N/A
0.75 to 1.5 inches	1/2 inch
1.5 to 2 inches	3/4 inch
2.5 to 6 inches	1-1/4 inches
8 to 10 inches	2-1/2 inches
Over 10 inches	3-1/2 inches

- d. Marker colors:

Marker Color System ID ⁽¹⁾	Fluid Service	Text/Arrow Color	Background Color
1	Flammable and oxidizing fluids	Black	Yellow
2	Potable, cooling, boiler feed, and other waters	White	Green
3	Compressed air	White	Blue
4	Fire quenching fluids	White	Red
5	Toxic and corrosive fluids	Black	Orange
6	Combustible fluids	White	Brown

Notes:

(1) See Pipe Schedule.

2. Self-adhesive type markers:
 - a. Manufacturers: One of the following or equal:
 - 1) Marking Services, Inc.
 - 2) Seton, (of Brady Corporation), Opti Code Pipe Markers.
 - b. Materials:
 - 1) Self-adhesive vinyl.
3. Snap-on markers:
 - a. Manufacturers: One of following or equal:
 - 1) Brady Snap-On.
 - 2) Seton (of Brady Corporation) Setmark.

- B. For piping with outer diameter less than 3/4 inch, provide identification tags and flow direction arrows:
 - 1. Manufacturer: The following or equal:
 - a. Seton (of Brady Corporation).
 - 2. Tag and chain materials:
 - a. Copper piping: Brass.
 - b. Ferrous piping: Type 316 stainless steel.
 - c. Plastic piping: Stainless steel
 - 3. Flow direction arrow colors shall adhere to the same requirements as for piping with outer diameter greater than or equal to 3/4 inch, as specified in this Section.
- C. Pipe bands:
 - 1. When bands are required by the Pipe Schedule for a specific piping system, provide solid-colored 4-inch-wide bands.
 - a. Color as specified in the Pipe Schedule.
 - 2. Self-adhesive type.
 - 3. Suitable for outdoor application from -40 degrees to 180 degrees Fahrenheit.

2.02 BURIED PIPELINE IDENTIFICATION

- A. Underground warning tape:
 - 1. Manufacturer: One of the following or equal:
 - a. Seton (of Brady Corporation).
 - b. T. Christy Enterprises, Inc.
 - 2. Material:
 - a. Polyethylene tape for prolonged underground use.
 - b. Minimum tape thickness: 4 mils.
 - c. Overall tape width: 4 inches.
 - d. Message: "CAUTION" with the name of the service followed by "LINE BURIED BELOW." in black lettering on colored background in accordance with approved American Public Works Association (APWA) colors.

Service	Color
Potable water	Blue
Reclaimed water, irrigation, and slurry lines	Purple
Sewers and drain lines	Green
Gas, oil, steam, petroleum, chemicals, or other service	Yellow

- B. Tracer wire:
 - 1. Manufacturers: One of the following or equal:
 - a. Aegion Corpro.
 - b. Kris-Tech Wire.
 - 2. Materials:
 - a. Solid copper conductor.
 - b. Thickness minimum: 10 gauge.
 - c. Insulation:
 - 1) Match insulation color to the color of the pipe being installed.
 - 2) UF type, direct bury.
 - 3) 30-mil HMWPE.

3. Splicing kit:
 - a. Manufacturers: The following or equal:
 - 1) 3M, Model 82 A1N.
 4. Station box:
 - a. Lid and collar materials: Cast iron.
 - b. Lid type: Locking.
 - c. Able to withstand heavy traffic loading.
 - d. Manufacturers: One of the following or equal:
 - 1) CP Test & Valve Products, Inc., Glenn Test Station.
 - 2) Farwest Corrosion Control.
- C. Witness markers:
1. Manufacturers: One of the following or equal:
 - a. Carsonite Composites, Utility Marker.
 2. Materials:
 - a. Glass fiber and resin-reinforced thermosetting composite material.
 - b. UV resistant.
 3. Constructed as a single piece.
 4. Pointed at the bottom end.
 5. Information to be included on the marker:
 - a. "Caution" (type of service) "Pipeline".
 - b. Phone number for Underground Service Alert.
 - c. Phone number for the Owner in case of emergency.
 - d. Station number.
 - e. Offset: Only provide offset if marker is not directly over the pipe.
 - f. Name of appurtenance or fitting (e.g., 45, BO, ARV, etc.).

PART 3 EXECUTION

3.01 EXAMINATION

- A. Verify satisfactory conditions of substrate for applying identification.
- B. Verify that conditions are satisfactory for installation and application of products as specified in Section 01_60_01 - Product Requirements.

3.02 PREPARATION

- A. Prepare and coat piping with the coating systems defined in the Pipe Schedule.
- B. Prepare surface in accordance with the identification product manufacturer's instructions.

3.03 EXPOSED AND IN-CHASE PIPING IDENTIFICATION

- A. Identify exposed and in-chase piping with flow direction arrows and lettering (for piping with outer diameter greater than or equal to 3/4 inch) or tags (for piping with outer diameter less than 3/4 inch).

- B. Provide lettering (or tags for pipes with outer diameter less than 3/4 inch) and flow direction arrows near equipment served, adjacent to valves, both sides of walls and floors where pipe passes through, at each branch or tee, and at intervals of not more than 50 feet in straight runs of pipe.
 - 1. Label chemical tank fill pipelines at locations that are visible from chemical fill stations.
 - 2. Place markers on piping so they are visible from the operator's position in walkway or working platform near piping. Locate markers along horizontal centerline of pipe, unless better visibility is achieved elsewhere.
 - 3. Do not apply markers, arrows, or tags to piping that is regularly submerged.
- C. Where scheduled in the Pipe Schedule, space solid-color bands along piping at 5-foot intervals.
 - 1. Do not apply bands to piping that is regularly submerged.

3.04 BURIED PIPING IDENTIFICATION

- A. Underground warning tape:
 - 1. Non-detectable:
 - a. Place continuous run of warning tape in pipe trench, 12 inches above the pipe.
 - 2. Detectable:
 - a. Place continuous run of warning tape in pipe trench, 12 inches above the pipe or a greater height if necessary to limit the tape bury depth to 36 inches. Do not bury detectable warning tape deeper than 36 inches.
- B. Tracer wire:
 - 1. Install on all non-metallic pipe.
 - 2. Install an electrically continuous run of tracer wire along the entire length of the pipe with wire terminations in valve boxes, vaults, or structures.
 - 3. Install tracer wire on top of the pipe and secure to pipe with tape a minimum of every 10 feet.
 - 4. Where approved by the Engineer, splice sections of wire together using approved direct bury wire nuts.
 - a. Twisting the wires together is not acceptable.
 - 5. Install tracer wire access points at a maximum spacing of 500 LF. Locate station boxes in the median, sidewalk, or as indicated on the Drawings and approved by the Owner.
 - 6. Provide 2-foot minimum slack of coiled wire in the station box after meeting final grade.
 - 7. Ground the station box at dead ends such as manholes or dead-end pipe with 1.5 lb drive-in magnesium ground rod with a minimum of 20 feet of lead wire.
 - 8. It is the Contractor's responsibility to protect the tracer wire from damage during pipe installation and backfill. All costs associated with finding discontinuities in the tracer wire and repair of the connections shall be borne by the Contractor.

9. Verify tracer wire installation by using low frequency (512 Hz or similar) line locating equipment.
 - a. Provide 2 days advance notice to the Owner prior to testing.
 - b. Test shall be witnessed and approved by the Owner.
 - c. Test tracer wire for continuity between test stations and/or valve boxes prior to final paving.
 10. As part of the as-built drawings, record station and pipe offset of station boxes.
- C. Witness markers:
1. Install over pipe in unpaved open-space areas at intervals not greater than 200 feet.
 2. Place markers at appurtenances located in unpaved areas.
 3. Embed markers at least 18 inches into the soil.

END OF SECTION

SECTION 40_05_00.09
PIPING SYSTEMS TESTING

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
1. Test requirements for piping systems.

1.02 REFERENCES

- A. American Water Work Association (AWWA):
1. C600-17 - Installation of Ductile Iron Mains and Their Appurtenances.
 2. C605-21 - Underground Installation of PVC and PVCO Pressure Pipe and Fittings.
- B. Underwriters Laboratories Inc. (UL).

1.03 TESTING REQUIREMENTS

- A. General requirements:
1. Testing requirements are stipulated in laws and regulations, specified in the Pipe Schedule in Section 40_05_00.01 - Common Work Results for General Piping, specified in the Specifications covering the various types of piping, and are specified in this Section.
 2. Requirements in laws and regulations supersede other requirements of the Contract Documents, except where requirements of the Contract Documents are more stringent, including higher test pressures, longer test times, and lower leakage allowances.
 3. Test plumbing piping in accordance with laws and regulations, the plumbing code, as specified in Section 01_41_00 - Regulatory Requirements, and UL requirements.
 4. Air test of natural gas piping:
 - a. For less than 125 pounds per square inch gauge working pressure, test in accordance with mechanical code, as specified in Section 01_41_00 - Regulatory Requirements, or the National Fuel Gas Code, whichever is more stringent.
 5. Air test of digester gas piping shall not exceed 25 psi.
 6. When testing with water, the specified test pressure is considered to be the pressure at the lowest point of the piping section under test.
 - a. Lower test pressure as necessary (based on elevation) if testing is performed at a higher point of the pipe section.
- B. Furnish necessary personnel, materials, and equipment, including bulkheads, restraints, anchors, temporary connections, pumps, water, pressure gauges, and other means and facilities required to perform tests.

- C. Water for testing, cleaning, and disinfecting:
 - 1. As specified in Section 01_50_00 - Temporary Facilities and Controls.
 - a. Use potable water for all potable waterlines.
 - b. Use potable water or 3W for all other pipes.
- D. Pipes to be tested:
 - 1. Test only those portions of pipes that have been installed as part of this Contract.
 - 2. Test new pipe sections prior to making final connections to existing piping.
 - 3. Furnish and install test plugs, bulkheads, and restraints required to isolate new pipe sections.
 - 4. Do not use existing valves as test plug or bulkhead.
- E. Unsuccessful tests:
 - 1. Correct defects or remove defective piping and appurtenances and install piping and appurtenances that comply with the specified requirements.
 - 2. Repeat testing until tests are successful.
- F. Test completion: Drain and leave piping clean after successful testing.
- G. Test water disposal:
 - 1. Dispose in accordance with requirements of federal, state, county, and city regulations governing disposal of wastes in the location of the Project and disposal site.
 - 2. Requirements and costs associated with notifications and obtaining any discharge permit or approvals shall be the responsibility of the Contractor.

1.04 SUBMITTALS

- A. Furnish Submittals as specified in Section 01_33_00 - Submittal Procedures.
- B. Schedule and notification of tests:
 - 1. Submit a list of scheduled piping tests by noon of the working day preceding the date of the scheduled tests.
 - 2. Notification of readiness to test: Immediately before testing, notify the Engineer in writing of readiness, not just intention, to test piping.
 - 3. Have personnel, materials, and equipment specified in place before submitting notification of readiness.
- C. Pipe system test report:
 - 1. Submit a report for all piping tested. At a minimum, the test report shall include the following information:
 - a. Description of piping being tested:
 - 1) Pipe material.
 - 2) Section of piping being tested:
 - a) Date and time of pipe test.
 - b) Name of person performing the pipe test.
 - c) Specified test method and testing requirements (low-head, high-head, test pressure, test duration, etc.).
 - d) Initial test pressure and time of pressure.
 - e) Final test pressure and time of pressure.

- f) Status of test: Pass or fail.
- g) Signature of the Contractor and Owner's representative that witnessed the pipe test.

1.05 SEQUENCE

- A. Clean piping before pressure or leak tests.
- B. Test gravity piping underground, including sanitary sewers, for visible leaks before backfilling and compacting.
- C. Underground pressure piping may be tested before or after backfilling when not indicated or specified otherwise.
- D. Backfill and compact trench or provide blocking that prevents pipe movement before testing underground piping with a maximum leakage allowance.
- E. Test underground piping before encasing piping in concrete or covering piping with slab, structure, or permanent improvement.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 TESTING ALIGNMENT, GRADE, AND DEFLECTION

- A. Alignment and grade:
 - 1. Visually inspect the interior of gravity piping with artificial light, reflected light, or laser beam.
 - 2. Consider inspection complete when no broken or collapsed piping, no open or poorly made joints, no grade changes that affect the piping capacity, or no other defects are observed.
- B. Deflection test:
 - 1. Pull a mandrel through the clean piping section under test.
 - 2. Perform the test not sooner than 30 days after installation and not later than 60 days after installation.
 - 3. Use a 9-rod mandrel with a contact length of not less than the nominal diameter of the pipe within 1 percent plus or minus.
 - 4. Consider test complete when the mandrel can be pulled through the piping with reasonable effort by 1 person, without the aid of mechanical equipment.

3.02 AIR TESTING METHOD FOR PRESSURE PIPING

- A. Air test piping, indicated with "AM" in the Pipe Schedule, with air or another nonflammable or inert gas.

- B. Test gas, air, liquefied petroleum gas, liquid chlorine, and chlorine gas piping by the air test method:
 - 1. Test chlorine piping with dry air or nitrogen having a dew point of -40 degrees Fahrenheit or less. Supply temporary air dryers as necessary.
- C. Test at pressure as specified in the Pipe Schedule in Section 40_05_00.01 - Common Work Results for General Piping as indicated on the Drawings:
 - 1. Provide temporary pressure relief valve for piping under test:
 - a. Set at 110 percent of the test pressure.
 - 2. Gradually increase test pressure to an initial pressure of 1/2 the test pressure and inspect joint seals for leaks. If no leaks are found, gradually increase test pressure in 10 percent increments until target pressure is reached.
 - 3. At each step in the pressure, examine and test piping for leaks with soap solution.
 - 4. Consider examination complete when the piping section under test holds the test pressure for 15 minutes without losses.

3.03 TESTING GRAVITY FLOW PIPING

- A. Test gravity flow piping, indicated with "GR" in the Pipe Schedule, as follows:
 - 1. Unless specified otherwise, subject gravity flow piping to the following tests:
 - a. Alignment and grade.
 - b. For plastic piping test for deflection.
 - c. Visible leaks and pressure with maximum leakage allowance, except for storm drains and culverts.
 - 2. Inspect piping for visible leaks before backfilling.
 - 3. Provide temporary restraints when needed to prevent movement of piping.
 - 4. Pressure test piping with maximum leakage allowance after backfilling.
 - 5. With the lower end plugged, fill piping slowly with water while allowing air to escape from high points. Keep piping full under a slight head for the water at least 24 hours:
 - a. Examine piping for visible leaks. Consider examination complete when no visible leaks are observed.
 - b. Maintain piping with water or allow a new water absorption period of 24 hours for the performance of the pressure test with maximum leakage allowance.
 - c. After successful completion of the test for visible leaks and after the piping has been restrained and backfilled, subject piping to the test pressure for a minimum of 4 hours while accurately measuring the volume of water added to maintain the test pressure:
 - 1) Consider the test complete when leakage is equal to or less than the following maximum leakage allowances:
 - a) For concrete piping with rubber gasket joints: 80 gallons per day per inch of diameter per mile of piping under test:
 - (1) Advise the manufacturer of concrete piping with rubber gasket joints of more stringent than normal maximum leakage allowance.
 - b) For vitrified clay piping: 500 gallons per day per inch of diameter per mile of piping under test.

- c) For polyvinyl chloride (PVC) gravity sewer pipe: 25 gallons per day per inch diameter per mile of piping under test.
- d) For other piping: 80 gallons per day per inch diameter per mile of piping under test.

3.04 TESTING HIGH-HEAD PRESSURE PIPING

- A. Test piping for which the specified test pressure in the Pipe Schedule is 20 pounds per square inch gauge or greater, by the high head pressure test method, indicated with "HH" in the Pipe Schedule.
- B. General:
 - 1. Test connections, hydrants, valves, blowoffs, and closure pieces with the piping.
 - 2. Do not use installed valves for shutoff when the specified test pressure exceeds the valve's maximum allowable seat differential pressure. Provide blinds or other means to isolate test sections.
 - 3. Do not include valves, equipment, or piping specialties in test sections if test pressure exceeds the valve, equipment, or piping specialty safe test pressure allowed by the item's manufacturer.
 - 4. During the performance of the tests, test pressure shall not vary more than plus or minus 5 pounds per square inch gauge with respect to the specified test pressure.
 - 5. Select the limits of testing to sections of piping. Select sections that have the same piping material and test pressure.
 - 6. When test results indicate failure of selected sections, limit tests to piping:
 - a. Between valves.
 - b. Between a valve and the end of the piping.
 - c. Less than 500 feet long.
 - 7. Test piping for a minimum of 2 hours for visible leaks test and a minimum of 2 hours for the pressure test with maximum leakage allowance.
- C. Testing procedures:
 - 1. Fill piping section under test slowly with water while venting air.
 - 2. Before pressurizing for the tests, retain water in piping under slight pressure for a water absorption period of a minimum of 24 hours.
 - 3. Raise pressure to the specified test pressure and inspect piping visually for leaks:
 - a. Consider visible leakage testing complete when no visible leaks are observed.
- D. Pressure test with maximum leakage allowance:
 - 1. Leakage allowance is zero for piping systems using flanged, National Pipe Thread threaded and welded joints.
 - 2. Pressure test piping after completion of visible leaks test.
 - 3. For piping systems using joint designs other than flanged, threaded, or welded joints, accurately measure the makeup water necessary to maintain the pressure in the piping section under test during the pressure test period:
 - a. Consider the pressure test to be complete when makeup water added is less than the allowable leakage and no damage to piping and appurtenances has occurred.

- b. Successful completion of the pressure test with maximum leakage allowance shall be achieved when the observed leakage during the test period is equal or less than the allowable leakage and no damage to piping and appurtenances has occurred.
- c. When leakage is allowed, calculate the allowable leakage in accordance with AWWA C605-21 or AWWA C600-17 by using the following formula:

$$L = \frac{SD\sqrt{P}}{148,000}$$

wherein the terms shall mean:

L = Allowable leakage in gallons per hour.

S = Length of the test section in feet.

D = Nominal diameter of the piping in inches.

P = Average observed test pressure in pounds per square inch gauge, at the lowest point of the test section, corrected for elevation of the pressure gauge.

3.05 TESTING LOW-HEAD PRESSURE PIPING

- A. Test piping for which the specified test pressure is less than 20 pounds per square inch gauge, by the low head pressure test method, indicated with "LH" in the Pipe Schedule.
- B. General:
 - 1. Test pressures shall be as scheduled in Section 40_05_00.01 - Common Work Results for General Piping.
 - 2. During the performance of the tests, test pressure shall not vary more than plus or minus 2 pounds per square inch gauge with respect to the specified test pressure.
 - 3. Test connections, blowoffs, vents, closure pieces, and joints into structures, including existing bell rings and other appurtenances, with the piping.
 - 4. Test piping for a minimum of 2 hours for visible leaks test and a minimum of 2 hours for the pressure test with maximum leakage allowance.
- C. Visible leaks test:
 - 1. Subject piping under test to specified pressure measured at the lowest end.
 - 2. Fill piping section under test slowly with water while venting air:
 - a. Use potable water for all potable waterlines and where noted on the Pipe Schedule.
 - 3. Before pressurizing for the tests, retain water in piping under slight pressure for the water absorption period of a minimum of 24 hours.
 - 4. Raise pressure to the specified test pressure and inspect piping visually for leaks. Consider testing complete when no visible leaks are observed.
- D. Pressure test with maximum leakage allowance:
 - 1. Pressure test piping after completion of visible leaks test.

2. Accurately measure the makeup water necessary to maintain the pressure in the piping section under test during the pressure test period:
 - a. Consider the pressure test to be complete when makeup water added is less than the allowable leakage of 80 gallons per inch of nominal diameter, per mile of piping section under test after 24 hours, and no damage to piping and appurtenances has occurred.
 - b. Successful completion of the leakage test shall have been achieved when the observed leakage is equal or less than the allowable leakage and no damage to piping and appurtenances has occurred.
- E. Optional joint test:
1. When joint testing is allowed by note in the Pipe Schedule, the procedure shall be as follows:
 - a. Allowed only for low head pressure piping.
 - b. Does not replace and is not in lieu of any testing of the piping system or trust restraints.
 2. May be performed with water or air.
 3. Joint test piping after completion of backfill and compaction to the top of the trench.
 4. Joint testing with water:
 - a. Measure test pressure at the invert of the pipe. Apply pressure of 4 feet plus the inside diameter of the pipe in water column within 0.20 feet in water column.
 - b. Maintain test pressure for 1 minute.
 - c. Base the allowable leakage per joint on 80 gallons per inch nominal diameter, per mile of piping, per 24 hours equally distributed to the actual number of joints per mile for the type of piping.
 - d. Consider the pressure test to be complete when makeup water added is less than the allowable leakage.
 - e. Successful completion of the joint test with water shall have been achieved when the observed leakage is equal or less than the allowable leakage.
 5. Joint testing with air:
 - a. Apply test pressure of 3 pounds per square inch gauge with a maximum variation of plus 0.20 and minus 0.00 pounds per square inch.
 - b. Maintain test pressure for 2 minutes.
 - c. Consider the pressure test to be complete when the test pressure does not drop below 2.7 pounds per square inch for the duration of the test.

END OF SECTION

SECTION 40_05_06.01

PIPING SPECIALTIES

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Piping specialties, including:
 - a. Flexible rubber connections.
 - b. Bellows type expansion joints.
 - c. Slip type expansion joints.
 - d. Rubber expansion joints.

1.02 REFERENCES

- A. American Society of Mechanical Engineers (ASME):
 - 1. B16.5 - Pipe Flanges and Flanged Fittings: NPS 1/2 through NPS 24, Metric/Inch Standard.
- B. American Water Works Association (AWWA):
 - 1. C110 - Standard for Ductile-Iron and Gray-Iron Fittings.
 - 2. C151 - Standard for Ductile-Iron Pipe, Centrifugally Cast.
- C. ASTM International (ASTM):
 - 1. A148 - Standard Specification for Steel Castings, High-Strength, for Structural Purposes.
 - 2. A193 - Standard Specification for Alloy-Steel and Stainless Steel Bolting for High Temperature or High Pressure Service and Other Special Purpose Applications.
 - 3. A194 - Standard Specification for Carbon Steel, Alloy Steel, and Stainless Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both.
 - 4. A536 - Standard Specification for Ductile Iron Castings.
- D. NSF International (NSF):
 - 1. 61 - Drinking Water System Components - Health Effects, Includes Errata.
 - 2. 372 - Drinking Water System Components - Lead Content.

1.03 SUBMITTALS

- A. Furnish Submittals as specified in Section 01_33_00 - Submittal Procedures and Section 01_60_01 - Product Requirements.
- B. Product data:
 - 1. Design features.
 - 2. Load capacities.
 - 3. Material designations by UNS alloy number or ASTM Specification and Grade.

4. Data needed to verify compliance with the Specifications.
 5. Catalog data.
- C. Installation instructions:
1. Provide manufacturer's installation instructions.
- D. Quality Control Submittals:
1. Manufacturer's Certificate of Installation Verification as specified in Section 01_75_17 - Commissioning.

1.04 DELIVERY, STORAGE, AND HANDLING

- A. As specified in Section 01_60_01 - Product Requirements.

1.05 WARRANTY

- A. As specified in Section 01_78_36 - Warranties and Bonds.

PART 2 PRODUCTS

2.01 GENERAL

- A. As specified in Section 01_60_01 - Product Requirements.

2.02 FLEXIBLE RUBBER CONNECTIONS

- A. Manufacturers: One of the following or equal:
1. Mercer Rubber Co., Type 150 Vibraflex.
 2. Red Valve Co., Inc., Part Number P-5.
- B. Provide flexible rubber connections with 3/8-inch thick neoprene or EPDM rubber tube with full-faced flanged ends suitable to withstand a pressure of 150 pounds per square inch gauge.
- C. Provide complete flexible rubber connections, including galvanized retaining rings and control rods.

2.03 BELLOWS TYPE EXPANSION JOINTS

- A. For general service:
1. Flexible bellows type, or as otherwise specified or indicated on the Drawings.
 2. Manufacturers:
 - a. Expansion joints: One of the following or equal:
 - 1) Flex-Weld, Inc., Keflex, Series 308.
 - 2) Senior Flexonics Pathway, Inc., Controlled Flexing Expansion Joint.
 - 3) Victaulic, Depend-o-Lok, Omniflex stainless bellows expansion joint.
 - b. Pipe alignment guides: One of the following or equal:
 - 1) Flex-Weld, Inc.
 - 2) Senior Flexonics Pathway, Inc.

- c. Intermediate supports: Provide with protective saddles. One of the following or equal:
 - 1) Bergen-Paterson Pipe Support Corp.
 - 2) Unistrut Corporation, Roller-type.
 - 3. Design:
 - a. Expansion joint rating: 150 pounds per square inch gauge, at 300 degrees Fahrenheit.
 - b. Bellows: Multi-ply (3 ply minimum) stainless steel, equipped with a self-draining liner guide.
 - c. Axial travel of expansion joints: Not less than 1.5 inches.
 - d. Ends: 150-pound ASME flanges, Victaulic, Depend-o-Lok Airmaster/Fluidmaster coupled ends, or plain suitable for welding connections, as required for piping in which installed.
- B. Copper piping expansion joints:
 - 1. As specified before, except externally guided, and provide for 3-1/4-inch expansion per 100 feet of piping.
- C. Roof drain expansion joints:
 - 1. Neoprene bellows between roof drain fitting and drain piping.
 - 2. Up to 12-inch static head.
 - 3. Complete with Type 316 stainless steel clamps.
 - 4. Manufacturers: One of the following or equal:
 - a. Flexicraft Industries, DWV.
 - b. Watts, Model RD-900.

2.04 SLIP TYPE EXPANSION JOINTS

- A. PVC expansion joints:
 - 1. Flexible bellows type.
 - 2. Manufacturers: One of the following or equal:
 - a. Chemtrol.
 - b. NDS Flow Management, Quik-Fix.
 - 3. Materials: PVC with EPDM O-ring.
 - 4. Design:
 - a. 150 pounds per square inch pressure rating.
 - b. Double O-ring seal.
 - c. Axial travel: Not less than 1.5 inches.
 - d. Ends: 150-pound ASME flanges, or plain end suitable for solvent welding connections.

2.05 RUBBER EXPANSION JOINTS

- A. Manufacturers: One of the following or equal:
 - 1. Mercer Rubber Co., Style 500 or 700.
 - 2. Proco Products, Inc., Series 230 or 240.
 - 3. Red Valve Co., Inc., Type J-1.
- B. Provide rubber expansion joints complete with control units and split retaining rings.

- C. Design:
1. Neoprene rubber, reinforced with embedded steel rings, and a strong synthetic fabric.
 2. Expansion rings, suitable for pressures of at least 125 pounds per square inch gauge, except as follows:
 - a. Expansion joints in pump suction piping and where indicated on the Drawings suitable for minimum 90 pounds per square inch gauge pressure, and minimum 30 inches mercury vacuum.
 - b. Ends of expansion joints: 1.
 - c. 50-pound ASME flanges with drilling to match that of the piping.
 3. Bolts, nuts, control rods/plates, and retaining rings shall be galvanized steel unless otherwise specified.
 4. Bolts, nuts, control rods/plates, and retaining rings for low pressure air systems provide materials matching the piping system.
 5. Bolts, nuts, control rods/plates, and retaining rings submerged in water or wastewater, buried, in wet vaults or structures, adjacent to wet walls, or above open water-containing structures shall be Type 316 stainless steel in accordance with ASTM A193, Grade B8M for bolts, and in accordance with ASTM A194, Grade 8M, for nuts.
- D. For blowers: Butyl type rubber formulated for service application and for maximum temperature of 250 degrees Fahrenheit, suitable for minimum 40 pounds per square inch gauge pressure, and minimum 15 inches mercury vacuum.

2.06 PIPE COUPLINGS FOR STAINLESS STEEL PIPING

- A. Flexible hose:
1. General:
 - a. Type: Flexible stainless steel hose.
 - 1) Unbraided for pressures up to 150 pounds per square inch.
 - 2) Single braided for pressures up to 225 pounds per square inch.
 - 3) Double braided for pressures up to 360 pounds per square inch.
 - b. End connections: Flanged, or as needed to comply with the specified type of joint:
 - 1) Sizes 2-1/2 inches and smaller may have threaded nipples.
 - 2) Sizes 2 inches through 12 inches may have grooved ends.
 2. Design:
 - a. Open pitch spacing of corrugation.
 - b. 1 fixed and 1 floating raised face flanged end connection.
 - c. Able to withstand up to 1-inch offset motion from centerline.
 3. Materials:
 - a. Hose: Type 316 stainless steel.
 - b. Flanges: Carbon steel.

PART 3 EXECUTION

3.01 GENERAL

- A. As specified in Section - Product Requirements.
- B. Bellows type expansion joints and vibration control joints:
 - 1. Protect joints against damage during pressure test.

3.02 INSTALLATION

- A. Expansion control joints:
 - 1. Install bellows type expansion control joints at piping connections to mechanical equipment to prevent damaging stresses due to normal expansion and contraction with temperature changes in piping and connected equipment.
 - 2. Install bellows type expansion joints so as to allow 2-1/4-inch expansion per 100 linear feet of piping.
 - 3. Install expansion joints adjacent to an anchor and provide 1 concentric guide on piping within 12 pipe diameters, but not more than 5 feet, from the end of the joint opposite the anchor.
 - a. Locate a similar guide approximately 30 diameters but not more than 10 feet from the first.
 - 4. For expansion joints not installed adjacent to an anchor provide 2 concentric guides similarly located at each end of the joint.
 - 5. Provide control rods and additional guides where indicated on the Drawings but at no greater intervals than recommended by the joint manufacturer in published instructions.
 - 6. Space intermediate supports a minimum of 10 feet, and tack weld the protective saddles to the pipe.
- B. Furnish Manufacturer's Certificate of Installation Verification.

3.03 FIELD QUALITY CONTROL

- A. Manufacturer services:
 - 1. Required only for:
 - a. Transition couplings.
 - b. Tapping sleeves for large diameter pipe.
- B. Field testing:
 - 1. As specified in Section 40_05_00.01 - Common Work Results for General Piping.
 - 2. Protect bellows type expansion joints and vibration control joints.

END OF SECTION

SECTION 40_05_06.03

PIPE COUPLINGS

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Pipe couplings for ductile iron piping.
 - 2. Pipe couplings for carbon steel piping.
 - 3. Pipe couplings for stainless steel piping.

1.02 REFERENCES

- A. American National Standards Institute (ANSI).
- B. American Society of Mechanical Engineers (ASME):
 - 1. B31.1 - Power Piping.
 - 2. B31.9 - Building Services Piping.
- C. American Water Works Association (AWWA):
 - 1. C111 - Standard for Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings.
 - 2. C207 - Standard for Steel Pipe Flanges for Waterworks Service - Sizes 4 Inches. Through 144 Inches.
 - 3. C213 - Standard for Fusion-Bonded Epoxy Coatings and Linings for Steel Water Pipe and Fittings.
 - 4. C219 - Bolted, Sleeve-Type Couplings For Plain-End Pipe.
 - 5. C227 - Bolted, Split-Sleeve Couplings.
 - 6. C606 - Standard for Grooved and Shouldered Joints.
- D. ASTM International (ASTM):
 - 1. A36 - Standard Specification for Carbon Structural Steel.
 - 2. A53 - Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless.
 - 3. A193 - Standard Specification for Alloy Steel and Stainless Steel Bolting Materials for High Temperature or High Pressure Service and Other Special Purpose Applications.
 - 4. A240 - Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications.
 - 5. A351 - Standard Specification for Castings, Austenitic, for Pressure-Containing Parts.
 - 6. A449 - Standard Specification for Hex Cap Screws, Bolts and Studs, Steel, Heat Treated, 120/105/9 ksi Minimum Tensile Strength, General Use.
 - 7. A536 - Standard Specification for Ductile Iron Castings.
 - 8. A576 - Standard Specification for Steel Bars, Carbon, Hot-Wrought, Special Quality.

9. A588 - Standard Specification for High-Strength Low-Alloy Structural Steel, up to 50 ksi (345 MPa) Minimum Yield Point, with Atmospheric Corrosion Resistance.
 10. C425 - Standard Specification for Compression Joints for Vitrified Clay Pipe and Fittings.
 11. C443 - Standard Specification for Joints for Concrete Pipe and Manholes, Using Rubber Gaskets.
 12. C564 - Standard Specification for Rubber Gasket for Cast Iron Pipe and Fittings.
 13. C1173 - Standard Specification for Flexible Transition Couplings for Underground Piping Systems.
 14. D1869 - Standard Specification for Rubber Rings for Asbestos-Cement Pipe.
 15. D2000 - Standard Classification System for Rubber Products in Automotive Applications.
 16. D5926 - Standard Specification for Poly (Vinyl Chloride) (PVC) Gaskets for Drain, Waste, and Vent (DWV), Sewer, Sanitary, and Storm Plumbing Systems.
 17. F593 - Standard Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs.
 18. F594 - Standard Specification for Stainless Steel Nuts.
- E. NSF International (NSF):
1. 61 - Drinking Water System Components - Health Effects.
 2. 372 - Drinking Water System Components - Lead Content.

1.03 SUBMITTALS

- A. Furnish Submittals as specified in Section 01_33_00 - Submittal Procedures.
- B. Product data:
1. For each product in this Section as applicable:
 - a. Design features.
 - b. Load capacities.
 - c. Material designations by UNS alloy number or ASTM specification and grade.
 - d. Data needed to verify compliance with the Specifications.
 - e. Catalog data.
 - f. Clearly mark Submittal information to show specific items, materials, and accessories or options being furnished.
 - g. For grooved joint couplings used in flexible radius-cut type joints, provide information on coupling axial and angular deflection values.
- C. Calculations:
1. Provide calculations in accordance with NSF 372 for materials in contact with drinking water.

1.04 WARRANTY

- A. Provide warranty as specified in Section 01_78_36 - Warranties and Bonds.

PART 2 PRODUCTS

2.01 GENERAL

- A. As specified in Section - Product Requirements:
 - 1. Materials in contact with drinking waters: In accordance with NSF 61 and NSF 372.
- B. Known acceptable manufacturers are listed by specific products.
- C. Provide references as specified in this Section by specific product.
- D. Manufacturer's representatives requirements as specified in Section 01_75_17 - Commissioning and this Section by specific product.
- E. Gaskets for flexible couplings and flanged coupling adapters:
 - 1. Provide gasket materials for piping applications as follows:
 - a. Low-pressure and high-pressure air, steam, hot water: EPDM.
 - b. All other piping applications: EPDM.
- F. Exterior coatings for underground and submerged applications:
 - 1. Manufacturers: One of the following or equal:
 - a. Kop-Coat Co., Inc., Bitumastic Number 50.
 - b. Tapecoat Co., Inc., T.C. Mastic.
 - 2. Thickness: Minimum 0.040 inch.

2.02 PIPE COUPLINGS FOR DUCTILE IRON PIPING

- A. Dismantling joints:
 - 1. Manufacturers: One of the following or equal:
 - a. Romac Ind., Inc., Style DJ400.
 - b. Smith-Blair, Inc., Series 975.
 - 2. Materials:
 - a. Flanged spool: AWWA C207 steel pipe:
 - 1) ASTM A53 for sizes 3 inches to 12 inches.
 - 2) ASTM A36 for sizes 14 inches to 72 inches.
 - b. End ring and body:
 - 1) For sizes 3 inches to 12 inches: Ductile iron in accordance with ASTM A536.
 - 2) For sizes 14 inches to 72 inches: Steel in accordance with ASTM A36 or ASTM A53.
 - c. Follower ring: Ductile iron in accordance with ASTM A536.
 - d. Bolts and hex nuts:
 - 1) Aboveground: High strength, low alloy steel in accordance with ASTM A588.
 - 2) Buried and underwater: Type 316 stainless steel bolts in accordance with ASTM F593.
 - e. Tie rods: High tensile steel in accordance with ASTM A193, Grade B7.

3. Flange design: Class D steel ring flange in accordance with AWWA C207, compatible with ANSI Class 125 and 150 bolt circles.
 4. Coating and lining: Manufacturer's standard fusion bonded epoxy, NSF 61 certified.
- B. Equipment connection fittings:
1. Manufacturers: The following or equal:
 - a. Romac Ind., Inc., Style ECF400.
 2. Design:
 - a. In accordance with AWWA C219.
 - b. Suitable for minimum 150 pounds per square inch working pressure.
 - c. Consist of 2 flanged coupling adapters, plain end section of pipe, thrust restraint rods, and associated fittings designed to transmit thrust without transmitting shear to the thrust restraint rods and without compromising provision for accommodating angular and parallel misalignment.
 - 1) Face to face length adjustment:
 - a) For sizes 3 inches to 12 inches: 2 inches.
 - b) For sizes 14 inches to 72 inches: 3 inches.
 - d. Provide both lateral and angular misalignment adjustment between flanges.
 - 1) Shall accommodate a minimum of 1/4-inch lateral offset and 2 degrees deflection.
 - e. Provide full pressure thrust restraint between flanges.
 - 1) Thrust rod:
 - a) Selected to provide sufficient freedom of movement through all bolt holes to allow unrestricted maximum adjustment of equipment connection fittings.
 - b) No transmission of any shear to the thrust rods.
 - c) Allows full development of thrust restraint at thrust rod tension take-ups.
 - d) Number and diameter selected as recommended by the manufacturer for the working pressure of the coupling.
 3. Materials:
 - a. Flanged spool: AWWA C207 steel pipe:
 - 1) ASTM A53 for sizes 3 inches to 12 inches.
 - 2) ASTM A36 for sizes 14 inches to 72 inches.
 - b. End ring and body:
 - 1) For sizes 3 inches to 12 inches: Ductile iron in accordance with ASTM A536.
 - 2) For sizes 14 inches to 72 inches: Steel in accordance with ASTM A36 or ASTM A53.
 - c. Bolts and hex nuts:
 - 1) Aboveground: Type 316 stainless steel bolts in accordance with ASTM F593.
 - d. Tie rods: Type 316 stainless steel in accordance with ASTM A193 B8M.
 - e. Flange design: Class D steel ring flange in accordance with AWWA C207, compatible with ANSI Class 125 and 150 bolt circles.
 - f. Harness lugs: ASTM A36 steel.
 - g. Coating and lining: Manufacturer's standard fusion bonded epoxy, NSF 61 certified.

- C. Flanged coupling adapters: 12-inch size and smaller:
 - 1. Manufacturers: One of the following or equal:
 - a. Dresser, Inc., Style 128-W.
 - b. Romac Ind., Inc., Style FCA501.
 - c. Smith-Blair, Inc., Series 912.
 - 2. Materials:
 - a. Flanged body: Ductile iron in accordance with ASTM A536.
 - b. Follower ring: Ductile iron in accordance with ASTM A536.
 - c. Bolts and hex nuts:
 - 1) Aboveground: High strength, low alloy steel in accordance with AWWA C111.
 - 2) Buried and underwater: Type 316 stainless steel bolts in accordance with ASTM F593.
 - 3. Flange design: Class D steel ring flange in accordance with AWWA C207, compatible with ANSI Class 125 and 150 bolt circles.
 - 4. Coating and lining: Manufacturer's standard fusion bonded epoxy, NSF 61 certified.
- D. Flanged coupling adapters: Greater than 12-inch size:
 - 1. Manufacturers: One of the following or equal:
 - a. Dresser, Inc., Style 128-W.
 - b. Romac Ind., Inc., Style FC400.
 - c. Smith-Blair, Inc., Series 913.
 - 2. Materials:
 - a. Flange and flanged body: Ductile iron or low carbon steel having a minimum yield strength of 30,000 pounds per square inch.
 - b. Follower ring: Low carbon steel having a minimum yield strength of 30,000 pounds per square inch.
 - c. Bolts and hex nuts:
 - 1) Aboveground: High strength, low alloy steel in accordance with AWWA C111.
 - 2) Buried and underwater: Type 316 stainless steel bolts in accordance with ASTM F593.
 - 3. Flange design: Class D steel ring flange in accordance with AWWA C207, compatible with ANSI Class 125 and 150 bolt circles.
 - 4. Coating and lining: Manufacturer's standard fusion bonded epoxy, NSF 61 certified.
- E. Flexible couplings:
 - 1. Manufacturers: One of the following or equal:
 - a. Dresser, Inc., Style TX3 2-bolt coupling.
 - b. Romac Ind., Inc., Style 501.
 - c. Smith-Blair, Inc., Series 441.
 - 2. Materials:
 - a. Center rings: Ductile iron in accordance with ASTM A536.
 - b. Follower rings: Ductile iron in accordance with ASTM A536.
 - c. Bolts and hex nuts:
 - 1) Aboveground: High strength, low alloy steel in accordance with AWWA C111.
 - 2) Buried and underwater: Type 316 stainless steel in accordance with ASTM F593.

3. Coating and lining: Manufacturer's standard fusion bonded epoxy, NSF 61 certified.
4. Center sleeve dimensions: Provide center sleeves with lengths in accordance with the following table:

Nominal Pipe Size	Sleeve Length
3-inch and smaller	Manufacturer's standard
4-inch through 8-inch	7 inches
10-inch through 14-inch	12 inches
Greater than 16-inch	Use steel flexible coupling per pipe couplings for steel piping

F. Flexible couplings (gravity flow):

1. Manufacturers: The following or equal:
 - a. Fernco Flexible Coupling.
2. Materials:
 - a. In accordance with ASTM D5926, ASTM C1173, and applicable portions of ASTM C443, C425, C564, and D1869.
3. Requirements:
 - a. In underground and underwater installations, couplings shall be corrosion resistant or coated with a fusion applied epoxy coating in accordance with AWWA C213.
 - b. Bolts and hardware shall be stainless steel 18-8 Type 316.

G. Restrained flange coupling adapter:

1. Manufacturers: One of the following or equal:
 - a. Romac Ind., Inc., Style RFCA.
 - b. Star Pipe Products, 3200 StarFlange™.
2. Materials:
 - a. Flange and flanged body: Ductile iron in accordance with ASTM A536.
 - b. Follower ring: Lug type restraint system.
 - 1) Follower ring: Ductile iron in accordance with ASTM A536.
 - 2) Restraining lugs: Ductile iron in accordance with ASTM A536.
 - a) Designed to contact the pipe and apply forces evenly.
 - 3) Restraining bolts:
 - a) Ductile iron in accordance with ASTM A536.
 - b) Bolt heads shall be designed to twist off when the proper torque has been applied.
 - c. Bolts and hex nuts:
 - 1) Aboveground: High strength, low alloy steel in accordance with AWWA C111.
 - 2) Buried and underwater: Type 316 stainless steel bolts in accordance with ASTM F593.
3. Flange design: Class D steel ring flange in accordance with AWWA C207, compatible with ANSI Class 125 and 150 bolt circles.
4. Coating and lining: Manufacturer's standard fusion bonded epoxy, NSF 61 certified.

H. Grooved joint couplings:

1. Manufacturers: The following or equal:
 - a. Victaulic, Series 31 or equal.

2. Materials:
 - a. Housings: Ductile iron in accordance with ASTM A536.
 - b. Gasket:
 - 1) Grade "M" FlushSeal® Elastomer in accordance with ASTM D2000.
 - 2) Halogenated butyl (brown color code).
 - 3) Temperature range: -20 to 200 degrees Fahrenheit.
 - 4) UL classified in accordance with NSF 61.
 - c. Bolts and nuts: Electroplated steel in accordance with ASTM A449.
 - d. Coating: As specified in Section 09_96_01 - High-Performance Coatings.
3. For use with rigid or flexible radius cut grooved joints in accordance with AWWA C606.
4. For connection to IPS steel pipe sizes: Victaulic transition coupling Style 307.

2.03 PIPE COUPLINGS FOR CARBON STEEL PIPING

- A. Dismantling joints:
 1. Manufacturers: One of the following or equal:
 - a. Romac Ind., Inc., Style DJ400.
 - b. Smith-Blair, Inc., Series 975.
 2. Materials:
 - a. Flanged spool:
 - 1) For sizes 3 inches to 12 inches: AWWA C207 Schedule 40 pipe in accordance with ASTM A53.
 - 2) For sizes 14 inches to 72 inches: Steel for pipe in accordance with ASTM A36 or ASTM A53.
 - b. End ring and body:
 - 1) For sizes 3 inches to 12 inches: Ductile iron in accordance with ASTM A536.
 - 2) For sizes 14 inches to 72 inches: Steel in accordance with ASTM A36.
 - c. Follower ring: Ductile iron in accordance with ASTM A536 or steel in accordance with ASTM A36 or ASTM A576.
 - d. Bolts and hex nuts:
 - 1) Aboveground: High strength, low alloy steel in accordance with AWWA C111.
 - 2) Buried and underwater: Type 316 stainless steel bolts in accordance with ASTM F593.
 - e. Tie rods: High tensile steel in accordance with ASTM A193, Grade B7.
 3. Flange design: Class D steel ring flange in accordance with AWWA C207, compatible with ANSI Class 125 and 150 bolt circles.
 4. Coating and lining: Fusion bonded epoxy certified in accordance with NSF 61.
- B. Flanged coupling adapters:
 1. Manufacturers: One of the following or equal:
 - a. Dresser, Inc., Style 128-W.
 - b. Romac Ind., Inc., Style FCA501 (10 inch and smaller) or Style FC400 (12 inch and larger).
 - c. Smith-Blair, Inc., Series 913.
 2. Materials:
 - a. Flange and flanged body: Ductile iron or low carbon steel having a minimum yield strength of 30,000 pounds per square inch.

- b. Follower ring: Low carbon steel having a minimum yield strength of 30,000 pounds per square inch.
- c. Bolts and hex nuts:
 - 1) Aboveground: High-strength, low-alloy steel in accordance with AWWA C111.
 - 2) Buried and underwater: Type 316 stainless steel bolts in accordance with ASTM F593.
- 3. Flange design: Class D steel ring flange in accordance with AWWA C207, compatible with ANSI Class 125 and 150 bolt circles.
- 4. Coating and lining: Manufacturer's standard fusion bonded epoxy, NSF 61 certified.

C. Flexible couplings:

- 1. Manufacturers: One of the following or equal:
 - a. Dresser, Inc., Style 38.
 - b. Romac Ind., Inc., Style 511 or Style 400.
 - c. Smith-Blair, Inc., Series 411.
- 2. Materials:
 - a. Center sleeve and follower flanges: Ductile iron or low carbon steel having a minimum yield strength of 30,000 pounds per square inch.
 - b. Bolts and hex nuts:
 - 1) Aboveground: High strength, low alloy steel in accordance with AWWA C111.
 - 2) Buried and underwater: Type 316 stainless steel bolts in accordance with ASTM F593.
- 3. Coating and lining: Manufacturer's standard fusion bonded epoxy, NSF 61 certified.
- 4. Center sleeve dimensions: Provide center sleeves with lengths in accordance with the following table:

Nominal Pipe Diameter	Sleeve Length
2-1/2 inch and smaller	Manufacturer's standard
3-inch through 6-inch	7 inches
8-inch through 14-inch	7 inches
Greater than 14-inch	10 inches

D. Restrained flange coupling adapters:

- 1. Manufacturers: One of the following or equal:
 - a. Romac Ind. Inc., Style RFCA.
 - b. Star Pipe Products, 3200 StarFlange™.
- 2. Materials:
 - a. Flange and flanged body: Ductile iron in accordance with ASTM A536.
 - b. Follower ring: Lug type restraint system.
 - 1) Follower ring: Ductile iron in accordance with ASTM A536.
 - 2) Restraining lugs: Ductile iron in accordance with ASTM A536.
 - a) Designed to contact the pipe and apply forces evenly.
 - 3) Restraining bolts: Ductile iron in accordance with ASTM A536. Bolt heads shall be designed to twist off when the proper torque has been applied.

- c. Bolts and hex nuts:
 - 1) Aboveground: High-strength, low-alloy steel in accordance with AWWA C111.
 - 2) Buried and underwater: Type 316 stainless steel bolts in accordance with ASTM F593.
 - 3. Flange design: Class D steel ring flange in accordance with AWWA C207, compatible with ANSI Class 125 and 150 bolt circles.
 - 4. Coating and lining: Manufacturer's standard fusion bonded epoxy certified in accordance with NSF 61.
- E. Grooved joint couplings:
 - 1. Model numbers from one manufacturer are shown to indicate type only. Equivalent products of other manufacturers may be submitted for approval.
 - 2. Coating: As specified in Section 09_96_01 - High-Performance Coatings.
 - 3. Sizes 2 inches through 12 inches:
 - a. Rigid type:
 - 1) Housings shall be cast with offsetting angle-pattern bolt pads to provide rigidity and system support and hanging in accordance with ASME B31.1 and B31.9.
 - 2) Installation-ready, for direct stab installation without field disassembly, with EHP gasket rated to 250 degrees Fahrenheit.
 - 3) Manufacturers: One of the following or equal:
 - a) Victaulic, Style 107.
 - b) Victaulic, Zero-Flex Style 07.
 - b. Flexible type:
 - 1) For use in locations where vibration attenuation and stress relief are required.
 - 2) 3 flexible couplings may be used in lieu of a flexible connector.
 - 3) Couplings shall be placed in close proximity to the source of the vibration.
 - 4) Installation-ready, for direct stab installation without field disassembly, with EHP gasket rated to 250 degrees Fahrenheit.
 - 5) Manufacturers: One of the following or equal:
 - a) Victaulic, Style 77.
 - b) Victaulic, Style 177.
 - c. Flange adapter:
 - 1) Flat face, ductile iron housings with elastomer pressure responsive gasket, for direct connection to ANSI Class 125 or 150 flanged components.
 - 2) Manufacturers: The following or equal:
 - a) Victaulic, Style 741.
 - 4. Sizes 14 inches through 24 inches:
 - a. Victaulic, AGS series, with lead-in chamfer on housing key and wide width FlushSeal® gasket.
 - b. Rigid type:
 - 1) Housing key shall fill the wedge shaped AGS groove and provide rigidity and system support and hanging in accordance with ASME B31.1 and B31.9.
 - 2) Manufacturers: The following or equal:
 - a) Victaulic, Style W07.

- c. Flexible type:
 - 1) Housing key shall fit into the wedge shaped AGS groove and allow for linear and angular pipe movement.
 - 2) Manufacturers: The following or equal:
 - a) Victaulic, Style W77.
- d. Flange adapter:
 - 1) Flat face, ductile iron housings with elastomer pressure responsive gasket, for direct connection to ANSI Class 125 or 150 flanged components.
 - 2) Manufacturers: The following or equal:
 - a) Victaulic, Style W741.
- 5. Sizes 30 inches and larger:
 - a. Manufacturers: The following or equal:
 - 1) Victaulic, Style AGS.

Size	Pipe Schedule	Max. Joint Working Pressure
6 inches	80	3,000 psig (20,690 kPa)
	160	4,000 psig (27,586 kPa)
8 inches	80	2,500 psig (17,241 kPa)
	160	3,500 psig (24,138 kPa)
10 inches	80	2,500 psig (17,241 kPa)
	160	3,000 psig (20,690 kPa)
12 inches	80	2,000 psig (13,793 kPa)
	160	2,500 psig (17,241 kPa)

2.04 PIPE COUPLINGS FOR STAINLESS STEEL PIPING

- A. Flexible couplings:
 - 1. Manufacturers: The following or equal:
 - a. Dresser, Inc., Style 38.
- B. Grooved joint couplings:
 - 1. Manufacturers: The following or equal:
 - a. Victaulic.
 - 2. Materials:
 - a. Housings:
 - 1) Ductile iron in accordance with ASTM A536.
 - 2) Stainless steel in accordance with ASTM A351.
 - b. Gasket: Elastomer in accordance with ASTM D2000.
 - c. Bolts and nuts:
 - 1) Electroplated steel in accordance with ASTM A449.
 - 2) Stainless steel in accordance with ASTM F593.
 - 3. Rigid type:
 - a. Victaulic, Style 89 and W89 (ductile iron housings).
 - b. Victaulic, Style 489 (stainless steel housings).
 - 4. Flexible type: Victaulic, Style 77S.

PART 3 EXECUTION

3.01 INSTALLATION

- A. In underground and underwater installations, coat the exterior of coupling with a protective coating in accordance with the manufacturer's instructions.
- B. Joints and flexible connections shall be installed centered with no angular deflection unless otherwise indicated on the Drawings.
- C. Flexible couplings and flange coupling adapters: Install with gap between pipe ends in accordance with the following table unless a greater gap is indicated on the Drawings. Maximum gap tolerance shall be within 1/8 inch.
 - 1. Install flexible coupling with pipe gap located in middle of center sleeve.
 - 2. Install flanged coupling adapter with end of plain end pipe in middle of flanged coupling body.

Center Ring Length	Gap Dimension and Tolerance
4 inches through 6 inches	3/8-inch
7 inches	5/8-inch
10 inches and greater	7/8-inch

- D. Provide harnesses (tie-downs) for flexible couplings unless otherwise indicated on the Drawings with a written note.
 - 1. Design harnesses (tie-downs) for the test pressures as specified in the Pipe Schedule in Section - Common Work Results for General Piping.
- E. Grooved joint couplings:
 - 1. Grooved ends: Clean and free from indentations, projections, and roll marks in the area from pipe end to groove.
 - 2. Gaskets: Elastomer grade suitable for the intended service, and molded and produced by the coupling manufacturer.
- F. Bolted, split-sleeve couplings:
 - 1. Inspect each coupling to ensure that there are no damaged portions of the coupling.
 - a. Pay particular attention to the sealing pad/sealing plate area.
 - b. Before installation, thoroughly clean each coupling of any foreign substance which may have collected thereon and shall be kept clean at all times.
 - 2. Wrenches:
 - a. Conform to manufacturer instructions.
 - b. Bolts and studs shall be tightened so as to secure a uniform gasket compression between the coupling and the body of the pipe with all bolts or studs tightened approximately the same amount.
 - c. Final tightening shall be done by hand (no air impact wrenches) and is complete when the coupling is in uniform contact with the outside surface of the pipe all around the circumference of the pipe.
 - 3. No joint shall be misfit in any plane.
 - 4. On fixed ends of bolted, split-sleeve couplings, shoulders shall bear on restraint rings all around with no visible gap.

5. Ends of piping where coupler are installed shall be smooth and free of defects.
 - a. Remove weld splatter and grind smooth.
 - b. Grind pipe seam welds flush with pipe wall and smooth.

END OF SECTION

SECTION 40_05_07.01

PIPE SUPPORTS

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Supports for pipe, fittings, valves, and appurtenances.

1.02 REFERENCES

- A. ASTM International (ASTM):
 - 1. A123 - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
 - 2. A380 - Standard Practice for Cleaning, Descaling, and Passivation of Stainless Steel Parts, Equipment, and Systems.
 - 3. A967 - Standard Specification for Chemical Passivation Treatments for Stainless Steel Parts.
- B. Manufacturers Standardization Society (MSS):
 - 1. SP-58 - Pipe Hangers and Supports - Materials, Design, Manufacture, Selection, Application, and Installation.

1.03 TERMINOLOGY

- A. The words and terms listed below are not defined terms that require initial capital letters, but, when used in this Section, have the indicated meaning.
 - 1. Anchor: Elements (including hardware) connecting hangers and supports to the structure.
 - 2. Hardware: Nuts, bolts, straps, clamps, threaded rod, etc.
 - 3. Supports: Structural member on which the pipe is mounted.

1.04 SUBMITTALS

- A. Submit as specified in Section 01_33_00 - Submittal Procedures.
- B. Product data:
 - 1. Design features.
 - 2. Load capacities.
 - 3. Material designations by UNS alloy number or ASTM Specification and Grade.
 - 4. Catalog data.

1.05 WARRANTY

- A. Provide warranty as specified in Section 01_78_36 - Warranties and Bonds.

PART 2 PRODUCTS

2.01 GENERAL

- A. As specified in Section 01_60_01 - Product Requirements.

2.02 MATERIALS

- A. General:
 - 1. Hot dip galvanized:
 - a. Fabricate as specified in Section 05_50_00 - Metal Fabrications.
 - b. Hot dip after fabrication of support in accordance with ASTM A123.
 - c. Repair galvanized surface as specified in Section 05_50_00 - Metal Fabrications.
 - 2. Stainless steel:
 - a. Fabricate as specified in Section 05_50_00 - Metal Fabrications.
 - b. Finish requirements: Remove free iron, heat tint oxides, weld scale, and other impurities, and obtain a passive finished surface.
 - c. At the shop, perform pickling and passivation on all surfaces inside and out in accordance with ASTM A380 or ASTM A967.
 - d. Field welding is prohibited unless specifically allowed by the Owner. All field welds shall be passivated.
- B. Outdoor areas: Areas exposed to the natural outdoor environment:
 - 1. Type 316L stainless steel.
- C. Indoor areas: Areas exposed to an indoor environment, including galleries and tunnels:
 - 1. Type 316L stainless steel.
- D. Submerged, 3 feet or less above water level in a structure, or inside a water bearing structure:
 - 1. Type 316L stainless steel.
- E. Stainless steel piping system:
 - 1. Type 316L stainless steel.
- F. Fasteners:
 - 1. As specified in Section 05_50_00 - Metal Fabrications.

2.03 PIPE SUPPORTS

- A. Hanger rods: Sized to match suspended pipe hanger, or as indicated on the Drawings:
 - 1. Manufacturers: One of the following or equal:
 - a. For stainless steel piping:
 - 1) Bergen-Power, Figure 133.
 - 2) Nibco-Tolco, Figure 103.
 - b. For all other piping, unless indicated on the Drawings:
 - 1) Anvil International, Figure 140.

- 2) Bergen-Power, Figure 133.
 - 3) Cooper B-Line Systems, Inc., Figure B3205.
- B. Hanger rods, continuously threaded: Sized to match suspended pipe hanger, or as indicated on the Drawings:
 - 1. Manufacturers: One of the following or equal:
 - a. For stainless steel piping:
 - 1) Bergen-Power, Figure 94.
 - 2) FM Stainless Fasteners.
 - b. For steel and ductile iron piping:
 - 1) Anvil International, Figure 146.
 - 2) Bergen-Power, Figure 94.
- C. Eye bolts:
 - 1. For stainless steel piping:
 - a. Type 316 stainless steel, welded and rated equal to full load capacity of rod.
 - 2. For all other piping, unless indicated on the Drawings:
 - a. Welded and rated equal to full load capacity of rod.
- D. Welded eyebolt rod:
 - 1. Manufacturers: One of the following or equal:
 - a. For stainless steel piping:
 - 1) FM Stainless Fasteners.
 - 2) Nibco-Tolco, Figure 101.
 - b. For all other piping, unless indicated on the Drawings:
 - 1) Anvil International, Figure 278.
 - 2) Bergen-Power, Figure 93.
 - 3) Cooper B-Line Systems, Inc., Figure B3210.
- E. Adjustable ring hangers: MSS SP-58, Type 7 or Type 9 (system dependent):
 - 1. Manufacturers: One of the following or equal:
 - a. For stainless steel piping:
 - 1) Bergen-Power, Figure 100SS.
 - 2) Nibco-Tolco, Figure 1C.I.
 - b. For all other piping, unless indicated on the Drawings:
 - 1) Anvil International, Figure 69.
 - 2) Cooper B-Line Systems, Inc., Figure B3172.
- F. Adjustable clevis hangers: MSS SP-58, Type 1:
 - 1. Manufacturers: One of the following or equal:
 - a. For stainless steel piping:
 - 1) Cooper B-Line Systems, Inc., Figure B3100 or B3102.
 - 2) FM Stainless Fasteners, Figure 60.
 - b. For all other piping, unless indicated on the Drawings:
 - 1) Anvil International, Figure 260 or Figure 590.
 - 2) Bergen-Power, Figure 100.
 - 3) Cooper B-Line Systems, Inc., Figure B3100 or B3102.

- G. Adjustable clevis hangers for insulated pipe: Oversize:
 - 1. Manufacturers: One of the following or equal:
 - a. For stainless steel piping:
 - 1) Nibco-Tolco, Figure 1A.
 - b. For all other piping, unless indicated on the Drawings:
 - 1) Anvil International, Figure 300.
 - 2) Bergen-Power, Figure 100EL.
 - 3) Cooper B-Line Systems, Inc. Figure B3108.
- H. Single rod hangers for steam pipe: MSS SP-58, Type 43; malleable iron or steel yoke and roller hangers; swivel to allow rotation of yoke on rod:
 - 1. Manufacturers: One of the following or equal:
 - a. For stainless steel piping:
 - 1) Cooper B-Line Systems, Inc., Figure B3110.
 - 2) FM Fasteners, Figure 81.
 - 3) Nibco-Tolco, Figure 324.
 - b. For all other piping, unless indicated on the Drawings:
 - 1) Anvil International, Figure 181.
 - 2) Cooper B-Line Systems, Inc., Figure B3110.
- I. Double rod hangers for steam pipe: MSS SP-58, Type 41:
 - 1. Manufacturers: One of the following or equal:
 - a. For stainless steel piping:
 - 1) FM Stainless Fasteners, Figure 71.
 - b. For all other piping, unless indicated on the Drawings:
 - 1) Anvil International, Figure 171.
 - 2) Cooper B-Line Systems, Inc., Figure B3114.
- J. Brackets: MSS SP-58, Type 32 with back plate; rated for 1,500 pounds:
 - 1. Manufacturers: One of the following or equal:
 - a. For stainless steel piping:
 - 1) Cooper B-Line Systems, Inc., Figure B3066.
 - 2) FM Stainless Fasteners, Figure 98.
 - 3) Nibco-Tolco, Figure 30M.
 - b. For all other piping, unless indicated on the Drawings:
 - 1) Anvil International, Figure 195.
 - 2) Cooper B-Line Systems, Inc., Figure B3066.
- K. Brackets, heavy duty: MSS SP-58, Type 33 with back plate; rated for 3,000 pounds:
 - 1. Manufacturers: One of the following or equal:
 - a. Anvil International, Figure 199.
 - b. Cooper B-Line Systems, Inc., Figure B3067.
- L. Standard U-bolt: MSS SP-58, Type 24:
 - 1. Manufacturers: One of the following or equal:
 - a. For stainless steel piping:
 - 1) Cooper B-Line Systems, Inc., Figure B3188.
 - 2) FM Stainless Fasteners, Figure 37.
 - 3) Nibco-Tolco, Figure 110.

- b. For all other piping, unless indicated on the Drawings:
 - 1) Anvil International, Figure 137.
 - 2) Bergen-Power, Figure 283.
 - 3) Cooper B-Line Systems, Inc., Figure B3188.
- M. Riser clamps: MSS SP-58, Type 8:
 - 1. Manufacturers: One of the following or equal:
 - a. For stainless steel piping:
 - 1) Cooper B-Line Systems, Inc., Figure B3373.
 - 2) FM Stainless Fasteners, Figure 61.
 - b. For all other piping, unless indicated on the Drawings:
 - 1) Anvil International, Figure 261.
 - 2) Bergen-Power, Figure 126.
 - 3) Cooper B-Line Systems, Inc., Figure B3373.
- N. Pipe clamps: MSS SP-58, Type 4:
 - 1. Manufacturers: One of the following or equal:
 - a. For stainless steel piping:
 - 1) Cooper B-Line Systems, Inc., Figure 3140.
 - 2) Nibco-Tolco, Figure 4.
 - b. For all other piping, unless indicated on the Drawings:
 - 1) Anvil International, Figure 212.
 - 2) Bergen-Power, Figure 175.
 - 3) Cooper B-Line Systems, Inc., Figure B3140.
- O. Adjustable offset pipe clamp:
 - 1. Manufacturers: One of the following or equal:
 - a. For stainless steel piping:
 - 1) Cooper B-Line Systems, Inc., Figure B3149.
 - 2) FM Stainless Fasteners, Figure 63.
 - 3) Nibco-Tolco, Figure 4.
 - b. For all other piping, unless indicated on the Drawings:
 - 1) Anvil International, Figure 100.
 - 2) Cooper B-Line Systems, Inc., Figure B3149.
- P. Offset pipe clamp:
 - 1. Manufacturers: One of the following or equal:
 - a. For stainless steel piping:
 - 1) Cooper B-Line Systems, Inc., Figure 3148.
 - 2) Nibco-Tolco, Figure 8.
 - b. For all other piping, unless indicated on the Drawings:
 - 1) Anvil International, Figure 103.
 - 2) Cooper B-Line Systems, Inc., Figure B3148.
- Q. Floor stand or stanchion saddles: MSS SP-58, Type 37. Provided with U-bolt hold down yokes:
 - 1. Manufacturers: One of the following or equal:
 - a. For stainless steel piping:
 - 1) FM Stainless Fasteners, Figure 59.
 - 2) Nibco-Tolco, Figure 318.

- b. For all other piping, unless indicated on the Drawings:
 - 1) Anvil International, Figure 259.
 - 2) Bergen-Power, Figure 125.
 - 3) Cooper B-Line Systems, Inc., Figure B3090.
 - c. Threaded pipe stand support stanchion. Match pipe support material:
 - 1) Anvil International, Figure 63T.
 - 2) Bergen-Power, Figure 138.
 - 3) Cooper B-Line Systems Inc., Figure B3088ST.
- R. Spring hangers:
- 1. Manufacturers: One of the following or equal:
 - a. For stainless steel piping:
 - 1) Bergen-Power, Figure 920.
 - b. For all other piping, unless indicated on the Drawings:
 - 1) Anvil International, Figure B-268, Type G.
 - 2) Bergen-Power, Figure 920.
- S. One hole pipe clamps:
- 1. Manufacturers: One of the following or equal:
 - a. For stainless steel piping: Engineer knows of no product.
 - b. For all other piping:
 - 1) Anvil International, Figure 126.
 - 2) Carpenter & Paterson, Figure 237S.
- T. Welded beam attachment: MSS SP-58, Type 22:
- 1. Manufacturers: One of the following or equal:
 - a. For stainless steel piping:
 - 1) Cooper B-Line Systems, Inc., Figure 3083.
 - 2) Nibco-Tolco, Figure 304.
 - b. For all other piping, unless indicated on the Drawings:
 - 1) Anvil International, Figure 66.
 - 2) Bergen-Power, Figure 113A or 113B.
 - 3) Cooper B-Line Systems, Inc., Figure B3083.
- U. Heavy pipe clamp: MSS SP-58, Type 4:
- 1. Manufacturers: One of the following or equal:
 - a. For stainless steel piping:
 - 1) Nibco-Tolco, Figure 4H.
 - b. For all other piping, unless otherwise indicated on the Drawings:
 - 1) Anvil International, Figure 216.
 - 2) Bergen-Power, Figure 298.

- V. PTFE pipe slide assembly: MSS SP-58, Type 35 with lateral and vertical restraint:
 - 1. Manufacturers: One of the following or equal:
 - a. For stainless steel piping:
 - 1) Nibco-Tolco, Figure 426.
 - b. For all other piping, unless indicated on the Drawings:
 - 1) Anvil International, Figure 257, Type 3.
 - 2) Cooper B-Line Systems, Inc., Figure B3893.
- W. Anchor bolts, concrete anchors, concrete inserts, powder-actuated fasteners, and sleeve anchors: As specified in Section 05_12_00 - Structural Steel Framing.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Support, suspend, or anchor exposed pipe, fittings, valves, and appurtenances to prevent sagging, overstressing, or movement of piping; and to prevent thrusts or loads on or against connected pumps, blowers, and other equipment.
- B. Field verify support location, orientation, and configuration to eliminate interferences prior to fabrication of supports.
- C. Determine locations of inserts. Anchor to formwork prior to placing concrete.
- D. Use flush shells only where indicated on the Drawings.
- E. Do not use anchors relying on deformation of lead alloy.
- F. Do not use powder-actuated fasteners for securing metallic conduit or steel pipe larger than 1 inch to concrete, masonry, or wood.
- G. Suspend pipe hangers from hanger rods and secure with double nuts.
- H. Install continuously threaded hanger rods only where indicated on the Drawings.
- I. Use adjustable ring hangers or adjustable clevis hangers for 4-inch and smaller diameter pipe.
- J. Use adjustable clevis hangers for pipes larger than 4 inches in diameter.
- K. Secure pipes with double nutted U-bolts or suspend pipes from hanger rods and hangers.
 - 1. For stainless steel piping, use stainless steel U-bolts.
 - 2. For all other piping, use galvanized U-bolts.
- L. Support spacing:
 - 1. Support 2-inch and smaller piping on horizontal and vertical runs at maximum 5 feet on center, unless otherwise specified.
 - 2. Support larger than 2-inch piping on horizontal and vertical runs at maximum 10 feet on center, unless otherwise specified.

3. Support exposed polyvinyl chloride and other plastic pipes at maximum 5 feet on center, regardless of size.
 4. Support tubing, PVC pipe 1-inch and smaller, copper pipe and tubing, fiber-reinforced plastic pipe or duct, and rubber hose and tubing at intervals close enough to prevent sagging greater than 1/4-inch between supports.
 5. Do not suspend or support valves, pipe and fittings from another pipe or conduit.
- M. Install supports at:
1. Any change in direction.
 2. Both sides of flexible pipe connections.
 3. Base of risers.
 4. Floor penetrations.
 5. Connections to pumps, blowers, and other equipment.
 6. Valves and appurtenances.
- N. Securely anchor plastic pipe, valves, and headers to prevent movement during operation of valves.
- O. Anchor plastic pipe between expansion loops and direction changes to prevent axial movement through anchors.
- P. Provide elbows or tees supported from floors with base fittings where indicated on the Drawings.
- Q. Support base fittings with metal supports or, when indicated on the Drawings, support on concrete piers.
- R. Do not use chains, plumbers' straps, wire, or similar devices for permanently suspending, supporting, or restraining pipes.
- S. Support plumbing drainage and vents in accordance with plumbing code as specified in Section 01_41_00 - Regulatory Requirements.
- T. Supports, clamps, brackets, and portions of support system bearing against copper pipe: Copper plated, copper throughout, or isolated with neoprene or polyvinyl chloride tape.
- U. Where pipe is insulated, install over-sized supports and hangers.
- V. Install thermal pipe shield in accordance with MSS SP-58, Type 40 on pipe supports for insulated pipes.
- W. Install riser clamps at floor penetrations and where indicated on the Drawings.
- X. Coat support system components as specified in Section 09_96_01 - High-Performance Coatings.

END OF SECTION

SECTION 40_05_07.03

PREFORMED CHANNEL PIPE SUPPORT SYSTEM

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes: Preformed channel pipe support system consisting of preformed channels, fittings, straps, and fasteners engineered to support piping.

1.02 REFERENCES

- A. American Institute of Steel Construction (AISC).
- B. American Iron and Steel Institute (AISI).
- C. Manufacturer's Standardization Society (MSS):
 - 1. SP-58 - Pipe Hangers and Supports - Materials, Design, and Manufacture.

1.03 SUBMITTALS

- A. Submit as specified in Section 01_33_00 - Submittal Procedures.
- B. Product data.

1.04 QUALITY ASSURANCE

- A. Design preformed channel pipe support system for loads in accordance with applicable provisions of:
 - 1. AISC Manual of Steel Construction.
 - 2. AISI Cold-Formed Steel Design Manual.
- B. Product standards:
 - 1. Pipe support materials: In accordance with MSS SP-58.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Fabricate preformed channel pipe support system using, as a minimum, parts specified below and meeting the requirements specified under Design Criteria.
 - 1. Manufacturers: One of the following or equal:
 - a. Unistrut, Series P1000 or P1001; P5500 or P5501.
 - b. Allied Support Systems, Power Strut, Figure PS-200 or PS-200 2TS; PS-150 or PS-150 2TS.
 - c. Cooper Ind., B-Line, Channel Type B22 or B22A; B12 or B12A.

2.02 DESIGN AND PERFORMANCE CRITERIA

- A. Design responsibility:
 - 1. The manufacturer of the preformed channel pipe support system is responsible for the design of the support system.
 - 2. Prepare design calculations utilizing the design criteria included in these Specifications.
 - 3. Prepare detailed shop drawings illustrating the layout of the support system and identifying the components of the support system.
- B. Design criteria:
 - 1. Include live, dead, and seismic loads associated with piping, valves, and appurtenances. Consider the content of the pipes in load calculations.
 - 2. Minimum gauge thickness: 12-gauge.
 - 3. Allowable stress of channels:
 - a. Steel channels: The lesser of 25,000 pounds per square inch, or 0.66 times yield stress of steel.
 - b. Stainless steel channels: 0.66 times the yield stress of the stainless steel alloy.
 - 4. Maximum deflection: 1/240 of span.
 - 5. Allowable column loads: As recommended by manufacturer in published instruction for column's unsupported height and "K" value for calculating effective column length of not less than 1.0.
 - 6. Future loads:
 - a. Support systems indicated on the Drawings may include spaces intended to accommodate future pipes.
 - b. Assume such spaces are occupied by 6-inch diameter ductile iron pipes. Only the number of pipes that would physically fit into the space need be considered.
 - c. Include the weight of the pipe contents in determining future loads. Assume pipe contents are water.
 - 7. Seismic design criteria: As specified in Section 01_81_50 - Design Criteria as specified for mechanical equipment.
 - 8. Spacing of supports: As required to comply with design requirements but not more than 5 feet.
- C. Supports below the top of walls of water bearing structures: Use Type 316 stainless steel for support system components.
 - 1. Supports in other locations: Use hot-dipped galvanized components unless other materials are specifically indicated on the Drawings.

2.03 ACCESSORIES

- A. Preformed channel concrete inserts: Minimum 12 inches long:
 - 1. Manufacturers: One of the following or equal:
 - a. Unistrut, Series P-3200.
 - b. Allied Support Systems, Figure 282.
 - c. Cooper Ind., B-Line Series B32I.

- B. 90-degree angle fittings:
 - 1. Manufacturers: One of the following or equal:
 - a. Unistrut, P1026.
 - b. Allied Support Systems, Power Strut, P603.
- C. Pipe straps:
 - 1. For pipes 8 inches in diameter and smaller: Use 2-piece universal strap with slotted hex head screw and nut.
 - a. Manufacturers: One of the following or equal:
 - 1) Unistrut, Series P1109 through P1126.
 - 2) Allied Support Systems, PS1100.
 - 3) Cooper Ind., B-Line Series B2000.
 - 2. For pipes greater than 8 inches in diameter: Unless different material is otherwise indicated on the Drawings use 1-piece 1-inch-wide by 1/8-inch-thick steel strap, hot-dip galvanized after fabrication.
 - 3. For stainless steel pipes: Use type of strap required for the pipe sizes specified above but use Type 316 stainless steel materials.
- D. Prefabricated double channel bracket:
 - 1. Manufacturers: One of the following or equal:
 - a. Unistrut, P2542-P2546.
 - b. Cooper Ind., B-Line Series B297.
- E. Touch-up paint for galvanized surfaces:
 - 1. Manufacturers: The following or equal:
 - a. Galvinox, Galvo-Weld.
- F. Touch-up paint for painted surfaces: Same formulation as factory paint.
- G. Cushion strip:
 - 1. For solvent welded plastic pipes in elevated temperatures, use a thermoplastic elastomer, cushion wrap designed for use from -50 degrees Fahrenheit to 275 degrees Fahrenheit. Contractor to add a cushion strip at each pipe support strap that meets these criteria.
 - a. Manufacturers: One of the following or equal:
 - 1) Anvil, AS 3795.
 - 2) Unistrut, P2600 Unicushion.

2.04 FABRICATION

- A. Hot-dip galvanize support system components after fabrication to required length and shape.
- B. Do not galvanize or paint stainless steel components.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Install preformed channel concrete inserts for vertical support, quantity based on manufacturer's structural design calculations.
- B. Fasten preformed channel pipe supports to existing walls using Z-fittings and concrete anchors as indicated on the Drawings.
- C. Fasten preformed channel pipe supports to preformed channel concrete inserts embedded in ceiling using U-shaped fittings.
- D. Suspend threaded rods from concrete inserts embedded in ceiling. Support preformed channel pipe supports with threaded rods.
- E. Touchup cut or damaged galvanized surfaces.
- F. Prevent contact between pipes and support components of dissimilar metals. Utilize rubber coated, plastic coated, or vinyl coated components, stainless steel components, or wrap pipe with PVC or polyethylene tape.
- G. Install support as near as possible to concentrated loads.
- H. Install support within 2 feet of horizontal and vertical changes in pipe alignment.
- I. Adjust supports or install shims to obtain specified slope or elevation.

END OF SECTION

SECTION 40_05_17.05

COPPER WATER TUBE: SEAMLESS, ASTM B88

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Copper water tube-seamless, ASTM B88.

1.02 REFERENCES

- A. American Society of Mechanical Engineers (ASME):
 - 1. B16.18 - Cast Copper Alloy Solder Joint Pressure Fittings.
 - 2. B16.22 - Wrought Copper and Copper Alloy Solder Joint Pressure Fittings.
- B. ASTM International (ASTM):
 - 1. A536 - Standard Specification for Ductile Iron Castings.
 - 2. B32 - Standard Specification for Solder Metal.
 - 3. B88 - Standard Specification for Seamless Copper Water Tube.
 - 4. B813 - Standard Specification for Liquid and Paste Fluxes for Soldering of Copper and Copper Alloy Tube.
 - 5. B828 - Standard Practice for Making Capillary Joints by Soldering of Copper and Copper Alloy Tube and Fitting.
- C. International Association of Plumbing and Mechanical Officials (IAPMO):
 - 1. IS 3 - Installation Standard for Copper Plumbing Tube, Pipe and Fittings.

1.03 SUBMITTALS

- A. Submit as specified in Section 01_33_00 - Submittal Procedures.
- B. Product data: As specified in Section 40_05_00.01 - Common Work Results for General Piping.

PART 2 PRODUCTS

2.01 MATERIALS

- A. Seamless copper water tube:
 - 1. Type: ASTM B88:
 - a. Exposed copper piping or tubing: Type L hard-drawn, rigid.
 - b. Copper tubing buried in the ground or in plastic conduit: Type K soft-annealed.
 - 2. Fittings: Solder type forged or wrought copper.
 - a. Manufacturers: One of the following or equal:
 - 1) Hoke, Gyrolok.

- 2) Crawford Fitting Co., Swagelok.
 - 3) Parker.
3. Solder: ASTM B32, Alloy Grade Sb5.
4. Flux: ASTM B813.
5. Grooved end fittings: ASME B16.22 wrought copper or ASME B16.18 bronze castings with copper tube dimensioned grooved ends (flaring of tube and fitting ends to IPS dimensions is not permitted).
 - a. Manufacturers:
 - 1) Victaulic Company.
6. Grooved mechanical couplings:
 - a. "Installation Ready" stab-on coupling designed for direct 'stab' installation onto roll grooved copper tube without prior field disassembly and no loose parts.
 - b. Housings shall be ductile iron, cast with offsetting, angle-pattern bolt pads coated with copper-colored enamel.
 - c. Gasket shall be Grade "EHP" EPDM suitable for water temperatures up to 250 degrees Fahrenheit, and plated steel bolts and nuts.
 - d. Victaulic Style 607 QuickVic™
7. Grooved joint flange adapters:
 - a. ASTM A 536 ductile iron casting coated with copper-colored enamel, flat faced, designed for connecting directly to ANSI Class 125 and 150 flanged components.
 - b. Victaulic Style 641.
8. Dielectric insulating unions or waterway fittings:
 - a. Manufacturers: One of the following or equal:
 - 1) Mueller Co.
 - 2) Watts.
 - 3) Victaulic Co. Style 47.
9. Special thread to tube adapters:
 - a. Manufacturers: One of the following or equal:
 - 1) Crawford Fitting Co., Swagelok.
 - 2) Hoke, Gyrolok.
 - 3) Parker.

PART 3 EXECUTION

3.01 INSTALLATION

- A. General:
 1. Support copper piping and tubing as specified in Section 40_05_07.01 - Pipe Supports and Section 40_05_07.03 - Preformed Channel Pipe Support System.
 2. Clean copper lines with high-pressure air after first disconnecting piping at instruments, filters, pressure reducers, valve operators, and other special devices.
 3. Install copper pipe in accordance with IAPMO IS 3.
- B. Installation of copper piping:
 1. Connect copper pipe connected to ferrous pipe or valves, or other non-copper items, by means of dielectric insulating unions or fittings.

2. Where connections are made to meters or other devices having iron pipe size threaded fittings, provide special thread to tube adapters.
 3. Grooved joint piping systems shall be installed in accordance with the manufacturer's (Victaulic) guidelines and recommendations.
 - a. Grooved couplings and fittings shall be the products of a single manufacturer.
 - b. Grooving tools shall be of the same manufacturer as the grooved components.
 - c. Gasket style and elastomeric material (grade) shall be verified as suitable for the intended service as specified.
 - d. Gaskets shall be molded and produced by Victaulic.
 - e. Grooved end shall be clean and free from indentations, projections, and roll marks in the area from pipe end to groove for proper gasket sealing.
 - f. A Victaulic factory-trained field representative shall provide on-site training for Contractor's field personnel in the proper use of grooving tools and installation of grooved piping products.
 - g. Factory-trained representative shall periodically review the product installation.
 4. Remove and replace any improperly installed products.
- C. Installation of copper tubing:
1. In accordance with ASTM B828 and IAPMO IS 3.
 2. Straight runs, supported at intervals close enough to avoid sagging.
 3. Make cuts square with a tubing cutter or with a 32-tooth hacksaw.
 - a. Provide a sizing tool to correct distortions.
 4. Ream the inside of the tubing and remove burrs from the outside, holding the end of the tubing downward and preventing chips and fillings from entering the tubing.
 5. Perform flaring with a flare block and yoke type screw feed flaring tool:
 - a. After removing the tubing from the flare block, inspect both surfaces of the flare for splits, cracks, or other imperfections.
 - b. Where there are imperfections, cut off the imperfect flare, and prepare a new flare.

3.02 FIELD QUALITY CONTROL

- A. Test copper lines in the same manner as the piping system to which they connect.

END OF SECTION

SECTION 40_05_19.01

DUCTILE IRON PIPE: AWWA C151

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Ductile iron pipe, joints, connections, fittings, and pipe linings and coatings.
- B. As specified in Section - Common Work Results for General Piping.

1.02 REFERENCES

- A. American Society of Mechanical Engineers (ASME):
 - 1. B16.1 - Gray Iron Pipe Flanges and Flanged Fittings: Classes 25, 125, and 250.
- B. American Water Works Association (AWWA):
 - 1. C104 - Standard for Cement-Mortar Lining for Ductile-Iron Pipe and Fittings.
 - 2. C105 - Polyethylene Encasement for Ductile-Iron Pipe Systems.
 - 3. C110 - Standard for Ductile-Iron and Gray-Iron Fittings.
 - 4. C111 - Standard for Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings.
 - 5. C150 - Standard for Thickness Design of Ductile-Iron Pipe.
 - 6. C151 - Standard for Ductile-Iron Pipe, Centrifugally Cast.
 - 7. C210 - Liquid-Epoxy Coatings and Linings for Steel Water Pipe and Fittings.
 - 8. C222 - Polyurethane Coatings and Linings for Steel Water Pipe and Fittings.
 - 9. C600 - Installation of Ductile Iron Water Mains and Their Appurtenances.
 - 10. C606 - Standard for Grooved and Shouldered Joints.
- C. American Welding Society (AWS):
 - 1. D11.2 - Guide for Welding Iron Castings.
- D. ASTM International (ASTM):
 - 1. A536 - Standard Specifications for Ductile Iron Castings.
 - 2. B1000 - Standard Practices for Casting Preparation and Test Procedure of Porcelain Enamel-Lined Pipe, Fittings, and Valves for Use in the Municipal Wastewater, Sewage, and Water Treatment Industry.
 - 3. C33 - Standard Specification for Concrete Aggregates.
 - 4. C150 - Standard Specification for Portland Cement.
 - 5. C283 - Standard Test Methods for Resistance of Porcelain Enameled Utensils to Boiling Acid.
 - 6. D792 - Standard Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement.
 - 7. D4541 - Standard Test Method for Pull-Off Strength of Coatings Using Portable Adhesion Testers.

- E. Ductile Iron Pipe Research Association (DIPRA):
 - 1. Thrust Restraint Design Manual.
- F. International Organization for Standardization (ISO):
 - 1. 8179 - Ductile iron pipe, fittings, accessories and their joints - External zinc-based coating - Part 1: Metallic zinc with finishing layer.
- G. National Association of Pipe Fabricators, Inc. (NAPF):
 - 1. 500-03 - Surface Preparation Standard for Ductile Iron Pipe and Fittings in Exposed Locations Receiving Special External Coatings and/or Special Internal Linings.
- H. Society for Protective Coatings (SSPC):
 - 1. SP 11 - Bare Metal Power Tool Cleaning.
 - 2. PA 2 - Measurement of Dry Coating Thickness with Magnetic Gages.

1.03 SUBMITTALS

- A. Furnish Submittals as specified in Section 01_33_00 - Submittal Procedures.
- B. Product data.
- C. Manufacturer's qualifications.
 - 1. Manufacturer qualifications and list of projects using the specified material: 5 years minimum.
 - 2. Plural component epoxy and plural component polyurethane field repair: SSPC-QP 1 certification required.
- D. Manufacturer's Quality Assurance Manual:
 - 1. Submit manufacturer's coating and lining application quality assurance manual to the Engineer prior to beginning coating application.
 - a. Conformance to the requirements of the manual will be required.
 - b. Deviation from the requirements of the manual will be grounds for the Engineer to reject the applied coating.
- E. Shop Drawings:
 - 1. Detailed layout drawings showing alignment of pipes, location of valves, fittings, and appurtenances, types of joints, and connections to pipelines or structures.
 - 2. Thrust restraint systems.
 - 3. Photographs, drawings, and descriptions of fittings, gaskets, couplings, grooving of pipe and fittings.
- F. Calculations:
 - 1. Thrust restraint system design.
- G. Manufacturer's Certificate of Source Testing for ceramic epoxy, glass lined, plural component polyurethane, and zinc materials:
 - 1. Certify successful performance of holiday detection tests on 100 percent of lining in accordance with ASTM B1000.
 - 2. Identify each test piece by mark designation and show the actual test results during the final inspection by the manufacturer prior to shipment.

3. Zinc coating: Regular measurements in accordance with ISO 8179 Part 4.4.
4. Include the coating manufacturer's technical representative's reports.

1.04 QUALITY ASSURANCE

- A. Ductile iron pipe shall be supplied by a single manufacturer.
- B. Hydrostatically test each joint of ductile iron pipe in accordance with AWWA C151.
- C. Pre-installation meeting:
 1. Arrange for the coating manufacturer's technical representative to attend preconstruction conferences and to make periodic visits to the factory or shop to inspect surface preparation of pipe, fittings, and accessories; and to inspect application of linings to interior and coatings to exterior of pipe, fittings, and accessories.

1.05 DELIVERY, STORAGE, AND HANDLING

- A. Block piping and associated fittings for shipment to prevent damage to coatings and linings.
- B. Carefully handle piping and associated fittings during loading, unloading, and installation:
 1. Do not drop piping material from cars or trucks.
 2. Lower piping by mechanical means.
 3. Do not drop or pound pipe to fit grade.
- C. Handle pipe from the outside if lined with ceramic epoxy, glass or plural component polyurethane.
 1. No forks, chains, straps, hooks, or other lifting device shall be placed inside the pipe or fittings for lifting, positioning, or laying.
- D. Protect gaskets and polyethylene encasement from long-term exposure to sunlight.
- E. Store piping, fittings, and other accessories such that they do not accumulate and hold rainwater, dirt, and debris.

PART 2 PRODUCTS

2.01 MANUFACTURED UNITS

- A. Ductile iron piping:
 1. Manufacturers: One of the following or equal:
 - a. American Cast Iron Pipe Co.
 - b. McWane Ductile.
 - c. U.S. Pipe.

2.02 THRUST RESTRAINT SYSTEM DESIGN

- A. All exposed and buried piping shall be fully restrained.

2.03 DUCTILE IRON JOINTS AND CONNECTIONS

A. General:

1. Pressure class or special thickness class as specified in the Pipe Schedule provided in Section - Common Work Results for General Piping.
2. In accordance with AWWA C150 and AWWA C151.

B. Joints:

1. Flanged joints:
 - a. Screw-on flanges:
 - 1) Comply with the diameter, thickness, drilling, and other characteristics in accordance with ASME B16.1.
 - 2) Ductile iron.
 - 3) Long hub, threaded, and specially designed for ductile iron pipe.
 - 4) After attaching to pipe, machine flange face to make pipe end and flange even and perpendicular to the axis of the pipe.
 - b. Bolt holes on flanges: 2-holed and aligned at both ends of pipe.
 - c. Cap screw or stud bolt holes: Tapped.
 - d. Bolts and nuts:
 - 1) As specified in Section 40_05_00.01 - Common Work Results for General Piping.
 - e. Gaskets:
 - 1) As specified otherwise in Section 40_05_00.01 - Common Work Results for General Piping.
 - f. Flanged unit connections:
 - 1) Flanged to grooved joint adapters or a long enough spool with one end flanged and the other end grooved to prevent interference with the operation of adjacent valves, pumps, or other items.
2. Mechanical joints:
 - a. In accordance with AWWA C111.
 - b. Gaskets:
 - 1) As specified in Section 40_05_00.01 - Common Work Results for General Piping.
 - c. Bolts and nuts, including T-bolts:
 - 1) As specified in Section 40_05_00.01 - Common Work Results for General Piping.
3. Push-on rubber gasket joints:
 - a. In accordance with AWWA C111.
 - b. Gaskets:
 - 1) As specified in Section 40_05_00.01 - Common Work Results for General Piping.
4. Mechanical wedge action joint restraints:
 - a. Manufacturers: One of the following or equal:
 - 1) EBAA Iron, Inc., Megalug® Series 1100.
 - 2) Sigma Corp., One-Lok Model SLDE.
 - 3) Star Pipe Products, Split Stargrip Series 3000.
 - b. Materials:
 - 1) Gland body:
 - a) Ductile iron in accordance with ASTM A536.

- 2) Wedges and wedge actuating components:
 - a) Ductile iron in accordance with ASTM A536.
 - b) Wedges shall be heat treated to a minimum of 370 BHN.
- 3) Actuating bolts and nuts:
 - a) Ductile iron in accordance with ASTM A536.
 - b) Provide torque-limiting twist off components to ensure proper installation.
- 4) Gaskets:
 - a) As specified in Section 40_05_00.01 - Common Work Results for General Piping.
- c. Coatings:
 - 1) Provide manufacturer-applied coating system.
 - 2) Manufacturers: One of the following or equal:
 - a) EBAA Iron Inc., Mega-Bond polyester powder applied by an electrostatic spray process.
 - b) Sigma Corp., Corrsafe™ Electro-deposition coating.
 - c) Star Pipe Products, Star-Bond™ TGIC polyester powder coating applied by an electrostatic spray process.
- d. Working pressure:
 - 1) Shall include a minimum safety factor of 2:1.
 - 2) Sizes 3- through 16-inch: 350 pounds per square inch.
 - 3) Sizes 18- through 48-inch: 250 pounds per square inch.
- e. Restraint shall consist of multiple gripping wedges incorporated into a follower gland meeting the requirements of AWWA C111.
- f. Restraint shall allow post assembly angular deflection that is a minimum of 50 percent of the angular deflection allowed by the mechanical joint.
- g. Restraint must be in accordance with applicable requirements of AWWA C110 and AWWA C111 for mechanical joints.
5. Integrally restrained push-on joints:
 - a. Application:
 - 1) Where designation restrained push-on is specified in the Pipe Schedule provided in Section - Common Work Results for General Piping or as indicated on the Drawings, supply a restrained push-on joint piping system, which includes restrained push-on joints where necessary based upon thrust calculations.
 - 2) Standard push-on rubber gasket joints as specified above can be used where thrust calculations demonstrate restraint is not required.
 - b. Design:
 - 1) Restrained push-on joints of the configuration which utilizes a gripping or friction force for restraint will not be acceptable.
 - 2) Suitable for the following working pressures:
 - a) 4- through 24-inch pipe: 350 pounds per square inch gauge.
 - b) 30- through 54-inch pipe: 250 pounds per square inch gauge.
 - c. Gaskets:
 - 1) As specified in Section 40_05_00.01 - Common Work Results for General Piping.

- d. Manufacturers: One of the following or equal:
 - 1) American Cast Iron Pipe Co., Flex Ring or Lok-Ring.
 - 2) McWane Ductile, TR Flex.
 - 3) U.S. Pipe, HDSS.
 - e. Limit buried joints to half the manufacturer's published allowable angular joint deflection for purposes of pipeline alignment and elimination of fittings.
- C. Connections:
- 1. Tapping saddle as specified in the Owner's standard specification.
 - a. If the Owner does not have a standard specification, provide tapping saddles as specified in Section 40_05_06.01 - Piping Specialties.
 - 2. Tapping sleeve as specified in the Owner's standard specification.
 - a. If the Owner does not have a standard specification, provide tapping sleeves as specified in Section 40_05_06.01 - Piping Specialties.
 - 3. Welded outlet:
 - a. Not allowed without Engineer approval.
- D. Fittings:
- 1. Ductile iron in accordance with AWWA C110 or AWWA C153.
 - 2. Joint type:
 - a. Same as that of the associated piping as specified in Section 40_05_00.01 - Common Work Results for General Piping.
 - 3. Plain end-to-flanged joint connectors using setscrews are not acceptable.
- E. Coating:
- 1. Factory apply.

2.04 CEMENT MORTAR

- A. Line pipe with cement mortar in accordance with AWWA C104 and as specified in this Section.
- B. Cement:
- 1. Cement: In accordance with ASTM C150, Type II.
- C. Water:
- 1. In accordance with AWWA C104 and as specified in this Section.
- D. Sand and aggregate:
- 1. In accordance with AWWA C104.
 - 2. Provide silica sand or other aggregate that is not subject to leaching in accordance with ASTM C33.
- E. Lining:
- 1. Minimum thickness: Standard in accordance with AWWA C104.
 - 2. Apply cement mortar on clean bare metal surfaces.
 - 3. Extend to faces of flanges, ends of spigots, and shoulders of hubs.
 - 4. Line special pieces or fittings by mechanical, pneumatic, or hand placement.
 - a. Extend to faces of flanges and ends of spigots.

- b. Less than 12 inches in width: Coat with epoxy bonding agent prior to applying cement mortar.
 - c. Larger than 12 inches in width: Reinforced with 2-inch by 4-inch No. 13 gauge welded steel wire mesh prior to applying cement mortar.
- 5. Provide plastic end caps of sufficient thickness and strength to resist shipping, handling, and storage stresses.
- 6. Repair damage to the cement mortar lining, including disbondment, or cracking caused by improper curing, shipping, handling, or installation in accordance with AWWA C104 and approved by the Engineer.
 - a. Reinforce coating with 2 layers spirally-wound steel wire positioned approximately in center of mortar coating positioned approximately at the third points of mortar coating:
 - 1) No. 12 gauge spaced at maximum 1-inch centers.
 - 2) No. 14 gauge steel wire at maximum 1/2-inch centers.

2.05 POLYETHYLENE ENCASEMENT

- A. General:
 - 1. Polyethylene encasement shall be supplied by the pipe manufacturer.
- B. Materials: Supply one of the following polyethylene encasements:
 - 1. 2 layers of linear low-density polyethylene (LLDPE) film, minimum thickness of 8 mils in accordance with AWWA C105; or,
 - 2. Single layer of high-density, cross-laminated polyethylene (HDCLPE) film, minimum thickness of 4 mils in accordance with AWWA C105.
 - 3. Single layer of V-Bio® enhanced polyethylene encasement (3 layers of coextruded LLDPE film with anti-microbial additive and volatile corrosion inhibitor infused on the inside surface), meeting all requirements of AWWA C105.

2.06 PLURAL COMPONENT EPOXY

- A. Coat pipe with plural component, 100 percent solids, non-extended in accordance with AWWA C210 and as specified in this Section.
- B. Surface preparation:
 - 1. In accordance with SSPC-SP 10 or SSPC-SP 11.
 - 2. In accordance with AWWA C210 and as specified in this Section.
 - a. Steel pipe: SSPC-SP 5, 3.00 mil profile, minimum, or in accordance with the manufacturer's requirements, whichever is greater.
- C. Primer: In accordance with the coating manufacturer's requirements.
- D. High build epoxy coating:
 - 1. 2 component, high build polyamide or polyamine cured epoxy coating, suitable for direct burial or immersion, dry to touch in 2 or more hours, suitable for immersion or burial after full cure of coating.
 - 2. Manufacturers: One of the following or equal:
 - a. Carboline.
 - b. ICI Devoe.

- c. Sherwin-Williams.
 - d. Warren Environmental.
- E. Fast cure epoxy coating:
 - 1. 2 component, 100 percent solids by volume, fast cure epoxy coating suitable for direct burial or immersion, dry to touch in less than 1 hour at 72 degrees Fahrenheit, capable of curing while immersed or buried.
 - 2. Manufacturers: One of the following or equal:
 - a. North American Denso, Protal 7125 or Protal 7200.
 - b. Tapecoat Inc., TC 7010.
- F. Application:
 - 1. Apply coating using plural component spray equipment by a manufacturer certified coating applicator.
 - 2. Perform coating application in an environmentally controlled shop area that meets or exceeds the written environmental application requirements of the coating manufacturer.
 - a. It is not acceptable to apply coating in outdoor conditions without adequate environmental shelter, environmental controls, and/or dehumidification.
 - 3. In potable water applications, provide epoxy lining suitable for potable water contact in accordance with NSF 61, unless otherwise approved by the Engineer.
 - 4. Concrete embedded pipe penetrations: Extend epoxy coating a minimum of 6 inches outside of interior and exterior surfaces of concrete walls or floors.
 - 5. Concrete penetrations minimum dry film thickness: 12 mils.
 - 6. Apply heat shrink sleeves to buried transitions from epoxy to tape wrap or extruded polyolefin coating systems.
 - a. Backfill as soon as practical to limit exposure to direct sun or heat and potential thermal creep of sleeve.
- G. Self-priming, plural component, 100 percent solids, suitable for burial or immersion, and in accordance with AWWA C210 and the following, whichever is more stringent:
 - 1. Non-NSF certified: Ceramic fill.
 - 2. NSF certified: Poly amine epoxy or poly amide epoxy.
 - 3. Shop-applied coating thickness:
 - a. Minimum: 1 coat, 35 mils total dry film thickness.
 - 4. Shop-applied lining thickness:
 - a. Minimum: 1 coat, 35 mils total dry film thickness.
- H. Adhesion test procedures:
 - 1. Use self-aligning pneumatic pull off equipment and test procedures in accordance with ASTM D4541, Method E, using Delfesko Positest AT-A, except as modified in this Section.
 - a. Perform at an applied load rate of 100 pounds per square inch per second, plus or minus 10 pounds per square inch.
 - b. Use automatic adhesion test equipment.
 - c. Perform tests to coating or glue failure or maximum test load, whichever is happens first.
 - d. In accordance with ASTM D4541 using standard 20 millimeter dollies.

- e. Base adhesion testing on 3 tests:
 - 1) Conduct the tests by the same person, test equipment, and test procedure.
 - 2) Complete the tests within a 30-minute period.
- f. Conduct adhesion tests within an area not to exceed 6 inches by 6 inches.
- g. Score coatings with more than 10 percent elongation or 25 mils thick around dolly to metal substrate using manual methods and tools, normal to the pipe surface, and in a manner that does not stress or overheat the coating.
- 2. Attach dollies for adhesion testing to the coating surface using a 2-part epoxy or cyanoacrylate glue and cured for a minimum of 12 hours before testing or until full cure, whichever is greater.
 - a. Pipe fabricator and coating manufacturer determine glue type for the pipe diameter, temperatures, and environmental conditions.
- 3. Perform adhesion testing at temperatures between 55 and 90 degrees Fahrenheit or at temperatures in accordance with the coating manufacturer's requirements.
 - a. Testing up to 115 degrees Fahrenheit or below 55 degrees Fahrenheit will be permitted if tests can demonstrate no statistically detectable effect on test results and in accordance with the coating manufacturer's requirements and the Engineer's approval.
- 4. Epoxy coating and lining adhesion criteria:
 - a. Coating is acceptable if first dolly pull test exceeds 1,750 pounds per square inch, minimum.
 - b. If first dolly pull is less than 1,750 pounds per square inch, perform 2 additional tests with acceptance based on "Best of 3" evaluation method as defined in this Section.
- 5. Pipe lot performance criteria:
 - a. Minimum median value for coating or lining adhesion tests: 2,000 pounds per square inch.
 - b. Classify failing pipe lots as rejected until 100 percent of the pipe within the pipe lot has been tested for adhesion.
 - 1) Reject each pipe that fails the coating adhesion criteria.
- 6. Adhesion test evaluation and records:
 - a. Definition: "Best of 3" evaluation method is when 2 of 3 test values meet the adhesion criteria.
 - b. Consider adhesion tests as valid and suitable for acceptance or rejection of the coating, except where retesting is required.
 - c. Adhesion test failure:
 - 1) Adhesive or substrate failure.
 - a) Definition: A percentage of separation of the coating from the steel substrate or between distinct coating layers.
 - 2) Cohesive test failure.
 - a) Definition: A percentage of failure within the coating, resulting in coating remaining both on the steel substrate and test dolly.
 - d. Retest coating adhesion tests:
 - 1) When any test is glue failure at 25 percent or more of dolly surface area and the test value is less than the acceptance criteria or the minimum criteria.
 - 2) Within the same 6-inch by 6-inch test area as the original adhesion testing.

- 3) Retest disputed adhesion tests.
 - a) Owner's representative will witness dolly attachment and adhesion retesting.
 - e. Adhesion tests will be conducted on pipe coating and lining independently and will be accepted or rejected independently.
 - f. Maintain adhesion test records in an electronic spreadsheet that includes the following information:
 - 1) Pipe identification.
 - 2) Pipe coating date.
 - 3) Adhesion test date.
 - 4) Surface tested (interior or exterior).
 - 5) Surface temperature at time of test.
 - 6) Coating thickness.
 - 7) Tensile force applied.
 - 8) Applied load rate per second.
 - 9) Mode of failure.
 - 10) Percentage of failure types, previously defined, relative to dolly surface area.
 - 11) Dolly size and attachment glue used.
 - 12) If different coatings are tested, include coating manufacturer and product number.
- 7. Adhesion test repairs:
 - a. Fabricator or Contractor to complete adhesion repairs as specified this Section.
 - b. Randomly select repair patches on epoxy or polyurethane coating for adhesion testing in a manner as described in this Section and at the discretion of the coating inspector.
- I. Long term adhesion test:
 - 1. Acceptance criteria:
 - a. Not more than 10 percent loss of adhesion over duration of test.
 - b. Differential based on the highest average adhesion result to the lowest average adhesion result.
 - 2. Test durations, cumulative:
 - a. 1 day.
 - b. 7 days.
 - c. 3 weeks.
 - d. 2 months.
 - 3. Sample preparation:
 - a. SSPC-SP 5, 3.00 mil profile, minimum.
 - b. Test area minimum: 18 inches by 18 inches.
 - c. Curved steel plate:
 - 1) Minimum radius of 15 inches.
 - 2) Inclined between 30 and 45 degrees.
 - 4. Test procedure:
 - a. Expose samples to ambient, outdoor conditions, and facing in a southern direction for maximum UV exposure for the full duration of the test.
 - 5. Adhesion test results:
 - a. Based on 8 pulls per test period with the 3 lowest pulls discarded.
 - b. Based an average of the 5 highest pulls and identify the values used.

6. Record adhesion pulls and their failure mode.
7. Repair sample after adhesion tests to prevent water from causing any effects on subsequent adhesion tests.

PART 3 EXECUTION

3.01 INSTALLATION

A. General:

1. Install ductile iron piping in accordance with AWWA C600, or as modified in Section - Common Work Results for General Piping.
2. For underground piping, the trenching, backfill, and compaction:
 - a. Inspect coating prior to backfill.
 - b. As specified in Section 31_23_35 - Trenching.

B. Joints:

1. Install types of joints as specified in the Pipe Schedule provided in Section 40_05_00.01 - Common Work Results for General Piping.
2. Mechanical joints are not acceptable in above ground applications.
3. Field closure for restrained push-on pipe:
 - a. Locate field closures in areas where thrust calculations demonstrate restraint is not required.
4. Grooved joints:
 - a. Install piping with grooved joints as specified in the Pipe Schedule provided in Section 40_05_00.01 - Common Work Results for General Piping.
 - b. Assemble grooved joints in accordance with the manufacturer's published instructions.
 - c. Support grooved-end pipe in accordance with the manufacturer's published instructions.
 - 1) Install at least 1 support between consecutive couplings.

C. Connection:

1. Tapping ductile iron pipe:
 - a. Direct tapping of ductile iron pipe may be performed but is limited to the following conditions:
 - 1) Maximum allowable tap diameter by pipe diameter and pressure class:

Pipe Size (inches)	Pressure Class				
	150	200	250	300	350
	Maximum Allowable Direct Tap Size (inches)				
3	-	-	-	-	3/4
4	-	-	-	-	3/4
6	-	-	-	-	1
8	-	-	-	-	1
10	-	-	-	-	1
12	-	-	-	-	1-1/4

Pipe Size (inches)	Pressure Class				
	150	200	250	300	350
	Maximum Allowable Direct Tap Size (inches)				
14	-	-	1-1/4	1-1/2	1-1/2
16	-	-	1-1/2	2	2
18	-	-	2	2	2
20	-	-	2	2	2
24	-	2	2	2	2

- b. Maximum allowable tap diameter for pipelines greater than 24 inches is 2 inches.
- c. 2 layers of 3-mil thread sealant are required to minimize the torque required to effect a watertight connection.
- 2. Direct tapping of glass-lined ductile iron pipe may be performed only when approved in writing by the Engineer. Direct tapping of glass-lined pipe shall be performed in accordance with the above conditions for tapping ductile iron pipe in addition to the following conditions:
 - a. Drilling and tapping shall be performed using a hole saw.
 - 1) Use of a large drill bit is not acceptable.
 - b. As the hole saw approaches the glass lining, lessen the inward pressure to avoid excess chipping or cracking of the lining.
 - c. Minor chipping or spalling of the glass lining shall be repaired using an epoxy resin "glass repair kit" provided by the fabricator.
 - 1) Manufacturers: One of the following or equal:
 - a) Devoe, Devran 224 HS.
 - b) Sherwin-Williams Co., Sher-Tile High Solids Epoxy.
 - 2) Repair kit use is only allowed for areas of damage less than 1/2 inch in diameter.
 - a) Larger areas of damage will require replacement.
 - 3) Surface shall be prepared and repair kit shall be applied in accordance with the manufacturer's and/or fabricator's instructions.

3.02 DEFECTS IN COATINGS EXCEPT TAPE WRAP AND CEMENT MORTAR COATING

- A. Engineer will identify defective coating to be field repaired in accordance with the applicable AWWA standard.
 - 1. Pipe joints exceeding the following defect maximum will be rejected.
 - a. Minor defects:
 - 1) No more than 1.5 per 100 square feet of surface area.
 - 2) 2 or more minor repairs within an 8-inch diameter circle will be considered a single repair.
 - 3) Repairs for adhesion testing will not be included in the total number of repairs.
 - 4) Repair in accordance with the manufacturer's requirements.
 - b. Major defects:
 - 1) No more than 3 major repairs on each pipe joint.
 - 2) No more than 30 percent repairs on the pipe surface area with defects.

2. Minor repairs:
 - a. Less than 8 inches in the greatest dimension.
 - b. Repair in accordance with the manufacturer's requirements.
3. Major repairs:
 - a. Exceed 8 inches in the greatest dimension.
 - b. Repair in accordance with the manufacturer's requirements.

3.03 PLURAL COMPONENT EPOXY

- A. Joints:
 1. Field-applied coating shall be of the same density, smoothness, and thickness as shop-applied coating.
 2. Comply with same application requirements as shop-applied coating or lining.
 - a. Provide heating and/or dehumidification equipment as required to meet the environmental conditions necessary for proper coating application.

3.04 POLYETHYLENE ENCASEMENT

- A. Wrap buried ductile iron pipe and fittings in a single layer of V-Bio polyethylene wrap in accordance with AWWA C105 and as specified in this Section.
- B. Wrap polyethylene encasement to be continuous and terminated neatly at connections to below grade equipment or structures.
- C. At wall penetrations, extend encasement to the wall and neatly terminate.
- D. At slab penetrations, extend encasement to 2 inches below the top of slab and neatly terminate.
- E. When rising vertically in unimproved areas, extend encasement on pipe 6 inches above existing grade and neatly terminate.
- F. Repair tears and make joints with 2 layers of plastic tape.
- G. Work shall be inspected prior to backfilling of pipe and associated items.

3.05 FIELD QUALITY CONTROL

- A. Testing ductile iron piping:
 1. Test as specified in Section 40_05_00.01 - Common Work Results for General Piping and Section 40_05_00.09 - Piping Systems Testing.
- B. Repair damaged cement mortar lining to match quality, thickness, and bonding of original lining in accordance with AWWA C104.
 1. When lining cannot be repaired or repairs are defective, replace defective piping with undamaged piping.

- C. Verify that interior surfaces of ceramic epoxy and glass-lined pipe and fittings have continuous coverage:
1. Test random samples, as directed by the Engineer, in accordance with ASTM B1000.
 2. Discard lined piping and fittings found to have pinholes, crazing, or fish scales, which expose the metal substrate.

END OF SECTION

SECTION 40_05_23.01

STAINLESS STEEL PIPE AND TUBING

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Stainless steel piping and tubing.

1.02 REFERENCES

- A. American National Standards Institute (ANSI).
- B. American Society of Mechanical Engineers (ASME):
 - 1. B16.5 - Pipe Flanges and Flanged Fittings: NPS 1/2 through NPS 24, Metric/Inch Standard.
 - 2. B16.11 - Forged Fittings, Socket-Welding and Threaded.
 - 3. B31.3 - Process Piping.
 - 4. B36.19 - Stainless Steel Pipe.
 - 5. Section IX - Welding, Braising, Fusing Qualifications.
- C. ASTM International (ASTM):
 - 1. A123 - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
 - 2. A182 - Standard Specification for Forged or Rolled Alloy and Stainless Steel Pipe Flanges, Forged Fittings, and Valves and Parts for High-Temperature Service.
 - 3. A193 - Standard Specification for Alloy-Steel and Stainless Steel Bolting for High Temperature or High Pressure Service and Other Special Purpose Applications.
 - 4. A194 - Standard Specification for Carbon and Alloy Steel Nuts and Bolts for High Pressure or High Temperature Service, or Both.
 - 5. A240 - Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications.
 - 6. A269 - Standard Specification for Seamless and Welded Austenitic Stainless Steel Tubing for General Service.
 - 7. A276 - Standard Specification for Stainless Steel Bars and Shapes.
 - 8. A312 - Standard Specification for Seamless, Welded, and Heavily Cold Worked Austenitic Stainless Steel Pipes.
 - 9. A351 - Standard Specification for Castings, Austenitic, for Pressure-Containing Parts.
 - 10. A380 - Standard Practice for Cleaning, Descaling, and Passivation of Stainless Steel Parts, Equipment, and Systems.
 - 11. A403 - Standard Specification for Wrought Austenitic Stainless Steel Piping Fittings.
 - 12. A743 - Standard Specification for Castings, Iron-Chromium, Iron-Chromium-Nickel, Corrosion Resistant, for General Application.

13. A744 - Standard Specification for Castings, Iron-Chromium-Nickel, Corrosion Resistant, for Severe Service.
14. A774 - Standard Specification for As-Welded Wrought Austenitic Stainless Steel Fittings for General Corrosive Services at Low and Moderate Temperatures.
15. A778 - Standard Specification for Welded, Unannealed Austenitic Stainless Steel Tubular Products.
16. A789 - Standard Specification for Seamless and Welded Ferritic/Austenitic Stainless Steel Tubing for General Service.
17. A790 - Standard Specification for Seamless and Welded Ferritic/Austenitic Stainless Steel Pipe.
18. A928 - Standard Specification for Ferritic/Austenitic (Duplex) Stainless Steel Pipe Electric Fusion Welded with Addition of Filler Metal.
19. A967 - Standard Specification for Chemical Passivation Treatments for Stainless Steel Parts.
20. A995 - Standard Specification for Castings, Austenitic-Ferritic (Duplex) Stainless Steel, for Pressure-Containing Parts.
21. B98 - Standard Specification for Copper-Silicon Alloy Rod, Bar and Shapes.
22. B622 - Standard Specification for Seamless Nickel and Nickel-Cobalt Alloy Pipe and Tube.
23. B912 - Standard Specification for Passivation of Stainless Steels Using Electropolishing.
24. F593 - Standard Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs.
25. F594 - Standard Specification for Stainless Steel Nuts.

1.03 SUBMITTALS

- A. Submit as specified in Section 01_33_00 - Submittal Procedures and Section 01_60_01 - Product Requirements.
- B. Product data.
- C. Shop Drawings:
 1. Detailed layout drawings, including:
 - a. Dimensions and alignment of pipes.
 - b. Location of valves, fittings, and appurtenances.
 - c. Location of field joints.
 - d. Location of pipe hangars and supports.
 - e. Connections to equipment and structures.
 - f. Location and details of shop welds.
 2. Thickness and dimensions of fittings and gaskets.
 3. Photographs, drawings, and descriptions of pipe, fittings, welding procedures, and pickling and passivating procedures.
 4. Material specifications for pipe, gaskets, fittings, and couplings.
 5. Data on joint types and components used in the system, including flanged joints, grooved joint couplings and screwed joints.

1.04 WELDER QUALIFICATIONS

- A. Welders shall be qualified and tested to the material being welded.

- B. Welders shall hold the following certifications:
 - 1. ASME Section IX.
 - 2. AWS D10.9 for level AR-1 or AR-3 and shall be qualified to position 6G.

1.05 DELIVERY, STORAGE, AND HANDLING

- A. As specified in Section 01_60_01 - Product Requirements and the manufacturer's instructions.
- B. Storage: Segregate location of stainless steel piping from fabrication of any other piping materials.
- C. Shipment to Site:
 - 1. Protect flanges and pipe ends by encapsulating in dense foam.
 - 2. Securely strap all elements to pallets with nylon straps. Use of metallic straps is prohibited.
 - 3. Cap ends of tube, piping, pipe spools, fittings, and valves with non-metallic plugs.
 - 4. Load pallets so no tube, piping, pipe spools, fittings, or valves bear the weight of pallets above.
 - 5. Notify the Engineer when deliveries arrive so they may inspect the shipping conditions.
 - 6. Engineer may reject material due to improper shipping methods or damage during shipment.

PART 2 PRODUCTS

2.01 DESIGN AND PERFORMANCE CRITERIA

- A. Lay out and fabricate piping systems with sections as long as possible, while still allowing shipment, so that joints are minimized.
 - 1. Piping design indicated on the Drawings illustrates the piping layout and configuration and does not indicate the location of every joint and flexible coupling that may be needed to connect piping sections fabricated in the shop.
 - 2. Where joints and couplings are specifically indicated on the Drawings, design and shop-fabricate piping sections utilizing the joint or coupling indicated at the locations shown.
 - 3. Add joints and flexible couplings in a manner that achieves intent of maximizing size of individual piping sections.
- B. Fabricate piping sections in the shop and pickle and passivate at point of manufacture.
- C. Field assembly:
 - 1. Assemble shop-fabricated piping in the field using the joints designed into the piping layout or by using flexible couplings.
 - 2. Field welding is prohibited.

Service	Stainless Steel Grade	Pipe Manufacturing Process
For low chloride water service with chloride concentrates below 200 parts per million and/or free chlorine less than 2 parts per million at ambient temperatures.		
Piping 3 inches in nominal diameter and larger	Type 304L stainless steel in accordance with ASTM A240	In accordance with ASTM A778
Piping less than 3 inches in nominal diameter	Type 304L stainless steel in accordance with ASTM A240	In accordance with ASTM A312
Digester gas, oxygen and ozone service, membrane and reverse osmosis filtration systems with chloride concentrations less than 1,000 parts per million and/or free chlorine less than 4 parts per million at ambient temperatures.		
Piping 3 inches in nominal diameter and larger	Type 316L or LDX 2101 stainless steel in accordance with ASTM A240	Type 316L in accordance with ASTM A778
		Type LDX 2101 in accordance with ASTM A790
Piping less than 3 inches in nominal diameter	Type 316L or LDX 2101 stainless steel in accordance with ASTM A240	Type 316L in accordance with ASTM A312
		Type LDX 2101 in accordance with ASTM A790
Brackish water membrane and reverse osmosis membrane filtration systems with chloride concentrations between 1,000 and 10,000 parts per million.		
All piping diameters	Austenitic or duplex grades of material with PREN greater than 33	In accordance with ASTM A312, ASTM A778, ASTM A790, or ASTM A928
Brackish and seawater membrane and reverse osmosis membrane filtration systems with chloride concentrations between 10,000 to 20,000 parts per million		
All piping diameters	Austenitic and duplex grades of material with PREN greater than 40	In accordance with ASTM A312, ASTM A790, or ASTM A928
Brackish and seawater reverse osmosis concentrate (e.g., brine) with chloride concentrations greater than 20,000 parts per million		
All piping diameters	Austenitic and duplex grades of material with PREN greater than 45	In accordance with ASTM A312, ASTM A778, ASTM A790, or ASTM A928
PREN: Pitting Resistance Equivalency Number. PREN = Cr% + (3.3 x Mo%) + (16 x N%)		

UNS #	Alloy	Cr%	Mo%	N%	Other	PREN
N10276	C-276	14.5-16	15-17	-	W 3-4.5	64
S32750	Alloy 2507	24-26	6-8	0.24-0.32	-	48
S32654	654SMO	24-25	7-8	-	-	47
N06625	Alloy 625	20-23	8-10	-	Cb 3.25-4.15	46
N08366	AL6XN	20-22	6-7	-	-	40
N06985	Alloy G	21-23.5	5.5-7.5	-	-	39
S32760	Zeron 100	24-26	3-4	0.2-0.3	W 0.5-1.0	37
S32205	Alloy 2205	22-23	3-3.5	0.14-0.20	-	34
N08904	904L	19-23	4-5	-	-	32
S31726	317LNM	17-20	4-5	0.1-0.2	-	32
N08825	Alloy 825	19-23.5	2.5-3.5	-	-	27
S32101	LDX-2101	21.5	0.3	0.22	-	26
S31603	316L	16-18	2-3	-	-	23
S30403	304L	18-20	-	-	-	18

2.02 STAINLESS STEEL TUBING

- A. Stainless steel tubing:
 - 1. Seamless, Type 316L stainless steel, in accordance with ASTM A269.
 - a. Size: 2.5 inches and less.
 - b. Wall thickness: Not less than 0.035 inch.
- B. Fittings: Swage ferrule design:
 - 1. Components made of:
 - a. Type 316 stainless steel.
 - 2. Double acting ferrule design, providing both a primary seal and a secondary bearing force.
 - 3. Flare type fittings are not acceptable.
 - 4. Manufacturers: One of the following or equal:
 - a. Crawford Fitting Co., Swagelok.
 - b. Hoke, Gyrolok.
 - c. Parker, CPI.
- C. Valves for use with stainless steel tubing:
 - 1. Ball type valves with swage ends to match tubing diameter.
 - 2. Constructed from:
 - a. Type 316 stainless steel with TFE seats.
 - 3. Manufacturers: The following or equal:
 - a. Crawford Fitting Co., Swagelok.

2.03 SPARE PARTS

- A. Provide 1 new and unused Victaulic PFT-510 series tool to the Owner upon Project completion. Tool shall be provided as a complete set, which includes the following (at a minimum):
 - 1. 18-volt battery and charge: 1.
 - 2. Wire brush: 1.
 - 3. Paint stick: 1.
 - 4. Pipe marking gauges: 1 set.
 - 5. Standard Vic-Press™ Jaw: 1.
 - 6. Vic-Press™ ring with adaptor jaws to fit each size of pipe installed using this system: 1.
 - 7. Hard plastic tool case: 1.
 - 8. Hard plastic accessory case: 1.

2.04 SOURCE QUALITY CONTROL

- A. Visually inspect pipe for welding defects such as crevices, pits, cracks, protrusions, and oxidation deposits.
- B. Provide written certification that the pipe as supplied are in accordance with ASTM A778 and/or ASTM A312. Supplemental testing is not required.
- C. Provide written certification that the fittings as supplied are in accordance with ASTM A774. Supplementary testing is not required.
- D. Thoroughly clean any equipment before use in cleaning or fabrication of stainless steel.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Install piping in such a manner as not to impart strain to connected equipment.
- B. Slope horizontal lines so that they can be drained completely.
- C. Provide valve drains at low points in piping systems.
- D. Install eccentric reducers where necessary to facilitate draining of piping system.
- E. Provide access for inspection and flushing of piping systems to remove sediment, deposits, and debris.

3.02 FIELD ASSEMBLY OF SHOP-FABRICATED PIPING SECTIONS

- A. Join shop-fabricated piping sections together using backing flanges, flexible couplings, flanged coupling adapters, grooved couplings, or flanges.

3.03 FIELD QUALITY CONTROL

- A. Test piping to pressure and by method as shown on drawings
 - 1. If pressure testing is accomplished with water:
 - a. Use only potable quality water.
 - b. Piping: Thoroughly drained and dried or place immediately into service.

3.04 PROTECTION

- A. Preserve appearance and finish of stainless steel piping by providing suitable protection during handling and installation and until final acceptance of the Work.
 - 1. Use handling methods and equipment to prevent damage to the coating, include the use of wide canvas slings and wide padded skids.
 - 2. Do not use bare cables, chains, hooks, metal bars, or narrow skids.
 - 3. Store stainless steel piping and fittings away from any other piping or metals. Storage in contact with ground or outside without protection from bad weather is prohibited.
 - 4. Protect stainless steel piping and fittings from carbon steel projections (when grinding carbon steel assemblies in proximity) and carbon steel contamination (do not contact stainless steel with carbon steel wire brush or other carbon steel tool).

END OF SECTION

SECTION 40_05_24.01

STEEL PIPE - EXPOSED

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes requirements for the exposed and submerged portions of a steel piping system including:
 - 1. Pipe.
 - 2. Joints.
 - 3. Fittings.
 - 4. Specials.
 - 5. Coatings and linings
- A. Requirements in Section 01_60_01 - Product Requirements apply to this Section with amendments included in this Section:

1.02 REFERENCES

- A. American Society of Mechanical Engineers (ASME):
 - 1. B1.20.1 - Pipe Threads, General Purpose (Inch).
 - 2. B16.5 - Pipe Flanges and Flanged Fittings: NPS 1/2 Through NPS 24 Metric/Inch Standard.
 - 3. B16.47 - Large Diameter Steel Flanges: NPS 26 Through NPS 60 Metric/Inch Standard.
 - 4. B31.3 - Process Piping.
 - 5. B36.10 - Welded and Seamless Wrought Steel Pipe.
 - 6. BPVC Section IX - Welding and Brazing.
 - 7. BPVC Section V - Nondestructive Examination.
 - 8. BPVC Section VIII - Rules for Construction of Pressure Vessels.
- B. American Water Works Association (AWWA):
 - 1. C200 - Steel Water Pipe 6 Inches and Larger.
 - 2. C205 - Cement-Mortar Protective Lining and Coating for Steel Water Pipe 4 Inches, and Larger-Shop Applied.
 - 3. C206 - Field Welding of Steel Water Pipe.
 - 4. C208 - Standard for Dimensions for Fabricated Steel Water Pipe Fittings.
 - 5. C210 - Liquid Epoxy Coatings and Linings for Steel Water Pipe and Fittings.
 - 6. C213 - Fusion Bonded Epoxy Coatings and Linings for Steel Water Pipe and Fittings.
 - 7. C220 - Polyurethane Coatings and Linings for Steel Water Pipe and Fittings.
 - 8. C225 - Fused Polyolefin Coatings for Steel Water Pipelines
 - 9. M11 - Steel Pipe: A Guide for Design and Installation.

- C. ASTM International (ASTM):
1. A36 - Standard Specification for Carbon Structural Steel.
 2. A53 - Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless.
 3. A105 - Standard Specification for Carbon Steel Forgings for Piping Applications.
 4. A106 - Standard Specification for Seamless Carbon Steel Pipe for High-Temperature Service.
 5. A197 - Standard Specification for Cupola Malleable Iron.
 6. A234 - Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service.
 7. A516 - Standard Specification for Pressure Vessel Plates, Carbon Steel, for Moderate- and Lower-Temperature Service.
 8. A536 - Standard Specification for Ductile Iron Castings.
 9. E94 - Standard Guide for Radiographic Examination Using Industrial Radiographic Film.
 10. E1032 - Standard Practice for Radiographic Examination of Weldments Using Industrial X-Ray Film.
 11. B1000 - Standard Practices for Casting Preparation and Test Procedure of Porcelain Enamel-lined Pipe, Fittings, and Valves for Use in the Municipal Wastewater, Sewage, and Water Treatment Industry.
 12. C33 - Standard Specification for Concrete Aggregates.
 13. C150 - Standard Specification for Portland Cement.
 14. C283 - Standard Test Methods for Resistance of Porcelain Enameled Utensils to Boiling Acid.
 15. D792 - Standard Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement.
 16. D4541 - Standard Test Method for Pull-Off Strength of Coatings Using Portable Adhesion Testers.
- D. National Association of Pipe Fabricators (NAPF):
1. 500-03 - Surface Preparation Standard for Ductile Iron Pipe and Fittings in Exposed Locations Receiving Special External Coatings and/or Special Internal Linings.
- E. International Organization for Standardization (ISO).
- F. NSF International (NSF):
1. 61 - Drinking Water System Components - Health Effects.
- G. Steel Pipe Fabricators Association (SPFA).
- H. Society for Protective Coatings (SSPC):
1. PA 2 - Procedure for Determining Conformance to Dry Coating Thickness Requirements.
 2. QP 1 - Standard Procedure for Evaluating the Qualifications of Industrial/Marine Painting Contractors (Field application to Complex industrial and Marine Steel Structures.
 3. QP-3 - Certification Standard for Shop Application of Complex.
 4. Protective Coating Systems.
 5. SP 1 - Solvent Cleaning.

6. SP 3 - Power Tool Cleaning.
7. SP 5 - White Metal Blast Cleaning.
8. SP 6 - Commercial Blast Cleaning.
9. SP 10 - Near-White Metal Blast Cleaning.
10. SP 11 - Power Tool Cleaning to Bare Metal.
11. SP 13 - Surface Prep of Concrete.

1.03 SUBMITTALS

- A. Submit as specified in Section 01_33_00 - Submittal Procedures.
- B. Manufacturer's Instructions as specified in Section 01_60_01 - Product Requirements.
- C. Product data: As specified Section 01_60_01 - Product Requirements.
 1. Sufficient to verify requirements of this Technical Section.
- D. Shop drawings: As specified in specified Section 01_60_01 - Product Requirements including:
 1. Layout drawings indicating dimensions of piping and locations/dimensions all joints (including type), fittings and appurtenances.
 2. Tabulated layout schedules.
 3. Support locations and type.
- E. Calculations:
 1. Fabricated fitting dimensions. Calculations for all fittings including, but not limited to, mitered bends, reducers, tees, wyes, outlet reinforcement, etc. are required to be submitted and sealed by a professional engineer.
- F. Test reports:
 1. Factory hydrostatic pipe tests and test of fittings.
 2. Mill certificates, including chemical and physical test results for each type of steel, Charpy V-notch tests, and elongation tests.
 3. Certified test reports for factory welds of fittings from a third party independent Certified Welding Inspector paid for by the Pipe Manufacturer.
 4. Copies of Manufacturers' factory quality control tests.
 5. Pipe welding, welding procedures and qualification records in accordance with ASME BPVC Section IX, and include the following:
 - a. Welding Procedure Specifications (WPS) for each proposed welding procedure/process, including pipe welding, fitting welding, flange welding, and piping supports connected by welding to steel pipe shell. Procedure Qualification Record (PQR) for each WPS submitted. Pre-qualified welding procedures will not be allowed. A PQR shall be supplied for all welding procedures/processes.
 - b. Welder Performance Qualifications (WPQ) for each proposed WPS. A WPQ shall be required for all welders/welding operators working and the shop/field. The WPQ supplied for each field welder/welding operator shall be in the 6G position.
 - c. Preheat and post-weld heat treatment processes and equipment.

- d. Post-weld cleaning and de-scaling procedures.
 - e. Certified non-destructive examination (NDE) testing results and weld inspection reports, performed by the manufacturer in accordance with the applicable codes, submitted prior to the shipping of the piping.
- G. Inspector Qualifications:
 - 1. CWI certification of all third party CWIs.
 - 2. Certification of all personnel performing NDE or interpreting the test results to ASNT-TC-1A Level II as a minimum.
 - 3. NACE Level III Coating Inspector.
- H. Coating/Lining Manufacturer's qualifications:
 - 1. Manufacturer qualifications and list of projects using the specified material: 5 years minimum.
 - 2. SSPC QP-3 certification required.
 - 3. Plural component epoxy field repair: SSPC-QP 1 certification required.
- I. Coating/Lining Manufacturer's Quality Assurance Manual.
 - 1. Submit manufacturer's coating and lining application quality assurance manual to Engineer prior to beginning coating application.
 - a. Strict conformance to the requirements of the manual will be required.
 - b. Deviation from the requirements of the manual will be grounds for the Engineer to reject the applied coating.
- J. Coating/Lining Product information and recommended material for field repairs.
- K. Coating/Lining Applicator's Certificate of Source Testing:
 - 1. Certify successful performance of the quality control testing specified in the applicable AWWA standard and as specified herein:
 - a. Appearance, visual inspection.
 - b. Cure testing.
 - c. Dry film thickness testing.
 - d. Electrical continuity inspection.
 - e. Adhesion testing.
 - 2. Identify each test piece by mark designation and show the actual test results during the final inspection prior to shipment.

1.04 SHIPMENT, DELIVERY, STORAGE, AND HANDLING

- A. As specified in Section 01_60_01 - Product Requirements
- B. Manifolds to be shipped in the fabricated sections as indicated on the Drawings.
- C. Provide plastic end caps of sufficient thickness and strength to resist shipping, handling, and storage stresses.
- D. Block piping and associated fittings for shipment to prevent damage to coatings and linings.

- E. Carefully handle piping and associated fittings during loading, unloading, and installation:
 - 1. Lower by mechanical means with slings to protect coatings.
 - 2. Store piping, fittings, and other accessories such that they do not accumulate and hold rainwater, dirt, and debris.

PART 2 PRODUCTS

2.01 GENERAL

- A. Manufacturing of the piping system (pipe, fittings, lining, and coating) to be performed at a single location unless otherwise approved by Engineer.
- B. Shop welding to be by ASME certified welders utilizing procedures qualified under Section IX of the ASME BPVC.
- C. As shown on the Drawings, the Piping Schedule lists the requirements for individual components of the piping system shown as follows:
 - 1. Wall thickness.
 - 2. Pipe type as specified in this section.
 - 3. Type of joints, fittings, coating, and lining as specified in this Section.

2.02 PIPE SPECIFICATION

- A. Type ST1 - AWWA Welded Steel Water Pipe:
 - 1. In accordance with AWWA C200 from one of the materials or a combination of the materials listed in AWWA C200 Table 1.
- B. Type ST2 - ASME 53, Electronic Resistance Welded Carbon Steel Pipe:
 - 1. In accordance with ASTM A53, Type E, Grade A or B carbon steel and in accordance with ASME B36.10 dimensions.

2.03 FLANGES AND JOINTS

- B. Type SP-F1: AWWA Standard Steel-Ring Flange:
 - 1. For use with Type ST1 steel pipe.
 - 2. In accordance with AWWA C207 Class D, E, or F as scheduled.
 - 3. Pressure rating to meet or exceed that of the piping system.
 - 4. Manufactured from one of the following:
 - a. ASTM A105 forged steel.
 - b. ASTM A36 steel plate.
 - c. ASTM A516, Grade 65 or 70 steel plate.
- C. Type SP-F2: ASME Forged Steel Flanges:
 - 1. For use with Type ST2 and ST3 steel pipe.
 - 2. In accordance with ASME B16.5 Class 150 and Class 300.
 - a. Pressure rating to meet or exceed that of the piping system.
 - 3. Flanges shall be flat faced unless indicated on the drawings.
 - 4. Manufactured from ASTM A105 steel.

- D. Type SP-BW: Buttweld:
 - 1. Bead height of not more than 1/16-inch.
 - 2. 100 percent penetration to the interior weld joint.
 - 3. Cross-sectional thickness equal or greater than the base metal.
- E. Type SP-TH: Threaded
 - 1. In accordance with ASME B1.20.1 NPT.
- F. Type SP-GR: Grooved:
 - 1. In accordance with grooved coupling manufacturer's recommendations.
- G. Type SP-LW: Lap Welded:
 - 1. Double fillet welded.
 - 2. Leg equal to the connecting pipe wall thickness but not less than 1/4 inch.

2.04 FITTINGS

- A. Wrought steel, butt-welded.
 - 1. In accordance with ASME B16.9.
 - 2. Wall thickness shall match that of connecting piping.
 - 3. Manufactured from the following materials:
 - a. ASTM A234, Grade WPB for use with Type ST2 and ST3 steel pipe.
- B. Malleable iron, threaded:
 - 1. In accordance with ASME B16.3 Class 150 or 300.
 - a. Pressure rating to meet or exceed that of connected piping system.
 - 2. Material in accordance with ASTM A197 Cupola Malleable Iron.
- C. Forged steel, threaded:
 - 1. In accordance with ASME B16.11 Class 2000, 3000, or 6000.
 - a. Pressure rating to meet or exceed that of the connected pipe.
 - 2. Material in accordance with ASTM A105.
- D. Fabricated fittings:
 - 1. For use with Type ST1 steel pipe.
 - 2. Pipe cylinder shall be manufactured from the same material, shall have the same pipe wall thickness, and shall have the same internal diameter as the connected pipe.
 - 3. Outlet reinforcement shall be manufactured from the same material as the connected pipe.
 - 4. The radius of a mitered elbows shall not be less than 2.5 times the outside diameter of the pipe cylinder.
 - 5. In accordance with AWWA C208.
- E. Integrally reinforced branch outlets:
 - 1. In accordance with MSS-SP-97.
 - a. Forged steel in accordance with ASTM A105.
 - b. Pressure rating equal to or greater than the run pipe.
 - 2. Branch and run sizes as indicated on the Drawings.
 - 3. Connections to be the same as the connecting pipe.
 - 4. Markings in accordance with MSS SP-25.

5. Dimensions and configuration of butt-end weld in accordance with ASME B16.9 and ASME B16.25.
 6. Butt-welded branch outlets up to 24-inch diameter shall be joined to the pipe by full penetration welds suitable for radiographic inspection.
 7. Socket-welded branch outlets up to 4-inch diameter shall have weld socket dimensions on the branch in accordance with MSS-SP-97.
 - a. Outlets shall be joined to the branch pipe by fillet welds at the socket.
 - b. Branch outlet socket dimensions shall be in accordance with ASME B16.11.
 8. Threaded forged steel integrally reinforced branch outlets up to 4-inch diameter shall have female NPT threads meeting ASME B1.20.1 on the outlet. Branch outlets shall be joined to the main line pipe or pressure vessel by full penetration welds suitable for radiographic inspection.
- F. Blind flanges greater than 48 inches in diameter for AWWA steel pipe:
1. In accordance with ASME BPVC Section VIII, paragraph 1-6.
 2. Head configuration shall be ellipsoidal or torispherical.
 3. Pressure rating of dished head equal to or greater than that of connected piping system.

2.05 COATINGS AND LINING

- A. General:
1. Prepare, install, and repair in accordance with manufacturer's requirements.
 2. Extend pipe coatings for underground piping 6-inches above finished grade or 3 inches above finished floor, and neatly terminate.
 3. Prepare, install, and repair in accordance with manufacturer's requirements.
- B. Cement mortar:
1. In accordance with AWWA C205 and as specified in this Section.
 - a. Cement: In accordance with ASTM C150, Type II.
 - b. Sand and aggregate: non-leaching in accordance with ASTM C33.
 - c. Water: as specified in this Section.
 2. Line special pieces or fittings by mechanical, pneumatic, or hand placement.
 - 1) Extend to faces of flanges and ends of spigots.
 - 2) 12-inch diameter or less:
 - a) Coat with epoxy bonding agent prior to applying cement mortar.
 - 3) Larger than 12 inches diameter: Reinforced with 2-inch by 4-inch No. 13 gauge welded steel wire mesh prior to applying cement mortar.
 3. Provide plastic end caps of sufficient thickness and strength to resist shipping, handling, and storage stresses.
 4. Repair damage to the cement mortar lining, including disbondment, or cracking caused by improper curing, shipping, handling, or installation in accordance with AWWA C205 and approved by the Engineer.
 - a. Reinforce coating with 2 layers spirally-wound steel wire positioned approximately in center of mortar coating positioned approximately at the third points of mortar coating:
 - 1) No. 12 gauge spaced at maximum 1-inch centers.
 - 2) No. 14 gauge steel wire at maximum 1/2-inch centers.

- C. Fusion bonded epoxy:
 - 1. One component fusion bonded epoxy material applied to preheated substrate meeting the requirements of AWWA C213 or this Section, whichever is more stringent.
- D. Plural component epoxy:
 - 1. Liquid applied epoxy in accordance with AWWA C210 and as specified in this Section, whichever is more stringent.
 - a. In potable water applications, provide epoxy lining suitable for potable water contact in accordance with NSF 61.
 - 2. Single-coat, plural component, ultra-high solids, chemically cured epoxy coating, suitable for immersion service:
 - a. Surface preparation: SSPC-SP 5, 3.00 mil profile, minimum.
 - b. Primer: In accordance with coating manufacturer's requirements.
 - c. Thickness: minimum dry film thickness.
 - 1) Coating: 25 mils.
 - 2) Lining: 35 mils.
 - 3. Manufacturers: One of the following or equal:
 - a. Carboline.
 - b. ICI Devoe.
 - c. Sherwin Williams Sher-plate PW.
 - d. Warren Environmental, 301 Series.
- E. Plural component polyurethane:
 - 1. Elastomeric aromatic polyurethane in accordance with AWWA C222 and as specified in this Section, whichever is more stringent.
 - a. In potable water applications, provide polyurethane lining suitable for potable water contact in accordance with NSF 61.
 - 2. Single-coat, plural component, 100-percent solids, chemically cured aromatic polyurethane, suitable for immersion service:
 - a. Surface preparation: SSPC-SP 5, 3.00 mil profile, minimum.
 - b. Primer: In accordance with coating manufacturer's requirements.
 - c. Thickness: minimum dry film thickness.
 - 1) Coating: 20 mils.
 - 2) Lining: 35 mils.
 - 3. Manufacturers: One of the following or equal:
 - a. Lifelast, Durashield 110.
 - b. Sherwin Williams, Poly-Cote 115

2.06 SHOP TESTING OF PIPE

- A. Type ST1: Hydrostatically pressure test in accordance with AWWA C200.
- B. Type ST2, Type ST3, and ST4: Hydrostatically pressure test in accordance with ASTM A53.
- C. Record hydrostatic pressure testing results.

2.07 SHOP TESTING OF COATING AND LINING

- A. Contractor shall retain the services of a NACE level III coating inspector to perform quality control testing of factory applied coating and linings.
- B. Conduct AWWA specified quality control requirements.
- C. Conduct adhesion testing as specified herein, in addition to the AWWA quality control requirements.
 - 1. Adhesion testing: use self-aligning pneumatic pull off equipment and test procedures in accordance with ASTM D4541, Method E, using Delfesko Positest AT-A except as modified in this Section.
 - a. Perform at an applied load rate of 100 pounds per square inch per second, plus or minus 10 pounds per square inch.
 - b. Use automatic adhesion test equipment.
 - c. Perform tests to coating or glue failure or maximum test load, whichever happens first.
 - d. In accordance with ASTM D4541 using standard 20-millimeter dollies.
 - e. Base adhesion testing on 3 tests.
 - 1) Conduct the tests by the same person, test equipment, and test procedure.
 - 2) Complete the tests within a 30-minute period.
 - f. Conduct adhesion tests within an area not to exceed 6 inches by 6-inches.
 - g. Score coatings around dolly to metal substrate using manual methods and tools, normal to the pipe surface, and in a manner that does not stress or overheat the coating.
 - 2. Attach dollies for adhesion testing to the coating surface using a 2-part epoxy or cyanoacrylate glue and cured for a minimum of 12 hours before testing or until full cure, whichever is greater.
 - a. Pipe fabricator and coating manufacturer determine glue type for the pipe diameter, temperatures, and environmental conditions.
 - 3. Perform adhesion testing at temperatures between 55 and 90 degrees Fahrenheit or at temperatures in accordance with coating manufacturer's requirements.
 - a. Testing up to 115 degrees Fahrenheit or below 55 degrees Fahrenheit will be permitted if tests can demonstrate no statistically detectable effect on test results and in accordance with coating manufacturer's requirements and Engineer's approval.
 - 4. Coating and lining adhesion criteria:
 - a. Coating is acceptable if first dolly pull test exceeds 1,750 pounds per square inch, minimum.
 - b. If first dolly pull is less than 1,750 pounds per square inch, perform 2 additional tests with acceptance based on "Best of 3" evaluation method as defined in this Section.
 - 5. Pipe lot performance criteria:
 - a. Minimum median value for coating or lining adhesion tests: 2,000 pounds per square inch.
 - b. Classify failing pipe lots as rejected until 100 percent of the pipe within the pipe lot has been tested for adhesion.
 - 1) Reject each pipe that fails the coating adhesion criteria.

6. Adhesion test evaluation and records:
 - a. Definition: "Best of 3" evaluation method is when 2 of 3 test values meet the adhesion criteria.
 - b. Consider adhesion tests as valid and suitable for acceptance or rejection of the coating, except where retesting is required.
 - c. Adhesion test failure:
 - 1) Adhesive or substrate failure.
 - a) Definition: A percentage of separation of the coating from the steel substrate or between distinct coating layers.
 - 2) Cohesive test failure.
 - a) Definition: A percentage of failure within the coating, resulting in coating remaining both on the steel substrate and test dolly.
 - d. Retest coating adhesion tests:
 - 1) When any test is glue failure at 25 percent or more of dolly surface area and the test value is less than the Acceptance Criteria or the Minimum Criteria.
 - 2) Within the same 6-inch by 6-inch test area as the original adhesion testing.
 - 3) Retest disputed adhesion tests.
 - a) Owner's representative will witness dolly attachment and adhesion retesting.
 - e. Adhesion tests will be conducted on pipe coating and lining independently and will be accepted or rejected independently.
 - f. Maintain adhesion test records in an electronic spreadsheet that includes the following information:
 - 1) Pipe identification.
 - 2) Pipe coating date.
 - 3) Adhesion test date.
 - 4) Surface tested (interior or exterior).
 - 5) Surface temperature at time of test.
 - 6) Coating thickness.
 - 7) Tensile force applied.
 - 8) Applied load rate per second.
 - 9) Mode of failure.
 - 10) Percentage of failure types, previously defined, relative to dolly surface area.
 - 11) Dolly size and attachment glue used.
 - 12) If different coatings are tested, include coating manufacturer and product number.
7. Adhesion test repairs:
 - a. Fabricator or contractor to complete adhesion repairs as specified this Section.
 - b. Randomly select repair patches on epoxy or polyurethane coating for adhesion testing in a manner as described in this Section and at the discretion of the coating inspector.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Installation of steel piping shall be in accordance with ASME B31.3 and AWWA C206.
- B. Pipe and fittings shall be installed true to alignment and rigidly supported as indicated on the Drawings.
- C. Joints:
 - 1. Cutting and beveling of pipe done by machine in a neat workmanlike manner without damage to the pipe.
 - 2. Remove burrs from pipe prior to welding.
- D. The Contractor shall be responsible for filling out the Flange Bolting Worksheet, located at the end of this Section, for all flanged joints on the project. The joints shall be identified in accordance with the designation included in the approved laying schedule. The form shall be submitted to the Owner's Representative at the end of each workday, after the 24-hour re-tightening sequence, for filing in the project records.

3.02 WELDING

- A. Field and shop welding of above ground steel piping shall be carried out in accordance with AWWA C206 and Chapter V in ASME B31.3. Only welding procedures submitted and approved under this Section shall be used.
- B. Complete joint penetration butt welds shall be aligned using pipe line-up clamps or other methods in order to achieve the minimum requirements specified in ASME B31.3.
 - 1. Fit up full penetration butt-welded field joints for pipe larger than 8-inch diameter using line-up clamps. Submit alternative methods to line-up clamps proposed by the Contractor with welding submittals for Engineer's approval.
 - 2. Do not use of backing rings.
- C. Repairs shall be made in accordance with the lining and coatings suppliers submitted procedures.
- D. All welds shall have a neat, professional, and workmanlike appearance.

3.03 CERTIFIED WELD INSPECTOR AND NON-DESTRUCTIVE EXAMINATION OF SHOP WELDS

- A. Manufacturer shall retain the services of a certified weld inspector and non-destructive examination technician for the review of welding procedure specification, qualification, and individual welder's certifications.
- B. Shop welding shall be tested in accordance with AWWA C200.

3.04 CERTIFIED WELD INSPECTOR AND NON-DESTRUCTIVE EXAMINATION OF FIELD WELDS

- A. Owner shall retain the services of a certified weld inspector and non-destructive examination technician for the review of welding procedure specification, qualification, and individual welder's certifications.
- B. NDE Types and Acceptance Criteria:
 - 1. Weld Acceptance Criteria in accordance with Table 341.3.2 of ASME B31.3 for the scheduled fluid service.
 - 2. Visual Examination (VT), in accordance with ASME BPVC, Section V, Article 9.
 - 3. Magnetic Particle Examination (MT), in accordance with ASME BPVC, Section V, Article 7.
 - 4. Liquid Penetrant Examination (LT), in accordance with ASME BPVC, Section V, Article 6.
 - 5. Radiographic Examination (RT), in accordance with ASME BPVC, Section V, Article 2.
 - 6. Ultrasonic Examination (UT), in accordance with ASME BPVC, Section V, Article 4.
- C. Level 1 Testing:
 - 1. Complete joint penetration butt welds shall be inspected as follows:
 - a. All root passes of all complete joint penetration butt-welds shall be 100 percent VT. The root pass shall be ground prior to visual examination.
 - b. All final cover passes of all complete joint penetration butt-welds shall be 100 percent VT and 20 percent MT or LT.
 - 2. Fillet welds shall be inspected as follows:
 - a. Root and cover passes of all fillet welds shall be 100 percent VT and 20 percent MT or LT.
 - b. Provide records in accordance with ASME B31.3 Part 341.4.1.(c).
 - 3. If more than 20 percent of welds fail the Level 1 testing criteria the contractor shall be required to meet the requirements of Level 2 testing at no additional cost to the Owner.
- D. Level 2 Testing:
 - 1. Complete joint penetration butt welds shall be inspected as follows:
 - a. All root passes of all complete joint penetration butt-welds shall be 100 percent VT. The root pass shall be ground prior to visual examination.
 - b. All final cover passes of all complete joint penetration butt-welds shall meet the requirements of Level 1 and 10 percent shall be RT or UT.
 - 2. Fillet welds shall be inspected as follows:
 - a. Root and cover passes of all fillet welds shall be 100 percent VT and 50 percent MT or LT.
 - 3. RT procedures, radiographs, and UT procedures are to be developed and interpreted by a qualified technician hired by the Owner.
 - 4. If more than 20 percent of welds fail the Level 2 testing criteria the contractor shall be required to meet the requirements of Level 3 testing at no additional cost to the Owner.

- E. Level 3 Testing:
1. Complete joint penetration butt welds shall be inspected as follows:
 - a. All root passes of all complete joint penetration butt-welds shall be 100 percent VT and RT or UT. The root pass shall be ground prior to visual examination.
 - b. All final cover passes of all complete joint penetration butt-welds shall meet the requirements of Level 1 and 10 percent shall be RT or UT.
 2. Fillet welds shall be inspected as follows:
 - a. Root and cover passes of all fillet welds shall be 100 percent VT and 100 percent MT or LT.
 3. RT procedures, radiographs, and UT procedures are to be developed and interpreted by a qualified technician hired by the Owner.
 4. If more than 20 percent of welds fail the Level 2 testing criteria the contractor shall be required to meet the requirements of Level 3 testing at no additional cost to the Owner.
 5. If more than 20 percent of welds fail the Level 3 testing criteria the contractor shall be required remove all welders employed by the contractor and/or all welders employed by welding subcontractor from jobsite and retain services a new, qualified welding subcontractor at no additional cost to the owner.

3.05 DEFECTS IN COATINGS

- A. Owner shall retain the services of a NACE Level III coating inspector to provide continuous quality control inspection and testing for all field applied coatings.
1. Submit coating inspector's reports within 3 days of coating application.
- B. Owner will identify defective coating to be field repaired.
1. Repair defects in accordance with manufacturer's recommendations.
 2. Coating and linings exceeding the following defect maximums will be rejected.
 - a. Minor defects:
 - 1) No more than 1.5 repairs on each pipe joint or 100 square feet of surface area.
 - 2) Two or more minor repairs within an 8-inches diameter circle will be considered a single repair.
 - b. Major defects:
 - 1) No more than 3 major repairs on each pipe joint or 150 square feet of surface area.
 - 2) No more than 30 percent repairs on the pipe surface area with defects.
 - c. Minor repairs:
 - 1) Repairs less than 8-inches in the greatest dimension.
 - 2) Major repairs:
 - 3) Repairs that exceed 8-inches in the greatest dimension.
 - d. Repairs for adhesion testing will not be included in the total number of repairs.

3.06 CEMENT MORTAR LININGS

- A. Lining:
1. Field applied lining and repairs shall be of the same density, smoothness, and thickness as shop applied lining.

3.07 FUSION BONDED EPOXY

- A. Field applied coating or lining and repairs shall be of the same density, smoothness, and thickness as shop applied coating or lining.
 - 1. Repair coating and lining as specified for Plural Component Epoxy.

3.08 PLURAL COMPONENT EPOXY

- A. Field applied coating or lining and repairs shall be of the same density, smoothness, and thickness as shop applied coating or lining.
- B. Comply with same surface preparation and application requirements as shop applied coating or lining.
 - 1. Provide heating and/or dehumidification equipment as required to meet the environmental conditions necessary for proper coating application.

3.09 PLURAL COMPONENT POLYURETHANE

- A. Field applied coating or lining and repairs shall be of the same density, smoothness, and thickness as shop applied coating or lining.
- B. Comply with same surface preparation and application requirements as shop applied coating or lining.
 - 1. Provide heating and/or dehumidification equipment as required to meet the environmental conditions necessary for proper coating application.

END OF SECTION

ATTACHMENT A - FLANGE BOLTING WORKSHEET

Steel Pipe - Exposed

40_05_24.01-15

203505

CO/Thornton/203505-100000/04 Design/04 Specs/Carollo/SWPS/40_05_24.01 (IFB2)

Thornton Water Project (12-777XP)

Source Water Pump Station

May 2026

FLANGE BOLTING WORKSHEET

Worksheet Instructions:

1. Fill in location/identification number as shown on the submitted lay sheets.
2. Fill in nominal bolt size.
3. Fill in flange finish.
4. Fill in lubricant used.
5. Initial either the "4-bolt and 8-bolt flanges" or "12-bolt flanges and above" procedure. Initials indicate that joint assembler adhered to round target torques and specified torque sequencing.
6. Fill in round target torques.
7. Initial the final round procedure. Initials indicate that joint assembler adhered to the final target torque and specified torque sequencing.
8. Identify with a mark the tightening method used.
9. Sign the form as required.
10. Submit completed form to Owner's Representative as specified.

Location/Identification:

Nominal Bolt Size:

Gasket Contact Surface Finish on Flange:

Lubricant Used:

Final Target Torque (from Spec Tables):

ft-lbs

4-bolt and 8-bolt flanges:

Round 1 Target Torque	ft-lbs (30% of final target torque)
Round 2 Target Torque	ft-lbs (60% of final target torque)
Round 3 Target Torque	ft-lbs (100% of final target torque) (Note 1)

12-bolt flanges and above:

Round 1 Target Torque	ft-lbs (20% of final target torque)
Round 2 Target Torque	ft-lbs (40% of final target torque)
Round 3 Target Torque	ft-lbs (80% of final target torque)
Round 4 Target Torque	ft-lbs (100% of final target torque) (Note 1)

Note 1: Use rotational or clockwise tightening sequence, starting with bolt No. 1, for one complete round and continue until no further nut rotation occurs at 100% of the Final Target Torque value for any nut.

Final Round - Re-torque after 24 hours to the final target torque.

TIGHTENING METHOD USED:

Torque Wrench

Hydraulic Cassette Wrench

Hydraulic Stud Tensioner

Last Calibration Date

Last Calibration Date

Last Calibration Date

Worksheet Information By:

Date:

Joint Assembler:

Date:

SECTION 40_05_31.17

POLYVINYL CHLORIDE (PVC) PIPE: SCHEDULE TYPE

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Schedule type PVC pipe and fittings.

1.02 REFERENCES

- A. ASTM International (ASTM):
 - 1. D1784 - Standard Specification for Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds.
 - 2. D1785 - Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120.
 - 3. D2466 - Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 40.
 - 4. D2564 - Standard Specification for Solvent Cements for Poly(Vinyl Chloride) (PVC) Plastic Piping Systems.
 - 5. D2855 - Standard Practice for the Two-Step (Primer and Solvent Cement) Method of Joining Poly (Vinyl Chloride) (PVC) or Chlorinated Poly (Vinyl Chloride) (CPVC) Pipe and Piping Components with Tapered Sockets.
 - 6. F645 - Standard Guide for Selection, Design and Installation of Thermoplastic Water-Pressure Piping Systems.
- B. NSF International (NSF):
 - 1. 61 - Drinking Water System Components - Health Effects.

1.03 SUBMITTALS

- A. Furnish Submittals as specified in Section 01_33_00 - Submittal Procedures.
- B. Product data:
 - 1. As specified in Section 40_05_00.01 - Common Work Results for General Piping.

1.04 DELIVERY, STORAGE, AND HANDLING

- A. Protect from sunlight, scoring, and distortion.
- B. Do not allow surface temperatures to exceed 120 degrees Fahrenheit.
- C. Store and handle as recommended by the manufacturer in published instructions.

PART 2 PRODUCTS

2.01 MATERIALS

- A. Extruding and molding material: Virgin material containing no scrap, regrind, or rework material, except where permitted in the referenced standards.
 - 1. Pipe: Designation PVC 1120 in accordance with ASTM D1785 and appendices:
 - a. Extruded from Type I, Grade 1, Class 12454 material in accordance with ASTM D1784.
 - b. Schedule 40 unless otherwise indicated on the Drawings.
 - 2. Fittings: In accordance with ASTM D2466.
 - a. Same material as the pipe and of equal or greater pressure rating.
 - b. Supplied by the pipe manufacturer.
 - c. Unions 4 inches and smaller:
 - 1) Use socket end screwed unions.
 - d. Unions 6 inches and larger:
 - 1) Use socket flanges with 1/8-inch full-face soft gasket.
 - a) Gasket material: As specified in the Pipe Schedule.
 - 2) Van Stone flanges are not allowed.
 - 3. Solvent cement:
 - a. In accordance with ASTM D2564.
 - b. Manufacturers: The following or equal:
 - 1) IPS Corp.
 - a) Primer: Type P70
 - b) Cement: Type 724.
 - c. Certified by the manufacturer for the service of the pipe.
 - d. In potable water applications: Provide solvent cement listed by NSF for potable water applications.

2.02 SOURCE QUALITY CONTROL

- A. Meets or exceeds all quality assurance test requirements stated in ASTM D1785.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Install piping in accordance with ASTM F645, or the manufacturer's published instructions for installation of piping, as applicable.
- B. Provide molded transition fittings for transitions from plastic to metal pipe.
 - 1. Do not thread pipe.
 - 2. Do not use flanged transition fittings unless specifically indicated on the Drawings.
- C. Locate unions where indicated on the Drawings, and elsewhere where required for adequate access and assembly of the piping system.

- D. Provide serrated nipples for transition from pipe to rubber hose.
- E. Solvent weld joints in accordance with ASTM D2855.

3.02 FIELD QUALITY CONTROL

- A. Test pipe as specified in Section 40_05_00.01 - Common Work Results for General Piping and Section 40_05_00.09 - Piping Systems Testing.

END OF SECTION

SECTION 40_05_51.01

COMMON WORK RESULTS FOR VALVES

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Basic requirements for valves.

1.02 REFERENCES

- A. American Water Works Association (AWWA):
 - 1. C111/A21.11 - Standard for Rubber-Gasket Joints for Ductile-Iron Pressure Pipe Fittings.
 - 2. C550-17 - Protective Interior Coatings for Valves and Hydrants.
- B. ASTM International (ASTM):
 - 1. A126 - Standard Specification for Gray Iron Casting for Valves, Flanges, and Pipe Fittings.
 - 2. A380 - Standard Practice for Cleaning, Descaling, and Passivation of Stainless Steel Parts, Equipment, and Systems.
 - 3. A480 - Standard Specification for General Requirements for Flat-Rolled Stainless and Heat-Resisting Steel Plate, Sheet, and Strip.
 - 4. A536 - Standard Specification for Ductile Iron Castings.
- C. National Electrical Manufacturers Association (NEMA):
 - 1. 250 - Enclosure Types.
- D. NSF International (NSF):
 - 1. 61 - Drinking Water System Components - Health Effects.
 - 2. 372 - Drinking Water System Components - Lead Content.
- E. Society for Protective Coatings (SSPC):
 - 1. SP 10 - Near-White Blast Cleaning.

1.03 SUBMITTALS

- A. Furnish Submittals as specified in Section 01_33_00 - Submittal Procedures.
- B. Product data:
 - 1. Valves:
 - a. Manufacturer.
 - b. Model number.
 - c. Type.
 - d. Size.
 - e. Materials.
 - f. Pressure rating.

- g. Cv factor.
 - h. Finishes.
 - 2. Manual actuators:
 - a. Manufacturer.
 - b. Size.
 - c. Material.
 - d. Model number.
 - 3. Valve tags and engraving schedule.
- C. Shop Drawings:
 - 1. Description of component parts, dimensions, weights, and materials.

1.04 QUALITY ASSURANCE

- A. Manufacturer qualifications:
 - 1. Valves manufactured by manufacturers whose valves have had successful operational experience in comparable service.

1.05 DELIVERY, STORAGE, AND HANDLING

- A. Protect valves and protective coatings from damage during handling and installation. Repair coating where damaged.

PART 2 PRODUCTS

2.01 GENERAL

- A. Valves in contact with drinking water:
 - 1. As specified in Section 01_41_00 - Regulatory Requirements.

2.02 DESIGN AND PERFORMANCE CRITERIA

- A. Valves shall be the same size as the adjoining pipe unless otherwise indicated on the Drawings.
- B. Valves shall open left (counterclockwise) unless otherwise specified. Each valve shall have the word OPEN readily visible on the valve body, indicating the open direction of the operator.
- C. Valve supplier shall be responsible for determining the size of operators, handwheels, chainwheels, and electric actuators.
- D. All parts to be replaced during regular maintenance shall be accessible with minimal dismantling of the equipment and appurtenances.
 - 1. Valve assembly shall be designed to prevent vibration and physical distortion detrimental to valve operation under all specified conditions.
- E. Valve mechanisms shall be designed to operate smoothly and efficiently under all specified conditions.

- F. Pressure rating:
 - 1. Suitable for service under minimum working pressures of 150 pounds per square inch gauge.
 - 2. When a piping system is specified in the Pipe Schedule to be tested at a pressure greater than 150 pounds per square inch gauge, provide valves for that piping system with design working pressure which is sufficient to withstand the test pressure.
- G. Valve to piping connections:
 - 1. Metallic valves:
 - a. 3 inches nominal size and larger: Flanged ends.
 - b. Less than 3 inches nominal size: Screwed ends.
 - 2. Plastic valves in plastic piping systems:
 - a. Up to 4 inches: Provide solvent or heat welded unions, except for plastic butterfly valves.
 - 1) Plastic butterfly valves shall be flanged as specified in Section 40_05_64 - Butterfly Valves.
 - b. 6 inches and larger: Provide solvent or heat-welded flanges.

2.03 MATERIALS

- A. Stainless steel: In accordance with ASTM A480, Type 316 or Type 304, UNS Alloy S31600 or S30400.
 - 1. Repair damaged stainless steel surfaces in accordance with ASTM A380.
- B. Valve nuts and bolts, including flange nuts and bolts, as specified in Section 40_05_00.01 - Common Work Results for General Piping:
 - 1. Fabricated of stainless steel for the following installation conditions:
 - a. Submerged in sewage or water.
 - b. In an enclosed space above sewage or water.
 - c. In structures containing sewage or water, below top of walls.
 - d. At openings in concrete or metal decks.
 - 2. Where dissimilar metals are being bolted, use stainless steel bolts with isolation bushings and washers.
 - 3. Underground bolts: Low-alloy steel in accordance with AWWA C111/A21.11.
- C. Bronze and brass alloys: Not more than 6 percent zinc and not more than 2 percent aluminum in the manufacture of valve parts.
 - 1. UNS Alloy C83600 or C92200 unless specified otherwise.
- D. Cast iron valve bodies: In accordance with ASTM A126, Class 30 minimum.
- E. Ductile iron valve bodies: In accordance with ASTM A536, Grade 65-45-12 minimum, unless specified otherwise.

2.04 INTERIOR PROTECTIVE LINING

- A. When specified in the particular valve Specification, provide valves with type of protective lining specified in the particular valve Specification.
- B. Apply protective lining to interior, non-working surfaces, except stainless steel surfaces.
- C. Lining types:
 - 1. Fusion bonded epoxy:
 - a. Manufacturers: The following or equal:
 - 1) 3-M Company, ScotchKote 134; certified in accordance with NSF 61 for drinking water use.
 - b. Clean surfaces in accordance with SSPC-SP 10, as recommended by the epoxy manufacturer.
 - c. Apply in accordance with the manufacturer's published instructions.
 - d. Lining thickness: 0.010 to 0.012 inch, except that:
 - 1) In grooves for gaskets: 0.005 inch.
 - 2) Do not coat seat grooves in valves with bonded seat.
 - e. Quality control:
 - 1) Lining thickness: Measured with a non-destructive magnetic type thickness gauge.
 - 2) Verify lining integrity with a wet sponge-testing unit operating at approximately 60 volts, or as recommended by the lining manufacturer.
 - 3) Consider tests successful when lining thickness meets specified requirements and when no pinholes are found.
 - 4) Correct defective lining disclosed by unsuccessful tests and repeat test.
 - 5) Repair pinholes with liquid epoxy recommended by the manufacturer of the epoxy used for lining.
 - 2. High solids epoxy:
 - a. Product equivalent to high solids epoxy EPX-M-1-PWS as specified in Section 09_96_01 - High-Performance Coatings.
 - 1) Certified in accordance with NSF 61 for drinking water use.
 - 2) Interior: Coat valve interior with the manufacturer's equivalent high performance high solids epoxy coating system with a certifiable performance history for the service conditions and as approved by the Engineer.
 - a) Manufacturer shall provide for approval, coating information sufficient to allow the Engineer to assess equivalence to the specified high solids epoxy EPX-M-1-PWS as specified in Section 09_96_01 - High-Performance Coatings.
 - b. Clean surfaces in accordance with SSPC-SP 10, or as recommended by the coating manufacturer.
 - c. Quality control: After coating is cured, check coated surface for porosity with a holiday detector set at 1,800 volts, or as recommended by the coating manufacturer.
 - 1) Repair holidays and other irregularities and retest coating.
 - 2) Repeat procedure until holidays and other irregularities are corrected.

2.05 UNDERGROUND VALVES

- A. Provide underground valves with flanged, mechanical, or other type of joint required for the type of pipe to which the valve is to be connected.
- B. Coating and wrapping:
 - 1. After installation, encase valves in polyethylene wrap as specified for ductile iron piping in Section 40_05_19.01 - Ductile Iron Pipe: AWWA C151.
 - a. Ensure polyethylene wrapping does not affect operation of valve.

2.06 VALVE BOXES

- A. Provide cast-iron valve boxes at each buried valve to access valve and valve operators.
- B. Do not support boxes on valve, valve operator, or pipe.
- C. Boxes:
 - 1. 2-piece, fabricated of cast iron; provide cover, with asphalt varnish or enamel protective coating.
 - 2. Adjustable to grade, install centered around the upper portions of the valve and valve operator.
- D. Manufacturers: One of the following or equal:
 - 1. Neenah Foundry Co.
 - 2. Tyler Pipe Industries, Inc.

2.07 VALVE OPERATORS

- A. Provide valves located below operating level or deck with extensions for key operation or floor stands and handwheels, as indicated on the Drawings.
- B. Provide manually operated valves located not more than 6 feet above the operating level with tee handles, wrenches, or handwheels.
 - 1. Make the valve operator more conveniently accessible by rolling valves, located more than 5 feet but less than 6 feet above the operating level, toward the operating side.
 - 2. Secure tee handles and wrenches to the valve head or stem, except where a handle or wrench so secured constitutes a hazard to personnel; in which case, stow handle or wrench immediately adjacent to the valve on or in a suitable hanger, bracket, or receptacle.
- C. Fit manually operated valves located more than 6 feet above operating level with chain-operated handles or valve wheels.
 - 1. Chains: Sufficient length to reach approximately 4 feet above the operating level.
 - 2. Where chains constitute a nuisance or hazard to operating personnel, provide holdbacks or other means for keeping the chains out of the way.

- D. Provide an operator shaft extension from valve or valve operator to finished grade or deck level when buried valves and other valves located below the operating deck or level are specified or indicated on the Drawings to be key operated.
 - 1. Provide 2 inches square AWWA operating nut, and box and cover as specified, or a cover where a box is not required.

2.08 LIMIT SWITCHES

- A. Provide limit switches for manually operated valves and gates as indicated on the Drawings.
 - 1. Heavy-duty, industrial grade, oiltight, with not less than 2 auxiliary contacts.
 - 2. Rating: 10 amps, 120 volts alternating current.
 - 3. Enclosure:
 - a. NEMA Type 4X with stainless steel levers and arms.
 - b. NEMA Type 7 enclosure for switches located within areas designated as Class I, Division 1 or Class I, Division 2, as specified or indicated on the Drawings.

2.09 VALVE AND GATE IDENTIFICATION

- A. Provide a tag or nameplate for each valve and gate identified on the Drawings.
 - 1. Tag numbers as indicated on the Drawings.
- B. Tags for exposed valves:
 - 1. General:
 - a. 2-inch diameter.
 - b. Character height: 1/4 inch minimum.
 - c. Laser engraved.
 - d. Contrast filled: Black.
 - e. 3/16-inch hole for attachment.
 - 2. Materials:
 - a. Stainless steel: Type 304, 20 gauge.
- C. Nameplates for buried valves:
 - 1. General:
 - a. 4 inches wide by 2 inches high.
 - b. Stainless steel: Type 3042B, 22 gauge.
 - c. Character height: 1/4 inch minimum.
 - d. Laser engraved.
 - e. Contrast filled: Black.
 - 2. Nameplate content:
 - a. Valve tag number.
 - b. Valve type.
 - c. Valve size.
 - d. System service.
 - e. Number of turns and direction to open.

- D. Installation:
 - 1. Attach tags to exposed valves and gates using nylon coated stainless steel wire.
 - a. Attach the tag to the operator base so that it allows for free and full operation of the valve or gate.
 - b. Secure the wire using a wire clamp or crimp.
 - 2. Attach buried valve nameplates to a concrete marker as indicated on the Drawings.

2.10 FINISHES

- A. Interior and exterior ferrous surfaces:
 - 1. In accordance with AWWA C550-17.
 - 2. Do not coat the following surfaces:
 - a. Interior machined surfaces.
 - b. Surfaces of gaskets and elastomeric seats and stem seals.
 - c. Bearing surfaces.
 - d. Stainless steel surfaces and components.
- B. Exterior ferrous surfaces:
 - 1. Rust-inhibitive primer:
 - a. Field coat the valve to match the color of the pipe it is installed in.
 - 2. For valves that will have a topcoat applied at the Project Site, prepare the surface in accordance with the manufacturer's instructions.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Preparation prior to installation:
 - 1. Determine after flanged valves and flanged check valves are selected, the face-to-face dimensions of flanged valves and flanged check valves.
- B. Fabricate piping to lengths accounting for the dimensions of flanged valves and flanged check valves.

3.02 INSTALLATION

- A. Install the valves in accordance with the manufacturer's installation instructions.
- B. Provide incidental work and materials necessary for installation of valves, including flange gaskets, flange bolts and nuts, valve boxes and covers, concrete bases, blocking, and protective coating.
- C. Provide additional valves for proper operation and maintenance of equipment and plant facilities under the following circumstances:
 - 1. Where such additional valves are required for operation and maintenance of the particular equipment furnished by the Contractor.
 - 2. Where such additional valves are required as a result of a substitution or change initiated by the Contractor.

- D. Valve and actuator orientation:
 - 1. Coordinate with the valve supplier final orientation of valve and actuator assembly based on the Contractor's selection of equipment manufacturers and the valve and piping arrangement as indicated on the Drawings.
 - a. Rotate valve and/or actuator mounting orientation as specified in this Section unless otherwise indicated on the Drawings.
 - 2. Install valves with their stems in vertical position above the pipe, except as follows:
 - a. Butterfly valves, gate valves aboveground, globe valves, ball valves, and angle valves may be installed with their stems in the horizontal position.
 - b. Install buried plug valves with geared operators with their stems in a horizontal position.
 - 3. Install valves so that handles clear obstructions when the valves are operated from fully open to fully closed.
- E. Place top of valve boxes flush with finished grade or as otherwise indicated on the Drawings.
- F. Valves with threaded connections:
 - 1. Install valves by applying wrench on end of valve nearest the joint to prevent distortion of the valve body.
 - 2. Apply pipe joint compound or Teflon™ tape on external (male) threads to prevent forcing compound into valve seat area.
- G. Valves with flanged connections:
 - 1. Align flanges and gasket carefully before tightening flange bolts.
 - 2. When flanges are aligned, install bolts and hand tighten.
 - 3. Tighten nuts opposite each other with equal tension before moving to the next pair of nuts.
- H. Valves with soldered connections:
 - 1. Do not overheat connection to prevent damage to resilient seats and metal seat rings.
 - 2. Position valves in full open position before starting soldering procedure.
 - 3. Apply heat to piping rather than to valve body.

3.03 FIELD-APPLIED COATING OF VALVE EXTERIOR

- A. Match color and be compatible with the manufacturer's coating system and as specified in Section 09_96_01 - High-Performance Coatings.
 - 1. When shop-applied finish coating matches field-applied coating on adjacent piping, touch up shop coating in damaged areas in accordance with instructions recommended by the paint manufacturer.
 - 2. When shop-applied coating does not match field coating on adjacent piping, or when damage has occurred to the shop-applied coating that requires more than touchup, blast clean valve surfaces or utilize other surface preparation recommended by the manufacturer of the coating material and apply the coating system used for coating adjacent piping.

3.04 QUALITY CONTROL

- A. Provide manufacturer's services for the following as specified in the valve Technical Sections:
1. Source Testing and the Manufacturer's Certificate of Source Testing.
 2. Manufacturer's Certificate of Installation Verification.
 3. Functional Testing and the Manufacturer's Certificate of Functional Compliance.
 4. Owner Training.

END OF SECTION

SECTION 40_05_57.13

MANUAL ACTUATORS

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Valve actuators.
 - 2. Handwheel actuators.
 - 3. Key-operated valves.
 - 4. Accessory equipment.

1.02 REFERENCES

- A. Aluminum Association (AA):
 - 1. DAF-45 - Designation System for Aluminum Finishes.
- B. American Water Works Association (AWWA).
- C. National Electrical Manufacturers Association (NEMA):
 - 1. 250 - Enclosures for Electrical Equipment (1,000 V Maximum).

1.03 SUBMITTALS

- A. Submit Shop Drawings and product data with associated valve.

1.04 QUALITY ASSURANCE

- A. Provide valve actuators integral with valve, except for valve actuators utilizing T-wrenches or keys.
- B. Provide similar actuators by one manufacturer.

1.05 MAINTENANCE

- A. Extra materials:
 - 1. Key-operated valve keys or wrenches: Furnish a minimum 4 keys with 4-foot shafts and 3-foot pipe handles or wrenches with 4-foot shafts and 3-foot handles for operating key-operated valves.

PART 2 PRODUCTS

2.01 VALVE ACTUATORS

- A. Valve actuators:
 - 1. Manual actuators:
 - a. Material: Type 316 stainless steel.

- b. Design: Hand lever.
- c. Spring release handle: 12-inch.
- d. Notch plate: 10 position.
- e. Secure with mounting bolts.
- f. Locking device so that valve can be locked in any position with a wing nut.
- 2. Stem and cover:
 - a. For submerged valves, provide an extension stem as indicated on the Drawings.

2.02 HANDWHEEL ACTUATORS

- A. Manufacturers: One of the following or equal:
 - 1. Rodney Hunt.
 - 2. Waterman Valves, LLC.
- B. Coating: As specified in Section 09_96_01 - High-Performance Coatings.
- C. Bearings above and below finished threaded bronze operating nut: Ball or roller.
- D. Wheel diameter: Minimum 24 inches.
- E. Indicator: Counterclockwise opening with arrow, and word OPEN cast on top of handwheel indicating direction for opening.
- F. Pull to operate: Maximum 40-pound pull at most adverse design condition.
- G. Stem travel limiting device: Setscrew locked stop nuts above and below lift nut.
- H. Grease fittings: Suitable for lubrication of bearings.

2.03 ACCESSORY EQUIPMENT

- A. Wall brackets or haunches: As indicated on the Drawings.
- B. Stems: Stainless steel; sized to match output of actuator; minimum gate or valve operating stem diameter; maximum 200 slenderness ratio.
- C. Stem couplings: Stainless steel; internally threaded to match stem; lockable to stem by set screw.
- D. Stem guides: Cast-iron with silicon bronze bushing; maximum 200 slenderness ratio; capable of being mounted with wall bracket; adjustable in 2 directions.
- E. Wall brackets: Cast-iron, capable of withstanding output of actuator, adjustable in 2 directions.
- F. Stem stuffing boxes: Cast-iron, with adjustable gland and packing.
- G. Fasteners: Type 316 stainless steel.

- H. Anchor bolts: As specified in Section 05_05_24 - Mechanical Anchoring and Fastening to Concrete and Masonry, except that the material shall be Type 316 stainless steel.
- I. Geared valve actuators: Provided with cut gears, either spur or worm; sized to operate valves at most adverse design condition; with maximum 40-pound pull at handwheel or chain wheel rim.
- J. Geared valve traveling nut actuators: Acceptable only where specified or indicated on the Drawings.
- K. Accessory equipment for valves and gates requiring remote actuators: Operating stems, stem couplings, stem guides, wall brackets, and stem stuffing boxes.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Provide geared actuators for the following manually operated valves:
 - 1. Butterfly valves larger than 6 inches, nominal size, on liquid service.
 - 2. Butterfly valves larger than 10 inches, nominal size, on gas and air service.
 - 3. Plug valves 6 inches, nominal size, and larger.

END OF SECTION

SECTION 40_05_57.24
ELECTRIC ACTUATORS

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Electric motor-driven actuators for valves and gates.
- B. Equipment tag numbers:
 - 1. As scheduled.

1.02 REFERENCES

- A. American Water Works Association (AWWA):
 - 1. C504 - Standard for Rubber-Seated Butterfly Valves.
 - 2. C542 - Standard for Electric Motor Actuators for Valves and Slide Gates.
- B. International Organization for Standardization (ISO):
 - 1. 12944 - Paints and Varnishes.
- C. National Electrical Manufacturers Association (NEMA):
 - 1. 250 - Enclosures for Electrical Equipment (1,000 V Maximum).

1.03 SUBMITTALS

- A. Furnish Submittals as specified in Section 01_33_00 - Submittal Procedures and Section 01_60_01 - Product Requirements.
- B. Provide a complete list/schedule of actuators being provided with their associated tag names, as indicated on the Drawings and/or Specifications, service process area and the size of the valve they are actuating.
- C. Product data:
 - 1. Electrical ratings:
 - a. Voltage and number of phases.
 - b. Starting and running current.
 - c. Voltage levels and source for control and status.
 - 2. Description of integral control interface.
 - 3. Remote control station components (If applicable).
 - 4. Environmental ratings, including NEMA enclosure rating and submergence capabilities.
 - 5. Gear ratios for both manual and motorized actuation.
 - 6. Opening and closing directions.
 - 7. Electric motor data.
 - 8. Allowable starts per hour.
 - 9. List of included options and accessories.

10. Full travel times.
 11. Gearbox data, including gear ratio, and gearbox efficiency.
- D. Shop Drawings:
1. Wiring diagrams:
 - a. Include options and expansion cards furnished with each actuator.
 2. Dimensioned drawings of each valve and actuator combination.
 3. Dimensioned drawings of each valve gearbox.
- E. Calculations:
1. Operating torque.
 2. Maximum torque calculations for seating and unseating.
 3. Maximum operating torque at starting and normal operation.
- F. Installation instructions:
1. Detail the complete installation of the equipment, including rigging, moving, and setting into place.
 2. Provide manufacturer's installation instructions.
- G. Quality Control Submittals:
1. Manufacturer's representative qualifications.
 2. Manufacturer's Certificate of Source Testing as specified in Section 01_75_17 - Commissioning.
 3. Manufacturer's Certificate of Installation as specified in Section 01_75_17 - Commissioning.
 4. Manufacturer's Certificate of Functional Compliance as specified in Section 01_75_17 - Commissioning.
- H. Owner Training Submittals:
1. As specified in Section 01_75_17 - Commissioning.
- I. Operation and maintenance manuals:
1. As specified in Section 01_78_24 - Operation and Maintenance Manuals.
 2. Include a list of configurable parameters and the final values for each.
 3. Include a troubleshooting chart covering the complete valve and controls/electrical power systems, showing description of trouble, probable cause, and suggested remedy.

1.04 DELIVERY, STORAGE, AND HANDLING

- A. As specified in Section 01_60_01 - Product Requirements, Section 46_05_10 - Common Work Results for Mechanical, and the manufacturer's instructions.

1.05 PROJECT OR SITE CONDITIONS

- A. As specified in Section 01_81_50 - Design Criteria.

1.06 MAINTENANCE

- A. As specified in Section 01_60_01 - Product Requirements.
- B. Spare parts:
 - 1. Provide the following (minimum 10 percent of total number of actuators of each model type furnished, but not less than 1 for each model of actuator furnished):
 - a. Stem nut.
 - b. Worm shaft subassembly.
 - c. Drive sleeve subassembly.
 - d. Complete actuator seal kit.
 - e. Actuator gearbox oil (sufficient quantity to fill 4 gearboxes).
 - f. Encoder.
 - g. Control module.
 - 2. Provide 1 spare motor for each size motor furnished.
- C. Setting tool:
 - 1. Provide a handheld setting tool capable of non-intrusive calibration and interrogation of the actuator.
 - a. Furnish 1 setting tool for every 10 actuators.
 - b. Capable of communicating with PC-based configuration software and transferring the following in either direction between the computer and programmer and setting tool, and between the setting tool and actuator.
 - c. Actuator configurations:
 - 1) Capable of storing up to 10 different configurations.

1.07 WARRANTY

- A. As specified in Section 01_78_36 - Warranties and Bonds.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Lines 3 inches and smaller:
 - 1. The following or equal:
 - a. Rotork Controls, Inc.
 - 1) CMA range:
 - a) CMR - Multi-turn.
 - b) CMQ - Quarter-turn.
- B. Lines 4 inches and larger:
 - 1. One of the following or equal:
 - a. Auma:
 - 1) SA/GK (multi-turn) with Aumatic AC controls.
 - 2) SQ (quarter-turn) with Aumatic AC controls.
 - b. Limitorque Corp.:
 - 1) Accutronix MX for multi-turn applications.
 - 2) Accutronix QX quarter-turn applications.

- c. Rotork Controls Inc. IQ3 Range:
 - 1) IQ for multi-turn applications.
 - 2) IQT for quarter-turn applications.

2.02 MATERIALS

- A. Enclosures:
 - 1. Constructed of materials suitable for the environment where the actuator will be installed.
 - 2. Stainless steel external fasteners.
 - 3. Provide O-ring seals for each of the following areas:
 - a. Between the terminal compartment and the internal electrical elements.
 - b. Between the mechanical and electrical portions to protect from the ingress of oil, and to protect the mechanical components of oil from dust and moisture when the electrical terminal is open.
 - 4. Ratings:
 - a. As scheduled and specified:
 - b. NEMA Type 6P: Double sealed and IP68 rated for prolonged submergence.
 - c. XP: Factory Mutual (FM) approved for Class I, Division 1 and Division 2 locations.
- B. Coatings:
 - 1. Material requirements:
 - a. Factory prime and coat with an ISO 12944 classification coating of C5M (Marine, offshore estuaries with high salinity) coating with 15-year durability.
 - b. Touch-up damaged coatings with manufacturer provided coating repair kit.
 - 2. Application requirements:
 - a. Painting shall commence within 4 hours of blast cleaning.
 - b. Each paint coat within the system is to be applied in accordance with the paint manufacturer's instructions.
 - c. Paint thickness shall be checked for each coat on each actuator.
 - 3. Qualification requirements:
 - a. Operators shall be experienced and proficient in surface preparation and coating application techniques.
 - b. Personnel shall have relevant knowledge of health and safety hazards, use of protective equipment, coating materials, mixing and thinning coatings, coating pot life, surface requirements, etc.
 - c. Personnel carrying out inspection or verification shall be certified as NACE coating inspector or equivalent such as ICorr.

2.03 CHARACTERISTICS FOR ACTUATORS ON LINES 3 INCHES AND SMALLER

- A. Actuators for valves 3 inches and smaller:
 - 1. Complete and operable with all components and accessories required for operation.
 - 2. Power supply:
 - a. Valve motion independent of power supply phase rotation.
 - b. As indicated on the Drawings.

3. Size actuator to move valves from full open to closed position within the time indicated in the Actuator Schedule:
 - a. If an operating time is not indicated on the Actuator Schedule, size the actuator to move valves at minimum 12 inches per minute under maximum load. Measure closure rate for valves at the maximum diameter of disc, plug, or ball.
4. For outdoor or vault installations, provide an integral anti-condensation heater when available as an option.
5. Control inputs:
 - a. Capable of using discrete dry contacts.
 - b. Controls the valve when local-stop-remote is in REMOTE.
 - c. Material: Type 316 stainless steel.
 - d. Provide the following inputs at the actuator:
 - 1) OPEN.
 - 2) CLOSE.
6. Status outputs:
 - a. Dry contact outputs configured for the functions indicated on the Drawings. Provide the following outputs for all actuators:
 - 1) FULLY CLOSED.
 - 2) FULLY OPEN.
 - 3) REMOTE.
 - b. Output contacts rated for 5 amps, 120 VAC.
7. Analog input:
 - a. Provide a 4 to 20 analog input for analog modulating valves when indicated on the Drawings.
 - b. Modulate valve to maintain position based on analog input value.
 - c. Maximum input impedance 250 ohms.
8. Analog output:
 - a. Provide an isolated 4 to 20 mA analog output when indicated on the Drawings.
9. Components:
 - a. Motors:
 - 1) Torque ratings equal to or greater than that required for valve seating and dynamic torques with a 25 percent factor of safety.
 - 2) Rated for operating under the following conditions without exceeding temperature limits with ambient temperature of 40 degrees Celsius.
 - a) Continuous operation for 15 minutes or twice the open-to-close operating time (whichever is greater) at normal operating torque or 33 percent of maximum torque (whichever is greater).
 - b) 60 starts per hour minimum for open/close service.
 - b. Manual actuation:
 - 1) Handwheel for manual operation.
 - c. Gearing: Self-locking, high-alloy steel gears.
10. Communication options:
 - a. As specified in the Contract Documents.

2.04 CHARACTERISTICS FOR ACTUATORS ON LINES 4 INCHES AND LARGER

- A. Provide actuators complete and operable with all components and accessories required for operation.

- B. Power supply:
 - 1. Voltage and phases as indicated in the Actuator Schedule.
 - 2. Valve or gate motion independent of power supply phase rotation.
 - 3. Provide an internal backup power source or mechanical indicator to maintain settings and track valve position when main power is off.
 - 4. Actuators shall incorporate major components such as the motor, starter, local controls, terminals, etc., housed within a self-contained, sealed enclosure.
- C. Size actuator to move gates or valves from full open to closed position within the time indicated in the Actuator Schedule:
 - 1. If an operating time is not indicated on the Actuator Schedule, size the actuator to move gates or valves at minimum 12 inches per minute under maximum load. Measure rate of closure for valves at maximum diameter of disc, plug, or ball.
 - 2. Size actuators so that gear boxes are not required where possible.
- D. Control interface:
 - 1. Configuration:
 - a. Provide a non-intrusive, non-contacting interface for configuring input and output settings, control values, ranges, torque switch settings, valve positions switch settings, and options.
 - 1) Configurable from a handheld configuring tool or input devices on the actuator.
 - 2. Local interface, integral to actuator:
 - a. Non-intrusive, non-contacting selector switches:
 - 1) LOCAL-STOP-REMOTE:
 - a) Motor actuator operation is prevented with the switch in STOP.
 - 2) OPEN-CLOSE:
 - a) Controls the valve when LOCAL-STOP-REMOTE is in LOCAL.
 - b) Spring return to center.
 - c) Configurable between maintained (actuator runs until end of travel, high torque, or a LOCAL-STOP-REMOTE is switched to STOP) and momentary (actuator stops when lever is released).
 - b. Local display:
 - 1) Valve fully open and fully closed indicators.
 - 2) Numerical display showing actual valve or gate position in percent of travel.
 - 3. Remote hand station (VCP):
 - a. For actuators located more than 5 feet above finished floor/grade or where indicated on the Drawings in the Schedule.
 - b. Wall mounted or pole mounted as indicated on the Drawings.
 - c. Configuration: Bluetooth configuration tool.
 - d. Power: Via attached actuator (24 VDC output).
 - 4. Control inputs:
 - a. Capable of using discrete 120 VAC.
 - b. Controls the valve when LOCAL-STOP-REMOTE is in REMOTE.
 - c. Isolated inputs capable of operating from external control voltage source or internal power supply.
 - d. Provide the following inputs:
 - 1) OPEN.

- 2) CLOSE.
 - 3) STOP.
- e. OPEN and CLOSE inputs configurable between maintained (actuator runs until end of travel, high torque, or a STOP input) and momentary (actuator stops when command is removed).
- 5. Status outputs:
 - a. Monitor relay output: Dry contact, normally closed, opens when actuator is not in REMOTE or in the event of any internal fault or alarm condition.
 - b. Dry contact outputs configured for the functions indicated on the Drawings. Provide the following outputs for all actuators:
 - 1) Fully closed.
 - 2) Fully open.
 - 3) LOCAL-STOP-REMOTE in REMOTE position.
 - c. Contacts and communications:
 - 1) As specified in the Contract Documents.
 - 2) Dry contacts rated for both 120 VAC and 24 VDC.
 - d. Analog input:
 - 1) 4 to 20 mA analog input for analog modulating valves when indicated on the Drawings.
 - e. Analog output:
 - 1) Isolated 4 to 20 mA analog output when indicated on the Drawings.
 - a) Loop power sourced from the actuator power supply.
 - b) Output proportional to process value(s) indicated on the Drawings.
- E. Features:
 - 1. Time delay on reversal: Incorporate time delay between stopping actuator and starting in opposite direction to limit excessive current, torque, and heating from instantaneous reversal.
 - 2. Data logging:
 - a. Store diagnostic data and reference data.
 - b. Time-stamped historical operating data, including number of operations.
 - 1) Store reference data (recorded during commissioning) and data from last operation.
 - 3. Provide display of logged data on the actuator, or provisions to download to a personal computer.
- F. Components:
 - 1. Motors:
 - a. Specifically designed for valve actuator service with high starting torque, totally enclosed non-ventilated construction.
 - b. Torque ratings equal to or greater than that required for valve seating and dynamic torques with a 25 percent factor of safety.
 - 1) Design requirements for rubber-seated AWWA butterfly valves:
 - a) Design actuators for maximum gate or valve operating torque, in accordance with and using safety factors required in AWWA C504 and AWWA C542.
 - (1) Valve actuator torque requirement for open-close service: Not less than the required valve-seating and dynamic torques under design operating conditions in accordance with AWWA C504.

- (2) Valve actuator torque requirement for modulating service:
Not less than twice the required valve dynamic torque under design operating conditions in accordance with AWWA C504.
 - 2) Design requirements for slide gates, gate valves, knife gate valves, globe valves, and diaphragm valves:
 - a) Design valves and actuators for maximum operating torque in accordance with and using safety factors required in AWWA C542.
 - b) Design for the maximum torque and thrust running load over the full cycle.
 - c) Maximum torque or thrust rating: Actuator stall torque or maximum thrust output shall not exceed the torque or thrust capability of the valve or gate, as determined by the valve or gate manufacturer.
 - c. Capable of being removed and replaced without draining the actuator gear case.
 - d. Motor bearings shall be amply proportioned of the anti-friction type and permanently lubricated.
 - e. Rated for operating under the following conditions without exceeding temperature limits with ambient temperature of 40 degrees Celsius.
 - 1) Continuous operation for 15 minutes or twice the open-to-close operating time (whichever is greater) at normal operating torque or 33 percent of maximum torque (whichever is greater).
 - 2) 60 starts per hour for open/close service or 1,200 starts per hour for modulating service.
 - f. Provide the following motor protection features:
 - 1) Jammed valve (no valve motion detected through a time delay).
 - 2) High motor temperature (sensed by an embedded thermostats).
 - 3) High torque.
 - 4) Single phasing protection.
- G. Position sensing:
 1. Electronic and adjustable using a solid-state encoder wheel.
 - a. Mechanical limit switches and potentiometers are not acceptable.
 2. Capable of retaining position and monitoring valve or gate motion when valve is manually actuated and when main power is not present.
 3. Valve range and position switch outputs field adjustable.
- H. Torque sensing:
 1. Torque shutdown setting: 40 percent to 100 percent rated torque:
 - a. Adjustable in 1 percent increments.
 2. Torque display: 0 to 100 percent-rated torque.
 3. Capable of interrupting control circuits during both opening and closing and when valve torque overload occurs.
 4. Electrical or electronic torque sensing.
 5. Independent of variations in frequency, voltage, or temperature.
 6. Actuator shall store actual operational torque curves for retrieval by plant maintenance staff.

7. Provide a temporary inhibit of the torque sensing system during unseating or during starting in mid-travel against high inertia loads.
 8. Provide visible verification of torque switch status without any housing disassembly.
- I. Manual actuators:
1. Hand wheel for manual operation.
 - a. Maximum 80-pound pull on rim when operating gate or valve under maximum load.
 - b. Provide pull chain when motorized actuator is located more than 6 feet above floor surface.
 - 1) Chain shall be of sufficient length to reach approximately 4 feet above the operating level.
 - 2) Where the chain obstructs an aisle or walkway, provide holdback or other means to ensure chain does not create a nuisance or hazard to operating personnel.
 - 3) Provide Type 316 stainless steel.
 2. Declutch lever: Padlockable, capable of mechanically disengaging motor and related gearing and freeing hand wheel for manual operation.
- J. Gearing: Hardened alloy steel spur or helical gears and self-locking, alloy bronze worm gear set.
1. Accurately cut to ensure minimum backlash.
- K. Bearings:
1. Anti-friction bearing with caged balls or rollers throughout.
 2. Sealed-for-life type thrust bearings housed in a separate thrust base.
- L. Drive bushing:
1. Easily detachable for machining to suit the valve stem or gearbox input shaft.
 2. Positioned in a detachable base of the actuator.
- M. Lubrication:
1. Provide totally enclosed actuator gearing with oil or grease filled gear case suitable for operation at any angle.
 2. Actuators requiring special or exotic lubricants are not acceptable.

2.05 ACCESSORIES

- A. Software:
1. Furnish PC-based diagnostic and configuration software to display diagnostic data and configure actuators.
 2. Provide software communications to the valve actuator and handheld setting tool using Bluetooth wireless or IrDA infrared communications.
 - a. Provide accessories and drivers required for operation and communications with a standard personal computer running Microsoft Windows.
 - b. Where infrared communications are used, furnish an IrDA to USB adapter with a mounting device to secure the infrared element to the valve actuator IrDA port:
 - 1) Provide with a minimum cable length of 3 feet, capable of being extended with a standard USB extension cable.

- B. Termination module cover:
 - 1. For actuators on a valve network, provide a means to keep the valve network in service, in the event where the actuator must be removed.
 - 2. Provide sunshades for outdoor installations of remote control stations that use an LCD or similar screen. Regular pushbutton, sector switches, and pilot light control stations will not require a sunshade.

2.06 SOURCE QUALITY CONTROL

- A. Source Testing:
 - 1. Design and performance test reports in accordance with AWWA C542.
 - 2. Test each actuator with a simulated load.
 - a. Simulate a typical valve load.
 - 3. Furnish test reports and the Manufacturer's Certificate of Source Testing.

PART 3 EXECUTION

3.01 INSTALLATION

- A. As specified in Section 46_05_10 - Common Work Results for Mechanical Equipment.
- B. Install the equipment in accordance with the manufacturer's instructions.
- C. Position visual indicators so that they are most easily visible.
- D. Installation Verification:
 - 1. Furnish Manufacturer's Certificate of Installation Verification.

3.02 FIELD QUALITY CONTROL

- A. As specified in Section 01_75_17 - Commissioning, Section 46_05_94 - Mechanical Equipment Testing, and this Section.
- B. Functional Testing:
 - 1. Installed actuator:
 - a. Test witnessing: Witnessed.
 - b. Conduct Level 2 General Equipment Performance Tests.
 - 2. Electrical Instrumentation and Controls:
 - a. Test witnessing: Witnessed.
 - b. Conduct testing as specified in Section 40_80_01 - Commissioning for Instrumentation and Controls.
 - 3. Furnish test reports and the Manufacturer's Certificate of Functional Compliance.

3.03 OWNER TRAINING

- A. Perform Owner Training as specified in Section 01_75_17 - Commissioning.
 - 1. Number of sessions:
 - a. Operations: 1.
 - b. Maintenance: 2.

3.04 ACTUATOR SCHEDULE

- A. Provide actuators indicated on the Drawings:
 - 1. Major process actuators are listed in the Actuator Schedule shown in Attachment A - Actuator Schedule.
 - a. Attachment A - Actuator Schedule does not include all number and types of actuators required for the Project.

END OF SECTION

ATTACHMENT A - ACTUATOR SCHEDULE

ACTUATOR SCHEDULE

Item	Reference DWG	Type	Size	Duty	NEMA Rating	Voltage/Phase/Hz	Notes	Service	Controls
VAL 301(Future)	P942-M-401	PV	16"	MOD	4X	480/3/60 Hz	1	CTRL	A
VAL 302 Pump 2 Discharge	P942-M-410	PV	16"	MOD	4X	480/3/60 Hz	1	CTRL	A
VAL 303 Pump 3 Discharge	P942-M-401	PV	16"	MOD	4X	480/3/60 Hz	1	CTRL	A
VAL 310 42" Flow Meter Isolation	P942-M-410	BFV	42"	STD	4X	480/3/60 Hz	1	O/C	D
VAL 311 18" Flow Meter Isolation	P942-M-410	BFV	18"	STD	4X	480/3/60 Hz	1	O/C	D

Notes:

- (1) Provide actuators with remote control station.
- (2) New motorized actuator to be installed on existing equipment. Field verify characteristics prior to sizing motor actuator.

Abbreviations:

Type:

BFV = Butterfly Valve.
 BV = Ball Valve.
 PV = Plug Valve.
 SG = Slide Gate.

NEMA Rating:

4X for general locations.
 6P for vaults and possible submergence.
 XP for Class I, Division 1 and Division 2 locations.

Controls:

A = Analog.
 D = Discrete.
 DP = Profibus DP.
 E-IP = Ethernet/IP.

Duty:

MD = Modulating duty (~1,200 starts/hr).
 MOD = Modulating.
 STD = Standard service (0-60 starts/hr) duty.

Service:

CTRL = Control.
 O/C = Open/Close.

E-TCP = Ethernet TCP or TCP/IP.
 FF = Foundation Fieldbus H1.
 MB = Modbus RTU (RS-485).
 NET = Manufacturer's proprietary network.
 PA = Profibus PA.

SECTION 40_05_57.43

HYDRAULIC POWER SUPPLY SYSTEMS

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Hydraulic power supply systems, accumulators, and appurtenances.

1.02 REFERENCES

- A. American Society of Mechanical Engineers (ASME):
 - 1. Boiler and Pressure Vessel Code (BPVC):
 - a. Section VIII - Rules for Construction of Pressure Vessels Division 1.
- B. U.S. Environmental Protection Agency (EPA).
- C. Underwriters Laboratory (UL).

1.03 SUBMITTALS

- A. Furnish Submittals as specified in Section 01_33_00 - Submittal Procedures and Section 01_60_01 - Product Requirements.
- B. Product data:
 - 1. Manufacturer's product data for all system components.
- C. Shop Drawings:
 - 1. Integrated hydraulic system schematic, including valve and tubing sizes, based on the manufacturer's recommended design.
 - 2. Hydraulic connection details.
 - 3. Electrical schematics and elevations for local control panel.
 - 4. Interconnection diagrams with power supply and instrumentation for electrically operated equipment and local control panel.
- D. Calculations:
 - 1. Provide calculations demonstrating proper system function as specified in this Section, including, but not limited to:
 - a. Head loss calculations.
 - b. Pump sizing calculations.
 - c. Accumulator sizing calculations.
 - d. Cylinder sizing calculations.
 - e. Operating pressure calculations.
 - f. Speed and force calculations.

- E. Delegated Design Submittals:
 - 1. Provide project-specific calculations based on support conditions and requirements to resist loads specified in Section 01_81_50 - Design Criteria.
 - a. For equipment installed outdoors.
 - b. For wall mounted equipment weighing 125 pounds or more.
- F. Installation instructions:
 - 1. Detail the complete installation of the equipment, including rigging, moving, and setting into place.
 - 2. Provide manufacturer's installation instructions.
- G. Quality Control Submittals:
 - 1. Manufacturer's representative qualifications.
 - 2. Manufacturer's Certificate of Source Testing as specified in Section 01_75_17 - Commissioning.
 - 3. Manufacturer's Certificate of Installation Verification as specified in Section 01_75_17 - Commissioning.
 - 4. Manufacturer's Certificate of Functional Compliance as specified in Section 01_75_17 - Commissioning.
- H. Owner Training Submittals:
 - 1. As specified in Section 01_75_17 - Commissioning.
- I. Operation and maintenance manuals:
 - 1. As specified in Section 01_78_24 - Operation and Maintenance Manuals.

1.04 DELIVERY, STORAGE, AND HANDLING

- A. As specified in Section 01_60_01 - Product Requirements, Section 46_05_10 - Common Work Results for Mechanical, and the manufacturer's instructions.

1.05 PROJECT OR SITE CONDITIONS

- A. As specified in Section 01_81_50 - Design Criteria.

1.06 WARRANTY

- A. As specified in Section 01_78_36 - Warranties and Bonds.

1.07 SUPPLIER QUALIFICATION

- A. A service center must be located within a 150-mile radius of the jobsite to ensure rapid response to service requests.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. One of the following or equal:
 - 1. Hydraquip, Hydraulic Power System.
 - 2. DeZURIK, Hydraulic Power System.

2.02 DESIGN AND PERFORMANCE CRITERIA

- A. Design requirements:
 - 1. Hydraulic power unit shall be designed to operate one 54-inch cast iron intake gate or one 54-inch bonneted knife gate valve as indicated on the Drawings. Hydraulic cylinder actuators as specified in Section 40_05_57.65 - Hydraulic and Pneumatic Cylinder Actuators.
 - 2. System working pressure range:
 - a. Unit connections to field piping.
 - 1) Minimum: As required to provide cylinder, as specified in Section 40_05_57.65 - Hydraulic and Pneumatic Cylinder Actuators.
 - 2) Maximum: 3,000 pounds per square inch minimum.
- B. Number of hydraulic power supply systems: 1.
- C. Number of pumps per system: 2.
- D. Hydraulic power supply system skid-mounted packaged unit includes the following:
 - 1. Components:
 - a. Local control panel enclosure.
 - b. Pumps and motors.
 - c. Valves: Including, but not limited to:
 - 1) Manual valve.
 - 2) Solenoid directional control valves.
 - 3) Speed control valves.
 - 4) Check valves.
 - 5) Pressure relief valves.
 - 6) Isolation valves.
 - d. Reservoir with sight gauge and drain valve.
 - e. Accumulators.
 - f. Filters.
 - g. Pressure gauges.
 - h. Pressure transmitters.
 - i. Tank level transmitter.
 - j. High oil temperature switch.
 - 2. Hydraulic fluid:
 - a. Provide for the entire hydraulically actuated system, including:
 - 1) Reservoirs.
 - 2) Accumulators.
 - 3) System tubing.
 - 4) Hydraulic cylinders.
 - 5) Specified spare parts inventory fluid.
 - 3. Factory-installed hydraulic tubing on HPU:
 - a. Size shall be sufficient to prevent cavitation or starvation and undue temperature rise or turbulence.
 - b. Wall thickness safety factor minimum at nominal operating pressure: 6 to 1.
 - c. Maximum fluid velocities in piping shall be as follows:
 - 1) Pump suction, feet per second: 4.
 - 2) Pressure lines to system, feet per second: 15.
 - 3) Return lines from system, feet per second: 15.

- E. Performance requirements:
1. Each power unit shall be able to open or close one 54-inch gate or on 54-inch bonneted knife gate valve.
 2. System accumulator sized to supply, between maximum and minimum working pressure, an oil volume equivalent to close one 54-inch gate or on 54-inch bonneted knife gate valve, whichever is larger.
 3. Emergency gate accumulator sized to supply, between maximum and minimum working pressure, an oil volume equivalent to close one 54-inch gate or on 54-inch bonneted knife gate valve, whichever is larger.
 4. Manufacturer of actuated equipment shall be wholly responsible for design of the hydraulic system, including sizing of field installed hydraulic lines between the cylinders and hydraulic power unit, in accordance with the requirements specified in this Section.
 5. Under normal operating conditions, the hydraulic power unit shall be capable of simultaneously opening or closing all slide gates and bonneted knife gate valve at a rate of 12 inches per minute using oil from the accumulators. During emergency operation the hydraulic power unit shall be capable of closing one 54-inch gate or on 54-inch bonneted knife gate valve, whichever is larger, at a rate of 108 inches per minute using oil from the accumulators.
 6. System accumulator sized to supply, between pump off and pump on pressures, an oil volume equal to 125 percent of that necessary to fully close one 54-inch gate or on 54-inch bonneted knife gate valve, whichever is larger, from the fully opened position.
 7. Pump and motor sized to fully recharge the accumulator from the pump on pressure to the pump off pressure in 2 minutes or less.
 8. Total un-throttled valve pressure loss for oil hydraulic valves in a circuit at maximum flow and minimum hydraulic fluid temperature shall not exceed 200 pounds per square inch, or the valve manufacturer's recommendations, whichever is lower.

2.03 HYDRAULIC POWER SUPPLY SYSTEMS

- A. Pressure: 2,000 pounds per square inch (nominal) systems, designed to operate between the specified working pressure limits.
- B. Sufficient size and capacity to operate the hydraulic cylinders against the design thrust requirements.
- C. Designed and manufactured in compliance with good engineering practice.
- D. Components shall be mounted on the skid in a position which will facilitate adjustment and maintenance of the unit.
- E. Provide lifting eyes to facilitate handling of the system.
- F. Constructed to allow lifting by a fork truck.
- G. Seal openings in hydraulic equipment prior to shipment.
- H. Clearly label field connection.

- I. Electrical components:
 - 1. UL labeled and approved for use inside of enclosure.
 - 2. Provide diagram holder inside of door.

2.04 HYDRAULIC FLUID

- A. Premium grade vegetable-based oil.
 - 1. Compatible with system pumps, valves, accumulators, seals, gaskets, and other wetted components.
 - 2. Suitable for use in ambient temperature range of 15 degrees Fahrenheit to 100 degrees Fahrenheit.
 - 3. Flash point not less than 420 degrees Fahrenheit.
 - 4. Pour point not greater than -20 degrees Fahrenheit.
 - 5. Viscosity at 15 degrees Fahrenheit: Not more than 500 centistokes. Operating viscosity to remain 50 to 200 SUS at 50 to 60 degrees Fahrenheit.
 - 6. Biodegradability not less than 60 percent in 28 days in accordance with EPA 560/6-82-003.
 - 7. Manufacturers: The following or equal:
 - a. Mobil EAL 224H.
 - 8. Aquatic toxicity LC50 not less than 1,000 parts per million in 96-hour test, in accordance with EPA 560/6-82-002.

2.05 RESERVOIRS

- A. Styled, designed, and constructed to minimize entry of foreign matter, including water.
- B. General:
 - 1. Minimum reservoir size shall be 1.25 times the maximum return oil volume, including the operating volume in all accumulators, or the volume discharged by the pump in 4 minutes, whichever is greater.
 - 2. Reservoir shall be designed to provide adequate heat dissipation at ambient conditions. Tank shall be mounted overhead to ensure pump inlet head pressure.
 - 3. Fluid level shall be visible in the sight gauge during the normal operating cycle.
 - a. Sight gauge shall be marked with high and low oil levels.
 - 4. Reservoir shall be large enough to provide an adequate mounting surface for the hydraulic system components.
 - 5. Provide baffling between the intake and return lines to facilitate the separation of air and foreign matter from the hydraulic fluid.
 - 6. Intake and return lines shall terminate 2 inches above the bottom of the reservoir to prevent cavitation and aeration.
 - 7. Cleanouts shall be provided, located, and sized for complete maintenance access to reservoir interior.
 - 8. A tank drain shall be provided.
 - 9. Provide pressure filter on return line with a maximum of 6 micrometer mesh.

- C. Breather: Filler assembly:
 - 1. Built-in strainer for straining the fluid while filling.
 - 2. Air cleaner shall be desiccant style and of sufficient capacity to maintain approximate atmospheric pressure at maximum demands of the hydraulic system and shall prevent entrance of splashed liquids

2.06 PUMPS AND MOTORS

- A. Pump:
 - 1. Manufacturers: The following or equal:
 - a. Parker.
 - b. Danfoss
- B. Provide a double acting hydraulic hand pump permanently installed in each power unit, suitable for emergency standby use.
- C. Pump and motor shall be piston style, pressure compensated/load sense with adjustable max volume stop and shall operate free of mechanical or electrical defects, excessive noise (maximum dB of 85 at 3 feet) or vibration, and without cavitation, overheating, or overloading.
 - 1. Sized to provide sufficient volume of fluid to operate the cylinders as specified at the design speed and pressure.
- D. Motor shall be a 3-phase, 460-volt, 60 hertz, totally enclosed fan cooled motor.
- E. Flexible couplings shall be used between the pump and the motor:
 - 1. Coupling shall have adequate capacity to transmit the power required.
 - 2. Mounting surface provided for the pump and motor shall be rigid and prevent coupling misalignment due to workload and temperature variation. Provide C-face to pump mount adaptor.
 - 3. A detachable safety guard shall be fastened over the coupling.
 - 4. Provisions shall be made in the electrical control circuit to alternate the pumps or otherwise provide a means of operating each of these pumps as specified in this Section.
 - 5. Direction of rotation shall be clearly indicated on each motorized pump.

2.07 FILTERS

- A. Each pump shall have an indicating discharge filter properly sized and matched to the pump flow rate.
- B. Provide 10-micron filter with bypass on the return line.
- C. Provide a submerged suction strainer on the suction of the hand pumps.

2.08 PRESSURE GAUGES

- A. Where indicated on the Drawings.
- B. Supplied with snubber and shut-off valve to permit replacement without shutting down the system.

2.09 VALVES AND ACCESSORIES

- A. Valves shall be of the type and size designed specifically for the application and for the Project. Valves shall be 12VDC and provide load sense port, manual spool flow limit adjustments, and built in manual spring centered level.
- B. System connections shall be terminated at the power unit with ball valves, with the body made of the same material as the hydraulic tubing and a union-type or flanged connection between the valve and the power unit.
- C. Check valves:
 - 1. At pumps discharge.
 - 2. Where indicated on the Drawings.
 - 3. Wherever required in the circuit to provide proper system operation.
- D. Pressure transmitters shall be supplied with pressure snubbers to prevent pressure fluctuations from producing unwanted and unnecessary pump starts.
- E. Hydraulic valves provided with external drain connections shall be piped independently to the reservoir or to vented manifold.
- F. Valves shall be provided to control required speeds and force limits to each cylinder.
- G. Valves shall be provided to keep gates/valves in open position.
- H. Other valves and accessories provided as required to meet the necessary performance requirements.

2.10 ACCUMULATORS

- A. Manufacturers: The following or equal:
 - 1. Parker.
 - 2. Accumulators, Inc.
- B. Sized to provide sufficient volume and pressure to operate the cylinders as specified in this Section, plus an additional 10 percent safety factor.
- C. Built in accordance with the requirements in ASME BPVC, Section VIII, and shall bear the ASME stamp.
- D. Rated and designed for a working pressure of not less than 3,000 pounds per square inch.
- E. Each accumulator, or accumulator assembly if multiple accumulators are used, shall be fitted with valves as follows:
 - 1. A status switch shall be furnished to alarm actuation of the flow fuse, rated not less than 2 amps, 120 volts alternating current.

- 2. Speed control valve with check-valve bypass to regulate accumulator discharge flow rate.
- 3. Safety valve including isolation, block/bleed, pressure limits, and pressure measurement.
- F. When multiple accumulators are used, each shall be provided with over-pressure relief valve shut-off valves on both gas and liquid ends.
- G. Means shall be provided for safely relieving accumulator gas and liquid pressure.
- H. Pre-charge fluid shall be nitrogen gas.
- I. Provide a method to automatically determine when a loss of pre-charge pressure occurs and to activate an alarm condition. A gas end cap proximity switch shall be provided to alarm when gas pressure is low.
- J. Accumulators with appurtenant valves and controls shall be an integral part of the factory assembled hydraulic power supply system.
- K. System accumulators shall be mounted directly on the hydraulic power supply system.

2.11 HPU PLUMBING

- A. O-ring face seal hose and tube fittings/adaptors.
- B. O-ring boss ports and adaptors.

2.12 ELECTRICAL CONTROLS

- A. Power unit electrically activated devices shall be factory wired to the electrical control enclosure on the skid.
- B. Necessary electrical controls, operating devices, and monitoring devices shall be wired to self-contained control enclosure.
- C. Control enclosure shall be rated as specified in Section 26_05_00 - Common Work Results for Electrical.
- D. Necessary relays, timers, and other components shall be supplied to provide for the systems specified in this Section.
- E. Field connections: Wire to a terminal strip in the enclosure with connections labeled to correspond to the electrical schematic diagram.
- F. Control enclosures shall have hinged covers which swing horizontally and shall be held closed with mechanical fasteners.
 - 1. Control enclosures shall include wiring diagram holder inside door of each control bucket.

- G. Electrical controls shall include necessary motor starters with overload protection, disconnect switches or circuit breakers, plus control power transformers to provide a complete system requiring only input power.
- H. Electrical controls description shall include UL label and be approved for use inside of enclosure. As specified in Section 40_67_01 - Control Systems: Panels, Enclosures, and Panel Components.

2.13 INSTRUMENTATION

- A. Provide necessary sensing contacts on equipment as specified in this Section to accommodate hydraulically powered control scheme indicated on the Drawings.
- B. Control circuits and solenoid valves shall operate at 120 volt, single phase, alternating current.
- C. When programmable logic controller control is furnished for the hydraulic power supply system, submit the slide gate manufacturer's information necessary to program the programmable logic control.
- D. System operation:
 - 1. Controls shall permit operation of only 1 pump at a time on each hydraulic power supply system.
 - 2. Each hydraulic power supply system shall have a 3-position hand-off-auto (HOA) switch on its local control panel.
 - 3. Panel shall be capable of opening/closing each slide gate and/or knife gate independently. The gate/knife gate valve shall maintain position within 5 percent automatically.
 - 4. Panel shall be capable of entering a percent open for each gate/knife gate independently. The gate/knife gate valve shall maintain position within 5% automatically. The position of each gate/knife gate valve shall be clearly visible on the control panel and shall provide a position indication back to SCADA.
 - 5. Provide lights indicating open/closed or intermediate position for each gate/knife gate valve.
 - 6. Panel shall provide a fault if system pressure is lost or gate/knife gate valve cannot maintain preset position.
 - 7. The following conditions shall be locally and remotely alarmed for each hydraulic power unit:
 - a. High oil temperature in the reservoir.
 - b. Low oil level in the reservoir.
 - c. Pump motor overload for pump no. 1.
 - d. Pump motor overload for pump no. 2.
 - e. Low oil flow rate for more than 0 to 1 minute.
 - f. Low accumulator gas charge in system accumulator.
 - g. Low accumulator gas charge in reserve accumulator.
 - 8. The following conditions shall be locally and remotely alarmed for the emergency gate accumulator:
 - a. Low accumulator gas charge.
 - b. Flow fuse actuated.

9. The following conditions shall stop the duty pump and prevent start of the reserve pump:
 - a. High oil temperature in the reservoir.
 - b. Low oil level in the reservoir.
 - c. Flow fuse actuated.
10. The following conditions shall stop the duty pump and the reserve pump shall automatically be placed in "duty" status, and the alternator shall be temporarily bypassed:
 - a. Pump motor overload.
 - b. Low oil flow rate for more than 0 to 1 minute.

2.14 COATING

- A. Factory coat with high-solids epoxy as specified in Section 09_96_01 - High-Performance Coatings.

2.15 MAINTENANCE

- A. Spare parts:
 1. Provide the following:
 - a. 1 hydraulic pump, motor, and coupling for each size pump provided.
 - b. 1 check valve of each type and size provided.
 - c. 1 complete replacement volume of the hydraulic fluid provided for each system.
 - d. 2 filters of each type provided.
 - e. 1 solenoid directional control valve of each size and type provide.
 - f. 2 pressure relief valves of each type and size provided.
 - g. 1 pressure reducing valve of each type and size provided.
 - h. 1 counterbalance valve of each type and size provided.
 2. 1 complete set of seals, gaskets, and expendable hardware required for installation of each spare valve or valve assembly.
 3. Spare parts shall be packaged and clearly identified.
 4. Tank breather.
 5. Electrical equipment spares recommended by the manufacturer.

2.16 SOURCE QUALITY CONTROL

- A. Source Testing (Factory Acceptance Tests):
 1. As specified in Section 01_75_17 - Commissioning.
 2. Witnessed, in-person.
 - a. Number of Owner and Engineer representatives in person: 2.
 3. Test as specified in Section 46_05_94 - Mechanical Equipment Testing:
 - a. Conduct Level 1 General Equipment Performance Test.
 - b. Conduct Level 1 Vibration Test.
 - c. Conduct Level 1 Noise Test.
 4. Furnish test reports and the Manufacturer's Certificate of Source Testing.

PART 3 EXECUTION

3.01 PREPARATION

- A. Anchoring and bracing to structures:
 - 1. Prepare equipment anchor setting template(s) and use to position anchors during construction of supporting structure(s).
 - 2. Install anchors of type and material indicated on approved anchoring designs.
 - 3. Install anchors with embedment indicated on approved anchoring designs.

3.02 INSTALLATION

- A. Install the equipment in accordance with the accepted installation instructions and anchorage details.
- B. Hydraulic equipment, including power units, piping, accumulators, and appurtenances shall be installed in accordance with requirements of ASME BPVC.
- C. Hydraulic tubing between the hydraulic power supply system and associated cylinders shall be provided by the Contractor.
 - 1. Materials:
 - a. Seamless annealed stainless steel tube:
 - 1) ASTM A269 Type 316 bright annealed to a No. 2BA finish and mechanically polished to a No. 4 finish. Manufactured by, one of the following or equal:
 - a) Tioga Pipe Supply Company, Philadelphia, Pennsylvania.
 - b) Outokumpu Piping Products, Wildwood, Florida.
 - c) Rath Gibson, Janesville, Wisconsin.
 - d) Swagelok, Solon, Ohio.
 - e) Plymouth Tube, Warrenville, Illinois.
 - f) Bristol Metals (Brismet), Bristol, Tennessee.
 - g) Alaskan Copper Works, Seattle, Washington.
 - h) McMaster-Carr Supply Company, Chicago, Illinois.
 - 2) Connections shall be made with compression fittings and adaptors manufactured by one of the following, or equal:
 - a) Tube fittings and adapters manufactured by Swagelok, Solon, Ohio.
 - b) Gyrolok fittings manufactured by Hoke, Spartanburg, South Carolina.
 - c) Tube fittings manufacture by the Tube Fittings Division, Parker Hannifin Corporation, Columbus, Ohio.
 - d) Tube fittings manufactured by Brennan Industries, Solon, Ohio.
 - b. Tubing and connections shall be rated for the maximum working pressure of the hydraulic power supply system.

- D. Provide bleed valves at non submerged high points in the lines and at hydraulic cylinders.
 - 1. Supply interconnecting wiring and tubing.
 - 2. Installed in accordance with ASME piping code.
 - 3. Fittings, oil passages, and cored or drilled holes shall be free of burrs and foreign matter that might cause damage to hydraulic components or contaminate the hydraulic fluid.
- E. Furnish Manufacturer's Certificate of Installation Verification.

3.03 FIELD QUALITY CONTROL

- A. Functional Testing:
 - 1. Test witnessing: Witnessed.
 - a. Coordinate installation, test, flush, and start-up of the hydraulic system components, and the hydraulically operated equipment.
 - 1) Hydraulic fluid shall be identical to that furnished with the power units.
 - 2) Hydraulic fluid shall be drained and purged from the system upon satisfactory completion of testing and flushing and replaced with new, unused fluid.
 - 3) Waste hydraulic fluid shall be disposed of in a legal manner.
 - b. Manufacturer's start-up personnel must be factory-trained, full-time employees of the hydraulic gate operator manufacturer having a minimum of 15 years of experience in municipal gates and hydraulic systems.
 - c. Supply the dry nitrogen needed for accumulator pre-charge.
 - d. Supply pumps and other equipment required for pressure testing and flushing the system.
 - e. Process test.
 - 2. Furnish test reports and the Manufacturer's Certificate of Functional Compliance.

3.04 OWNER TRAINING

- A. Perform Owner Training as specified in Section 01_75_17 - Commissioning.
 - 1. Number of sessions:
 - a. Operations: 2.
 - b. Maintenance: 2.

END OF SECTION

SECTION 40_05_57.65
HYDRAULIC CYLINDER ACTUATORS

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Hydraulic actuators, hydraulic control valves, and control stations.

1.02 REFERENCES

- A. American Water Works Association (AWWA):
 - 1. C520 - AWWA C520-14 Knife Gate Valves, Sizes 2 In. (50 mm) Through 96 In. (2,400 mm).
 - 2. C541 - Hydraulic and Pneumatic Cylinder and Vane-Type Actuators for Valves and Slide Gates.
- B. National Electrical Manufacturers Association (NEMA):
 - 1. 250 - Enclosures for Electrical Equipment (1,000 V Maximum).
- C. National Fire Protection Association (NFPA):
 - 1. 79 - Electrical Standard for Industrial Machinery.

1.03 DELEGATED DESIGN

- A. As specified in Section 01_35_73 - Delegated Design Procedures.
- B. Calculations.

1.04 SUBMITTALS

- A. Furnish Submittals as specified in Section 01_33_00 - Submittal Procedures and Section 01_60_01 - Product Requirements.
- B. Product data.
- C. Shop Drawings.
- D. Delegated Design Submittals:
 - 1. Calculations:
 - a. Cylinder and rod sizing based on force and torque requirements.
 - b. Rod bending and column load.
 - c. System pressure loss.
 - d. Anchor and anchor bolt sizing.

- E. Installation instructions:
 - 1. Detail the complete installation of the equipment, including rigging, moving, and setting into place.
 - 2. Provide manufacturer's installation instructions.
- F. Quality Control Submittals:
 - 1. Manufacturer's representative qualifications.
 - 2. Manufacturer's Certificate of Source Testing as specified in Section 01_75_17 - Commissioning.
 - 3. Manufacturer's Certificate of Installation Verification as specified in Section 01_75_17 - Commissioning.
 - 4. Manufacturer's Certificate of Functional Compliance as specified in Section 01_75_17 - Commissioning.

1.05 WARRANTY

- A. As specified in Section 01_78_36 - Warranties and Bonds.

1.06 MAINTENANCE

- A. Provide the following:
 - 1. One valve or valve assembly for each set of identical valves or valve assemblies furnished.
 - 2. One additional valve or valve assembly for each whole lot of 10 identical valves or valve assemblies furnished.
 - 3. One complete set of seals, gaskets, and expendable hardware required for installation of each spare valve or valve assembly.
 - 4. One repair kit, including seals, gaskets, and expendable hardware, for each size and type of hydraulic cylinder furnished.
 - 5. One additional repair kit, including seals, gaskets, and expendable hardware, for each whole lot of 6 hydraulic cylinders of each size and type.

PART 2 PRODUCTS

2.01 GENERAL

- A. Furnish hydraulic operators, control valves, and control stations as an integrated package designed by the manufacturer of the operated equipment.

2.02 MANUFACTURERS

- A. Hydraulic cylinder operators:
 - 1. One of the following or equal:
 - a. Atlas Cylinder Corp.
 - b. Parker Hannifin.
 - c. Rexroth Corp.
 - d. Sheffer.

- B. Hydraulic control valves:
 - 1. One of the following or equal:
 - a. Parker.
 - b. Vickers.

2.03 DESIGN AND PERFORMANCE CRITERIA

- A. Design criteria:
 - 1. Oil-hydraulic cylinder operators:
 - a. In accordance with AWWA C541.
 - b. In accordance with NFPA 79.
 - c. Maximum operating pressure: 2,500 pounds per square inch gauge.
 - d. Minimum bursting pressure: 10,000 pounds per square inch gauge.
 - e. Design system working pressure at the hydraulic power unit: As specified in Section 40_05_57.43 - Hydraulic Power Supply Systems.
 - f. Calculate the system working pressure at the hydraulic cylinder based on the submitted oil-hydraulic power system layout.
 - 1) Pressure losses from oil-hydraulic power unit to cylinder shall include:
 - a) Line losses.
 - b) Valve and fitting losses.
 - c) Filter losses.
 - d) Changes in volume/pressure of accumulators.
 - g. Size cylinders for 1.5 times the maximum operating force of the operated equipment.
 - 2. Provide internal stops as required to protect bearings and rod in cylinders with long actuation length.
- B. Performance criteria:
 - 1. Open or close gates at a rate of 30 inches per minute.
 - 2. Open or close valves in 15 seconds.
 - 3. Total unthrottled valve pressure loss for oil hydraulic valves in a circuit at maximum flow and minimum hydraulic fluid temperature shall not exceed 150 pounds per square inch, or the valve manufacturer's recommendations, whichever is lower.

2.04 MATERIALS

- A. Oil-hydraulic cylinders:
 - 1. Cylinder head, cap barrel, and tie rods: 316 stainless steel.
 - 2. Piston rod: Chrome plated stainless steel.
 - 3. Tail rods, where required: Chrome plates.
 - 4. Seals and O-rings: Non-metallic and made of a material that is compatible with the system hydraulic fluid.

2.05 EQUIPMENT

- A. Cylinder construction:
 - 1. Hydraulic cylinders: Heavy duty, double acting type with cushions at both ends.
 - 2. Hydraulic cylinder operators: Tie rod construction type with heavy-duty front flange mounting.
 - 3. Pistons: Equip with lip type seals.

4. Rod cartridge: Removable without the use of special tools.
 5. Support rods with bell crank, cross head, internal stops, or other device to give support to extended piston rods and to reduce the rod's effective unsupported length.
 6. Provide tail rods when specified or indicated on the Drawings.
- B. Mounting:
1. Mount cylinders to valves at the factory in accordance with the manufacturer's recommendations. Support cylinders at both ends.
 2. Mount gate cylinders in field on heavy flanged pipe pedestals or spacers to be mounted and anchored to floor slab above gates.
 3. Pedestals:
 - a. Approximately 12 inches high.
 - b. 4 cutouts to allow access to lower packing gland without requiring removal of cylinder.
 - c. Capable of preventing transfer of lateral strain to gate stem, stem guides, or operating cylinder.
 - d. Withstand maximum upthrust and downthrust of cylinder if gate does not move when operated.
 4. Anchor bolts:
 - a. Capable of withstanding maximum upthrust or downthrust if gate does not move when operated.
 - b. As specified in Section 05_05_24 - Mechanical Anchoring and Fastening to Concrete and Masonry.
- C. Equipment with open/close indication:
1. Provide limit switches to indicate open and close positions on cylinder-actuated equipment.
 2. Limit switch enclosures:
 - a. Where explosion-proof construction is indicated on the Drawings, provide NEMA Type 7 enclosures.
 - b. Other locations: Provide NEMA Type 4X enclosures.
 3. Limit switches for gates: End-of-travel proximity switches mounted in the head and cap of the cylinder.
 4. Mount limit switches for valves on the valve.
- D. Gates with continuous position indication:
1. Provided on gates as specified in the Gate Schedule in Section 40_05_59.33 - Cast-Iron Slide Gates and on a knife gate valve as specified in Section 40_05_65.01 - Gate Valves.
 2. Transmitter enclosures:
 - a. Where explosion-proof construction is indicated on the Drawings, provide NEMA Type 7 enclosures.
 - b. Other locations: Provide NEMA Type 4X enclosures.
 3. Continuous position indicators:
 - a. Magnetically coupled position transducer mounted on cylinder head.
 - b. Incorporate transmitter to convert position sensor output to a 4 to 20 mA signal.
 - c. Powered from a 2-wire signal transmitter circuit.

- E. Control valves:
1. Mounted local control valves for the cylinders mounted on aluminum mounting plates, post or wall-mounted as indicated on the Drawings. Install valves within a lockable enclosure.
 2. Control valve assemblies: Modular, stackable construction, rated, designed, and manufactured for the service intended.
 3. Use directional control valves to direct the flow of oil, water, or air to the operating cylinder.
 - a. Valve: 4-way, 3-position type, solenoid-actuated or manual, as indicated on the Drawings.
 - b. Solenoid-actuated valves: Suitable for 110 volts alternating current, 60 hertz power, spring-centered, and manually operable.
 - c. Solenoid valves in outdoor locations: NEMA Type 4X rated.
 - d. Solenoid valves in indoor locations: NEMA Type 12 rated, except where explosion-proof construction is indicated on the Drawings or required: NEMA Type 7 rated.
 - e. Manually operated valves: 3-position detented or spring-centered, as indicated on the Drawings.
 4. Provide pilot operated check valves to maintain intermediate positioning of the cylinder.
 5. Provide pressure regulating valves to permit adjustment of opening and closing thrust of the cylinder.
 6. Provide speed control valves with ball check bypass to regulate operating speed of the cylinder.
 7. Install isolation ball valves on the oil, water, and air supply and return sides of each control valve assembly, with a union-type or flanged connection between the isolation valve and the control valve assembly.
 8. Other valves and accessories: Provided as required to meet the necessary performance requirements.
- F. Cylinder connections: Flexible connection with isolation ball valve.
- G. Local control stations:
1. As specified in Section 40_67_01 - Control Systems: Panels, Enclosures, and Components, and as indicated on the Drawings.
 2. Non-modulating equipment: Provide:
 - a. "LOCAL-OFF-REMOTE" selector control, with dry contact for "Remote" selection indication.
 - b. "OPEN-STOP-CLOSE" or "RAISE-STOP-LOWER" local pushbutton controls as indicated on the Drawings.
 - c. "OPEN-CLOSE" or "RAISED-LOWERED" status lights as indicated on the Drawings.
 3. Modulating equipment: Provide:
 - a. Continuous position indicating gauge.
 4. Enclosures for outdoor locations: NEMA Type 4X stainless steel.
 5. Enclosures for indoor locations: NEMA Type 12, except that where explosion-proof construction is indicated on the Drawings or required, provide NEMA Type 7 enclosures.

- H. Fittings:
 - 1. Oil-hydraulic systems: Stainless steel.
 - 2. Do not connect galvanized pipe fittings to bronze or copper.
- I. Coatings:
 - 1. Prime coat for exposed metal surfaces, including operator, support and position indicating devices as specified in Section 09_96_01 - High-Performance Coatings.

2.06 SOURCE QUALITY CONTROL

- A. Source Testing (Factory Acceptance Tests):
 - 1. Not witnessed.
 - 2. As specified in Section 01_75_17 - Commissioning.
 - 3. Proof-of-design and performance test in accordance with AWWA C541.
 - 4. Furnish test reports and the Manufacturer's Certificate of Source Testing.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Install the equipment in accordance with the accepted installation instructions and anchorage details.
- B. Position visual indicators so that they are most easily visible.
- C. Mount and adjust cylinders on valves at the factory.

3.02 FIELD QUALITY CONTROL

- A. Functional Testing:
 - 1. Witnessed.
 - 2. Test as specified in Section 46_05_94 - Mechanical Equipment Testing:
 - a. Conduct Level 2 General Equipment Performance Test.
 - b. Conduct Level 2 Vibration Test.
 - c. Conduct Level 2 Noise Test.
 - 3. Furnish test reports and the Manufacturer's Certificate of Functional Compliance.

3.03 OWNER TRAINING

- A. Perform Owner Training as specified in Section 01_75_17 - Commissioning.
 - 1. Number of sessions:
 - a. Operations: 1.
 - b. Maintenance: 1.

3.04 CYLINDER OPERATOR SCHEDULE

A. Schedule:

Valve Tag	Valve or Gate Type ⁽¹⁾	Operator Function ⁽²⁾	Service Fluid (Air, Water, Oil)	Notes

Notes:

(1) Abbreviations relating to valve or gate type:

- a. BFV: Butterfly valve.
- b. BV: Ball valve.
- c. DV: Diaphragm valve.
- d. PV: Plug valve.
- e. RBFV: Rectangular butterfly valve.
- f. SG: Slide gate.
- g. SLG: Sluice gate.

(2) Abbreviations relating to operator function:

- a. MOD: Modulating service.
- b. O/C: Open and close service.

END OF SECTION

SECTION 40_05_59.33
CAST-IRON SLIDE GATES

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Cast-iron slide gates.
 - a. Gate Schedule is included in Attachment A - Gate Schedule.

1.02 REFERENCES

- A. American Water Works Association (AWWA):
 - 1. C560 - Standard for Cast-Iron Slide Gates.
- B. ASTM International (ASTM):
 - 1. A36 - Standard Specification for Carbon Structural Steel.
 - 2. A48 - Standard Specification for Gray Iron Castings.
 - 3. A123 - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
 - 4. A126 - Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings.
 - 5. A276 - Standard Specification for Stainless Steel Bars and Shapes.
 - 6. B139 - Standard Specification for Phosphor Bronze Rod, Bar and Shapes.
 - 7. B584 - Standard Specification for Copper Alloy Sand Castings for General Application.
 - 8. D2000 - Standard Classification System for Rubber Products in Automotive Applications.

1.03 TERMINOLOGY

- A. The words and terms listed below are not defined terms that require initial capital letters, but, when used in this Section, have the indicated meaning.
 - 1. Seating head: Pressure applied to gate slide from weight of water column above gate centerline that forces gate slide into seat.
 - 2. Slenderness ratio: The largest ratio obtained by dividing the unsupported length of the stem by the radius of gyration of the stem cross section.
 - 3. Unseating head: Pressure applied to gate slide from weight of water column above gate centerline that forces gate slide away from seat.

1.04 DELEGATED DESIGN

- A. As specified in Section 01_35_73 - Delegated Design Procedures.
- B. Anchoring and bracing.

1.05 SUBMITTALS

- A. Furnish Submittals as specified in Section 01_33_00 - Submittal Procedures and Section 01_60_01 - Product Requirements.
- B. Delegated Design Submittals:
 - 1. Anchoring and bracing: Provide project-specific calculations based on support conditions and requirements to resist loads specified in Section 01_81_50 - Design Criteria.
- C. Shop Drawings:
 - 1. Layout and installation drawings for each gate size and type.
 - 2. Complete bill of materials.
- D. Installation instructions:
 - 1. Detail the complete installation of the equipment, including rigging, moving, and setting into place.
 - 2. Provide manufacturer's installation instructions.
- E. Calculations:
 - 1. Calculations and design data substantiating conformance with the Drawings and Specifications.
 - 2. For coordination purposes, the gate manufacturer shall supply calculations verifying the suitability of the selected operator for the application.
 - a. For all gates:
 - 1) Maximum torque required for operation of the gate (including breakaway from seat) with a safety factor of 1.4.
 - 2) Indicate thrust value and stem factor.
 - b. For Hydraulically operated gates, coordinate with Section 40_05_57.43 - Hydraulic Power Supply Systems and Section 40_05_57.65 - Hydraulic Cylinder Actuators.
- F. Quality Control Submittals:
 - 1. Manufacturer's representative qualifications.
 - 2. Manufacturer's Certificate of Source Testing as specified in Section 01_75_17 - Commissioning.
 - 3. Manufacturer's Certificate of Installation Verification as specified in Section 01_75_17 - Commissioning.
 - 4. Manufacturer's Certificate of Functional Compliance as specified in Section 01_75_17 - Commissioning.
 - 5. Leakage test results.
- G. Operation and maintenance manuals:
 - 1. As specified in Section 01_78_24 - Operation and Maintenance Manuals.

1.06 QUALITY ASSURANCE

- A. Factory markings:
 - 1. Mark gates according to the scheduled equipment tag numbers when such numbers are used.
 - 2. Where thimbles, frames, and other components are not interchangeable, match mark components.
- B. Assembled gates: Shop inspected, adjusted, and tested before shipment.

1.07 WARRANTY

- A. As specified in Section 01_78_36 - Warranties and Bonds.

PART 2 PRODUCT

2.01 MANUFACTURERS

- A. One of the following or equal:
 - 1. Hydro Gate, by Mueller.
 - 2. Rodney Hunt Co.
 - 3. Waterman Industries, Inc.
- B. Operators and wall thimbles: Provided by the cast iron slide gate manufacturer.

2.02 DESIGN AND PERFORMANCE CRITERIA

- A. In accordance with AWWA C560, as complemented and specified in this Section.
- B. Design to meet seating and unseating pressures listed in the Gate Schedule.
- C. Gate components:
 - 1. Slide and guides: Design for minimum safety factor of 5 with regard to tensile, compressive, and shear strength.
 - 2. Lifts: Provide tandem lifts with interconnecting shaft on gates with an aspect ratio (width divided by height) equal to or exceeding 2.0.
 - 3. Stem: Select diameter, guide quantity, and guide spacing based on the following criteria:
 - a. Slenderness ratio (l/r): Not exceeding 200.
 - b. Maximum diameter: Provide stem guides at a spacing to maintain stem diameter of 2.5 inches or less.
 - c. Tensile strength: Suitable to withstand the force generated by the operator with the application of a 200-pound force applied to the crank or handwheel or a 250-foot-pound torque applied to the wrench nut.
 - d. Compressive strength:
 - 1) Suitable to withstand buckling due to the force generated by the operator with the application of an 80-pound force applied to the crank or handwheel or a 100-foot-pound torque applied to the wrench nut.
 - 2) Determine buckling load using Euler Column formula defined in AWWA C560.

- e. Design force for power actuators:
 - 1) Hydraulic cylinder operators: 1.25 times the output thrust at maximum hydraulic fluid operating pressure.
 - 2) Electric motor operators: 1.25 times the output thrust in the stalled-motor condition.
- 4. Thrust nut:
 - a. Suitable to withstand thrust developed by operator with the application of a 40-pound force on the crank or handwheel with safety factor of 5.
 - b. Base design on ultimate strength of material used.
- 5. Yokes for self-contained gates:
 - a. Design yoke using design loading criteria for stem.
 - b. Maximum deflection at design load: Not to exceed 1/360 of the span.

2.03 MATERIALS

- A. Cast iron:
 - 1. ASTM A126, Class B.
 - 2. ASTM A48, Class 30.
- B. Bronze:
 - 1. Subject to submersion or splash: Not more than 6 percent zinc and no aluminum.
 - 2. Manganese bronze: ASTM B584, UNS C86500.
 - 3. Phosphor bronze: ASTM B139, UNS C51000.
 - 4. Silicon bronze: ASTM B584, UNS C87300.
- C. Galvanized structural steel: ASTM A36, galvanized in accordance with ASTM A123.
- D. Stainless steel: ASTM A276, Type 316.
- E. Neoprene: ASTM D2000, BC 615 to 625.

2.04 COMPONENTS

- A. Slide:
 - 1. Cast iron.
 - 2. Rectangular or square.
 - 3. One piece with integrally cast vertical and horizontal ribs.
 - 4. Machined dovetail grooves on the seat surfaces into which is forced a phosphor bronze or silicon bronze seat facing, machine finished in accordance with AWWA C560, after installation in the slide.
 - 5. Machine tongues on vertical sides with maximum 1/16-inch clearance between tongue and guide groove.
 - 6. Integrally cast wedge pads machined to receive wedges.
 - 7. Reinforced thrust nut pocket cast integrally on front face above horizontal center, shape as required to receive thrust nut, and with provisions for drainage of pocket.

- B. Frame:
1. Cast iron, 1-piece.
 2. Flanged back section with rectangular, square, or round opening as indicated on the Drawings.
 3. Machined dovetail grooves on the front face into which is forced a phosphor bronze or silicon bronze seat facing, machined in accordance with AWWA C560, after installation in the frame.
 4. Machine surfaces which contact slide and wall thimble.
- C. Guides:
1. Cast iron, 1-piece.
 2. Attachment to frame:
 - a. Gates smaller than 54 inches: Cast integrally with frame.
 - b. Gates 54 inches and larger: Bolt to frame with studs and nuts and pinned to prevent lateral movement.
 3. Length: Sufficient to retain at least half the height of the slide in the full open position.
 4. Grooves for tongues on slide:
 - a. Full length of guide.
 - b. Machined on all contact surfaces.
 - c. Maximum 1/16-inch clearance between tongue and groove wall.
- D. Wedges and wedge seats:
1. Sufficient quantity to result in full contact between the slide and frame when slide is in the closed position and subjected to design pressure specified in the gate schedules.
 2. Locations:
 - a. Both vertical sides.
 - b. Top and bottom: When gates 24 inches or more in width are subject to unseating head conditions.
 3. Wedges:
 - a. Adjustable to allow alignment with seat.
 - b. Silicon bronze with machined mating and contact surfaces.
 - c. Type 316 stainless steel hold down bolt.
 - d. Stainless steel adjustment bolt and lock nut that allows proper field adjustment and permanently maintains position of wedge after final adjustment.
 - e. Side wedges: Keyed and bolted to machined pads on slide.
 - f. Top and bottom wedges: Hook shaped and bolted to machine pads on slide.
 4. Wedge seats:
 - a. Side wedges:
 - 1) Gates smaller than 54 inches: Keyed and bolted to machined pad on guide.
 - 2) Gates 54 inches and larger:
 - a) Integrally cast with guide and machined to match wedge face.
 - b) Provide support ribs on guide at each seat location to resist wedging forces.
 - b. Top and bottom wedges:
 - 1) Keyed to prevent movement under force.

- 2) Attach to frame with 2 Type 316 stainless steel bolts.
- 3) Machined contact surfaces.

E. Stem:

1. Type 316 stainless steel.
2. Machine cut or rolled full depth ACME threads.
3. Stem couplings:
 - a. Silicon bronze or Type 316 stainless steel.
 - b. Threaded and keyed to stem or threaded and bolted to stem.
4. Stem guides:
 - a. Cast iron.
 - b. Split collar.
 - c. Adjustable in 2 directions.
 - d. Silicon bronze bushings.
5. Provide manganese bronze stop collar on stem above actuator.
6. Connect stem to slide with thrust nut and nut pocket.

F. Thrust nut:

1. Silicon bronze.
2. Construct thrust nut and slide to prevent turning of thrust nut in the thrust nut pocket.
3. Rising-stem gates: Thread and key, or thread and pin thrust nut to stem.
4. Nonrising-stem gates: Thread thrust nut to stem without keys or pins, so that nut and slide can move up and down the stem as the stem turns.

G. Gate operators: As specified in Section 40_05_57.65 - Hydraulic and Pneumatic Cylinder Actuators.

1. Provide cranks and gears necessary to bring operator to height specified, or typical operator height of 3 feet-6 inches if not otherwise shown.

H. Coordination with hydraulic cylinder actuator supplier:

1. Gate manufacturer's responsibility shall be to appropriate size for the actuator for each gate based on:
 - a. Design seating and unseating head.
 - b. Recommended open/close speed.
 - c. Torque safety factor of 1.4, minimum, applied to the maximum torque requirement, including breakaway from seat.
2. Gate supplier shall machine the stem nuts, provide proper mounting adaptation, and adaptation hardware to ensure adequate interface between the hydraulic cylinder actuator and the slide gates.

I. Bolts, nuts, and fittings: Type 316 stainless steel.

2.05 SELF-CONTAINED SLIDE GATES

A. Conform to requirements for cast-iron slide gates and the following additional provisions:

1. Extend guides and frame so that bottom of yoke is at least 12 inches above top of slide at full open position.
2. Machine pads at top of guide for mounting yoke.
3. Machine pads on bottom of yoke where faces contact pads on guides.

4. Machine top of yoke where operating mechanism is mounted.
5. Yoke: Cast iron or galvanized structural steel.
6. Bolt yoke to guide with stainless steel bolts.
7. Unless otherwise indicated on the Drawings, position handwheel or geared operator 36 inches (nominal) above walking surface.

2.06 FINISHES

- A. Coat slide gates in the factory, prior to testing.
- B. Operators, stands, and other accessory equipment: Surface preparation, factory prime, field prime, and finish coats as specified in Section 09_96_01 - High-Performance Coatings.

2.07 SOURCE QUALITY CONTROL

- A. Source Testing (Factory Acceptance Tests):
 1. As specified in Section 01_75_17 - Commissioning.
 2. Not witnessed.
 3. Furnish test reports and the Manufacturer's Certificate of Source Testing.

PART 3 EXECUTION

3.01 PREPARATION

- A. Anchoring and bracing to structures:
 1. Prepare equipment anchor setting template(s) and use to position anchors during construction of supporting structure(s).
 2. Install anchors of type and material indicated on approved anchoring designs.
- B. Install anchors with embedment indicated on approved anchoring designs.

3.02 INSTALLATION

- A. Install the equipment in accordance with the accepted installation instructions and anchorage details.
- B. Mount thimbles and gates plumb in both vertical planes and level in horizontal plane.
- C. Coat seating surfaces between frame and wall thimble with a waterproof plastic compound prior to tightening of frame studs.
- D. Adjust wedges or other parts of the gate to the point where it will not be possible to insert a 0.004-inch feeler gauge between the gate slide and the gate frame at any point.
 1. Securely lock wedges into position after adjustment.
- E. Adjust limit switches in electric and hydraulic operators in accordance with the manufacturer's instructions.
- F. Furnish Manufacturer's Certificate of Installation Verification.

3.03 FIELD QUALITY CONTROL

- A. Functional Testing:
 - 1. Test witnessing: Witnessed.
 - 2. Exercise each gate from the closed position to fully open position and back to the closed position at least twice and verify gate is properly seated.
 - 3. Leakage tests:
 - a. Conduct in accordance with AWWA C560.
 - b. Comply with allowable leakage limits in accordance with AWWA C560.
 - 4. Furnish test reports and the Manufacturer's Certificate of Functional Compliance.

3.04 GATE SCHEDULE

- A. As specified in Attachment A - Gate Schedule. Gate Schedule is not a take-off list.
 - 1. Provide gates specified and as indicated on the Drawings.

END OF SECTION

ATTACHMENT A - GATE SCHEDULE

GATE SCHEDULE

Equipment Tag No.	Opening Size	Opening Shape	Seating Head	Unseating Head	Wall Thimble	Type of Closure	Operator Mounting	Operator Type	Service	Stem Type	Notes
GAT 340 (Upper Intake Structure)	54-inch x 54-inch	Square	19 feet	19 feet	None (Direct Wall Mount)	Standard	Self-Contained w/ Pedestal Mount	Hydraulic Cylinder	Open/Close	Non-Rising Stem	
GAT 341 (Lower Intake Structure)	54-inch x 54-inch	Square	30.4 feet	30.4 feet	None (Direct Wall Mount)	Standard	Self-Contained w/ Pedestal Mount	Hydraulic Cylinder	Open/Close	Non-Rising Stem	

SECTION 40_05_62

PLUG VALVES

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Eccentric plug valves.

1.02 REFERENCES

- A. American Water Works Association (AWWA):
 - 1. C517 - Resilient-Seated Cast Iron Eccentric Plug Valves.
 - 2. C606 - Grooved and Shouldered Joints.
- B. ASTM International (ASTM):
 - 1. A536 - Standard Specification for Ductile Iron Castings.

1.03 SUBMITTALS

- A. Submit as specified in Section 01_33_00 - Submittal Procedures and Section 40_05_51.01 - Common Work Results for Valves.
- B. Product data: As specified in Section 01_60_01 - Product Requirements.
- C. Shop Drawings: Installation arrangement of major component assemblies.
- D. Calculations.
- E. Vendor operation and maintenance manual as specified in Section 01_78_24 - Operation and Maintenance Data.
- F. Commissioning Submittals:
 - 1. Provide Manufacturer's Certificate of Source Testing as specified in Section 01_75_17 - Commissioning:
 - a. Interior coating.
 - 2. Provide Manufacturer's Certificate of Installation and Functionality Compliance as specified in Section 01_75_17 - Commissioning.

1.04 WARRANTY

- A. Provide warranty as specified in Section 01_78_36 - Warranties and Bonds.

PART 2 PRODUCTS

2.01 GENERAL

- A. As specified in Section 01_60_01 - Product Requirements and Section 40_05_51.01 - Common Work Results for Valves.

2.02 CYLINDRICAL ECCENTRIC PLUG VALVES (PV00)

- A. Manufacturers: One of the following or equal:
 - 1. Clow Valve.
 - 2. DeZurik, PEC.
- B. Design:
 - 1. Type: Non-lubricated eccentric type, in accordance with AWWA C517.
 - 2. Plug face: Resilient material that operates satisfactorily at a temperature of 180 degrees Fahrenheit continuous and 215 degrees Fahrenheit intermittent, except for valves in compressed air or digester gas service.
 - a. Valves in compressed air service: Resilient material suitable for continuous duty at 250 degrees Fahrenheit.
 - b. Valves in digester gas service: Resilient material suitable for petroleum or digester gas at continuous duty at 180 degrees Fahrenheit.
 - 3. Compression washer: Provide flat compression washer made of Teflon™, or of a material having equal physical characteristics on valve stem between plug and bonnet.
 - 4. Stem seals: Provide stem seals serviceable without unbolting the valve bonnet assembly.
 - 5. Grit excluders: Provide PTFE grit excluders at upper plug journals to prevent entry of foreign solids in bearing area.
 - 6. Clearly mark valves to indicate their open and closed positions.
 - 7. Provide valves with ends as required by piping details indicated on the Drawings.
- C. Materials:
 - 1. Body and plug: ASTM A536, Grade 65-45-12, ductile iron, with plug face of EPDM material suitable for the intended service as specified under the "Design" article above.
 - 2. Body seats in valves 3-inch size and larger: Provide with overlay of not less than 90-percent nickel and minimum thickness of 1/8 inch on surfaces contacting the plug face.
 - 3. Stem bearing and bottom bearing: Type 316 stainless steel.
 - 4. Internal parts, except the body and plug: Type 316 stainless steel.
 - 5. Exposed nuts, bolts, and washers: Zinc plated. Exception: Exposed nuts, bolts, and washers for buried service: Stainless steel.

2.03 VALVE OPERATORS

- A. Furnish valves with an operating wrench or worm gear operator:
 - 1. Equip valves 4-inch nominal size and smaller with a lever operator.
 - 2. Equip valves 6-inch nominal size and larger with a worm gear operator.

2.04 COATING

- A. Coat and test interior metal surfaces as specified in Section 40_05_51.01 - Common Work Results for Valves.
- B. Field applied coating of valve exterior:
 - 1. Match color and be compatible with the manufacturer's coating system and as specified in Section 09_96_01 - High-Performance Coatings.
 - a. When shop applied finish coating matches field applied coating on adjacent piping, touch up shop coating in damaged areas in accordance with instructions recommended by the paint manufacturer.
 - b. When shop applied coating does not match field coating on adjacent piping, or when damage has occurred to the shop applied coating that requires more than touchup, blast clean valve surfaces or utilize other surface preparation recommended by the manufacturer of the coating material and apply the coating system used for coating adjacent piping.

2.05 SHIPMENT, SPARE PARTS, MAINTENANCE PRODUCTS, AND SPECIAL TOOLS

- A. As specified in Section 01_60_01 - Product Requirements.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Install valves as specified in Section 40_05_51.01 - Common Work Results for Valves and the manufacturer's instructions.
 - 1. Unless otherwise indicated on the Drawings, install valves so that in the closed position the pressure in the pipeline applies a seating head on the valves.
 - 2. Install valves so that in the open position, the plug is located in the top half of the valve body.
 - 3. Furnish Manufacturer's Certificate of Installation Verification.
- B. Valves requiring lubrication: Lubricate and fill extended lubricant pipes with lubricant suitable for service intended.

3.02 COMMISSIONING

- A. As specified in Section 01_75_17 - Commissioning and this Section.
- B. Functional Testing:
 - 1. Tests: NA.
 - 2. Conduct pressure and leak test as specified in Section 40_05_51.01 - Common Work Results for Valves.
 - 3. Furnish Manufacturer's Certificate of Functional Compliance.

END OF SECTION

SECTION 40_05_63

BALL VALVES

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Ball valves.

1.02 REFERENCES

- A. American Petroleum Institute (API):
 - 1. 6D - Specification for Pipeline Valves (Steel Gate, Plug, Ball, and Check Valves) - Gate Valves; Plug Valves; Ball Valves; Check Valves.
- B. American Society of Mechanical Engineers (ASME):
 - 1. B1.20.1 - Pipe Threads, General Purpose, Inch.
 - 2. B16.10 - Face-to-Face and End-to-End Dimensions of Valves.
 - 3. B16.34 - Valves--Flanged, Threaded, and Welding End.
 - 4. B16.5 - Pipe Flanges and Flanged Fittings: NPS 1/2 through 24.
- C. American Water Works Association (AWWA):
 - 1. C507 - Standard for Ball Valves 6 Inch Through 48 Inch.
 - 2. C800 - Standard for Underground Service Line Valves and Fittings.
- D. ASTM International (ASTM):
 - 1. A276 - Standard Specification for Stainless Steel Bars and Shapes.
 - 2. A351 - Standard Specification for Castings, Austenitic, for Pressure-Containing Parts.
 - 3. B283 - Standard Specification for Copper and Copper-Alloy Die Forgings (Hot-Pressed).
 - 4. B584 - Standard Specification for Copper Alloy Sand Castings for General Applications.
 - 5. D1784 - Standard Classification System and Basis for Specification for Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds.
- E. Manufacturers Standardization Society of the Valve and Fittings Industry (MSS):
 - 1. SP-110 - Ball Valves Threaded, Socket-Welding, Solder Joint, Grooved and Flared Ends.
- F. NSF International (NSF):
 - 1. 61 - Drinking Water System Components - Health Effects.

1.03 SUBMITTALS

- A. Furnish Submittals as specified in Section 01_33_00 - Submittal Procedures.
- B. Product data:
 - 1. Valves:
 - a. Manufacturer.
 - b. Model number.
 - c. Type.
 - d. Size.
 - e. Materials.
 - f. Pressure rating.
 - g. Cv factor.
 - h. Finishes.
 - 2. Manual actuators:
 - a. Manufacturer.
 - b. Size.
 - c. Material.
 - d. Model number.
 - 3. Valve tags and engraving schedule.
- C. Shop Drawings:
 - 1. Description of component parts, dimensions, weights, and materials.
- D. Installation instructions:
 - 1. Detail the complete installation of the equipment, including rigging, moving, and setting into place.
 - 2. Provide manufacturer's installation instructions.
- E. Quality Control Submittals:
 - 1. Manufacturer's representative qualifications.
 - 2. Manufacturer's Certificate of Installation Verification as specified in Section 01_75_17 - Commissioning.
 - 3. Manufacturer's Certificate of Functional Compliance as specified in Section 01_75_17 - Commissioning.
 - 4. Certifications that valves and coatings for drinking water applications are in accordance with NSF 61.
 - 5. Metal body ball valves 6 inches and larger:
 - a. Affidavit of compliance in accordance with AWWA C507.
- F. Operation and maintenance manuals:
 - 1. As specified in Section 01_78_24 - Operation and Maintenance Manuals.
 - 2. Installation, operation, and maintenance instructions for each type of manual valve 4 inches in nominal size and larger, and all non-manual valves.
 - 3. Include information on valve operators.

1.04 DELIVERY, STORAGE, AND HANDLING

- A. As specified in Section 01_60_01 - Product Requirements, Section 40_05_51.01 - Common Work Results for Valves, and the manufacturer's instructions.

1.05 WARRANTY

- A. As specified in Section 01_78_36 - Warranties and Bonds.

PART 2 PRODUCTS

2.01 GENERAL

- A. Valves in contact with drinking water:
 - 1. As specified in Section 01_41_00 - Regulatory Requirements.

2.02 DESIGN AND PERFORMANCE CRITERIA

- A. As specified in Section 40_05_51.01 - Common Work Results for Valves.
- B. Valves shall be the same size as the adjoining pipe unless otherwise indicated on the Drawings.
- C. Ball valves shall open left (counterclockwise) unless otherwise specified. Each valve shall have the word OPEN readily visible on valve body indicating the open direction of the operator.
- D. Valve supplier shall be responsible for determining the size of operators, handwheels, chainwheels, and electric actuators.
- E. All parts to be replaced during regular maintenance shall be accessible with minimal dismantling of the equipment and appurtenances.
 - 1. Valve assembly shall be designed to prevent vibration and physical distortion detrimental to valve operation under all specified conditions.
 - 2. Valve mechanisms shall be designed to operate smoothly and efficiently under all specified conditions.

2.03 THERMOPLASTIC TRUE-UNION BALLS VALVES

- A. General:
 - 1. 2-way and 3-way corrosion resistant thermoplastic true-union ball valves, 0.5 to 4 inches in diameter.
 - 2. Valves shall have a minimum cold working pressure of 150 psi.
 - 3. Inlet and outlet connections shall be furnished with true-union connections allowing removal of valve body with requiring removal of valve connection to piping.
 - 4. Valves shall have an integral plate for lock-out/tag-out.
 - 5. Manufactured to allow attachment of electric actuators in accordance with ISO 5211.
- B. Inlet and outlet connections:
 - 1. Female socket ends for solvent cement bonding.
 - 2. Female NPT threaded-ends in accordance with ASME B1.20.1.

C. Materials:

1. Valve body, ball, and stem components materials shall be coordinated with adjoining piping:
 - a. PVC piping systems: ASTM D1784, Type 1, Cell Classification 12454 poly vinyl chloride (PVC).
 - b. CPVC Piping Systems: ASTM D1784, Type 4, Cell Classification 23447 chlorinated poly vinyl chloride (CPVC).
 - c. HDPE piping systems: PVC piping system material.
2. Hand operator: Manufactured from the same material as the body, ball and stem components.
3. Seats, stems and end connectors: As specified in the following table for the chemical service:

Chemical	Material
Chlorine solution	FKM (Viton™)
Ferric chloride	FKM (Viton™) or EPDM
Ferrous chloride	FKM (Viton™) or EPDM
Sodium hydroxide	EPDM
Sodium hypochlorite	FKM (Viton™)
Aluminum sulfate	FKM (Viton™) or EPDM
Aqua ammonia	EPDM
Water	FKM (Viton™) or EPDM

4. Seats: FKM.
5. Stem O-rings: FKM.
6. End connector O-rings: FKM.

D. Manufacturers: One of the following or equal:

1. Asahi-America, Type 21.
2. Hayward Flow Control, Series TB.
3. Spears Manufacturing, Series 2000.

2.04 RESILIENT-SEATED FORGED BRASS 2-PIECE BALL VALVES

A. General:

1. Valves 0.25 to 2 inches in diameter shall have a minimum cold working pressure of 600 psi.
2. Valves shall be in accordance with MSS SP-110.

B. Inlet and outlet connections:

1. Female NPT threaded-ends in accordance with ASME B1.20.1.

C. Materials:

1. Body, ball, and stem: ASTM B283, Alloy C37700.
2. Seat and packing: PTFE.
3. Handle: Type 304 or Type 316 stainless steel.

D. Manufacturers: One of the following or equal:

1. Aalberts Integrated Piping Systems, 77F-100 Series, Apollo Valves.

2. Crane Valve, 9201 Series.
3. NIBCO, Inc., Model T-FP-600N.

2.05 RESILIENT-SEATED CAST BRONZE 3-PIECE BALL VALVES

- A. General:
 1. Valves 0.25 to 4 inches in diameter shall have a minimum cold working pressure of 600 psi.
 2. Valves shall be in accordance with MSS SP-110.
- B. Inlet and outlet connections:
 1. Female NPT threaded ends in accordance with ASME B1.20.1.
- C. Materials:
 1. Body: ASTM B584, Alloy C84400.
 2. Ball and stem: ASTM A276, Type 316 stainless steel.
 3. Seat and packing: PTFE.
 4. Handle: Type 304 or Type 316 stainless steel.
- D. Manufacturers: One of the following or equal:
 1. Aalberts Integrated Piping Systems, 82-100 Series, Apollo Valves.
 2. NIBCO, Inc., Model T-590-Y-66.

2.06 RESILIENT-SEATED STAINLESS STEEL 2-PIECE BALL VALVES

- A. General:
 1. Valves 0.25 to 2 inches in diameter shall have a minimum cold working pressure of 2,000 psi.
 2. Valves shall be in accordance with MSS SP-110.
- B. Inlet and outlet connections:
 1. Female NPT threaded ends in accordance with ASME B1.20.1.
- C. Materials:
 1. Body and ball: ASTM A351, Grade CF8M stainless steel.
 2. Stem: ASTM A276, Type 316 stainless steel.
 3. Seat and packing: PTFE.
 4. Handle: Type 304 or Type 316 stainless steel.
- D. Manufacturers: One of the following or equal:
 1. Aalberts Integrated Piping Systems, 76-100 Series, Apollo Valves.
 2. Crane Valve, 9431-LL Series.
 3. NIBCO, Inc., Model T580-S6-66-LL.

2.07 RESILIENT-SEATED STAINLESS STEEL 3-PIECE BALL VALVES

- A. General:
 1. Valves 0.25 to 2 inches in diameter shall have a minimum cold working pressure of 800 psi.
 2. Valves shall be in accordance with MSS SP-110.

- B. Inlet and outlet connections:
 - 1. Female NPT threaded-ends in accordance with ASME B1.20.1.
- C. Materials:
 - 1. Body, end caps, and ball: ASTM A351, Grade CF8M stainless steel.
 - 2. Stem: ASTM A276, Type 316 stainless steel.
 - 3. Seat, packing, and joint gaskets: PTFE or graphite.
 - 4. Handle: Type 304 or Type 316 stainless steel.
 - 5. Bolts: Type 304 or Type 316 stainless steel.
- D. Manufacturers: One of the following or equal:
 - 1. Aalberts Integrated Piping Systems, 86R-100 Series, Apollo Valves.
 - 2. Crane Valve, 9500 Series.
 - 3. NIBCO, Inc., Model TM-590-S6-R-66-FS-LL.

2.08 RESILIENT-SEATED STAINLESS STEEL SPLIT BODY FULL PORT BALL VALVES

- A. General:
 - 1. Valves 4 to 12 inches in diameter shall have a minimum cold working pressure of 275 psi.
 - 2. Valves shall be in accordance with ASME B16.34.
 - 3. Face-to-face dimensions in accordance with ASME B16.10.
- B. Inlet and outlet connections:
 - 1. Flanged ends in accordance with ASME B16.5, Class 150.
- C. Materials:
 - 1. Body, end caps, and ball: ASTM A351, Grade CF8M stainless steel.
 - 2. Stem: ASTM A276, Type 316 stainless steel.
 - 3. Seat, packing, and joint gaskets: PTFE, RTFE, or graphite.
 - 4. Handle: Type 304 or Type 316 stainless steel.
 - 5. Bolts: Type 304 or Type 316 stainless steel.
- D. Manufacturers: One of the following or equal:
 - 1. Aalberts Integrated Piping Systems, 87A-100 Series, Apollo Valves.
 - 2. ASC Engineered Solutions, Sharpe Series 50.
 - 3. NIBCO, Inc., Model F-515-S6-F-66-FS.

2.09 RESILIENT-SEATED STAINLESS STEEL INSTRUMENTATION BALL VALVES

- A. General:
 - 1. Valves 0.25 to 0.75 inches in diameter shall have a minimum working pressure of 3,000 psi.
- B. Inlet and outlet connections:
 - 1. Female NPT threaded ends in accordance with ASME B1.20.1.
 - 2. Tube compression fittings.
- C. Materials:
 - 1. Body, ball, end caps, and stem: ASTM A351, Grade CF8M stainless steel.

2. Seat and packing: PTFE or PKA.
 3. Handle: Type 304 or Type 316 stainless steel.
- D. Manufacturers: One of the following or equal:
1. Hoke, Flowmite 71 Series.
 2. Parker Hannifin, Series MB.
 3. Swagelok, Series 40.

2.10 METAL SEATED STAINLESS STEEL V-PORT BALL VALVES

- A. General:
1. Valves 1 to 20 inches in diameter shall have a minimum cold working pressure of 285 psi.
 2. Manufactured to allow attachment of electric actuators in accordance with ISO 5211.
- B. Inlet and outlet connections:
1. Flanged ends in accordance with ASME B16.5, Class 150.
- C. Materials:
1. Body, v-port ball, end cap (retainer): ASTM A351, Grade CF8M stainless steel.
 2. Seat: ASTM A351, Grade CG8M, Type 317 stainless steel or solid Stellite®, Type 316 stainless steel.
 3. Stem bearings and packing: RPTFE.
 4. Handle: Type 304 or Type 316 stainless steel.
- D. Manufacturers: One of the following or equal:
1. DeZURIK, Model VPB.
 2. Emerson, KTM V-Port Control Ball Valve.

2.11 BALL CORPORATION STOPS

- A. General:
1. Ball corporation stops 0.25 to 2 inches in diameter shall have a minimum working pressure of 300 psi.
- B. Inlet and outlet connections:
1. Taper threads in accordance with AWWA C800 at direct tap to piping.
 2. Female NPT threaded ends in accordance with ASME B1.20.1.
- C. Materials:
1. Body, ball, and stem: ASTM B584, Alloy C89833 bronze. Ball shall be coated in PTFE.
 2. Seats: PTFE.
- D. Manufacturers: One of the following or equal:
1. Ford Meter Box, Model FB-1600-4-NL.
 2. Mueller, Model B-20045N.

- E. Venting requirements:
 - 1. Metal ball valves for hydrogen peroxide service:
 - a. Provide valve with a factory drilled 0.125-inch hole in the upstream side of the ball.
 - b. Provide an engraved Type 316 stainless steel tag permanently attached to the valve stem stating, "One side of ball drilled for hydrogen peroxide service."

2.12 ACCESSORIES

- A. Electric actuators as specified in Section 40_05_57.24 - Electric Actuators.
- B. Limit switches, when indicated on the Drawings:
 - 1. Mechanical cam type with watertight enclosure and suited for remote indication of valve open-close status.
 - 2. Mount on valve actuator.
 - 3. Contacts: 120 VAC, 20 A at 75 to 100 percent power factor and 24 VDC, 5 A minimum.
- C. Valve identification:
 - 1. As specified in Section 40_05_51.01 - Common Work Results for Valves.

2.13 FINISHES

- A. As specified in Section 40_05_51.01 - Common Work Results for Valves.

PART 3 EXECUTION

3.01 EXAMINATION

- A. As specified in Section 40_05_51.01 - Common Work Results for Valves.

3.02 INSTALLATION

- A. As specified in Section 40_05_51.01 - Common Work Results for Valves.
- B. Furnish Manufacturer's Certificate of Installation Verification.

3.03 FIELD QUALITY CONTROL

- A. Functional Testing:
 - 1. Witnessed.
 - 2. Conduct pressure and leak test as specified in Section 40_05_00.09 - Piping Systems Testing.
 - 3. Furnish test reports and the Manufacturer's Certificate of Functional Compliance.

END OF SECTION

SECTION 40_05_64

BUTTERFLY VALVES

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Butterfly valves.

1.02 REFERENCES

- A. American Society of Mechanical Engineers (ASME):
 - 1. B16.1 - Cast Iron Pipe Flanges and Flanged Fittings, Classes 25, 125, and 250.
 - 2. B16.5 - Pipe Flanges and Flanged Fittings, NPS 1/2 through NPS 24.
- B. American Water Works Association (AWWA):
 - 1. C110 - Standard for Ductile-Iron and Gray-Iron Fittings.
 - 2. C504 - Rubber-Seated Butterfly Valves.
 - 3. C540 - Standard for Power-Actuating Devices for Valves and Sluice Gates.
 - 4. C550 - Protective Interior Coatings for Valves & Hydrants.
 - 5. C606 - Standard for Grooved and Shouldered Joints.
- C. ASTM International (ASTM):
 - 1. A126 - Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings.
 - 2. A216 - Standard Specification for Steel Castings, Carbon, Suitable for Fusion Welding, for Higher-Temperature Service.
 - 3. A276 - Standard Specification for Stainless Steel Bars and Shapes.
 - 4. A351 - Standard Specification for Castings, Austenitic, for Pressure-Containing Parts.
 - 5. A395 - Standard Specification for Ferritic Ductile Iron Pressure-Retaining Castings for Use at Elevated Temperatures.
 - 6. A479 - Standard Specification for Stainless Steel Bars and Shapes for Use in Boilers and Other Pressure Vessels.
 - 7. A515 - Standard Specification for Pressure Vessel Plates, Carbon Steel, for Intermediate - and Higher-Temperature Service.
 - 8. A516 - Standard Specification for Pressure Vessel Plates, Carbon Steel, for Moderate - and Lower-Temperature Service.
 - 9. A536 - Standard Specification for Ductile Iron Castings.
 - 10. A564 - Standard Specification for Hot-Rolled and Cold-Finished Age-Hardening Stainless Steel Bars and Shapes.
 - 11. A582 - Standard Specification for Free-Machining Stainless Steel Bars.
 - 12. A743 - Standard Specification for Castings, Iron-Chromium, Iron-Chromium-Nickel, Corrosion Resistant, for General Application.
 - 13. A890 - Standard Specification for Castings, Iron-Chromium-Nickel-Molybdenum Corrosion-Resistant, Duplex (Austenitic/Ferritic) for General Application.

14. B462 - Standard Specification for Forged or Rolled UNS N06030, UNS N06022, UNS N06035, UNS N06200, UNS N06059, UNS N10362, UNS N06686, UNS N08020, UNS N08024, UNS N08026, UNS N08367, UNS N10276, UNS N10665, UNS N10675, UNS N10629, UNS N08031, UNS N06045, UNS N06025, UNS R20033 Alloy Pipe Flanges, Forged Fittings, and Valves and Parts for Corrosive High-Temperature Service.
 15. B584 - Standard Specification for Copper Alloy Sand Castings for General Applications.
 16. B691 - Standard Specification for Iron-Nickel-Chromium-Molybdenum Alloys (UNS N08366 and UNS N08367) Rod, Bar, and Wire.
 17. D429 - Standard Test Methods for Rubber Property-Adhesion to Rigid Substrate.
- D. Compressed Gas Association (CGA):
1. G-4.1 - Cleaning Equipment for Oxygen Service.
- E. NSF International (NSF):
1. 61 - Drinking Water System Components - Health Effects.
- F. United States Code of Federal Regulations (CFR):
1. 21 - Food and Drugs.

1.03 SUBMITTALS

- A. Furnish Submittals as specified in Section 01_33_00 - Submittal Procedures.
- B. Product data:
1. For general purpose AWWA butterfly valves, include description of the method of attachment of the disc edge to the valve disc.
 2. Interior epoxy coatings: Affidavit of compliance attesting that epoxy coatings applied to interior surfaces of butterfly valves comply with all provisions in accordance with AWWA C550.
 3. Certification, for valves and coatings in contact with potable water, that the products used are suitable for contact with drinking water in accordance with NSF 61.
- C. Installation instructions:
1. Detail the complete installation of the equipment, including rigging, moving, and setting into place.
 2. Provide manufacturer's installation instructions.
- D. Quality Control Submittals:
1. Manufacturer's representative qualifications.
 2. Manufacturer's Certificate of Installation Verification as specified in Section 01_75_17 - Commissioning.
 3. Manufacturer's Certificate of Functional Compliance as specified in Section 01_75_17 - Commissioning.
- E. Operation and maintenance manuals:
1. As specified in Section 01_78_24 - Operation and Maintenance Manuals.

1.04 WARRANTY

- A. As specified in Section 01_78_36 - Warranties and Bonds.

PART 2 PRODUCTS

2.01 DESIGN AND PERFORMANCE CRITERIA

- A. Design requirements:
- B. Design requirements for butterfly valves with power actuating devices:
 - 1. Design valves and actuators for maximum operating torque, in accordance with and using safety factors required in AWWA C540, using the following values:
 - a. Maximum water velocity: 16 feet per second with valve fully open.
 - b. Maximum pressure differential across the closed valve equal to the pressure class designation.
 - c. Coefficient for seating and unseating torque, dynamic torque, and bearing friction in accordance with the valve manufacturer's published recommendations.
 - 2. Valve disc: Seat in an angular position of 90 degrees to the pipe axis and rotate an angle of 90 degrees between fully open and fully closed positions:
 - a. Do not supply valves with stops or lugs cast with or mechanically secured to the body of the valve for limiting the disc travel.
 - 3. Unacceptable thrust bearings: Do not provide valves with thrust bearings exposed to the fluid in the line and consisting of a metal bearing surface in rubbing contact with an opposing metal bearing surface.
- C. Performance requirements:
 - 1. Tight shutoff at the pressure rating of the valve with pressure applied in either direction.
 - 2. Suitable for the following service conditions:
 - a. Throttling.
 - b. Frequent operation.
 - c. Operation after long periods of inactivity.
 - d. Installation in any position and flow in either direction.

2.02 GENERAL PURPOSE AWWA BUTTERFLY VALVES (BFV00)

- A. Manufacturers: One of the following or equal:
 - 1. DeZURIK/Sartell Model BAW.
 - 2. Mueller/Pratt Co.
- B. Valve body:
 - 1. Material: Ductile iron, ASTM A536, Grade 65-45-12.
 - 2. Body design:
 - a. Body: Class 250B.
 - b. Flanges: ASME B16.1, Class 250.

- C. Disc:
 - 1. Material: Ductile iron with Type 316 stainless steel edge that matches seat in valve body.
 - 2. Secure valve disc to shaft by means of smooth-sided, taper or dowel pins, Type 316 stainless steel, or Monel.
 - 3. Extend pins through shaft and mechanically secure in place.
- D. Shaft and bearings:
 - 1. Shaft design:
 - a. Valves greater than 20-inch size: 2-piece, stub shaft design.
 - 2. Shaft seal: Vee type, chevron design.
 - 3. Type 17-4 pH stainless steel, ASTM A564.
 - 4. Shaft bearings: Self-lubricating sleeve type:
 - a. Teflon™ with stainless steel or fiberglass backing.
- E. Seats:
 - 1. Materials:
 - a. Other applications: EPDM.
 - 2. Retain seats mechanically or by adhesive:
 - a. Mechanical retainage: Retain seat by a clamping ring with segmented clamping ring locks with adjusting locking screws.
 - 1) Clamping ring, ring locks, and adjusting locking screws: Type 316 stainless steel.
 - 2) Provide means to prevent ring locks and screws used to retain seats from loosening due to vibration or cavitation.
 - b. Adhesive retainage: Inset the seat within a groove in the valve body and retain in place with epoxy injected behind the seat so that the seat expands into the body.
 - c. Do not provide valves with seats retained by snap rings or spring-loaded retainer rings.
 - 3. Resilient seat: Withstand 75 pounds per inch pull when tested in accordance with ASTM D429, Method B.
- F. Valve packing:
 - 1. Self-adjusting V-type packing or chevron-type packing. NBR or EPDM to match seat material.

2.03 COATING REQUIREMENTS FOR METAL VALVES

- A. Shop coat interior and exterior metal surfaces of valves, except as follows:
 - 1. Interior machined surfaces.
 - 2. Surfaces of gaskets and elastomeric seats and stem seals.
 - 3. Bearing surfaces.
 - 4. Stainless steel surfaces and components.
- B. Coating material for components in contact with potable water applications:
 - 1. Formulate interior coating material from materials in accordance with CFR 21, AWWA C550, and NSF 61.
 - 2. Submit affidavit of compliance attesting that epoxy coatings applied to interior surfaces of butterfly valves in accordance with CFR 21, AWWA C550, and NSF 61.

- C. Interior surfaces:
 - 1. Interior surfaces, except for valves used in low-pressure air service: High solids epoxy as specified in Section 09_96_01 - High-Performance Coatings, Attachment A - Coating Schedule.
 - 2. Interior surfaces of valves used in low-pressure air service: High temperature coating for range of 150 to 350 degrees Fahrenheit as specified in Section 09_96_01 - High-Performance Coatings, Attachment A - Coating Schedule.
- D. Exterior surfaces:
 - 1. Exterior surfaces of valves, actuators, and accessories coating as specified in Section 09_96_01 - High-Performance Coatings, Attachment A - Coating Schedule for the following conditions:
 - a. Exposed valves: High solids epoxy.
 - 2. Polished and machined surfaces: Apply rust-preventive compound:
 - a. Manufacturers: One of the following or equal:
 - 1) Houghton, Rust Veto 344.
 - 2) Rust-Oleum, R-9.
- E. Field applied coatings of valve exterior:
 - 1. Match color and be compatible with manufacturer's coating system and as specified in Section 09_96_01 - High-Performance Coatings.
 - a. When shop applied finish coating matches field applied coating on adjacent piping, touch up shop coating in damaged areas in accordance with instructions recommended by the paint manufacturer.
 - b. When shop applied coating does not match field coating on adjacent piping, or when damage has occurred to the shop applied coating that requires more than touchup, blast clean valve surfaces or utilize other surface preparation recommended by the manufacturer of the coating material and apply the coating system used for coating adjacent piping.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Install valves with valve shafts horizontal, unless a vertical shaft is required to suit a particular installation, and unless a vertical shaft is indicated on the Drawings.
- B. Install pipe spools or valve spacers in locations where butterfly valve disc travel may be impaired by adjacent pipe lining, pipe fittings, valves, or other equipment.
- C. Furnish Manufacturer's Certificate of Installation Verification.

3.02 FIELD QUALITY CONTROL

- A. Functional Testing:
 - 1. Test witnessing: NA.
 - 2. Conduct pressure and leak test, as specified in Section 40_05_51.01 - Common Work Results for Valves.
 - 3. Furnish test reports and the Manufacturer's Certificate of Functional Compliance.

END OF SECTION

SECTION 40_05_65.01

GATE VALVES

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes: Knife Gate Valves.
- B. As specified in Section 40_05_51.01 - Common Work Results for Valves.

1.02 REFERENCES

- A. American Society of Mechanical Engineers (ASME):
 - 1. B16.47 - Large Diameter Steel Flanges: NPS 26 through NPS 60-inch Standard.
- B. American Water Works Association (AWWA):
- C. ASTM International (ASTM):
 - 1. ASTM A193 – Standard Specification for Alloy-Steel and Stainless Steel Bolting for High Temperature or High Pressure Service and Other Special Purpose Applications.
 - 2. ASTM A240 - Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications.
 - 3. ASTM A351 - Standard Specification for Castings, Austenitic, for Pressure-Containing Parts.
 - 4. ASTM A582 - Standard Specification for Free-Machining Stainless Steel Bars.

1.03 SUBMITTALS

- A. Submit as specified in Section 01_33_00 - Submittals.
- B. Product data: As specified in Section 40_05_51.01 - Common Work Results for Valves.
- C. Operations and maintenance data as specified in 01_78_24 - Operation and Maintenance Manuals.
 - 1. Include number of turns required to open/close valve.
- D. Commissioning submittals: For valves larger than 16 inches:
 - 1. Provide Manufacturer's Certificate of Installation and Functionality Compliance as specified in Section 01_75_17 - Commissioning.

1.04 WARRANTY

- A. Provide warranty as specified in Section 01_78_36 - Warranties and Bonds.

PART 2 PRODUCTS

2.01 KNIFE GATE VALVES

- 1. Manufacturers: One of the following:
 - a. Hilton, H200B.
 - b. Pratt.
- 2. Design:
 - a. Size and configuration: Indicated on the Drawings.
 - b. Body pressure rating shall be 50 psig.
 - c. Full round port, raised face design, resilient seated.
 - d. Full flanged design drilled and tapped to Flange drilling per ASME B16.47 Class 150.
 - e. Rounded gate with beveled edge, finish-ground to 32 RMS, maximum, on both sides.
 - f. Materials:
 - 1) Body: ASTM A351 CF8M stainless Steel.
 - 2) Valve gate: ASTM A240 316L stainless steel.
 - 3) Resilient seats and seals shall be of Aflas material.
 - 4) The valve drive stem: ASTM A582 416 stainless steel.
 - 5) Yoke sleeve: Acid resisting bronze or nickel aluminum bronze.
 - 6) Yoke Bearings and stem drive nut shall be of 45,000 psi bronze.
 - 7) All mechanical fasteners on valve body shall be ASTM A193/4 CF8M Class 1.
- 3. Operation:
 - a. Valves shall be rising stem design. Valves to be hydraulically actuated.

Testing: Valve body shall be tested at 1.5 times the rated pressure and the valve gate at 1.1 times the rated pressure while in the fully shut position with zero cc/min leakage permitted past the seat or to valve exterior.

PART 3 EXECUTION

3.01 INSTALLATION

- 1. Knife gate valves shall be flange mounted with base support.

3.02 COMMISSIONING

- A. As specified in Section 01_75_17 - Commissioning and this Section.
- B. Manufacturer services: For valves larger than 16 inches.
 - 1. Provide certificates:
 - a. Manufacturer's Certificate of Installation and Functionality Compliance.

- C. Functional testing:
 - 1. Valves:
 - a. Test witnessing: Nonwitnessed.
 - b. Conduct pressure and leak test as specified in Section 40_05_51.01 - Common Work Results for Valves.

END OF SECTION

SECTION 40_05_65.24

CHECK VALVES

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Tilting (slanting) disc check valves.
 - 2. Ball check valves:
 - a. Metal body ball check valves.
 - b. Plastic ball check valves.

1.02 REFERENCES

- A. American Society of Mechanical Engineers (ASME):
 - 1. B16.1 - Gray Iron Pipe Flanges and Flanged Fittings: Classes 25, 125, and 250.
- B. American Water Works Association (AWWA):
 - 1. C508 - Standard for Swing-Check Valves for Waterworks Service 2 Inch Through 24 Inch NPS.
- C. ASTM International (ASTM):
 - 1. A126 - Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings.
 - 2. A213 - Standard Specification for Seamless Ferritic and Austenitic Alloy-Steel Boiler, Superheater, and Heat-Exchanger Tubes.
 - 3. A276 - Standard Specification for Stainless Steel Bars and Shapes.
 - 4. A313 - Standard Specification for Stainless Steel Spring Wire.
 - 5. A536 - Standard Specification for Ductile Iron Castings.
 - 6. A582 - Standard Specification for Free-Machining Stainless Steel Bars.
 - 7. A743 - Standard Specification for Castings, Iron-Chromium, Iron-Chromium-Nickel, Corrosion Resistant, for General Application.
 - 8. B16 - Standard Specification for Free-Cutting Brass Rod, Bar and Shapes for Use in Screw Machines.
 - 9. B61 - Standard Specification for Steam or Valve Bronze Casting.
 - 10. B62 - Standard Specification for Composition Bronze or Ounce Metal Castings.
 - 11. B584 - Standard Specification for Copper Alloy Sand Castings for General Applications.
- D. National Electrical Manufacturers Association (NEMA):
 - 1. 250 - Enclosure Types.
- E. NSF International (NSF):
 - 1. 61 - Drinking Water Components - Health Effects.
 - 2. 372 - Drinking Water System Components - Lead Content.
- F. Underwriters Laboratories, Inc. (UL).

1.03 SUBMITTALS

- A. Furnish Submittals as specified in Section 01_33_00 - Submittal Procedures.
- B. Product data:
 - 1. As specified in Section 01_60_01 - Product Requirements.
- C. Quality Control Submittals
 - 1. Provide Manufacturer's Certificate of Installation Verification as specified in Section 01_75_17 - Commissioning.

1.04 WARRANTY

- A. As specified in Section 01_78_36 - Warranties and Bonds.

PART 2 PRODUCTS

2.01 GENERAL

- A. As specified in Section 01_60_01 - Product Requirements and Section 40_05_51.01 - Common Work Results for Valves.
- B. Provide check valves as specified in the Valve Schedule and suitable for service:
 - 1. In either horizontal or vertical position.
 - 2. For working pressures up to 150 pounds per square inch.
- C. Check valve materials as follows unless otherwise specified.
 - 1. Cast iron in accordance with ASTM A126, Grade B.
 - 2. Ductile iron in accordance with ASTM A536, Grade 65-45-12.
 - 3. Type 303 stainless steel in accordance with ASTM A582 (UNS S30300).
 - 4. Type 316 stainless steel in accordance with ASTM A313.
- D. Flanges: Drilled in accordance with ASME B16.1 Class 125/150, unless otherwise specified or indicated on the Drawings.

2.02 TILTING (SLANTING) DISC CHECK VALVES (CKV05)

- A. Manufacturers: One of the following or equal:
 - 1. APCO, Series 800-T.
 - 2. Crispin, Series TD.
 - 3. Val-Matic, Series 9800-T.
- B. Design: 2-piece construction, bolted at the center, with disc at an angle of 55 angular degrees:
 - 1. Minimum cross-sectional area throughout valve body: Equal to cross-sectional area of the pipe connected to the valve.
 - 2. Control disc closing with top-mounted, oil-filled, cushion chamber.
 - 3. Fit cylinder with a flow control valve.
 - 4. Ends: Flanged, ASME B16.1.

- C. Materials:
1. Body and disc: Cast iron, ASTM A126, Class B.
 2. Seat ring and disc ring: Bronze, ASTM B584, Alloy C 92200, Alloy C 83600, Alloy C 94700, or Alloy C 93700.
 3. Pivot pins: Stainless steel, ASTM A582.
 4. Bushings: Stainless steel.
 5. Oil reservoirs: Stainless steel.

Valve Size (inch)	8	10	12	14	16	18	20	24	30	36
Shaft Size (inch)	1.75	2.125	2.5	3 10	3.5	3.75	4	3	3.75	4

2.03 PLASTIC BALL CHECK VALVES (CKV65)

- A. Manufacturers: One of the following or equal:
1. Georg Fischer Piping Systems.
 2. Hayward Flow Control.
 3. Nibco, Chemtrol Series.
 4. Plast-O-Matic.
- B. Design:
1. Ball type design.
 2. Materials: As specified in the Valve Schedule.
 3. Inlet pressure rating:
 - a. PVC, CPVC, or PVDF: 150 pounds per square inch at 77 degrees Fahrenheit.
 - b. PP: 100 pounds per square inch at 77 degrees Fahrenheit.

2.04 INTERIOR PROTECTIVE LININGS

- A. As shown in the valve schedules and as specified in Section 40_05_51.01 - Common Work Results for Valves.

PART 3 EXECUTION

3.01 FIELD QUALITY CONTROL

- A. Manufacturer services:
1. Provide the Manufacturer's Certificate of Installation Verification.
- B. Functional Testing:
1. Test witnessing: NA.
 2. Conduct pressure and leak test, as specified in Section 40_05_00.09 - Piping Systems Testing.

END OF SECTION

SECTION 40_05_67.37

PRESSURE CONTROL VALVES

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes: Pressure reducing and pressure relief valves for water, air, sludge and chemical service.
- B. As specified in Section 40_05_51.01 - Common Work Results for Valves.

1.02 REFERENCES

- A. American Society of Mechanical Engineers (ASME):
 - 1. B16.42 - Ductile Iron Pipe Flanges and Flanged Fittings: Classes 150 and 300.
- B. ASTM International (ASTM):
 - 1. A536 - Standard Specification for Ductile Iron Castings.
- C. Underwriters Laboratories, Inc. (UL).

1.03 SUBMITTALS

- A. Submit as specified in Section 01_33_00 - Submittal Procedures.
- B. Product data: As specified in Section 40_05_51.01 - Common Work Results for Valves.
- C. Commissioning submittals:
 - 1. Provide Manufacturer's Certificate of Installation and Functionality Compliance as specified in Section 01_75_17 - Commissioning.

1.04 WARRANTY

- A. Provide warranty as specified in Section 01_78_36 - Warranties and Bonds.

PART 2 PRODUCTS

2.01 METAL BODY PRESSURE REDUCING VALVES - WATER SERVICE (PRV00)

- A. Metallic pressure reducing valves for water service, 2 1/2 inches and smaller:
 - 1. Manufacturers: One of the following or equal:
 - a. Watts, Series LF223.
 - b. Zurn Wilkins, 500 Series.
 - 2. Direct operated, single seat type pressure reducing valve.
 - 3. Downstream pressure adjustment range: 30 to 300 pounds per square inch gauge (psig).

4. Materials:
 - a. Body and spring cover: Bronze or brass alloy meeting the zinc and aluminum requirements of Section 40_05_51.01 - Common Work Results for Valves.
 - b. Valve seat: Type 316 stainless steel.
 - c. Diaphragm: Reinforced Buna Nitrile.
 - d. Disk: EPDM.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Install as specified in Section 40_05_51.01 - Common Work Results for Valves.

3.02 COMMISSIONING

- A. As specified in Section 01_75_17 - Commissioning and this Section.
- B. Manufacturer services:
 1. Provide certificates:
 - a. Manufacturer's Certificate of Installation and Functionality Compliance.
- C. Functional testing:
 1. Valves:
 - a. Test witnessing: NA.
 - b. Conduct pressure and leak test as specified in Section 40_05_51.01 - Common Work Results for Valves.

END OF SECTION

SECTION 40_05_67.40
AIR AND VACUUM RELIEF VALVES

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Air release valves, air and vacuum valves, and air vents.
- B. As specified in Section 40_05_51.01 - Common Work Results for Valves.

1.02 REFERENCES

- A. American Society of Mechanical Engineers (ASME):
 - 1. B16.1 - Gray Iron Pipe Flanges and Flanged Fittings: Classes 25, 125, and 250.
 - 2. B16.5 - Pipe Flanges and Flanged Fittings: NPS 1/2 through NPS 24, Metric/Inch Standard.
- B. American Water Works Association (AWWA).
- C. ASTM International (ASTM):
 - 1. A126 - Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings.
 - 2. A240 - Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications.
 - 3. A270 - Standard Specification for Seamless and Welded Austenitic Stainless Steel Sanitary Tubing.
 - 4. B584 - Standard Specification for Copper Alloy Sand Castings for General Applications.

1.03 SUBMITTALS

- A. Submit as specified in Section 01_33_00 - Submittal Procedures.
- B. Product data: As specified in Section 40_05_51.01 - Common Work Results for Valves.
- C. Commissioning Submittals:
 - 1. Provide Manufacturer's Certificate of Installation and Functionality Compliance as specified in Section 01_75_17 - Commissioning.

1.04 WARRANTY

- A. Provide warranty as specified in Section 01_78_36 - Warranties and Bond.

PART 2 PRODUCTS

2.01 METAL BODY AIR RELEASE VALVES - WATER SERVICE (ARV00)

- A. Manufacturers: One of the following or equal:
 - 1. Multiplex Manufacturing Co., Crispin PL Series.
 - 2. Valve and Primer Corp., DeZURIK/APCO Series 200.
- B. Design:
 - 1. Pressure rating: 150 pounds per square inch gauge unless differently indicated on the Drawings.
 - 2. Provide low pressure seat when the operating pressure is below 10 psi.
 - 3. Inlet: Screwed, 2-inch.
 - 4. Orifice size: 1/4-inch diameter.
- C. Materials:
 - 1. Valve body: Cast iron.
 - 2. Float and internal trim: Type 316 stainless steel.
 - 3. Seat or valve plunger: Buna-N.

2.02 PLASTIC BODY AIR RELEASE VALVES - CHEMICAL OR WATER SERVICE (ARV40)

- A. Manufacturers: The following or equal:
 - 1. Plast-O-Matic, ARV.
- B. Materials:
 - 1. Body:
 - a. PVC piping systems: PVC.
 - b. CPVC piping system: CPVC.
 - 2. Elastomers: Match the gasket material specified in the Piping Schedule.
 - 3. Minimum pressure rating at 75 degrees Fahrenheit: 150 pounds per square inch gauge.
 - 4. Connection: 1/4-inch NPT minimum.

2.03 METAL BODY AIR AND VACUUM VALVES - WATER SERVICE (AVV00)

- A. Manufacturers: One of the following or equal:
 - 1. Multiplex Manufacturing Co., Crispin A Series.
 - 2. Valve and Primer Corp., DeZURIK/APCO Series 140.
- B. Design:
 - 1. Minimum performance requirements:
 - a. Air in-flow through valve: Not less than 40 standard cubic feet per minute.
 - b. Air exhaust through valve: Not less than 40 standard cubic feet per minute.
 - 2. Pressure rating: Up to 125 pounds per square inch gauge unless differently indicated on the Drawings.
 - 3. Inlet: Threaded.
- C. Materials:
 - 1. Body: Cast iron.
 - 2. Float: Type 316 stainless steel.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Install as specified in Section 40_05_51.01 - Common Work Results for Valves and the manufacturer's instructions.
- B. Install air release valves and air and vacuum valves with suitable discharge lines to nearest drainage system.

3.02 COMMISSIONING

- A. As specified in Section 01_75_17 - Commissioning and this Section.
- B. Manufacturer services:
 - 1. Provide certificates:
 - a. Manufacturer's Certificate of Installation and Functionality Compliance.
- C. Functional Testing:
 - 1. Valves:
 - a. Test witnessing: NA.
 - b. Conduct pressure and leak test as specified in Section 40_05_51.01 - Common Work Results for Valves.

END OF SECTION

SECTION 40_61_00

COMMON WORK RESULTS FOR PROCESS CONTROL AND INSTRUMENTATION SYSTEMS

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Process control and instrumentation systems requirements for common components including installation, including, but not limited to, the following:
 - a. Hardware.
 - b. Software.
 - c. Vendor Programming
 - d. Testing.
 - e. Commissioning.
 - 2. Loop drawings:
 - a. Provide complete loop drawings for all systems, including packaged equipment furnished as part of a vendor furnished package, and pre-purchased equipment.
 - b. The form, minimum level of detail, and format for the loop drawings must match that of the sample loop drawings included in the Contract Documents.
 - c. Owner and Engineer are not responsible for providing detailed loop diagrams for Contractor-furnished equipment.
 - 3. Requirements of the Instrumentation and Control Specifications apply to all Instrumentation and Control Work specified in Technical Sections, including packaged mechanical systems, local control panels (LCPs), vendor control panels (VCPs), etc.
- B. Contract Drawings:
 - 1. Schematic diagrams:
 - a. Use schematic diagrams in conjunction with the descriptive operating sequence in the Technical Sections to furnish a coordinated and fully functional control system.
 - b. Schematic diagrams show control function only.
 - 1) Incorporate other necessary functions for proper operation and protection of the system.
 - c. Controls are indicated on the Drawings as de-energized.
 - d. Add relays, where required, to provide necessary contacts for the control system or where needed to function as interposing relays for control voltage coordination, equipment coordination, or control system voltage drop considerations.
 - e. Mount devices shown on motor controller schematic diagrams in the controller compartment enclosure, unless otherwise noted or indicated on the Drawings.

- C. System description:
1. The new system shall control the Source Water Station pumps, testing and associated station equipment.
 - a. Hardware shall be included for both newly planned and future components.
 - b. Power Supply and conditioning equipment shall be sized for new and future equipment and instrumentation.
 - c. This system will use the Modicon 580 PLC family hardware.

1.02 REFERENCES

- A. Abbreviations:
1. ACB: Automatic current balance.
 2. ATS: Automatic transfer switch.
 3. CCS: The PCS central computer system (CCS) consisting of computers and software. The personal computer-based hardware and software system that includes the operator interface, data storage, data retrieval, archiving, alarming, historian, reports, trending, and other higher level control system software and functions.
 4. DPDT: Double-pole, double-throw.
 5. ECP: Electronic circuit protector.
 6. ES: Ethernet switch.
 7. FAT: Factory acceptance test, also known as Source Test.
 8. HART: Highway addressable remote transducer.
 9. HMI: Human machine interface is a software application that presents information to an operator or user about the state of a process, and to accept and implement the operators control instructions. Typically, information is displayed in a graphical format.
 10. HOA: Hand-Off-Auto control function that is totally PLC based. In the Hand mode, equipment is started or stopped, valves are opened or closed through operator direction under the control of the PLC software. In the Auto mode, equipment is started or stopped, and valves are opened or closed through a control algorithm within the PLC software. In the Off mode, the equipment is prohibited from responding from the PLC control.
 11. I/O: Input/output.
 12. ICSC: Instrumentation and control system contractor: Subcontractor who specializes in the design, construction, fabrication, software development, installation, testing, and commissioning of industrial instrumentation and control systems.
 13. IJB: Instrument junction boxes: A panel designed with cord sets to easily remove, replace, or relocate instrument signals.
 14. IP: Internet protocol or ingress protection.
 15. LAN: Local area network: A control or communications network that is limited to the physical boundaries of the facility.
 16. LCP: Local control panel: Operator interface panel that may contain an HMI, pilot type control devices, operator interface devices, control relays, etc. and does not contain a PLC or RIO.
 17. LOI: Local Operator Interface is an operator interface device consisting of an alphanumeric or graphic display with operator input functionality. The LOI is typically a flat panel type of display mounted on the front of an enclosure with either a touch screen or tactile button interface.

18. LOR: Local-Off-Remote control function. In the Remote mode, equipment is started or stopped, and valves are opened or closed through the PLC based upon the selection of the LOR. In the Local mode, equipment is started or stopped, valves are opened or closed based upon hardwired control circuits completely independent of the PLC with minimum interlocks and permissive conditions. In the Off mode, the equipment is prohibited from responding to any control commands.
19. NP: Network panel. An enclosure that contains network equipment.
20. P&ID: Process and instrumentation diagram.
21. PC: Personal computer.
22. PCIS: Process control and instrumentation system: Includes the entire instrumentation system, the entire control system, and all of the Work specified in the Instrumentation and Control Specifications and depicted on the Instrumentation Drawings. This includes all the PCS and instruments and networking components as well as the various servers, workstations, thin clients, etc.
23. PCM: Process control module: An enclosure containing any of the following devices: PLC, RTU, or RIO.
24. PCS: Process control system: A general name for the computerized system that gathers and processes data from equipment and sensors and applies operational controls to the process equipment. It includes the PLCs and/or RIOs, LOIs, HMIs, both LCPs, VCPs, and all data management systems accessible to staff.
25. PLC: Programmable logic controller.
26. PS: Power supply.
27. RIO: Remote I/O device for the PLC consisting of remote I/O racks or remote I/O blocks.
28. RTU: Remote telemetry unit: A controller typically consisting of a PLC and a means for remote communications. The remote communications devices typically are radios, modems, etc.
29. SCADA: Supervisory control and data acquisition system: A general name for the computerized system that gathers and processes data from sensors and equipment located outside of the facility, such as wells, lift stations, metering stations, etc.
30. SELV: Safety extra-low voltage.
31. SFP: Small form-factor pluggable.
32. SPDT: Single-pole, double-throw.
33. SPST: Single-pole, single-throw.
34. UPS: Uninterruptible power supply.
35. VCP: Vendor control panel: Control panels that are furnished with particular equipment by a vendor other than the ICSC. These panels may contain PLCs, RIO, LOI, HMI, etc.
36. WAN: Wide area network: A control or communications network that extends beyond the physical boundaries of the facility.

B. Standards:

1. American Petroleum Institute (API):
 - a. RP 550 - Manual on Installation of Refinery Instruments and Control Systems; Part II-Process Stream Analyzers; Section 5-Oxygen Analyzers.
 - b. RP 551 - Process Measurement Instrumentation.

2. International Organization for Standardization (ISO):
 - a. 9001 - Quality Management Systems - Requirements.
3. International Society of Automation (ISA):
 - a. 5.1 - Instrumentation Symbols and Identification.
 - b. 5.4 - Instrument Loop Diagrams.
 - c. 20 - Instrument Forms Plus Pro-Combo-Enterprise Version (Microsoft SQL Server Express Database Software based).
4. National Electrical Manufacturers Association (NEMA):
 - a. 250 - Enclosures for Electrical Equipment (1,000 V Maximum).
5. National Fire Protection Association (NFPA):
 - a. 70 - National Electrical Code (NEC).
6. National Institute of Standards and Technology (NIST).
7. Underwriters Laboratories, Inc. (UL):
 - a. 508 - Standard of Safety for Industrial Control Equipment.
 - b. 508A - Standard of Safety for Industrial Control Panels.

1.03 TERMINOLOGY

- A. The words and terms listed below are not defined terms that require initial capital letters, but, when used in this Section, have the indicated meaning.
1. 2-wire transmitter (loop powered): A transmitter that derives its operating power supply from the signal transmission circuit and requires no separate power supply connections. As used in this Section, 2-wire transmitter refers to a transmitter that provides a signal such as 4 to 20 mA 24 VDC regulation of a signal in a series circuit with an external 24 VDC driving potential:
 - a. Fieldbus communications signal or both.
 2. 4-wire transmitter: A transmitter that utilizes a power loop separate from the signal loop. With the power loop isolated from the signal loop, the source of instrument power can be 24 VAC/VDC or 120/240 VAC. The transmitter provides a 4 to 20 mA 24 VDC signal.
 3. Control circuit: Any circuit operating at 120 volts alternating current (VAC) or direct current (VDC) or less, whose principal purpose is the conveyance of information (including performing logic) and not the conveyance of energy for the operation of an electrically powered device.
 4. Digital bus: A communication network, such as PROFIBUS, Foundation Fieldbus, or DeviceNet, allowing instruments and devices to transmit data, control functions, and diagnostic information.
 5. Instrument: A measurement device that includes a sensor for taking the measurement and one or both of the following:
 - a. A local display.
 - b. A device for communicating the measurement to a remote location such as a PLC or DCS.
 6. Modifications: Changing, extending, interfacing to, removing, or altering an existing circuit.
 7. Panel: An instrument support system that may be a flat surface, a partial enclosure, or a complete enclosure for instruments and other devices used in process control systems.
 8. Power circuit: Any circuit operating at 90 volts (AC or DC) or more, whose principal purpose is the conveyance of energy for the operation of an electrically powered device.

9. Powered transmitters: A transmitter that requires a separate power source (120 VAC, 240 VAC, etc.) in order for the transmitter to develop its signal. As used in this Section, the produced signal may be a 4 to 20 mA 24 VDC signal, a digital bus communications signal, or both.
10. Programmer: Responsible for PLC programming and SCADA/HMI software configuration.
11. RS-485: Also known as TIA-485 or EIA-485. Is a standard defining the electrical characteristics of drivers and receivers for use in serial communications system. Electrical signaling is balanced, and multipoint systems are supported, can be used with data rates up to 10 Mbit/s or at lower speeds distances up to 1,200 meters (4,000 feet).
12. Signal circuit: Any circuit operating at less than 50 VAC or VDC, which conveys analog information or digital communications information.

1.04 DELEGATED DESIGN

- A. Requirements for Delegated Design are specified in the Technical Sections.

1.05 SUBMITTALS

- A. General:
 1. Adhere to the wiring numbering scheme as specified in Section 26_05_53 - Identification for Electrical Systems throughout the Project:
 - a. Uniquely number each wire.
 - b. Wire numbers must appear on equipment drawings.
 2. Some items of Work are represented schematically and are designated for the most part by numbers, as derived from criteria in ISA-5.1:
 - a. Employ the nomenclature and numbers specified in this Section and indicated on the Drawings exclusively throughout Shop Drawings, datasheets, and similar Submittals.
 - b. Replace any other symbols, designations, and nomenclature unique to a manufacturer's, Supplier's, or Subcontractor's standard methods with those specified in this Section and indicated on the Drawings.
- B. Specific Submittal requirements:
 1. Control panel drawings:
 - a. General requirements:
 - 1) Submit panel, enclosure, console, furniture, and cabinet layout drawings for items provided.
 - 2) Use equipment and instrument tags as depicted on the P&IDs for all Submittals.
 - 3) Nameplates and wire labeling:
 - a) Nameplate legend, including text, letter size, materials, and colors.
 - b) As specified in Section 26_05_53 - Identification for Electrical Systems or as indicated on the Drawings.
 - 4) Structural requirements:
 - a) Anchoring method and leveling criteria, including manufacturer's recommendations for the Project Site seismic criteria.
 - b) Weight.

- 5) Clearly show modifications to existing circuits:
 - a) Show existing unmodified wiring to clearly depict the functionality and electrical characteristics of the complete modified circuits.
- b. Required for materials and equipment listed in this and other Technical Sections.
- c. Front, side, rear, internal, external elevations, and top and bottom views, showing all dimensions and all to scale.
 - 1) Locations of conduit entrances and access plates.
 - 2) Component layout and identification.
 - 3) Complete and detailed bills of materials:
 - a) Including quantity, description, manufacturer, and part number for each assembly or component for each control panel.
 - b) Include all items within an enclosure.
 - 4) Requirements for physical separation between control system components and 120 VAC, 480 VAC, and medium-voltage power cables.
 - 5) Complete grounding requirements for each system component, including any requirements for PLCs, process LANs, and control system equipment.
 - 6) PLC rack and card layout:
 - a) Provide a count of current I/O allocation.
 - b) Future I/O allocation.
 - c) Quantity of spares provided.
 - 7) NEMA rating.
 - 8) Material and finish.
2. Schematics and wiring diagrams:
 - a. General requirements:
 - 1) Submit panel wiring diagrams for every panel that contains wiring.
 - 2) Use equipment and instrument tags as depicted on the P&IDs for all Submittals.
 - 3) Nameplates and wire labeling:
 - a) As specified in Section 26_05_53 - Identification for Electrical Systems or as indicated on the Drawings.
 - 4) Clearly show modifications to existing circuits:
 - a) Show existing unmodified wiring to clearly depict the functionality and electrical characteristics of the complete modified circuits.
 - b. Include the following information:
 - 1) Name of panel.
 - 2) Wiring sizes and types.
 - 3) Terminal strip numbers.
 - 4) Terminal identification for device and field connections.
 - 5) Wire tags and labels.
 - 6) Functional name and manufacturer's designation for items to which wiring are connected.
 - 7) Set points for relays and control or alarm contact settings.
 - c. Incorporate equipment manufacturer's Shop Drawing information into the schematic diagrams in order to document the entire control system.

3. Loop drawings:
 - a. Submit loop drawings after an accepted Commissioning Test Reports Submittal as specified in Section 40_80_01 - Commissioning for Instrumentation and Controls.
 - 1) Engineer recommends submitting a sample/template loop drawing for review prior to this Submittal.
 - b. General requirements:
 - 1) Submit loop drawings for every analog, discrete, fieldbus signal, vendor-supplied equipment packages, and control panels.
 - a) Includes monitoring, alarming, interlocks, and control devices.
 - 2) Use equipment and instrument tags as depicted on the P&IDs for all Submittals.
 - 3) Show and identify each component of each loop or system using requirements and symbols from ISA-5.4.
 - 4) Provide drawings for every instrumentation loop system:
 - a) Furnish a separate drawing sheet for each system or loop diagram.
 - 5) Nameplates and wire labeling:
 - a) As specified in Section 26_05_53 - Identification for Electrical Systems or as indicated on the Drawings.
 - 6) Clearly show modifications to existing circuits:
 - a) Show existing unmodified wiring to clearly depict the functionality and electrical characteristics of the complete modified circuits.
 - 7) Provide loop drawings in the format indicated in the Contract Drawings.
 - c. Provide a complete index in the front of each bound volume:
 - 1) Index the loop drawings by systems or process areas.
 - d. In addition to the ISA-5.4 requirements, show the following details:
 - 1) Functional name of each loop.
 - 2) Reference name, drawing, and loop diagram numbers for any signal continuing off the loop diagram sheet.
 - 3) Show all terminal numbers, regardless of the entity providing the equipment.
 - 4) MCC panel, circuit, and breaker numbers for power feeds to the loops and instrumentation.
 - 5) Terminal assignments associated with every manhole, pull-box, junction box, conduit, and panel through which the loop circuits pass.
 - 6) Show VCP, instrument panel, conduit, junction box, equipment and PCS terminations, termination identification, wire numbers and colors, power circuits, and ground identifications.
 - 7) Cables required for communication requirements.
4. PLC I/O list:
 - a. A complete listing of the PCS system point I/O database:
 - 1) Include relevant parameters for each datapoint, such as range, contact orientation, limits, incremental limits, I/O hardware address, and PLC assignment.
 - 2) Organize on a site-by-site basis and separate by point type.
 - 3) In addition to the active I/O points, list the implemented spare I/O points and the available I/O points remaining on each card, as well as other defined future points specified or shown.

- 4) Upon completion of the Work, update I/O lists to indicate the final as-built configuration of the systems:
 - a) Organize as-built I/O list on a site-by-site basis, separated by equipment and point type.
5. Control descriptions:
 - a. For each control loop, provide programming logic in the form of a written functional description indicating the operation of the equipment, signals, and controls based on the requirements specified Section 40_61_16.10 - Specific Control Strategies, and as shown on the P&IDs:
 - 1) Start from the specific control strategies provided in the Specifications.
 - a) Maintain same organization and format, and expand/edit the specific control strategies as needed.
 - b) Functional descriptions shall be modified to reflect the actual programming to be implemented in the PLCs.
 - 2) Include each function depicted or described in the Contract Documents.
 - 3) Include within the control description content:
 - a) Specific requirements.
 - b) Common requirements that pertain in general to all loops.
 - c) Listing ranges, setpoints, timers, values, counter values, etc.
 - d) Manual keyboard entries.
 - e) Entry codes.
 - f) System responses.
 - g) Modes:
 - (1) Startup.
 - (2) Routine and normal operation.
 - (3) Regulation and control.
 - (4) Shutdown under specified modes of operation.
 - (5) Emergency operating shutdown.
6. Instrument datasheets:
 - a. Datasheets provided with the instrument specifications are preliminary and are not complete but are provided to assist with the completion of final instrument datasheets. Additional datasheets may be required.
 - b. Furnish fully completed datasheets for each instrument and component according to ISA-20 Specification Forms for Process Measurement and Control Instruments, Primary Elements and Control Valves.
 - c. Format: Microsoft Word or Microsoft Excel.
 - 1) Features and options that are furnished.
 - d. Provide completed datasheet as specified in the Technical Sections and for each control system component.
7. Instrument installation drawings:
 - a. Provide instrument installation, mounting, and anchoring details for components and assemblies, including access requirements and conduit connection or entry details.
 - b. Each installation shall be identified by the equipment or instrument by tag number.
 - c. Provide certification by the instrument manufacturer that the proposed installation is in accordance with the instrument manufacturer's recommendations and is fully warrantable.

- d. Provide, at a minimum, the following contents for each detail:
 - 1) Necessary sections and elevation views required to define instrument location by referencing tank, building, or equipment names and numbers, and geographical qualities such as north, south, east, west, basement, first floor, etc.
 - 2) Ambient temperature and humidity where the instrument is to be installed.
 - 3) Corrosive qualities of the environment where the instrument is to be installed.
 - 4) Hazardous rating of the environment where the instrument is to be installed.
 - 5) Process line pipe or tank size, service, and material.
 - 6) Process tap elevation and location.
 - 7) Upstream and downstream straight pipe lengths between instrument installation and pipe fittings and valves.
 - 8) Routing of tubing and identification of supports.
 - 9) Mounting brackets, stands, anchoring devices, and sunshades.
 - 10) Conduit entry size, number, location, and delineation between power and signal.
 - 11) NEMA ratings of enclosures and components.
 - 12) Clearances required for instrument servicing.
 - 13) List itemizing manufacturer makes, model numbers, quantities, lengths required, and materials of each item required to support the implementation of the detail.
- 8. Product data:
 - a. Provide a technical brochure or bulletin (cutsheet) for each instrument or equipment on the Project, labeled with equipment and instrument tags as depicted on the P&IDs.
 - 1) Submit with the corresponding datasheets.
 - 2) Organization: Index product data in the Submittal by systems or loops.
 - b. Engineering data:
 - 1) Test data and performance curves, when applicable.
 - c. Manufacturer's technical reference manuals.
- 9. Quality Control Submittals:
 - a. As specified in Section 01_75_17 - Commissioning.
 - b. Manufacturer representative qualifications.
 - c. Manufacturer certificates.
 - d. Test Plans.
 - e. Test Reports.
- 10. Owner Training Submittals.
 - a. As specified in Section 01_75_17 - Commissioning.
- 11. Operation and maintenance manuals:
 - a. As specified in Section 01_78_24 - Operation and Maintenance Manuals.
 - b. Organize the operation and maintenance manuals for each process in the following manner:
 - 1) Section A - Process and Instrumentation Diagrams.
 - 2) Section B - Control Panel Drawings.
 - 3) Section C - Schematics and Wiring Diagrams.
 - 4) Section D - Loop Drawings.
 - 5) Section E - Network Diagrams.
 - 6) Section F - PLC I/O List.

- 7) Section G - Control Descriptions.
- 8) Section H - Instrument Datasheets.
- 9) Section I - Instrument Installation Drawings.
- 10) Section J - Product Data.
- 11) Section K - Sizing Calculations.
- 12) Section L - Test Results.
- 13) Section M - Operational Manual.
- 14) Section N - Spare Parts List.

1.06 QUALITY ASSURANCE

- A. Manufacture instruments at facilities certified to the quality standards of ISO 9001.
- B. Provide equipment listed by and bearing the label of UL or of an independent testing laboratory acceptable to the Engineer and the Authority Having Jurisdiction.
- C. ICSC must have their own operating UL listed panel fabrication facility.
 1. Panels must be fabricated at this facility and meet UL 508/508A requirements.

1.07 DELIVERY, STORAGE, AND HANDLING

- A. Upon receipt of instruments in the field:
 1. Outside of the package: Prominently display tag number identification.
 2. On each instrument: Provide a nameplate as specified in this Section.
- B. **Special instructions:**
 1. Ship the PCS equipment listed below to the programmer's office within 175 days after Notice to Proceed is issued to the Contractor:
 - a. PLCs to be programmed by programmer, including chassis, power supplies, CPUs, IO modules, cables, programming software, and related equipment.
 - b. Network communications equipment and cables less than 10 feet in length.
 - c. Any personal computers and related software.
 2. Programmer shall be allowed to keep the above equipment for a minimum of 180 calendar days and additionally until 30 days prior to the start of the factory test for the applicable PLC control panels.
 - a. Allow sufficient time in the Project schedule for this 180-day requirement.
 - b. Contractor is responsible to obtain necessary Submittal reviews, order equipment, and allow sufficient delivery time to comply with this requirement.
 - c. No schedule extension shall be allowed due to failure of the Contractor to comply with these requirements.
 3. Also supply, for the use of the programmer, samples of any devices or equipment that will communicate to the programmer-programmed PLCs using Modbus, Fieldbus, Ethernet, or any other digital network.
 - a. These samples must be shipped to the programmer's facility and remain there for a minimum of 90 days prior to the PLC panel factory tests.

4. Contractor shall be responsible for shipping the above equipment from the programmer's facility.
 - a. At the designated time for shipment of the above equipment to the factory test site or the field (whichever applies), send personnel to the programmer's office to package and ship the equipment to the factory test site.
 - b. Contractor shall have sole responsibility to package and ship the equipment, including packing materials and shipping charges.
 - c. Prior to packaging and shipping, examine and test equipment, as needed, and shall certify, in writing, that the equipment appears to be in proper working order, and shall deliver the certification to the programmer, who will forward copies to the Owner and Engineer.

1.08 PROJECT OR SITE CONDITIONS

- A. As specified in Section 01_81_50 - Design Criteria.
- B. Area classifications:
 1. Furnish enclosures that match the area classifications as specified in Section 26_05_00 - Common Work Results for Electrical.

1.09 ADMINISTRATIVE REQUIREMENTS

- A. Conduct the following meetings as specified in Section 01_31_19 - Project Meetings.
- B. Project PCIS overview conference:
 1. Contractor leads the meeting.
 2. Timing:
 - a. Prior to start of ICSC and programmer work.
 3. Attendees:
 - a. Engineer, Owner, ICSC, and programmer.
 - b. Contractor.
 - c. Electrical subcontractor.
 - d. Manufacturers furnishing major pieces of equipment must attend, including, but not limited to:
 - 1) VCPs.
 - 2) Chemical feed systems.
 - 3) Motor control centers.
 - 4) Switchgear.
 - 5) Variable frequency drives.
 - 6) Lighting.
 - 7) Engine generators.
 4. Agenda:
 - a. Meeting purpose:
 - 1) Review the entire Project, equipment, control philosophy, schedules, and Submittal requirements.
 - b. Review entire Project.
 - c. Review equipment lists.
 - d. Review control philosophy.
 - e. Review schedules.

- f. Review Submittal requirements.
 - g. Safety and security.
 - h. Action items.
 - i. Next meeting.
- C. System configuration meetings:
 - 1. Preliminary meeting:
 - a. Contractor leads the meeting.
 - b. Timing:
 - 1) Before configuration work begins.
 - c. Attendees:
 - 1) Engineer, Owner, and programmer.
 - d. Agenda:
 - 1) Meeting purpose:
 - a) Review the system configuration, the HMI system database, control schemes, displays, report formats, etc.
 - 2) Review the programmer provided examples of displays, display symbols, reports, etc., to show the capabilities of the system software.
 - 3) Safety and security.
 - 4) Action items.
 - 5) Next meeting.
 - 2. Development review meeting:
 - a. Contractor leads the meeting.
 - b. Timing:
 - 1) After the initial database is entered and typical screens and reports have been entered.
 - c. Attendees:
 - 1) Engineer, Owner, and programmer.
 - d. Agenda:
 - 1) Meeting purpose:
 - a) Review the system configuration, the HMI system database, control schemes, displays, report formats, etc.
 - 2) Review the system configuration.
 - 3) Review the HMI system database.
 - 4) Review the control schemes.
 - 5) Review the displays.
 - 6) Review the report formats.
 - 7) Safety and security.
 - 8) Action items.
 - 9) Next meeting.
 - 3. Pre-submittal review meeting:
 - a. Contractor leads the meeting.
 - b. Timing:
 - 1) Before producing any Submittals.
 - c. Attendees:
 - 1) Engineer, Owner, and programmer.

- d. Agenda:
 - 1) Meeting purpose:
 - a) Review the system configuration, the HMI system database, control schemes, displays, report formats, etc.
 - b) Review an informal hardcopy of developed HMI screens for review by the Engineer.
 - 2) Review the system configuration.
 - 3) Review the HMI system database.
 - 4) Review the control schemes.
 - 5) Review the displays.
 - 6) Review the report formats.
 - 7) Review an informal hardcopy of developed HMI screens.
 - 8) Review the Submittal schedule.
 - 9) Safety and security.
 - 10) Action items.
 - 11) Next meeting.
- 4. Final review meeting:
 - a. Contractor leads the meeting.
 - b. Timing:
 - 1) After initial completion of configuration work.
 - 2) Prior to the Source Test.
 - c. Attendees:
 - 1) Engineer, Owner, and programmer.
 - d. Agenda:
 - 1) Meeting purpose:
 - a) Review the system configuration, the HMI system database, control schemes, displays, report formats, etc.
 - 2) Review the system configuration.
 - 3) Review the HMI system database.
 - 4) Review the control schemes.
 - 5) Review the displays.
 - 6) Review the report formats.
 - 7) Safety and security.
 - 8) Action items.
 - 9) Next meeting.
 - e. Make final format revisions after this review.
- 5. Additional requirements as specified in the following:
 - a. Section 40_61_16.10 - Specific Control Strategies.
 - b. Section 40_64_01 - Control Systems: Programmable Logic Controllers.
- D. Control logic meetings:
 - 1. Preliminary meeting:
 - a. Contractor leads the meeting.
 - b. Timing:
 - 1) Before configuration work is begun on any PLCs programmed by the Contractor (including those provided through Subcontractors and Suppliers).

- c. Attendees:
 - 1) Owner, Engineer, and programmer.
 - 2) Individuals responsible for programming PLCs and other programmable devices supplied by the Contractor may attend by telephone conference call.
 - d. Agenda:
 - 1) Meeting purpose:
 - a) Discuss overall control logic.
 - 2) Review list of each PLC and other programmable devices that will interface to the rest of the control system, including make, model, and a description of the interface.
 - 3) Review contact information for each individual responsible for programming each said PLC and other programmable device.
 - 4) Review schedule of Submittals that will contain HMI/LOI interface information.
 - 5) Safety and security.
 - 6) Action items.
 - 7) Next meeting.
2. Development review meeting:
- a. Contractor leads the meeting.
 - b. Timing:
 - 1) After approximately one-half of the HMI/LOI interface Submittals have been submitted.
 - c. Attendees:
 - 1) Owner, Engineer, and programmer.
 - 2) Individuals responsible for programming PLCs and other programmable devices supplied by the Contractor may attend by telephone conference call.
 - d. Agenda:
 - 1) Meeting purpose:
 - a) Discuss progress on control logic.
 - 2) Discuss HMI/LOI interface Submittals to date.
 - 3) Discuss HMI/LOI interface future Submittals and their requirements.
 - 4) Discuss half of the screens “drafted” but not submitted.
 - 5) Review list of each PLC and other programmable devices that will interface to the rest of the control system, including make, model, and a description of the interface.
 - 6) Review contact information for each individual responsible for programming each said PLC and other programmable device.
 - 7) Review the schedule of Submittals that will contain HMI/LOI interface information.
 - 8) Safety and security.
 - 9) Action items:
 - a) Document VCP programming requirements.
 - 10) Next meeting.
3. Pre-submittal review meeting:
- a. Contractor leads the meeting.
 - b. Timing:
 - 1) Before producing any Submittals.
 - c. Attendees:
 - 1) Engineer, Owner, and programmer.

- d. Agenda:
 - 1) Meeting purpose:
 - a) Coordinate Submittals.
 - 2) Review the system configuration, the HMI system database, control schemes, displays, report formats, etc.
 - 3) Review an informal hardcopy of developed HMI screens for review by the Engineer to determine that requirements are being sufficiently met.
 - 4) Review the Submittal schedule.
 - 5) Safety and security.
 - 6) Action items.
 - 7) Next meeting.
- 4. Vendor programming meetings:
 - a. Contractor leads the meeting.
 - b. Timing:
 - 1) Prior to start of programming work for VCPs or other vendor equipment such as MCCs.
 - c. Attendees:
 - 1) Owner, Engineer, and programmer.
 - 2) Individuals responsible for programming PLCs and other programmable devices supplied by the Contractor may attend by telephone conference call.
 - 3) Each equipment supplier providing equipment with a PLC and/or LOI.
 - d. Agenda:
 - 1) Meeting purpose:
 - a) Coordinate control logic requirements for specific equipment.
 - 2) Review minimum VCP programming requirements:
 - a) PLC to PLC global data mapping.
 - b) PLCs to HMI tags mapping.
 - c) Communication methods.
 - 3) Review advanced VCP programming requirements, as applicable:
 - a) Tag naming conventions.
 - b) LOI screen colors and navigation.
 - c) Interlock and permissive definitions.
 - d) Alarms: Clearing, formats, colors, and status.
 - e) Standard code blocks for common control functionality.
 - 4) Safety and security.
 - 5) Action items.
 - 6) Next meeting.
- 5. Final review meeting:
 - a. Contractor leads the meeting.
 - b. Timing:
 - 1) After HMI/LOI interface Submittals have been submitted.
 - c. Attendees:
 - 1) Owner, Engineer, and programmer.
 - 2) Individuals responsible for programming PLCs and other programmable devices supplied by the Contractor may attend by telephone conference call.
 - d. Agenda:
 - 1) Meeting purpose:
 - a) Discuss HMI/LOI interface Submittals and requirements.

- 2) Review minimum programming requirements:
 - a) PLC to PLC global data mapping.
 - b) PLCs to HMI tags mapping.
 - c) Communication methods.
 - 3) Review advanced requirements, as applicable:
 - a) Tag naming conventions.
 - b) LOI screen colors and navigation.
 - c) Interlock and permissive definitions.
 - d) Alarms: Clearing, formats, colors, and status.
 - e) Standard code blocks for common control functionality.
 - 4) Safety and security.
 - 5) Action items.
 - 6) Next meeting.
6. Additional requirements as specified in the following:
- a. Section 40_61_16.10 - Specific Control Strategies.
 - b. Section 40_64_01 - Control Systems: Programmable Logic Controllers.
- E. Operator interface graphics generation meetings:
1. ICSC, through the Contractor, shall schedule the operator interface graphics meetings.
 2. Owner and Engineer shall attend these meetings.
 3. Topics shall include graphics for:
 - a. HMI graphics.
 - b. Data acquisition and graphics display system.
 4. Graphics Meeting No. 1: Held in conjunction with the preliminary meeting as specified above:
 - a. ICSC shall chair and develop an agenda 3 weeks in advance of the meeting, which shall address the basic criteria to be adhered to in the configuration and development of graphic displays:
 - 1) At this meeting, the ICSC shall distribute sample display formats for illustration purposes.
 - 2) As a minimum, this meeting shall address the following issues:
 - a) In-plant and remote site areas and conventions for identifying tag names and descriptors.
 - b) Designation of groups within each plant area along with tag names and descriptors.
 - c) Assignment of individual control loops and inputs to specific groups.
 - d) Organization of the systems universal display hierarchy.
 - e) Paging schemes to be used to enable the movement from one display to another.
 - f) An itemization of the type of display to be used at each level in the graphic hierarchy, i.e., pre-formatted displays, templates, custom graphics, etc.
 - g) Color convention to be employed on graphics for the annotation of various status information, differentiation between alarms based on alarm priority, background colors, static field colors, and dynamic field colors.
 - h) Utilization of blinking and conditional text.
 - i) Definition of graphic symbolism to be used on the Project. This listing shall include, but not be limited to, symbols to be used for

process instrumentation, process equipment, piping, vessels, and valves:

- (1) Symbolism must be specific as opposed to generic in that shapes must define both function and type, i.e., specific symbols for each valve design, each pump design, each type of flowmeter, etc.
 - (2) If the ICSC's library of shapes does not adequately describe plant or field conditions, the ICSC shall develop additional shapes to meet the plant or field requirements.
 - (3) Shapes and symbols used on the P&IDs shall be used as a guideline.
- j) Definition of display select commands that enable the operator to move within the display hierarchy.
- k) Utilization of cursor movement commands which enable the operator to move within a display.
- l) Definition of control input commands which enable the operator to interact with face plates control stations and custom graphic displays to implement control functions.
- m) Definition of data input commands which enable the operator to enter numeric values into the control system.
- n) Definition of the utilization of "poke" points or fields that are dynamically sensitive to operator inputs to facilitate operator entry directly into graphic displays.
- o) A review of graphic generation procedures.
- b. Subsequent to the adjournment of Graphics Meeting No. 1, the ICSC shall prepare and formalize a document titled "Graphics Criteria" which shall contain detailed meeting minutes and a definition of graphic guidelines to be adhered to:
 - 1) This report shall be supplemented by graphic examples which illustrate the incorporation and application of each graphic criteria.
 - 2) Report shall be submitted within 30 calendar days of the meeting's adjournment.
5. Graphics Meeting No. 2: Held in conjunction with the intermediate review meeting as specified above:
 - a. Subsequent to the finalization of the overall system-wide graphics criteria, the ICSC shall develop graphic packages for the entire operator interfaces being furnished under this Project.
 - b. At this meeting, the ICSC shall submit 5 copies, including:
 - 1) A review of the graphic package developed for the process areas for content and completeness.
 - 2) A review of data fields that display automatically updated process information.
 - 3) A review of required input commands associated with the graphic access and control manipulation.
 - c. Subsequent to the adjournment of Graphics Meeting No. 2, the ICSC shall prepare a formalized Submittal of the graphic package for review along with the detailed meeting minutes:
 - 1) Report shall be submitted within 30 calendar days of the meeting adjournment.
6. 10 additional displays shall be configured online during the pre-commissioning test period.

- F. Report generation meetings:
1. ICSC, through the Contractor, shall schedule the report generation meetings.
 2. Owner and Engineer shall attend these meetings.
 3. Reports Meeting No. 1: Held in conjunction with the preliminary meeting as specified above:
 - a. ICSC shall chair and develop an agenda 3 weeks in advance for a meeting, which shall address the basic criteria to be adhered to in the configuration and development of the reports:
 - 1) At this meeting, the ICSC shall distribute sample formats for illustration purposes.
 - 2) As a minimum, this meeting shall address the following issues:
 - a) In-plant and remote site data and conventions for identifying tag names and descriptors.
 - b) Designation of groups within each plant area along with tag names and descriptors.
 - c) Assignment of inputs to specific categories.
 - d) Organization of the systems universal report categories.
 - e) An itemization of the type of report available.
 - f) Definition of terms to be used on the reports.
 - g) Definition of report commands that enable the operator to move within the report editor.
 - h) Utilization of cursor movement commands that enable the operator to move within a report.
 - i) Definition of data input commands that enable the operator to enter numeric values into the system.
 - j) A review of report generation procedures.
 - b. Subsequent to the adjournment of the Reports Meeting No. 1, the ICSC shall prepare and formalize a document titled "Report Criteria" which shall contain detailed meeting minutes and a definition of report guidelines to be adhered to:
 - 1) This report shall be supplemented by report examples.
 - 2) Report shall be submitted within 30 calendar days of the meeting's adjournment.
 4. Reports Meeting No. 2: Held in conjunction with the intermediate review meeting as specified above:
 - a. Subsequent to the finalization of the overall report format criteria, the ICSC shall develop report packages for review.
 - b. At this meeting, the ICSC shall submit 5 copies, including:
 - 1) A review of the report package developed for the process area(s) for content and completeness.
 - 2) A review of data fields for process information.
 - 3) A review of required input commands associated with the report access and control manipulation.
 - c. Subsequent to the adjournment of Reports Meeting No. 2, the ICSC shall prepare a formalized Submittal of the report package for review along with the detailed meeting minutes:
 - 1) Report shall be submitted within 30 calendar days of the meetings adjournment.
 5. 10 additional reports shall be configured online during the pre-commissioning test period.

- G. Alarming priority meetings:
1. ICSC, through the Contractor, shall schedule the alarming priority meetings.
 2. Owner and Engineer shall attend these meetings.
 3. Alarming Priority Meeting No. 1: Held in conjunction with the preliminary meeting as specified above:
 - a. ICSC shall chair and develop an agenda 3 weeks in advance for a meeting, which shall address the basic criteria to be adhered to in the prioritization of alarms:
 - 1) At this meeting, the ICSC shall distribute a listing of plant alarms identified by tag names and descriptors.
 - 2) As a minimum, this meeting shall address the following issues:
 - a) Criteria for prioritizing alarms, including alarming priority levels (i.e., Priority 3 - alarm at PCS; Priority 2 - alarm at PCS and autodialer; Priority 1 - alarm at PCS, autodialer, and plant shutdown).
 - b) Alarm display banner basic criteria.
 - b. Subsequent to the adjournment of the Alarming Priority Meeting No. 1, the ICSC shall prepare and formalize a document titled "Alarm Criteria" which shall contain detailed meeting minutes and a definition of alarming guidelines to be adhered to:
 - 1) Report shall be submitted within 30 calendar days of the meeting's adjournment.
 4. Alarming Priority Meeting No. 2: Held in conjunction with the intermediate review meeting as specified above:
 - a. Subsequent to the finalization of the overall alarm criteria, the ICSC shall develop an alarming priority spreadsheet that will be populated at this meeting.
 - b. At this meeting, the ICSC shall provide a spreadsheet, including:
 - 1) A listing of plant alarms identified by tag names and descriptors.
 - 2) For each alarm listed, include a location to enter the alarm priority assignment.
 - 3) For each alarm listed, include a location to enter specific comments related to that alarm.
 - c. Subsequent to the adjournment of Alarming Priority Meeting No. 2, the ICSC shall prepare a formalized Submittal of the alarming priority spreadsheet for review along with the detailed meeting minutes:
 - 1) Spreadsheet and meeting minutes shall be submitted within 30 calendar days of the meeting's adjournment.

PART 2 PRODUCTS

2.01 GENERAL

- A. Furnish meters, instruments, and other components that are the most recent field proven models marketed by their manufacturers at the time of Submittal of the Shop Drawings unless otherwise specified to match existing equipment.

2.02 DESIGN AND PERFORMANCE CRITERIA

- A. Non-conditioned spaces:
 - 1. Provide additional temperature conditioning equipment to maintain equipment in non-conditioned spaces subject to these ambient temperatures, with a band of 10 degrees Fahrenheit above the minimum operating temperature and 10 degrees Fahrenheit below maximum operating temperature, as determined by the equipment manufacturer's guidelines.
- B. Outdoor installations:
 - 1. Provide electrical, instrumentation and control equipment suitable for operation in the ambient conditions where the equipment is located.
 - 2. Provide heating, cooling, and dehumidifying devices incorporated into and included with electrical equipment, instrumentation and control panels to maintain the enclosures within the rated environmental operating ranges as specified in the Sections for the equipment.
- C. Unless otherwise specified, furnish individual instruments that have a minimum accuracy of within 0.5 percent of full scale and a minimum repeatability of within 0.25 percent of full scale.
- D. Furnish current version of software unless specifically noted in the Contract Documents.
 - 1. Use of an older version to maintain functionality of an existing system is acceptable with written permission from the Engineer.
 - 2. Equipment or software with limited support or end of life with the vendor is not acceptable.
- E. Discrete circuit configuration:
 - 1. Configure discrete control circuits to fail safe, on loss of continuity, or loss of power.
 - 2. Alarm contacts: Fail to the alarm condition.
 - 3. Control contacts: Fail to the inoperative condition unless otherwise indicated on the Drawings.
- F. Grounding:
 - 1. Analog signal cables shields shall only be grounded at a single point in the loop. Unless otherwise noted, ground signal cable shields at control panel.
 - 2. For communication and data line signal cable shields and drain wires should be grounded at both ends of the cable.
 - 3. Insulate the shielding and exposed drain wire for each signal cable with heat-shrink tubing.
 - 4. Terminate the signal cable shield on a dedicated grounding terminal block.
 - 5. Provide isolating amplifiers within control panels for field equipment possessing a grounded input or output, except when the panel circuit is galvanically isolated.

- G. Instrument air:
1. Where indicated on the Drawings, provide dry, filtered control air at 30 pounds per square inch gauge nominal pressure piped to field instruments and instrument panels requiring air:
 - a. Provide each field instrument with an integral, non-adjustable filter/regulator assembly to provide regulated air.
 - b. Provide each instrument panel requiring air with an adjustable filter/regulator assembly with gauge and an air manifold to provide air to pneumatic instruments.
 - c. Filter air to 5-micron maximum particle size.
 - d. Provide low pressure switch to alarm on insufficient air supply.
- H. Terminal blocks:
1. Schematics do not reflect the actual conductor routing. Add intermediate terminal in enclosures and equipment as needed based on the actual conductor routing.
- I. Signal transmission:
1. Analog signals:
 - a. Furnish analog measurements and control signals that vary in direct linear proportion to the measured variable, unless otherwise indicated.
 - b. Furnish electrical analog signals outside control panels that are 4 to 20 mA 24 VDC, except as indicated.
 - c. Electrically or optically isolate analog signals from other signals.
 - d. Furnish regulated analog signals that are not affected by changes in supply voltage or load resistance within the unit's rating.
 - e. Maintain the total 4 to 20 mA loop impedance to 10 percent below the published value at the loop operating voltage.
 - f. Where necessary, reduce loop impedance by providing current-to-current (I/I) isolation amplifiers for signal re-transmission.
 2. Pneumatic signals: 3 to 15 pounds per square inch gauge.
 3. Discrete input signals: As indicated in the controller hardware specification.
 4. Discrete output signals:
 - a. Dry contacts or TRIAC outputs (with express written approval by the Engineer) as needed to coordinate with the field device.
 - b. Provide external terminal block mounted fuse with blown fuse indication for discrete outputs.
 - c. Provide interposing relays for discrete outputs for voltage and/or current compatibilities.
 - d. Provide interposing relays as required for functionality of the control circuit.
 5. Signal performance and design criteria:
 - a. Stability:
 - 1) After controls have taken corrective action, oscillation of the final control element shall not exceed 2 cycles per minute or a magnitude of motion of 0.5 percent of full travel.
 - b. Response:
 - 1) Any change in setpoint or controlled variable shall produce a corrective change in position of the final control element and stabilized within 30 seconds.

- c. Agreement:
 - 1) Setpoint indication of controlled variable and measured indication of controlled variable shall agree within 3 percent of full scale over a 6:1 operating range.
- d. Repeatability:
 - 1) For any repeated magnitude of control signal, from either an increasing or decreasing direction, the final control element shall take a repeated position within 0.5 percent of full travel regardless of force required to position the final element.
- e. Sensitivity:
 - 1) Controls shall respond to a setpoint deviations and measured variable deviations within 1.0 percent of full scale.
- f. Performance:
 - 1) Instruments and control devices shall perform in accordance with the manufacturers' specifications.

2.03 ACCESSORIES

- A. Provide flow conditioning devices or other required accessories as needed to meet the accuracy requirements in the Contract Documents.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

- A. PCIS configurations are diagrammatic:
 - 1. Locations of equipment are approximate unless dimensioned.
 - 2. Where Project conditions require, make reasonable changes in locations and arrangements.
- B. Field instruments installation:
 - 1. As specified in the Contract Documents, API RP 550 and RP 551, and the manufacturer's instructions.
 - 2. Mount field instruments so that they can be easily read, readily approached, and easily serviced, and so they do not restrict access to mechanical equipment:
 - a. Mount on a pipe stand or local panel, if they are not directly mounted, unless otherwise indicated on the Drawings.
 - b. Provide sun shields for field electronic instruments, panels, and enclosures located outdoors. Sun shields shall include standoffs to allow air gap between shield and equipment.
 - c. Orient LED, LCD, or other readout screens north to minimize sun glare and reduce potential of sun damage.

3. Make connections from rigid conduit systems to field instruments with PVC coated flexible conduit:
 - a. Type of flexible conduit required for the area classification:
 - 1) As specified in Section 26_05_00 - Common Work Results for Electrical.
 - b. Maximum length of 18 inches.
 4. Connect field instruments with cable as specified in the electrical Specifications, except when the manufacturer requires the use of special cable, or otherwise specified in this Section:
 - a. Special cable applications shall be in accordance with the NEC.
 5. Verify the correctness of each installation:
 - a. Polarity of electric power and signal connections.
 6. Ensure process connections are free of leaks.
- C. Process sensing lines and air tubing:
1. Install individual tubes parallel and/or perpendicular to and near the surfaces from which they are supported.
 2. Provide supports for rigid tubing at intervals of not more than 3 feet.
 3. Slope horizontal runs of instrument tubing at a minimum of 1/16 inch per foot to allow for draining of any condensate.
 4. Bends:
 - a. Make bends for parallel lines symmetrical.
 - b. Make bends without deforming or thinning the walls of the tubing.
 5. Square-cut and clean ends of tubing before being inserted in the fittings.
 6. Provide bulkhead fittings at panels requiring pipe and/or tubing entries.
 7. Use stainless steel tubing for piping hard piped from the air header, unless otherwise indicated on the Drawings or not compatible with the fluids or atmosphere in the area:
 - a. Use flexible connections only on moving equipment and under the constraint that the length shall be less than 1.5 times maximum travel of the equipment.
- D. Cable and conductor termination:
1. Terminate cables and conductors on terminal blocks.
 2. Terminal block enclosures:
 - a. Suitable for the area classification as specified in Section 26_05_00 - Common Work Results for Electrical.
- E. Surge protection:
1. Provide outdoor field instrument loops with voltage surge protection units installed on the instruments and the panel.
 2. Individually fuse each 4 to 20 mA DC loop with a 1/2-amp fuse between power supplies and receiver surge protectors.
 3. Provide voltage surge protection for 4-wire transmitters and analyzers:
 - a. Protect both power source and signal loop.

3.04 RE-INSTALLATION

- A. Existing instrumentation:
 - 1. Clean, recondition and re-calibrate each existing instrument to be reused, removed, or reinstalled using an authorized service facility of the instrument manufacturer.
 - 2. Provide certification of this Work before reinstallation of each instrument.

3.05 COMMISSIONING

- A. As specified in Section 01_75_17 - Commissioning.

3.06 FIELD QUALITY CONTROL

3.07 ADJUSTING

- A. Control valves:
 - 1. Stroke control valves, cylinders, drives and connecting linkages from the control system as well as local control devices and adjust to verify proper control action, hand switch action, limit switch settings, torque settings, remote control actions, and remote feedback of valve status and position.
 - 2. Check control valve actions and positioner settings with the valves in place to ensure that no changes have occurred since the bench calibration.
- B. Make revisions necessary to the control system software, as directed by the Engineer.
 - 1. It is understood that the Contractor knows and agrees that changes will be required in the control system software during Commissioning.

3.08 CLEANING

- A. Oxygen service devices, including piping, valves, and appurtenances shall be cleaned for oxygen service and certified by a qualified inspector prior to placing into service.
- B. Vacuum clean control panels and enclosures before process start-up and again after final completion of the Project.
- C. Clean panel surfaces.
- D. Return to new condition any scratches and/or defects.
- E. Wipe instrument faces and enclosures clean.
- F. Leave wiring in panels, manholes, boxes, and other locations in a neat, clean, and organized manner:
 - 1. Neatly coil and label spare wiring lengths.
 - 2. Shorten, re-terminate, and re-label excessive spare wire and cable lengths, as determined by the Engineer.

END OF SECTION

ATTACHMENT A - CYBER SECURITY INTERNAL AND EXTERNAL SCADA USAGE POLICY

***Wes Brown and Thornton Water Treatment Plants
Cyber Security Internal and External SCADA usage Policy***

08/13/2024

	Water Treatment Infrastructure	Original Author	Will Cirbo
		Implementation Date	08/13/2024
		Last Reviewed/Update Date	01/22/2025

Cyber Security Internal and External SCADA Access Policy

Overview:

This policy outlines standardized practices for issuing, monitoring, maintaining, and removing access to the Water Utility SCADA (Supervisory Control and Data Acquisition) System. It is designed to safeguard the system against accidental or intentional attacks by internal and external users, ensuring the secure operation and integrity of the water treatment process.

PURPOSE:

The primary purpose of this policy is to establish clear procedures for managing user access to the SCADA system and to ensure ongoing system security and reliability. It aims to protect the SCADA system from unauthorized access and to define the responsibilities of I&C SCADA Technicians and IT personnel in maintaining the system and its associated backups.

Applicability:

This policy applies to all employees, contractors, and external users who require access to the Water Utility SCADA system, including I&C SCADA Technicians, IT personnel, and approved external contractors. It also covers all equipment and software associated with the SCADA system.

Wes Brown and Thornton Water Treatment Plants

Cyber Security Internal and External SCADA usage Policy

08/13/2024

Scope:

The policy covers the entire lifecycle of SCADA system access, from account creation to removal, including user privilege management, remote access, and security measures for both hardware and software. It also includes provisions for system improvements, maintenance, and backup procedures.

Standards:

SCADA system End Users:

1. All SCADA users/accounts are maintained (created, deleted and assigned privileged usage) by the I&C SCADA Technicians team. See list of current users. Privileged usage is allowable access to areas within the SCADA system and control of. Some users will have the privilege of controlling the SCADA system only in certain areas, others will have limited access to areas and control of certain areas, or no control, just monitoring/viewing. Each End User's Supervisor will determine what access the End User needs and coordinate this with the I&C Team.
2. Employees that leave their position will have, their accounts disabled and deleted as soon as deemed necessary, usually their last day or before. Supervisors of employees will communicate with the Water Technical Operations Supervisor ASAP as to when the employee is leaving their position.
3. A list of External contractors that use the SCADA system will be maintained by I&C SCADA Technicians. Currently there are only Two (Veolia and Automation Services).
4. External contractor accounts will only be enabled while they are actively working on the SCADA system, otherwise their accounts will stay in disabled mode.
5. External contractors that use the SCADA System remotely will be approved by the COT IT department where an account will be added.
6. Remote access using VPN will only be granted once the multifactor authentication, DUO/MFA, has been approved by the Water Technical Operations Supervisor (WTOS). The WTOS will be notified prior to any remote access, if prior notification is not given, remote access will be denied.
7. New employees will be set up in the SCADA system by I&C SCADA Technicians once given the ok by their supervisor and approved by the Water Technical Operations Supervisor.
8. All SCADA users will have their own credentials, and unique passwords, and will not be allowed to share these credentials with anyone else. Passwords will be required to be changed every 90 days with a minimum of 12 characters.

Programming and Configuration of the SCADA system:

1. Internal SCADA system improvements will only be made by I&C SCADA Technician, approved contractors and IT personnel.

Wes Brown and Thornton Water Treatment Plants
Cyber Security Internal and External SCADA usage Policy

08/13/2024

2. Only authorized COT equipment can be used when making any modifications to the SCADA System. No other equipment is allowed to connect to the SCADA system. As an example: laptops, thumb drives, PADs, switches etc.
3. Contractors are not allowed to use their own equipment to connect directly to the SCADA system, unless they are connecting remotely through the VPN.
4. Contractors will be allowed to use COT equipment when making improvements or modifications. During this time COT staff, I&C SCADA Technician will be at their side monitoring all work.
5. Contractors will be allowed to send program files through a secure web base, determined by the COT. Once the code has been uploaded to a secure site, I&C staff will download the code and verify that the code is in good working condition. This will be done prior to downloading the modified code to a PLC. To prevent corruption of the network, when possible, that PLC will be isolated from the network during testing and commissioning. Once the new code is confirmed to be functional the PLC will rejoin the network.
6. All changes to the SCADA system will need to have a created backup file, which will then be transferred to the following locations. (instrumentation computer, NAS Server and external hard drive). These files are also backed on an IT server at 10:00am every day.

Maintenance of the SCADA system:

1. Any software that is used by the SCADA system will need prior approval by the IT Cybersecurity team.
2. All SCADA computer ports are to be disabled and not usable by external equipment. Example would be a USB thumb drive being connected to a SCADA computer
3. SCADA server rack or the rooms that house these servers are to be locked at all times. Only authorized personal will have a key to enter the rooms.
4. All PLC cabinet doors are to remain locked. Only authorized personal will have a key to unlock the racks/rooms.
5. All PLC cabinets and SCADA server racks, located within the Water Treatment Plants are to be checked monthly, to look for suspicious activity and condition of the PLC equipment.
6. All PLC's and HMI's will be updated with the latest firmware updates
7. All SCADA servers will be replaced every four years, along with the approved SCADA software
8. All local PLC HMI's will have the ability to lock within 15minutes of not being used. Local PLC HMI Passwords will be maintained by I&C SCADA Technicians. Operations staff will be given a monitoring PW with no control. If a full access PW is required by the Operations staff, that PW will be disable after that one-time use. The I&C SCADA Technicians will then create a new PW.
9. The IT department on a yearly basis will test back-up files that are being stored.

SCADA accounts, List below:

Wes Brown and Thornton Water Treatment Plants
Cyber Security Internal and External SCADA usage Policy

08/13/2024

SCADA Users			
NAME	Group	Name	Group
Hunter Kubiak Kwassi Samlan Steve Bernal Felix Rios Will Cirbo	I&C SCADA Technicians	Thomas Diesing	Meter Shop
Daniel Martinsen Tim Schnitzler Tom Yang Tuan Tran	IT Admin (IT_sysadmins)	Aaron Chacon Amanda King Hector Fernandez Ian Steinmann Joshua Sorenson Luke Gubbels Tony Nguyen	IT Tech Services (it_technicalservices)
Andy Nguyen Solomon Oyenugah Josh Kelley	IT Network Services (IT_NetAdmin_Admin_A ccounts)	Cory Sibley John Dorris Zach Gilbert Cindy Lindberg Devin Dymeck John Meyers Jonathan Campos Martin Kimmes Matthew Asher Mohamad Kassir Niko Peters Ralph Shearer Reese Clark Sean Shirvan Steve Foster	Operations
Jeff Adler (Automations Services)	Contractor	Veolia	Contractor

Wes Brown and Thornton Water Treatment Plants
Cyber Security Internal and External SCADA usage Policy

08/13/2024

Brian Lantzy Jose Chavez Josh Redman Kyle Johnson Kyle Wallis Rowlan Highland Carlos Huerta	UMM	Adam Pollack David Garcia Ed Lanyon Elena Acker Elizabeth Samlan Jason Helms Kyle Brough Rich Dewitt Ruthanna Moore Tracy Schultz Zack Wilkerson	Water resources

REVISION HISTORY:

Rev. No.	Effective Date	Responsible Person	Description of Revision
001	8/29/24	Kwass Samlan	Added Carlos Huerta to UMM authorized employees
002	1/16/25	Hunter Kubiak	Removed employees that left COT from SCADA users
003	1/21/2025	Will Cirbo	Programming and Configuration of the SCADA system: Minor change to #5.
004	1/21/2025	Hunter Kubiak	Updated the below from server racks to server rooms. 1. SCADA server rooms are to be locked at all times. Only authorized personal will have a key to enter the rooms.
005	1/23/2025	Will Cirbo	Updated Staff Operations and Water Resources
006	1/23/2025	Will Cirbo	Programming and Configuration of the SCADA system: Minor change to #5.

Wes Brown and Thornton Water Treatment Plants
Cyber Security Internal and External SCADA usage Policy

08/13/2024

007	6/25/25	Matthew Asher	Updated operator list.

READ BY:

NAME	TITLE	SIGNATURE	DATE
Will Cirbo	Water Ops Technical Supervisor	<i>Will Cirbo</i>	8/26/2024
Steve Bernal	I&C/SCADA TECH	<i>Steve Bernal</i>	8/28/2024
Kwasssi Samlan	I&C/CSADA TECH 1	<i>KWASSI SAMLAN</i>	8/29/2024
John Meyers	Senior Water Treatment Specialist	John Meyers	8/29/2024
Steve Foster	Water Plant Supervisor	Steve Foster	1/22/2025
Matthew Asher	Water Plant Supervisor	Matthew Asher	6/25/25
Felix Rios	I&C/CSADA TECH 1	<i>Felix Rios</i>	9/3/24
Devin Dymeck	Senior Water Treatment Specialist	Devin Dymeck	5/31/25
Hunter Kubiak	I&C/SCADA Technician III	<i>Hunter Kubiak</i>	1/21/25
John Dorris	Water Treatment Specialist	John Dorris	3/18/25
Sean Shirvan	Water Treatment Specialist	Sean Shirvan	4/14/2025

SECTION 40_61_16.10
SPECIFIC CONTROL STRATEGIES

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Loop descriptions for Specific control requirements and functional descriptions for individual control loops.
- B. Section excludes:
 - 1. PLC, LOI and SCADA-related programming services which will be provided by the Owner.

1.02 REFERENCES

- A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.
- B. Abbreviations:
 - 1. LCP - Local Control Panel.
 - 2. LOI - Local Operator Interface.
 - 3. PCS - Process Control System.
 - 4. PLC - Programmable Logic Controller.
 - 5. MCC - Motor Control Center.
 - 6. VCP - Vendor Control Panel.
 - 7. VFD - Variable Frequency Drive.
- C. Definitions:
 - 1. Loop description: Specific control requirements and functional descriptions for individual control loops.

1.03 SUBMITTALS

- A. Furnish Submittals as specified in Section 01_33_00 - Submittal Procedures and Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.
- B. Develop detailed loop descriptions based on the information in the Contract Documents:
 - 1. Submit loop descriptions with implemented modifications from this Section clearly marked.
 - 2. Remove all markings on final loop descriptions submitted with the applicable operation and maintenance manuals.

1.04 WARRANTY

- A. As specified in Section 01_78_36 - Warranties and Bonds.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 Source Water Pump Station

A. Source Water Pump Station Pumps:

1. General:

a. References:

1) P&ID drawings:

- a) 30N24.
- b) 30N25.
- c) 30N26.
- d) 30N27.
- e) 30N28.
- f) 30N29.

2) Control Schematic:

- a) 30N09.
- b) 30N10.
- c) 30N11.

b. Key equipment:

1) Pumps:

- a) PMP-301 – Source water Pump No. 1 (Future).
- b) PMP-302 – Source water Pump No. 2.
- c) PMP-303 – Source water Pump No. 3.
- d) PMP-304 – Source water Pump No. 4 (Future).
- e) PMP-305 – Source water Pump No. 5.
- f) PMP-306 – Source water Pump No. 6.

2) Flow Meters:

- a) FE/FIT-300 – Source Water Pump Station Flowmeter.
- b) FE/FIT-311 – Source Water Pump Station Flowmeter.

3) Flow Switches:

- a) FE/FSL-301 – Source Water Pump No. 1 Low Flow (Future).
- b) FE/FSL-302 – Source Water Pump No. 2 Low Flow.
- c) FE/FSL-303 – Source Water Pump No. 3 Low Flow.
- d) FE/FSL-304 – Source Water Pump No. 4 Low Flow (Future).
- e) FE/FSL-305 – Source Water Pump No. 5 Low Flow.
- f) FE/FSL-306 – Source Water Pump No. 6 Low Flow.

4) Valve Position Switches:

- a) ZSOC-301 – Source Water Pump No. 1 High Pressure Relief Valve.
- b) ZSOC-302 – Source Water Pump No. 2 High Pressure Relief Valve.
- c) ZSOC-303 – Source Water Pump No. 3 High Pressure Relief Valve.
- d) ZSOC-304 – Source Water Pump No. 4 High Pressure Relief Valve.
- e) ZSOC-305 – Source Water Pump No. 5 High Pressure Relief Valve.

- f) ZSOC-306 – Source Water Pump No. 6 High Pressure Relief Valve.
 - 5) Pressure Transmitters:
 - a) PIT-301 – Source Water Pump No. 1.
 - b) PIT-302 – Source Water Pump No. 2.
 - c) PIT-303 – Source Water Pump No. 3.
 - d) PIT-304 – Source Water Pump No. 4.
 - e) PIT-305 – Source Water Pump No. 5.
 - f) PIT-306 – Source Water Pump No. 6.
 - g) PIT-310 – Source Water Discharge Header.
 - h) PIT-PSV – Thornton Water Pipeline Signal Hill.
 - c. Abstract:
 - 1) The Source Water Pump Station Wet Well contains 6 pumps (2 future). The pumps will transmit water from the adjacent lake to the Thornton Water Pipeline (TWP). The pumps are variable speed in a duty/stand-by configuration. The planned control modes are shown with detail below.
- 2. Hardwired controls:
 - a. Pilot devices:
 - 1) Field:
 - a) None.
 - 2) LCP:
 - a) None.
 - 3) Drive/starter enclosure:
 - a) LOCAL-OFF-REMOTE (LOR) selector switch.
 - b) START pushbutton.
 - c) STOP pushbutton.
 - d) SPEED potentiometer.
 - 4) VCP: Hydraulic Gates
 - a) POSITION Status.
 - b) FAULT status.
 - b. Interlocks:
 - 1) Drive/starter enclosure:
 - a) HIGH VIBRATION.
 - b) LOW FLOW:
 - 2) VCP:
 - a) None.
 - c. Indicators and alarms:
 - 1) Field:
 - a) None.
 - 2) LCP:
 - a) None.
 - 3) Drive/starter enclosure:
 - a) SPEED indication.
- 3. Thornton Water Project Controls:
 - a. Modifications to existing Thornton Water Treatment Plant SCADA system.
 - 1) Abstract: Existing program shall be updated to include new flow rates from Segment A meter vault (FIT - 600) to the totalizer that calculates flow to the Wes Brown Treatment Plant (WBWTP).
 - 2) Provide tuning for blending different water sources based on the addition of the new source.

- b. For all auto control modes, if there is a shutdown or interruption that causes a shutdown alarm, the program will automatically enter a setpoint of "0" for all flow values so the system doesn't automatically restart once alarms are clear.
- c. WBWTP Flow Control Auto Mode:
 - 1) Abstract: Source Water Pump Station (SWPS) will operate to deliver between 3.5 (or minimum allowed pump flow) and 14.8 mgd to the Wes Brown Water Treatment Plant (WBWTP). Flow control to the WBWTP will be achieved by the Segment A sleeve valve and meter (VAL – 600 and FIT – 600). An Operator will select a flowrate between 3.5 (or minimum allowed pump flow) and 14.8 mgd in 0.1 mgd increments, the sleeve valve will modulate until the desired flow setpoint is reached at FIT – 600.
 - a) The operator will have a checkbox to initiate return flows in addition to WBWTP flow in this auto mode. If the box is checked, the operator will be prompted to choose the flow rate to each structure in 0.5 mgd increments, for a total flow between 0.5 and 7.0 mgd. The two return flow structures are the Greeley No. 2 canal structure and the Cache la Poudre River structure. Flowrate to the WBWTP is the priority in this mode, and flow to the return to the return structures will be limited by the difference of flow to the WBWTP and 14.8 mgd.
 - b) The maximum pressure allowable downstream of VAL-600 is approximately 6.9 psi. This number will be coordinated with equivalent elevations at the WBWTP.
 - c) Operator enters WBWTP flow setpoint (FIT-600). For flow rates between 3.5 (or minimum allowed pump flow) and 8.5mgd, the Source Water Pump Station will start the Duty 600 HP pump (PMP – 301 or PMP – 302) at 50% speed. SWPS Pumps will pressurize line until Signal Hill PIT reaches minimum pressure setpoint. SWPS pumps will maintain speed (speed will not be adjusted). Segment A Sleeve Valve (VAL – 600) will be set to a predetermined percentage open (a table will be produced for input into programming that contains approximate percent open for flow values, based on the Cv curve of the sleeve valve and the upstream pressure). Segment A Sleeve Valve (VAL-600) will maintain position and the SWPS pumps will speed up/slow down to achieve flow setpoint (FIT-600). If the flow setpoint cannot be reached, the pumps will hold as the sleeve valve will increase or decrease percent open.
 - d) For flow rates between 8.5 mgd and 14.8 mgd, the Source Water Pump Station will start the Duty 600 HP (PMP – 301 or PMP – 302) at 50% speed. The SWPS Pumps will pressurize line until Signal Hill PIT reaches minimum pressure setpoint. Once it has, the pump will ramp up to 100% speed over 1 minute. At that point the SWPS will start the Duty 3000 HP (PMP – 304 or PMP 305) at 50% speed, and increase speed until the flow setpoint is reached. The 600 HP pump will then shutdown. SWPS pumps will maintain speed (speed will not be adjusted). Segment A Sleeve Valve (VAL – 600) will be set to a predetermined percentage open (a table will be produced for

input into programming that contains approximate percent open for flow values, based on the Cv curve of the sleeve valve and the upstream pressure). Segment A Sleeve Valve (VAL-600) will maintain position and the SWPS pumps will speed up/slow down to achieve flow setpoint (FIT-600). If the flow setpoint cannot be reached, the pumps will hold as the sleeve valve will increase or decrease percent open.

- e) For shutdown, the pump station will reduce the active pump to 50% speed over 1 minute before shutting off.
- f) Simultaneously the sleeve valve will modulate to 95 percent closed and then close the remaining 5 percent over 300 seconds.

2) Permissive Check

- a) If SWPS is shutdown the return flow structures will automatically close.
- b) Return flow structure cannot be operated automatically if the SWPS is off. However, the structures can still be operated manually (SCADA push button, "Manual")
- c) Signal Hill Pressure Sensor to maintain a minimum of 20 psi.
- d) Intermediate High Point pressure sensor to maintain a minimum of 60 (need to get pressure from Segment F design) psi, only to be used if loss of signal from signal hill pressure sensor.
 - (1) Have a selector for Signal Hill vs Intermediate High Point as primary for permissive. Default is Signal Hill.
- e) Pump Permissives to Start:
 - (1) Wet Well Minimum LOW LEVEL: Minimum wet well level to keep submergence requirements.
 - (2) Pump Header PIT MINIMUM PRESSURE: Minimum pressure to verify TWP pipeline is full.
 - (a) An operator override (administrative level) will be available for operations where the pipeline is being filled.
 - (3) Signal Hill Tuning Fork: Notification that Segment A is full.
- f) Pump Shut Down Conditions
 - (1) An operator override for instruments only (administrative level) will be available for use at operator discretion.
 - (2) WBWTP Loss of Signal (60 seconds) or another signal that triggers WBWTP shutdown.
 - (3) Wet Well Minimum LOW LOW LEVEL: Stops the pump. Activates the LOW LOW LEVEL alarm.
 - (4) Signal Hill PIT LOW PRESSURE: Pressure reaches LOW PRESSURE SETPOINT of 5 psi for 5 seconds. Activates low pressure alarm.
 - (5) PIT-301,PIT-302, PIT-303,PIT-304, PIT-305, and PIT-306 HIGH PRESSURE: Pressure reaches or exceeds HIGH PRESSURE SETPOINT of 300 psi for 5 seconds. Stops the pump. Activates High Pressure Alarm.
 - (6) FIT-300/311 NO FLOW: If flow is not indicated after 5 seconds, stops the pump. Activates no flow alarm.

- d. PCS indicators and alarms:
 - 1) Pumps:
 - a) REMOTE indication
 - b) HAND-OFF-AUTO indication.
 - (1) Provide manual speed operation of pumps from SCADA.
 - c) RUNNING indication.
 - d) SPEED indication.
 - e) RUN TIME indication.
 - f) VFD FAIL alarm.
 - g) Motor HIGH TEMPERATURE alarm.
 - h) FAIL TO START alarm.
 - i) FAIL TO STOP alarm.
 - j) HIGH Pressure Alarm
 - k) LOW FLOW alarm.
 - 2) Segment A Sleeve Valve
 - a) Pressure Status
 - b) HIGH Pressure Alarm
 - c) Valve Percent Open Status.
 - d) Valve On-Line Status.
 - e) Flow Rate Status
 - f) Loss of Signal Alarm
- e. Return Flows Only Auto Mode:
 - 1) Abstract: Source Water Pump Station (SWPS) will operate in this mode when no flow is going to Thornton Water Treatment Plants, but flow is desired at one or both of the return flow structures. The two return flow structures are the Greeley No. 2 canal structure and the Cache la Poudre River structure. Minimum flow to the return flow structures is 3.5 mgd. Maximum flow for each return flow structure is 3.5 mgd each, for a total of 7.0 mgd. After selecting Return Flows Only Auto mode, the operator must choose flow rate to each structure in 0.5 mgd increments, for a total flow between 3.5 and 7.0 mgd. If one structure is offline, the constant flow rate of 3.5 mgd can be pumped through the active structure.
 - a) The duty 600 HP Pump (PMP – 301 or PMP – 302) will start at 50% speed and ramp up until flow has stabilized. It is anticipated that the pump station flow rate will fluctuate by a certain percentage above and below the return flow structure flow rate.
 - b) The sleeve valve (VAL-xx and VAL - xx) at each location will modulate to achieve the flow setpoint for each structure.
 - c) For shutdown, the pump station will reduce the active pump to 50% speed over 1 minute before shutting off.
 - d) Simultaneously the sleeve valves will each modulate to 95 percent closed, and then close the remaining 5 percent over 300 seconds.
 - 2) Permissive Checks:
 - a) Source Water Pump Station is off before this mode can be activated.
 - b) Signal Hill Pressure Sensor to maintain a minimum of 20 psi.

- c) Intermediate High Point pressure sensor to maintain a minimum of 60 psi, only to be used if loss of signal from signal hill pressure sensor.
 - (1) Provide a selector for Signal Hill vs Intermediate High Point as primary for permissive. Default is Signal Hill.
- 3) Indicators and alarms:
 - a) Pressure Status
 - b) HIGH Pressure Alarm
 - c) Valve Percent Open Status for each sleeve valve.
 - d) Valve On-Line Status for each sleeve valve.
 - e) Flow Rate Status
 - f) Loss of Signal Alarm
- f. Lower Clear Creek to Cooley Diversion Auto Mode:
 - 1) Abstract: Lower Clear Creek (LCC) PRV and meter will operate to divert flow from the TWP to the Cooley Reservoir. Manual isolation valves (VAL – 351, and VAL – 352) status will be confirmed and entered by operations manually into the SCADA (must be started at the LCC LOI and confirmed by SCADA operator remotely). An operator that is physically located at the LCC PRV LOI will enter rate from 5.4 to 22.9 cubic feet per second (3.5-14.8 mgd). The sleeve valve (VAL – 300) will modulate until the desired flow setpoint is reached at the LCC flowmeter (FIT-750) downstream. Flow rate is not controllable through SCADA and only controllable at the local LOI. However, the ability to STOP is available through SCADA and will close the sleeve valve.
 - a) The Source Water Pump Station will operate between a low pressure of 20 PSI and a high pressure of 175 PSI at Signal Hill (PIT-PSV)
 - b) The operator at the local LOI will input the minimum flow of 3.5 mgd to start and the sleeve valve (VAL – 300) will modulate to achieve this flow. After the 3.5 setpoint is reached, the operator can increase the flow in 1 mgd increments per 60-second duration to a maximum of 14.8 mgd.
 - c) For flow rates between 3.5 and 8.5mgd, the Source Water Pump Station will start the Duty 600 HP pump (PMP – 301 or PMP – 302) at 50 percent speed and ramp up to 100 percent over 1 minute.
 - d) For flow rates between 8.5 mgd and 14.8 mgd, the Source Water Pump Station will start the Duty 3,000 HP (PMP – 304 or PMP 305) at 50 percent speed and increase to 70 percent speed over 1 minute. The 600 HP pump will then shutdown.
 - e) For shutdown, the pump station will reduce the active pump to 50% speed over 1 minute before shutting off.
 - f) Simultaneously the sleeve valve will modulate to 95 percent closed, and then close the remaining 5 percent over 300 seconds.
 - 2) Permissive Checks:
 - a) Source Water Pump Station is off before this mode can be activated.
 - b) Confirmation button in SCADA to prompt operator verification that manual valve positions are correct.

- c) Initiate LCC diversion from LOI on site.
 - (1) Confirmation button in SCADA for Wes Brown operator to start.
 - 3) Indicators and alarms:
 - a) Pressure Status
 - b) HIGH Pressure Alarm
 - c) Valve Percent Open Status
 - d) Valve On-Line Status
 - e) Flow Rate Status
 - f) Loss of Signal Alarm
 - g) LSH – Water On Floor Alarm
- B. Source Water Pump Station Intake Structures:
 - 1. General:
 - a. References:
 - 1) P&ID drawings:
 - a) 30N30.
 - b. Key equipment:
 - 1) Lower and Upper Intake Structures:
 - 2) Level Transmitter.
 - a) LIT-301.
 - b) LIT-302.
 - c. Abstract:
 - 1) The Source Water Pump Station receives water from an upper and lower intake structure. These gates have hydraulic controls with Position Sensors and Fault Status. A level signal determines operations. The system provides level, high level alarm, and low level alarm to the SCADA system along with specific manufacturer alarms.
 - 2. Hardwired controls:
 - a. Pilot devices:
 - 1) Field:
 - a) None.
 - 2) LCP:
 - a) None.
 - 3) Drive/starter enclosure:
 - a) None.
 - 4) VCP:
 - a) FAULT Alarm.
 - b) POSITION Status.
 - b. Interlocks:
 - 1) Drive/starter enclosure:
 - a) Position Status.
 - b) Fault Alarm.
 - 2) VCP.
 - c. Indicators and alarms:
 - 1) Field:
 - a) Level.
 - b) High Level Alarm.
 - c) Low Level Alarm.
 - 2) LCP:
 - a) None.

3. PCS controls:
 - a. Manual mode:
 - 1) Manual Fill – These gates are hydraulically controlled and only operate manually. Position status and Fault Alarm are sent to the SCADA to help determine operations.
 - b. Indicators and alarms:
 - 1) Refer to Drawings for indicators and alarms.
 - 2) Additional indicators and alarms:
 - (1) Low Level Alarm.
 - (2) Gate Fault Alarm.
4. LOI control:
 - a. Monitoring and control. Refer to PCS control, indicators, and alarms.

3.02 TESTING

- A. As specified in Section 40_80_01 - Commissioning for Instrumentation and Controls.

END OF SECTION

SECTION 40_64_01

CONTROL SYSTEMS: PROGRAMMABLE LOGIC CONTROLLERS

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Programmable logic controller (PLC) based control systems hardware.
 - 2. Development software to be used with the specified PLC hardware.

1.02 REFERENCES

- A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.
- B. Abbreviations:
 - 1. CPU: Central processing unit.
 - 2. I/O: Input/Output.
- C. Standards:
 - 1. Institute of Electrical and Electronics Engineers (IEEE).

1.03 TERMINOLOGY

- A. The words and terms listed below are not defined terms that require initial capital letters, but, when used in this Section, have the indicated meaning.
 - 1. Application software: Software that is programmed specifically for the Project.
 - 2. Development operating software: Software provided by the PLC manufacturer for use in programming the PLC.

1.04 SUBMITTALS

- A. Furnish Submittals as specified in Section 01_33_00 - Submittal Procedures and Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.
- B. Product data:
 - 1. CPU:
 - a. Processor type.
 - b. Processor speed.
 - c. Memory.
 - d. Internal processor battery backup time.
 - 2. I/O modules:
 - a. Type.
 - b. Standard wiring diagram.
 - 3. Programming languages.
 - 4. Operating system requirements.

- C. Calculations:
 - 1. Calculations or documented estimate to verify that memory requirements of this Section are met, including spare requirements. If possible, use the PLC manufacturer's calculation or estimating worksheet.
 - 2. Calculations to verify that spare I/O requirements of this Section are met.
 - 3. Calculations to verify that PLC power supply requirements of this Section are met.
- D. Control logic:
 - 1. Fully annotated copy of programmed PLC logic.
 - 2. Cross-referenced index of PLC registers or points.
- E. Provide application software for the specific Project process requirements:
 - 1. Fully annotated copy of programmed PLC logic in its native format.
 - 2. Cross-referenced index of PLC registers or points.

1.05 QUALITY ASSURANCE

- A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.
- B. Provide PLC hardware manufactured at facilities certified to the quality standards of ISO 9001.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.

1.07 PROJECT OR SITE CONDITIONS

- A. As specified in Section 01_81_50 - Design Criteria.

1.08 ADMINISTRATIVE REQUIREMENTS (NOT USED)

1.09 WARRANTY

- A. As specified in Section 01_78_36 - Warranties and Bonds.

1.10 MAINTENANCE

- A. Furnish the following:
 - 1. CPU: 1 spare for each type of CPU in the system.
 - 2. I/O cards: 3 spares for each type of I/O card in the system.
 - 3. Power supplies: 2 spares for each type of power supply in the system.
 - 4. Network/communications cards: 2 spares for each type of network or communications card in the system.
 - 5. Remote adapter: 2 spares for each type of remote adapter in the system.
 - 6. Chassis: 2 spares for each chassis size in the system.
 - 7. Communication cable: 2 spares for each type of cable used in the system.

- B. Installed spare requirements:
 - 1. I/O points:
 - a. Provide total of 25 percent spare I/O capacity for each type of I/O at every PLC/RIO rack using the following calculation:

$$\left(1 - \frac{\text{UTILIZED IO POINT COUNT}}{\text{TOTAL IO POINT COUNT}}\right) * 100 = \% \text{SPARE}$$
 - b. Wire spare I/O points to field terminal blocks in the same enclosure the PLC/RIO resides in.
 - 2. PLC backplane capacity:
 - a. Provide 25 percent or 3 spare backplane slots, whichever is greater, in racks containing I/O.
 - 3. PLC memory:
 - a. Provide 50-percent spare program volatile memory.

PART 2 PRODUCTS

2.01 GENERAL

- A. Provide PLC hardware as indicated on the Drawings and as specified in this Section.

2.02 DESIGN AND PERFORMANCE CRITERIA

- A. Provide PLC system components by a single manufacturer:
 - 1. Third-party communication modules may be used only for communication or network media functions not provided by the PLC manufacturer.
- B. Use PLC manufacturer approved hardware, such as cable, mounting hardware, connectors, enclosures, racks, communication cable, splitters, terminators, and taps.
- C. PLC hardware, CPUs, I/O devices, and communication devices shall be new, free from defects, and produced by manufacturers regularly engaged in the manufacture of these products.
- D. Wherever possible, use the same model of each PLC module type throughout the Project.

2.03 MANUFACTURERS

- A. One of the following no equal:
 - 1. Modicon:
 - a. M580, BMEP58 Series.
- B. PLC programming software system shall be manufactured by PLC hardware manufacturer:
 - 1. Modicon:
 - a. Latest version of EcoStruxure Control Expert, no equal.

2.04 MANUFACTURED UNITS

A. Programmable logic controller:

1. Construction:
 - a. Furnish plug-in modular system.
 - b. Capable of operating in a hostile industrial environment without fans, air conditioning, or electrical filtering:
 - 1) Temperature: 0 to 55degrees Celsius.
 - 2) RFI: 80 to 1,000 MHz.
 - 3) Vibration: 10 to 500 hertz.
 - 4) Humidity: 0 to 95 percent.
 - c. Provide internal power supplies designed to protect against overvoltage and frequency distortion characteristics frequently encountered with the local power utility.
 - d. Design the PLC system to function as a standalone unit that performs all of the control functions described in this Section completely independent from the functions of the HMI system PC-based operator interfaces:
 - 1) Failure of the HMI system shall not impact data acquisition, control, scaling, alarm checking, or communication functions of the PLC.
2. CPU:
 - a. Configure each CPU so that it contains the software relays, timers, counters, number storage registers, shift registers, sequencers, arithmetic capability, and comparators necessary to perform the specified control functions.
 - b. Capable of interfacing with discrete inputs, analog inputs, discrete outputs, analog outputs, and communication cards to meet the specified requirements.
 - c. Capable of supporting and implementing closed-loop floating-point math and PID control that is directly integrated into the CPU control program.
3. Memory:
 - a. Non-volatile memory: On-board complementary metal-oxide-semiconductor (CMOS), electrically erasable programmable read-only memory (EEPROM), PCMCIA, compact flash card, or SD card.
 - b. Supply with sufficient memory to implement the specified control functions plus a reserve capacity as specified with the requirements of this Section:
 - 1) Reserve capacity:
 - a) Totally free from any system use.
 - 2) Programmed in a multi-mode configuration with multiple series or parallel contacts, function blocks, counters, timers, and arithmetic functions.
4. Programming:
 - a. Provide a system where processors are programmed by:
 - 1) Portable laptop computer both locally and via the PLC control network.
5. PLC power supply:
 - a. Input: 120 VAC.
 - b. Mounted in the PLC housing or as indicated on the Drawings.
 - c. Sized to power modules mounted in that housing, including an average module load for any empty housing slots, plus 50 percent above that total.

6. PLC input/output, I/O modules:
 - a. General:
 - 1) Compatible with all PLCs being furnished under the Contract and by the same manufacturer as the PLCs.
 - 2) Provide I/O modules that:
 - a) Isolate in accordance with IEEE Surge Withstand Standards and NEMA Noise Immunity Standards.
 - b) Provide A/D and D/A converters with optically or galvanically isolated inputs and outputs.
 - c) Accept dual-ended inputs.
 - 3) Use of common grounds between I/O points for modules that require individual isolation is not acceptable.
 - 4) Provide modules that are removable without having to disconnect wiring terminals:
 - a) Utilize a swing-arm or plug-in wiring connector.
 - 5) Provide at each PLC the I/O modules for the following:
 - a) Designated future I/O points contained in the I/O lists and/or shown on the P&IDs, control schematics, or described in the control strategies.
 - b) Installed spare capacity in accordance with the requirements of this Section.
 - c) Wire spares provided to the field terminal strip.
 - 6) Condition, filter, and check input signals for instrument limit conditions.
 - 7) Filter, scale, and linearize the raw signal into an engineering-units-based measurement.
 - 8) Alarm measurements for high, low, rate-of-change limits, and alarm trends.
 - 9) Provide external fuses mounted on the field connection terminal block for discrete input, discrete output, and analog input I/O points.
 - 10) When multiple cards of the same I/O type are provided and parallel equipment, instrumentation, or redundant processes exist, distribute I/O among cards to ensure that a single card failure will not render an entire process unavailable.
 - b. Discrete input modules:
 - 1) Defined as contact closure inputs from devices external to the input module.
 - 2) Provide inputs that are optically isolated from low-energy common-mode transients to 1,500 volts peak from users wiring or other I/O modules.
 - 3) Individually isolated inputs.
 - 4) With LEDs to indicate status of each discrete input.
 - 5) Input voltage: 120 VAC.
 - 6) Provide input module points that are individually fused with blown-fuse indicator lights, mounted external of the module on the output terminal strip:
 - a) Coordinate external fuse size with the protection located on the module so that the external fuse opens first under a fault condition.

- c. Discrete output modules:
 - 1) Defined as contact closure outputs for ON/OFF operation of devices external to the output module:
 - a) Triac outputs may be used with the permission of the Engineer. Care must be used in applying this type of module to ensure that the leakage current through the output device does not falsely signal or indicate an output condition.
 - 2) Optically isolated from inductively generated, normal mode and low-energy common-mode transients to 1,500 volts peak.
 - 3) LEDs to indicate status of each output point.
 - 4) Output voltage: 120 VAC.
- d. Analog input modules: individually isolated.
 - 1) Signal type: Provide 4 to 20 mA for most applications; other levels are acceptable to interface to vendor control panels.
 - 2) Analog-to-digital conversion: Minimum 12-bit precision with the digital result entered into the processor.
 - 3) Analog-to-digital conversion updated with each scan of the processor.
 - 4) Individually isolated each input.
 - 5) Coordinate the size of the external fuse with the protection located on the module, so that the external fuse opens first under a fault condition.
 - 6) Provide field mounted surge suppression modules for analog signals that are located outside the building that houses the PLC node:
 - a) Manufacturers: One of the following or equal:
 - (1) Emerson/Edco, model SS65-036-2, or similar for loop powered field instruments.
 - (2) Emerson, model 265 (SLAC) series.
 - (3) Phoenix Contact, PLUGTRAB SEC series, or similar for field instruments that require auxiliary power (24 VDC/VAC, 120 VAC, 230 VAC).
- e. Analog output modules:
 - 1) Signal type: Provide 4 to 20 mA for most applications; other levels are acceptable to interface to vendor control panels.
 - 2) Individual isolated output points each rated for loads of up to 1,000 ohms.
- 7. Communications modules:
 - a. Remote I/O adapter module:
 - 1) For any PLC location requiring more than 1 housing to mount all of the I/O modules or that is identified as a RIO, provide the appropriate remote I/O adapter module for communication with the secondary housing(s).
 - 2) Install the RIO adapter module in the PLC backplane and the RIO backplane.
 - 3) Provide adapter modules that support all available types of I/O modules required.
 - 4) Provide network taps, connectors, termination resistors, drop cables, and trunk cables necessary for remote I/O communications.
 - 5) Complete diagnostic LEDs.

- b. Network communications modules:
 - 1) General:
 - a) Install communications modules in the PLC backplane.
 - 2) Ethernet:
 - a) Ports: 3 RJ-45.
 - b) Communication rate: 10BASE-T/100BASE-TX.
 - c) Modicon M580: BMENOC0301.
 - 3) Serial link:
 - a) Ports: 2 RS-485/RS-232 RJ-45.
 - b) Communication rate: 57.6 kbits/s.
 - c) Modicon X80: BMXNOM0200.
 - 4) Provide network taps, connectors, termination resistors, drop cables, and trunk cables necessary for remote I/O communications.
 - 8. PLC backplane housing:
 - a. Mount the PLC power supply, CPU, communications module, and I/O modules in a suitable standard PLC backplane or housing.
 - b. Provide spare slots in each PLC and RIO location in accordance with the requirements of this Section.
 - c. Provide a blank slot filler module for each spare slot.
- B. PLC programming software:
 - 1. Furnished by Others.
- C. General control functions:
 - 1. Analog control functions:
 - a. PID, lead/lag, signal select, alarm, limit, delay, and time base.
 - b. Furnish the control system complete with a library of mathematical/calculation software to support averaging, weighted average, addition, subtraction, multiplication, division, square root extraction, exponential, AND, OR, NAND, NOR, XOR, and NXOR functions.
 - c. Math utilities must be linkable to process data points or manual inputs via control block configuration.
 - d. By linking control blocks to data points, the math library must support system unit conversion and calculation requirements.
 - 2. Discrete control functions:
 - a. AND, OR, NOT, EXCLUSIVE OR, comparators, delays, and time base.
 - 3. Control and status discrepancies:
 - a. Generate a discrepancy/fail alarm for any pump, valve, or final control element if a discrepancy exists between a system or operator command and the device status:
 - 1) For example: System commands to start (call) and the pump fails to start (run status report back) within a predetermined operator-programmable time delay (time disagree), then a discrepancy (fail) alarm shall be generated.
 - b. Involuntary change in the device's status must also generate an alarm:
 - 1) For example, a pump starts when not commanded to do so, or a pump shuts down while running even though it still has a command to run.
 - c. Each command, status, and alarm must cause the color of the symbol to change.

- d. Because many discrete final control elements have a cycle time in excess of the scan interval, provide each control output with an associated delay period selected to be longer than the operating period of the control element:
 - 1) Delay periods for each final control element must be adjustable at the operator interface.
 - 2) List time delays in the final documentation.
 - 4. Some of the above functions may be better accomplished in the data acquisition and graphic display software package; it is the responsibility of the ICSC to optimize the location of the various functions between all software packages.
- D. Control configuration:
 - 1. Provide software to allow control strategies to be developed and their operation initiated through the operator interface.
 - 2. Provide standardized control point displays for defining the control functions, including the function type, input/output addresses, setpoints, tuning constants, etc.
 - 3. Provide a mechanism to link separate control functions together into an integrated control strategy.
 - 4. Provide a mechanism to download operational/control setpoints developed at any operator interface to any PLC or RTU for operational implementation.
 - 5. Provide a mechanism to define and implement operational/control setpoints locally at the PLC or RTU and to upload them to the operator interface for operational record-keeping.
 - 6. Perform control configurations online at the operator interface; the PLC or RTU may be taken offline when being configured or downloaded.
- E. Remote inputs and outputs (RIOS):
 - 1. Compatible with all PLCs being furnished under this Contract, shall be by the same manufacturer as the PLCs, and, as a minimum, include:
 - a. Power supply.
 - b. Rack.
 - c. Backplane.
 - d. Communications module.
 - e. I/O modules.
 - f. Enclosure.
 - 2. Provide cables and software needed for a complete and operational RIO system as specified in the Contract Documents.
 - 3. Provide a group of pre-assigned diagnostic registers to report RIO system faults to the driver PLC.
 - 4. Control system must continue operation should a fault occur on a single RIO drop:
 - a. Upon clearing the fault, restart communications to that drop automatically.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 INSTALLATION

- A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.
- B. Utilize personnel to accomplish or supervise the physical installation of all elements, components, accessories, or assemblies:
 - 1. Employ installers who are skilled and experienced in the installation and connection of all elements, components, accessories, and assemblies.
- C. All components of the control system, including data network cables, are the installation responsibility of the ICSC unless specifically noted otherwise.
- D. Control system logic program shall reside at the PLC level.
- E. Use the tag and loop identifications found on the P&IDs for all tags used and/or assigned as part of the application software work provided by the ICSC.
- F. Program the PLC logic using the following language(s):
 - 1. Function Block Diagram.

3.03 TESTING

- A. As specified in Section 40_80_01 - Commissioning for Instrumentation and Controls.

3.04 OWNER TRAINING

- A. As specified in Section 40_80_01 - Commissioning for Instrumentation and Controls.

END OF SECTION

SECTION 40_64_21

CONTROL SYSTEMS: LOCAL OPERATOR INTERFACE (LOI)

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Local operator interface (LOI) control systems hardware and software.

1.02 REFERENCES

- A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.

1.03 SUBMITTALS

- A. Furnish Submittals as specified in Section 01_33_00 - Submittal Procedures and Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.
- B. Product data:
 - 1. Complete manufacturer's brochures for the following:
 - a. LOI hardware.
 - b. LOI programming software.
 - 2. Manufacturer's operation and installation instructions.
 - 3. Additional requirements:
 - a. Display type and size.
 - b. Operator input.
 - c. Processor type and speed.
 - d. Memory size.
 - e. Programming protocols.
 - f. Communication protocols.
 - g. Power requirements.
 - h. Operating temperature and humidity ranges.
 - i. NEMA ratings.
- C. Shop Drawings:
 - 1. System block diagram showing relationship and connections between devices. Include manufacturer and model.
 - 2. Mounting drawings with dimensions and elevations for each equipment location, including identification of all components, preparation and finish data, and nameplates.
 - a. Electrical connection diagrams.
 - b. Complete grounding requirements.
 - 3. Graphic screens:
 - a. Color printouts of each graphic screen and all control pop-ups.

4. Datasheets for each component together with a technical product brochure or bulletin:
 - a. Manufacturer's model number.
 - b. Project equipment tag.
 5. Complete and detailed bills of materials identified by each cabinet. Include with each bill of material item the following:
 - a. Quantity.
 - b. Description.
 - c. Manufacturer.
 - d. Part numbers.
- D. Owner Training Submittals:
1. As specified in Section 01_75_17 - Commissioning.
- E. Operation and maintenance manuals:
1. As specified in Section 01_78_24 - Operation and Maintenance Manuals.
- F. Record documents:
1. Electrical connection diagrams revised to reflect any changes made in the field and submitted as record drawings.

1.04 QUALITY ASSURANCE

- A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.
- B. Examine the complete set of Contract Documents and verify that the LOI equipment is compatible with the installed conditions.
- C. Notify the Engineer if any installation condition does not meet the manufacturer's recommendations or specifications.
- D. System compatibility:
 1. Software must be the standard operating software system designed specifically for use with the LOI hardware.
 2. Software must be furnished and developed by the manufacturer of the LOI hardware.

1.05 DELIVERY, STORAGE, AND HANDLING

- A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.

1.06 PROJECT OR SITE CONDITIONS

- A. As specified in Section 01_81_50 - Design Criteria:
 1. Provide LOI equipment suitable for the installed Site conditions, including, but not limited to, Site altitude, Site seismic conditions, humidity, and ambient temperatures.

1.07 ADMINISTRATIVE REQUIREMENTS (NOT USED)

1.08 WARRANTY

- A. As specified in Section 01_78_36 - Warranties and Bonds.

1.09 MAINTENANCE

- A. Provide system upgrades and maintenance fixes for a period of 2 years from Substantial Completion.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. The following or approved equal:
 - 1. Schneider Electric, Harmony GTU Touch Smart Display.
- B. Provide the LOI graphic software system manufactured by the LOI hardware manufacturer.
- C. One of the following or equal:
 - 1. Schneider Electric, Vijeo Designer.

2.02 MANUFACTURED UNITS

- A. Local Operator Interface:
 - 1. General:
 - a. Provide Local Operator Interface located on the face of the PCM as indicated on the Drawings.
 - b. NEMA 4X rated.
 - c. Local Operator Interface consists of graphical display screen with operator input capabilities.
 - d. Capable of stand-alone operation in conjunction with 1 PLC.
 - e. Equipped with data network communication capabilities.
 - 2. Display:
 - a. Type: Color TFT LCD screen.
 - b. Resolution: 1024 x 768 pixels.
 - c. Size: 15-inch.
 - d. Easy display viewing at any angle in various ambient light conditions.
 - e. Operator input:
 - 1) Configurable touch screen.
 - f. Screen update speed: The screen update speed and screen change speed less than 1 second.
 - g. Provide following features for outdoor use:
 - 1) Anti-glare screen overlay.
 - 2) Luminescence: Minimum 1,000 Nits.
 - 3. Graphic configuration:
 - a. Easily configured graphics by:
 - 1) Portable laptop computer both locally and via the PLC data network.
 - 2) SCADA Construction Manager's console via the PLC data network.
 - b. As specified in this Section.

- 4. Memory:
 - a. System:
 - 1) RAM: 256 MB minimum.
 - 2) Storage: 512 MB minimum.
 - 5. CPU: Minimum 100 MHz.
 - 6. Communications:
 - a. Ethernet.
 - b. Dual LAN port.
 - 7. Environment:
 - a. Temperature: 0 to 50 degrees Celsius.
 - b. Relative humidity: 10 to 90 percent.
 - 8. Electrical:
 - a. Power supply:
 - 1) 24 VDC.
- B. Local Operator Interface software:
- 1. Furnished by Others.

PART 3 EXECUTION

3.01 INSTALLATION

- A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.
- B. All components of the control system including all data network cables are the installation responsibility of the ICSC unless specifically noted otherwise.
- C. Provide panel support bracing if more than 25 percent of the area has been removed to allow for the mounting of the LOI.
- D. All tags used and/or assigned as part of the application programming work are to use the tag and loop identifications found on the P&IDs.
- E. Station graphics, provided by Others:
 - 1. Configure the graphic display for each device both in the treatment plant, and/or process area, including but not limited to:
 - a. Symbols for:
 - 1) Pumps.
 - 2) Valves.
 - 3) Major instruments.
 - 4) Flowmeters.
 - 5) Pressure transmitter.
 - 6) Major equipment.
 - b. Alarm symbols including intrusion alarm.
 - c. Relevant test and operational data.
 - d. Status for each controller or controlled device:
 - 1) Hand-Off-Auto Status.
 - 2) Local-Off-Remote Status.
 - 3) Run.
 - 4) Call.

- 5) Fail.
- 6) Open.
- 7) Close.
- 8) Hold.
- 9) Modulate.
- 10) Running.
- e. Depict a change of state of pumps and valves by a change in color.
- 2. Production and usage bar graph:
 - a. Depict the production for each site and/or piece of equipment, as determined during the requisite graphics meeting, within the treatment plant, summarized to type, and total usage, with a bar graph and numeric value for each analog value.
- 3. System level summary:
 - a. Show the level for the plant influent and effluent production, etc., via a display using bar graphs and numbers, as determined during the requisite graphics meeting.

3.02 CLEANING

- A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.

3.03 DEMONSTRATION AND TRAINING

- A. Perform the training using pre-approved and qualified representatives of the ICSC and or manufacturer:
 - 1. A representative of the ICSC may perform the training only if the representative has completed the manufacturer's training course for the LOI.

END OF SECTION

SECTION 40_66_01

CONTROL SYSTEMS: NETWORK MATERIALS AND EQUIPMENT

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Materials and equipment used in process control and LAN networks, including:
 - a. Network switches.
 - b. Media converters.
 - c. Routers.
 - d. Ethernet Remote I/O with Ethernet switch modules.
 - e. Patch panels and other data network hardware.
 - f. Related accessories.

1.02 REFERENCES

- A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.
- B. Standards:
 - 1. Electronic Industries Alliance (EIA):
 - a. 310-E - Cabinets, Racks, Panels, and Associated Equipment.
 - 2. Institute of Electrical and Electronics Engineers (IEEE):
 - a. 802.1X - Standard for Local and Metropolitan Area Networks—Port-Based Network Access Control.
 - b. 802.3 - Standard for Ethernet.
 - c. 802.11b - Standard for Information Technology - Telecommunications and information exchange between systems - Local and Metropolitan networks - Specific requirements - Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) specifications: Higher Speed Physical Layer (PHY) Extension in the 2.4 GHz band.
 - 3. National Electrical Manufacturers Association (NEMA):
 - a. 250 - Enclosures for Electrical Equipment (1,000 V Maximum).
 - 4. National Fire Protection Association (NFPA):
 - a. 70 - National Electrical Code (NEC).
 - 5. Telecommunications Industry Association (TIA):
 - a. 569 - Telecommunications Pathways and Spaces.
 - b. 607 - Generic Telecommunications Bonding and Grounding (Earthing) for Customer Premises.
 - 6. Underwriters Laboratories, Inc. (UL).

1.03 DELEGATED DESIGN

- A. As specified in Section 01_35_73 - Delegated Design Procedures.
- B. Anchoring and bracing.

1.04 SUBMITTALS

- A. Furnish Submittals as specified in Section 01_33_00 - Submittal Procedures.
- B. Product data:
 - 1. Include information on all network equipment.
 - 2. Manufacturer's operation and installation instructions.
- C. Shop Drawings:
 - 1. Complete set of drawings, including, but not limited to:
 - a. System block diagram showing relationship and connections between devices provided under this Contract, including connections to any existing equipment.
 - b. Include manufacturer and model information and address settings.
 - c. Network riser diagram.
 - d. Network port diagram, which physically locates all ports within the facility, and identifies their patch panel and switch port.
 - e. Construction drawings for equipment cabinets, including dimensions, identification of components, preparation and finish data, and nameplates.
 - f. Electrical connection diagrams.
 - g. Complete grounding requirements.
 - 2. Furnish data sheets for each component together with a technical product brochure or bulletin:
 - a. Manufacturer's model number.
 - b. Project equipment tag.
 - 3. Complete and detailed bills of materials broken up by each cabinet. Each bill of material item will include the following:
 - a. Quantity.
 - b. Description.
 - c. Manufacturer.
 - d. Part numbers.
- D. Delegated Design Submittals:
 - 1. Anchoring and bracing: Provide project-specific calculations based on support conditions and requirements to resist loads specified in Section 01_81_50 - Design Criteria.
 - a. To structures for equipment installed in structures designated as seismic design category C, D, E, or F.
- E. Calculations:
 - 1. Cooling calculations, including, but not limited to:
 - a. Highest expected ambient temperature for the enclosure's location.
 - b. Internal heat load.
 - c. Exposure to direct sunlight.
 - d. Dimensions of the enclosure in inches.
 - e. Maximum allowable temperature inside the enclosure, based on the lowest operating temperature limit of the installed components.
- F. Test reports:
 - 1. As specified in Section 26_05_20 - Fiber Optic Cable and Appurtenances and Section 40_80_01 - Commissioning for Instrumentation and Controls.

2. Signed test results as described in this Section.
 3. Test results shall include:
 - a. Narrative describing the test procedures followed.
 - b. Block diagram of test set up.
 - c. Manufacturer's information on test equipment used.
 - d. Detailed test results.
 - e. A narrative summarizing the results of the testing and identifying any further action required.
- G. Operating manuals:
1. Complete installation, operation, calibration, and testing manuals as specified in Section 01_75_17 - Commissioning.
- H. Record drawings:
1. As specified in Section 40_80_01 - Commissioning for Instrumentation and Controls.
 2. Electrical connection diagrams shall be revised to reflect any changes made in the field and submitted as record drawings.

1.05 QUALITY ASSURANCE

- A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.

1.06 PROJECT OR SITE CONDITIONS

- A. As specified in Section 01_81_50 - Design Criteria.

1.07 ADMINISTRATIVE REQUIREMENTS (NOT USED)

1.08 WARRANTY

- A. As specified in Section 01_78_36 - Warranties and Bonds.

PART 2 PRODUCTS

2.01 GENERAL (NOT USED)

2.02 DESIGN AND PERFORMANCE CRITERIA

- A. Vendor shall manufacture using low VOC-based materials to provide superior indoor air quality demonstrated by Greenguard certification.

2.03 MANUFACTURERS

- A. As listed below in the individual component paragraphs.

2.04 MANUFACTURED UNITS

A. Ethernet switches:

1. Managed enterprise Ethernet switches:
 - a. Manufacturers: The following or approved equal:
 - 1) Cisco, Catalyst 9300.
 - a) 48-port UPOE: C9300-48U-E.
 - b) 24-port PoE+: C9300-24P-E.
 - b. Properties:
 - 1) Hardware:
 - a) 19-inch rack mountable switch.
 - b) Power supply:
 - (1) Provide redundant power supplies.
 - (2) 120 VAC, 60 hertz, 1 phase, 1,600 watts.
 - c) Console management port.
 - d) Open module slots for the addition of modules, as described below.
 - e) Full power over ethernet (PoE+) enabled.
 - 2) Performance:
 - a) Switching capacity: 92 Gbps, minimum.
 - b) Address table size: 8,000 entries, minimum.
 - c) Gigabit throughput.
 - 3) Environment:
 - a) Operating temperature range: 32 to 113 degrees Fahrenheit.
 - b) Humidity: 10 to 90 percent, non-condensing.
 - 4) Capable of performing basic switching without special programming or configurations. Additional features available through software setup includes, but is not limited to:
 - a) Layer 3 routing.
 - b) Port monitoring.
 - c) Remote switch management.
 - d) Port security.
 - e) Rapid spanning tree protocol.
 - 5) Connections:
 - a) Copper: RJ-45.
 - (1) Standard: 1000BASE-T.
 - (2) Auto-negotiating.
 - (3) Quantity: As required to provide network connections indicated on the Drawings, plus 20 percent spare.
 - b) Fiber: SFP port.
 - (1) Quantity: As required to provide network connections indicated on the Drawings, plus 20 percent spare or 4 total, whichever is greater.
 - c) Digital optical monitoring (DOM).
 - d) Provide modules required to provide network connections as indicated on the Drawings.
 - 6) Spare parts:
 - a) Provide the following spare components:
 - (1) 1 spare module of each type provided.
 - (2) 1 spare Ethernet switch backplane.
 - (3) 2 spare SFP transceivers of each type provided.

2. Managed process Ethernet switches:
 - a. Manufacturers: The following or approved equal:
 - 1) Moxa EDS-G4012 Series.
 - b. Properties:
 - 1) Hardware:
 - a) Power supply:
 - (1) Accepts redundant power feeds.
 - (a) Provide NEC Class 2 power circuit.
 - (b) 24 VDC, 100 VA maximum rating.
 - b) No fans or moving parts.
 - 2) Performance:
 - a) Enclosure:
 - (1) All metal housing.
 - b) Capable of performing basic switching without special programming or configurations. Additional features available through software setup includes, but is not limited to:
 - (1) SNMP.
 - (2) VLAN.
 - (3) QoS.
 - (4) Port mirroring.
 - (5) DHCP server.
 - c) IGMP snooping with EtherNet/IP plug and play compatibility.
 - d) 802.1d, 802.1w, 802.1D RSTP.
 - 3) Environment:
 - a) Operating temperature range: 32 to 140 degrees Fahrenheit.
 - b) Humidity: 10 to 95 percent, non-condensing.
 - 4) Connections:
 - a) Copper: RJ-45.
 - (1) Auto-negotiating.
 - (2) Quantity: As required to provide network connections indicated on the Drawings, plus 20 percent spare.
 - b) Fiber: Gigabit SFP port.
 - (1) Quantity: As required to provide network connections indicated on the Drawings, minimum 2.
 - 5) Mounting:
 - a) DIN-rail mounting.
 - b) As indicated on the Drawings.
- B. SFP transceivers:
 1. Provide Gigabit transceivers unless otherwise indicated, or as required to interface with other equipment:
 - a. Single-mode: 1000BASE-LX10 or 1000BASE-ZX10 for long distance application.
 - b. Multi-source agreement compliant.
 2. Manufacturers: The following or equal:
 - a. Cisco, unless transceivers are provided by Ethernet switch vendor.

- C. Ethernet Remote I/O with Ethernet switch modules:
1. Manufacturers: The following or approved equal:
 - a. Moxa, ioLogix E1200 series.
 - 1) Quantity: As required by the applications.
 - 2) As indicated in the Drawings.
 - b. Properties:
 - 1) Hardware:
 - a) Number of power inputs: One.
 - b) Input voltage: 12 to 36 VDC.
 - c) No fans or moving parts.
 - 2) Performance:
 - a) Peer-to-peer networking.
 - b) User-definable Modbus TCP addressing.
 - (1) Mode: Server (Slave).
 - (2) Functions supported: 1 through 6, 15, 16 and 23.
 - (3) Client connections: Up to 10.
 - (4) Ethernet/IP:
 - (a) Mode: Adapter.
 - (5) Scanner connections: 9 (for read-only), 1 (for read/write).
 - c) Uses active push communications to SCADA for communicating changes in state or when configured events occur.
 - d) Ability to daisy chain multiple modules.
 - e) Capable of performing basic switching without special programming or configurations. Additional features available through software setup includes, but is not limited to:
 - (1) RESTful API.
 - (2) SNMPv1/v2c.
 - (3) SNMPv1 Trap.
 - (4) HTTP.
 - (5) DHCP Client.
 - (6) BOOTP.
 - (7) IPv4.
 - (8) TCP/IP.
 - (9) UDP.
 - f) Security:
 - (1) Access control list.
 - (2) Authentication: Local database.
 - 3) Enclosure:
 - a) Rating: UL Listed.
 - b) Plastic.
 - c) Wiring:
 - (1) I/O connections: 16 to 26 AWG.
 - (2) Power connections: 12 to 24 AWG.
 - d) LED indicators:
 - (1) Power.
 - (2) Ready.
 - (3) Port 1.
 - (4) Port 2.

- 4) Environment:
 - a) Wide operating temperature range: -40 to 167 degrees Fahrenheit.
 - b) Humidity: 10 to 95 percent, non-condensing.
- 5) Connections:
 - a) Two switched Ethernet ports.
 - b) Copper: RJ-45.
 - (1) Auto-negotiating.
 - (2) Quantity: As required to provide network connections indicated on the Drawings, minimum 2.
 - (3) MAC address: One (Ethernet bypass).
 - (4) Magnetic isolation protection: 1.5 kV, built-in.
- 6) Ethernet software features:
 - a) Configuration:
 - (1) Web console (HTTP).
 - (2) Windows Utility (ioSearch).
 - (3) MCC Tool.
 - b) Industrial protocols supported:
 - (1) Modbus TCP Server (Slave).
 - (2) Ethernet/IP Adapter.
 - (3) Moxa AOPC (active tag).
 - (4) MXIO Library.
- 7) Input/output interfaces:
 - a) Inputs/outputs: Screw fastened terminal blocks.
 - b) Digital inputs:
 - (1) Dry or wet contact.
 - (2) Counter frequency: 250 Hz.
 - (3) Digital filtering time interval: User configurable.
 - (4) Points per module: 4, 8 or 16 channels, depending on selected model.
 - c) Digital outputs:
 - (1) Sink or source, depending on selected model.
 - (2) I/O mode: DO or pulse output.
 - (3) Current rating: 200 mA or 500 mA, depending on selected model.
 - (4) Pulse output frequency: 500 Hz, maximum.
 - (5) Over-current protection: 1.5 or 2.6 A per channel, depending on selected model.
 - (6) Over-temperature shutdown: 175 degrees C, typical, 150 degrees C, minimum.
 - (7) Over-voltage protection: 35 VDC.
 - (8) Points per module: 4, 8 or 16, depending on selected module.
 - d) Relay outputs:
 - (1) Contact configuration: Form A, normally open (NO).
 - (2) Output: Relay or pulse, user configurable.
 - (3) Output current rating: 5A at 30 VFD, 110 VAC, 250 VAC.
 - (4) Output frequency: 0.3 Hz.
 - (5) Points per module: 6.

- e) Analog inputs:
 - (1) I/O mode: Current or voltage.
 - (2) I/O type: Differential.
 - (3) Resolution: 16 bits.
 - (4) Input range: 4 to 20 mA (with burn-out detection), 0 to 20 mA, or 0 to 10 VDC.
 - (5) Sampling rate: 12 samples/second per module.
 - (6) Input impedance: 10 mega-ohms, minimum.
 - (7) Points per module: 4 or 8, depending on selected module.
 - f) Analog outputs:
 - (1) I/O mode: Current or voltage.
 - (2) I/O range: 4 to 20 mA, 0 to 20 mA, or 0 to 10 VDC.
 - (3) Resolution: 12 bits.
 - (4) Input range: 4 to 20 mA (with burn-out detection), 0 to 20 mA, or 0 to 10 VDC.
 - (5) Load (current mode):
 - (a) Internal power: 400 ohms, maximum.
 - (b) 24 V external power: 1,000 ohms, maximum.
 - (6) Voltage output: short-circuit protection: 10 mA.
 - (7) Points per module: 4.
 - 8) Mounting:
 - a) DIN-rail mounting.
 - b) As indicated in the Drawings.
 - 9) Software:
 - a) Provide one copy of OPU UA server software.
 - b) Moxa model MX-AOPC UA Server
 - c) Licensed to the Owner.
- D. Fiber optic splice closures:
- 1. Manufacturers: The following or approved equal:
 - a. Corning, T2178-LS series.
 - 2. Properties:
 - a. Closure shall be installed underground in existing manhole or handhole.
 - 1) Contractor shall verify that selected splice enclosure is sized properly to fit inside the existing manhole/handhole.
 - b. Provide manufacturer's modular splicing assembly comprised of a splice cassette, splice tray, and factory-terminated pigtails.
 - c. No special tool requirements.
 - d. Closure shall have capability to increase cable entry and splice capacity in after initial installation.
 - e. Splice application: Inline.
 - f. Minimum splice capacity: 288 strands.
 - g. Cable entry:
 - 1) Backbone ports: 2.
 - 2) Lateral ports: 2.

E. Patch panels:

1. Fiber optic patch panels:

a. General:

- 1) Optical fiber cables shall be provided with strain relief and terminated at a fiber patch panel. Final connections between the patch panel and the fiber optic network equipment shall be made via factory tested fiber optic patch cords.
- 2) Fiber cable strands shall be terminated at the patch panels; no loose fiber strands are allowed.
- 3) Provide space for excess fiber and provide strain relief for the fiber cable.
- 4) Fiber cables shall be installed such that the outer sheath of the cable is carried into the interconnect enclosure or patch panels before breaking out buffer tubes.
- 5) Fiber connectors: LC.

b. 19-inch rack mounted:

- 1) Manufacturers: One of the following or equal:
 - a) Corning.
 - b) Optical Cable Corporation (OCC).
 - c) Panduit.
- 2) Properties:
 - a) Housing:
 - (1) Use for combination of splicing and termination of fiber-optic building cable or outside plant cables.
 - (2) Up to 4U rack units in height.
 - (3) Fully enclosed.
 - (4) Interconnect and cross-connect capability.
 - (5) Modules shall be interchangeable.
 - (6) Compatible with connector panels, modules, and cassettes.
- 3) Accessories:
 - a) Hinged front doors.
 - b) Front cable management trough.
 - c) Top cover panel.
 - d) Configurable internal strain relief.
 - e) Blanks for unused connector panels.
 - f) Splice tray.

c. DIN-rail mounted:

- 1) Manufacturers: One of the following or equal:
 - a) Corning.
 - b) DINSpace, SNAP Cu.
 - c) Hirschmann, MIPP.
- 2) Properties:
 - a) Use for the termination of a single cable inside of cabinets, in small enclosures or as indicated on the plans.
 - b) DIN-rail mounted fiber patch panels shall be provided as a complete unit, including the housing, connector panels, splice trays, and fiber connectors.

d. Wall mounted:

- 1) Manufacturers: One of the following or equal:
 - a) Corning.
 - b) Optical Cable Corporation (OCC).

- 2) Properties:
 - a) Use for the termination of a single cable outside of cabinets, in small enclosures or as indicated on the plans.
 - b) Wall-mounted fiber patch panels shall be provided as a complete unit, including the housing, connector panels, splice trays, and the fiber connectors.
 - c) Physical protection for incoming and outgoing cables and patch cords.
- 3) Accessories:
 - a) Door lock.
 - b) Blanks for unused connector panels.
2. Copper patch panels:
 - a. General:
 - 1) Equipment and premises cables shall be terminated at a patch panel, except for field equipment connections.
 - 2) Final connections between the patch panel and network equipment shall be by patch cords.
 - 3) Provide factory tested copper patch cords as required to support network devices.
 - a) Provide 25 percent spare copper patch cords.
 - 4) Cables shall be installed such that the outer sheath of the cable is carried into the patch panel before breaking out conductors.
 - 5) Maintain twist of broken out conductors in accordance with TIA standards.
 - 6) UL listed.
 - 7) Properties:
 - a) Modular, all metal construction with built-in strain relief.
 - b) Compatible with both shielded and unshielded jack modules.
 - c) Patch panel and jack modules shall be by same manufacturer.
 - d) Utilizes jack modules for copper Ethernet cable termination.
 - e) Provided shielded jack modules with a 360-degree conductive path to ground as required by the installation. Install in accordance with the manufacturer's recommendation.
 - f) Patch panel and jack modules shall meet or exceed category cable standard.
 - g) Jack module shall be capable of at least 20 termination cycles.
 - h) Provide 25 percent spare jack modules of each type.
 - 8) Accessories:
 - a) Removable rear cable management bracket.
 - b) Rear individual port labels.
 - c) Front color-coded individual port labels.
 - d) Termination tool.
 - b. Manufacturers: One of the following or equal:
 - 1) 19-inch rack mounted:
 - a) CommScope, SL series.
 - b) OCC, DCC series.
 - c) Panduit, Mini-Com series.
 - 2) DIN-rail mounted:
 - a) DINSpace, SNAP XL.
 - b) OCC, DTC.

F. Network and server cabinets:

1. Conditioned space:

- a. Manufacturers: One of the following or equal:
 - 1) APC; Schneider NetShelter AR series.
 - 2) nVent; Schroff Varistar series.
 - 3) Panduit Net-Access N-Type series.
- b. Properties:
 - 1) In accordance with EIA-310-E.
 - 2) Dimensions:
 - a) Height: 42-rack units.
 - b) Width: 30 inches.
 - c) Depth: 42 inches.
 - 3) Rack:
 - a) 19-inch mounting brackets.
 - b) Enclosed.
 - c) Fully welded frame.
 - d) Minimum static load-carrying capacity: 1,000 pounds.
 - e) Seismic rated as specified in Section 01_81_50 - Design Criteria.
 - 4) Doors:
 - a) Perforated.
 - (1) Minimum 65 percent open area perforation pattern.
 - b) Lever handle single point lock.
 - c) 180-degree opening angle.
 - d) Reversible.
 - 5) Top:
 - a) Flat top with optional cut-out zones.
 - 6) Side panels:
 - a) Removable.
 - 7) Base plate:
 - a) As required by the installation.
- c. Accessories:
 - 1) Assembly kit.
 - 2) Grounding kit.
 - 3) Vertical ground bar for equipment grounding.
 - 4) Accessory mounting brackets as needed.
 - 5) Cable strain relief bars and organization hardware.
 - 6) Cut-out edge protectors.
 - 7) Leveling feet.
 - 8) Horizontal and vertical cable management.
 - 9) Hook and loop cable wraps, plastic cable ties are not acceptable.
 - 10) LED light controlled by a door switch with an additional manual toggle switch for turning off the lights when the door is open.
 - 11) Provide any additional accessories as needed for a fully functional installation.
 - 12) Provide thermal load management as required by thermal heat calculations.
 - 13) Provide quiet variable speed exhaust fan tray controlled by cabinet temperature.

2. Horizontal wall-mounted:
 - a. Manufacturers: The following or equal:
 - 1) nVent: Hoffman ProTek Double-Hinged series.
 - b. Properties:
 - 1) Enclosure:
 - a) NEMA 12.
 - b) Single window door on front.
 - (1) Provide scratch resistant safety glass.
 - c) Construction:
 - (1) Type 304 painted steel.
 - (2) 14 gauge.
 - (3) Continuously welded seams ground smooth.
 - (4) Double-hinged to provide front and rear access.
 - d) Dimensions:
 - (1) Height: 32-rack units.
 - (2) Width: 23 inches.
 - (3) Depth: 24 inches.
 - 2) Rack:
 - a) 19-inch full height rack angles.
 - b) Square rack holes.
 - c) Fully welded frame.
 - d) Minimum static load-carrying capacity: 400 pounds.
 - c. Accessories:
 - 1) Assembly kit.
 - 2) Grounding kit.
 - 3) Vertical ground bar for equipment grounding.
 - 4) Accessory mounting brackets as needed.
 - 5) Horizontal and vertical cable management.
 - 6) Cable strain relief bars and organization hardware.
 - 7) Hook and loop cable wraps.
 - 8) LED light controlled by a door switch with an additional manual toggle switch for turning off the lights when the door is open.
 - 9) Provide any additional accessories as needed for a fully functional installation.
 - 10) Provide thermal load management as required by thermal heat calculations.
3. Vertical wall-mounted:
 - a. Manufacturers: The following or equal:
 - 1) Tripp Lite.
 - b. Properties:
 - 1) Enclosure:
 - a) IP20 protection rating.
 - b) Lockable top panel door.
 - c) Reversible, lockable, vented front door with latch.
 - d) Vented bottom.
 - e) Wall-mounting holes.
 - f) Minimum load capacity of 150 pounds.
 - g) Construction:
 - (1) Heavy-duty steel with powder-coated finish.
 - (2) Continuously welded seams ground smooth.

- h) Dimensions:
 - (1) Height: 44 inches.
 - (2) Width: 27 inches.
 - (3) Depth: 12 inches.
 - 2) Rack:
 - a) 19-inch rack.
 - b) 6U horizontal rack.
 - c) 2U slide-out vertical rack at the top of the enclosure.
 - 4. Process area or outdoors:
 - a. Manufacturers: The following or equal:
 - 1) nVent; Hoffman FS66S Global Free Stand Series.
 - b. Properties:
 - 1) Enclosure:
 - a) NEMA 4X.
 - b) Single door on front and rear.
 - (1) Heavy-duty 3-point latching lockable handle.
 - c) Construction:
 - (1) Type 316L stainless steel.
 - (2) 12 gauge.
 - (3) Continuously welded seams ground smooth.
 - (4) Seismic rated as specified in Section 01_81_50 - Design Criteria.
 - d) Dimensions:
 - (1) Height: 42-rack units.
 - (2) Width: 32 inches.
 - (3) Depth: 32 inches.
 - 2) Rack:
 - a) 19-inch full height rack angles.
 - b) Square rack holes.
 - c) Fully welded frame.
 - d) Minimum static load-carrying capacity: 1,000 pounds.
 - c. Accessories:
 - 1) Assembly kit.
 - 2) Grounding kit.
 - 3) Vertical ground bar for equipment grounding.
 - 4) Accessory mounting brackets as needed.
 - 5) Horizontal and vertical cable management.
 - 6) Cable strain relief bars and organization hardware.
 - 7) Hook and loop cable wraps.
 - 8) LED light controlled by a door switch with an additional manual toggle switch for turning off the lights when the door is open.
 - 9) Provide any additional accessories as needed for a fully functional installation.
 - 10) Provide thermal load management as required by thermal heat calculations.

G. Automatic transfer switches (ATS):

- 1. Manufacturers: One of the following or equal:
 - a. APC; Schneider, Rack ATS series.
 - b. Eaton, EATS series.

2. Properties:
 - a. Dual redundant power source inputs.
 - b. Voltage shall be 120 VAC, unless otherwise indicated on the Drawings.
 - c. User selectable primary power source.
 - d. LED status indicators.
 - e. Command line interface.
 - f. Horizontal rack mounted.
 - g. Connections to match UPS connections and as indicated on the Drawings.
 - h. Communication:
 - 1) Ethernet:
 - a) ATS shall include Ethernet network communication card.
 - b) Network protocols: SNMP.
 - c) Network interface: RJ45.
- H. Power distribution units (PDU):
1. Manufacturers: One of the following or equal:
 - a. APC; Schneider.
 - b. Eaton.
 - c. Tripp-lite.
 2. Properties:
 - a. UL listed.
 - b. Voltage shall be 120 VAC, unless otherwise indicated on the Drawings.
 - c. Rack height: 0U.
 - d. Tool-less rack mounting.
 - e. Cable connections shall be coordinated with network rack devices (UPS, ATS, network switch, servers, etc.).

2.05 ACCESSORIES

- A. Provide duplex patch cords to connect the interface cards provided with the associated patch panels.
- B. Provide dust covers or plugs for unused ports.

PART 3 EXECUTION

3.01 PREPARATION

- A. Equipment support and anchoring to structures:
 1. As specified in Section 01_81_50 - Design Criteria, including, but not limited to:
 - a. Anchor bolt layout.
 - b. Equipment templates.
 - c. Anchor installation.

3.02 INSTALLATION

- A. Provide installation and configuration for the new and existing managed Ethernet switches. Provide configuration of the Ethernet switch network for a complete, functioning plant control system as indicated on the Drawings and as specified in this Section.
 - 1. Refer to SCADA block diagrams for new network connections.
 - 2. Provide configuration for managed Ethernet switches and other components, including, but not limited to, VLAN (virtual local area network), additional plant PLC communication cards, and separate managed Ethernet switches as required, such that there is isolation of the following networks:
 - a. Remote I/O network: This includes the connections between the plant PLC and:
 - 1) Plant PLC expansion racks.
 - 2) Plant PLC remote I/O (RIO) racks.
 - b. Field network: This includes the connections between the PLC and:
 - 1) Field devices.
 - 2) LOI (Local Operator Interface).
 - 3) Vendor furnished Ethernet network components.
 - 4) Valve actuator network: This includes the connections between the PLC and the valve master stations.
 - c. PLC network: This includes the connections between the plant PLCs and the I/O server(s).
 - d. Process control network: This includes the connections between the I/O server(s) and other equipment, including, but not limited to, servers, workstations, and printers.
 - e. Security control network: This includes any security hardware with Ethernet communication as provided by the security subcontractor.
 - 3. Process floor managed Ethernet switches for the process control network shall be configured and programmed for rapid fail over protection.
 - 4. Enterprise level managed Ethernet switches shall be configured for a communication protocol that is compatible with the process control network's rapid fail over protocol.
- B. Racks shall be level and plumb.
- C. Work shall be performed in a professional and skillful manner.
- D. Cable management:
 - 1. Cables and equipment shall be installed in strict conformance with the manufacturer's recommendations.
 - 2. Install cable using lubricant designed for cable pulling.
 - 3. Install hook-and-loop wrap on all cable bundles within the network rack/enclosure. Plastic tie-wraps are not acceptable.
 - 4. Install network cables without splices.
 - 5. Installed bend radius shall be a minimum of 10 times the cable diameter.
 - 6. Terminate pairs at the jack and patch panel.
 - 7. Route cables through cable management or other form of containment. No loose, unsupported cables are permitted to span across network equipment.
 - 8. Use corner strips to protect cables from edges inside ducts and to maintain bend radius requirements.

- E. Internal rack wiring:
 - 1. Cables shall be installed avoiding sharp bends.
 - 2. Provide enough working space inside rack or cabinets such that closing enclosure doors does not crush or compress cabling.
 - 3. Bundle cables together in groups of no more than 12.
 - 4. Route cables from both sides of the rack to patch panels. Do not bring all bundles from a single side.
 - 5. No cabling shall obstruct equipment ventilation.
 - 6. Individual pairs will be untwisted less than 1/2-inch at termination points.
 - 7. Ground enclosure and equipment in accordance with TIA-607.
 - a. Individually bond network equipment chassis to the rack's grounding busbar. Do not daisy-chain bonding conductors.
 - b. Size the bonding conductor in accordance with the network equipment manufacturer's recommendation or #10 AWG, whichever is larger.
- F. External rack wiring:
 - 1. Do not install fiber cables in non-continuous cable supports such as cable ladders or wire baskets without radius cable supports or solid bottoms.
 - 2. Maintain cable separation in accordance with TIA-569.
 - a. Install cables a minimum of 40 inches away from electrical motors and transformers.
 - b. Install cables a minimum of 12 inches away from fluorescent lighting.
- G. Cables and terminations shall be labeled with cable designations as specified in Section 26_05_53 - Identification for Electrical Systems.
- H. Each data port shall be individually labeled with its patch panel/switch port ID:
 - 1. Labeling must be printed. No handwritten labels will be allowed.
- I. At the completion of the wiring installation, provide the following documentation:
 - 1. A plan-view of the premise(s) showing the jack numbering scheme.
 - 2. A printed certification report for the entire wiring installation showing compliance with TIA specifications for data cable.
 - 3. Reports such as those generated by Fluke DSP cable certification equipment meet this requirement.
- J. Managed Ethernet switches:
 - 1. Configure switches to prevent broadcast storms.
 - 2. Installations shall employ IGMP snooping to limit multicast messaging.

3.03 TESTING

- A. As specified in Section 40_80_01 - Commissioning for Instrumentation and Controls.

3.04 OWNER TRAINING

- A. Perform Owner Training as specified in Section 01_75_17 - Commissioning.

3.05 FIELD QUALITY CONTROL (NOT USED)

3.06 ADJUSTING

- A. Perform firmware installations, configuration, and other setup, as required, to place the network into proper operation.

END OF SECTION

SECTION 40_66_71

CONTROL SYSTEMS: WIRELESS COMMUNICATIONS - CELLULAR

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. General and design requirements applicable to industrial wireless cellular communication system Work and Submittals.
 - 2. General requirements for supply, installation, and commissioning of an industrial wireless cellular communication system, including, but not limited to, the following:
 - a. Materials, hardware, software, equipment fabrication, installation, configuration, programming, hardware and software testing, start-up, Commissioning, training, and documentation.

1.02 REFERENCES

- A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.
- B. Standards:
 - 1. American Concrete Institute (ACI):
 - a. 318 - Building Code Requirements for Structural Concrete.
 - 2. International Electrotechnical Commission (IEC).
 - 3. National Electrical Manufacturers Association (NEMA).
 - 4. Telecommunications Industry Association (TIA).
 - 5. State and local code requirements:
 - a. Colorado.

1.03 TERMINOLOGY

- A. The words and terms listed below are not defined terms that require initial capital letters, but, when used in this Section, have the indicated meaning.
 - 1. Antenna CL: Antenna center line mounting height.
 - 2. BER: Bit error rate, a unitless measure of the number of bit errors that occur in a given number of bit transmissions.
 - 3. Cellular signal strength survey: Report from the third-party cellular service provider showing the cellular signal strength for 2G, 3G, 4G, 5G, LTE technology at each of the sites.
 - 4. dB: Decibel, a relative expression representing a change in radio frequency power.
 - 5. dBd: A decibel referenced to a dipole antenna.
 - 6. dBi: A decibel referenced against an isotropic radiator.

7. dBm: A decibel referenced to 1 milliwatt (mW).
8. Receiver sensitivity: Minimum signal power level with an acceptable bit error rate (in dBm or mW) that is necessary for the receiver to accurately decode a given signal.

1.04 SUBMITTALS

- A. Furnish Submittals as specified in Section 01_33_00 - Submittal Procedures and Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.
 1. Product data:
 - a. Cellular modem.
 - b. SIM card(s).
 - c. Antenna.
 - d. Cable between cellular modem and antenna.
 - e. All other related accessories.
 - f. Communication port type and quantity.
 - g. Power sources such as an internal battery to supply power to the device when external power source is not available.
 2. Additional certification requirements recommended by the cellular network service provider/carrier.
 3. Installation details for each component indicated above.
 4. Type of cellular service that will be provided.
 - a. Provide setup/configuration information for the service.
 5. Certificate of approval of cellular modem by the cellular network service provider/carrier.
 6. Installation details for each component indicated above.
 7. Block diagram showing the location of each component of the cellular communication system.
 8. Cellular coverage map associated with each site.
- B. Quality Control Submittals:
 1. Manufacturer's representative qualifications as specified in Section 01_75_17 - Commissioning.
- C. Owner Training Submittals:
 1. As specified in Section 01_75_17 - Commissioning.

1.05 QUALITY ASSURANCE

- A. Procedure for verifying the communications between sites shall be as follows:
 1. Perform communication signal strength analysis study to verify the theoretical performance of the proposed paths.
 2. Field verify the cellular signal strength using field measurement and obtain an approval from the Owner and the Engineer prior to installation.
- B. After installation, verify using field collected data that the installed equipment is in accordance with reliability benchmark developed as part of the field testing.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.

1.07 PROJECT OR SITE CONDITIONS

- A. As specified in Section 01_81_50 - Design Criteria.

1.08 ADMINISTRATIVE REQUIREMENTS

- A. Coordination:
 - 1. Coordinate with the cellular communication service provider to obtain the latest cellular signal strength report at each of the locations to meet the requirements specified in this Section.
 - a. Submit results for the Engineer's approval prior to the procurement and installation of wireless cellular communication infrastructure.
 - 2. For a private, third-party owned cellular network, coordinate with the service provider and refer to the Contract Specification and Drawings for proper procurement and installation of cellular equipment and associated appurtenances.
 - 3. Coordinate cellular modem configuration and encryption options with the Owner and cellular service provider. Adjust configuration and encryption settings as deemed necessary by the Owner and the cellular service provider.
 - 4. Configure the cellular modem using a secure username and password authentication by the Owner.
 - a. Alerts shall be sent to defined list of recipients via pre-configured SMS text message.
 - b. Alerts shall be sent to defined list of recipients via SMTP (email) message.
- B. Meetings:
 - 1. Prepare and submit an agenda for 2 mandatory coordination meetings.
 - a. First meeting:
 - 1) Summarize their understanding of the Project.
 - 2) Discuss any proposed alternatives.
 - 3) Schedule access to Owner sites.
 - 4) Schedule the remaining coordination meetings.
 - 5) Request any additional information required from the Owner.
 - 6) Review the preliminary design and plan the site surveys.
 - 7) Select the hardware to be used during the on-site cellular signal strength measurement.
 - 8) Understand the project construction sequence.
 - 9) Understand municipal ordinance and other construction restrictions associated with the sites.
 - 10) Schedule meeting to coordinate with the Owner and the cellular service provider to understand the details of the cellular service contract.
 - b. Second meeting:
 - 1) Work with the cellular service provider to understand cellular modem requirements, signal strength and bandwidth details, and installation requirements.

- 2) Outline the recommended and optimal configuration for the Owner's wireless cellular system architecture.
- 3) Discuss any exceptions or deviations from design document installation details, models, and site locations.
- c. Discuss construction and work progress schedule.

1.09 WARRANTY

- A. As specified in Section 01_78_36 - Warranties and Bonds.
- B. Provide a minimum of 1 year of warranty from Substantial Completion date for all wireless communication equipment.
- C. Provide a lifetime manufacturer's warranty for the wireless cellular communication equipment when the appropriate surge protection and power supplies from the same manufacturer are utilized on the incoming power to the wireless network equipment.
 1. In addition, surge protection from the same manufacturer must be provided on communication, coaxial, and control signal lines that are connected to the radio and originate from an outdoor environment or run parallel to power conductors in a cable tray.

1.10 MAINTENANCE

- A. Furnish parts, materials, and additional components necessary for maintenance and calibration purposes for 1 year:
 1. Deliver supplies before Substantial Completion.

PART 2 PRODUCTS

2.01 GENERAL

- A. System overview:
 1. Furnish and install an industrial wireless communication system that will serve the following sites:

Site Name	Site Coordinates (Latitude N, Longitude W)	Cellular Modem Tag	Notes
Source Water Pump Station	Field Verify	To be coordinated with Thornton IT	Location per the drawings, inside network rack

2. Data shall be transmitted and received wirelessly at each site using the cellular technology identified as indicated on the Drawings.
3. System shall be configured as indicated on the Drawings and as specified in this Section.
4. Contract Documents for the components of the wireless cellular communication system are based on the cellular signal strength report.
 - a. Verify site conditions and provide a completely functional wireless cellular communication system.

2.02 DESIGN AND PERFORMANCE CRITERIA

- A. ICSC performs all of the Work related to the industrial wireless cellular communication system described in the Contract Documents.
- B. System must be in accordance with the following:
 - 1. ACI 318.
 - 2. TIA.
- C. Performance requirements for cellular communication:
 - 1. The following are the requirements for the cellular communication system:
 - a. Data rate: To be coordinated with Thornton IT.
 - b. Signal strength: To be coordinated with Thornton IT.

2.03 MANUFACTURERS

- A. Wireless cellular modem:
 - 1. The following, or approved equal:
 - a. Cradlepoint e3000.
- B. Antenna:
 - 1. One of the following or equal:
 - a. Cradlepoint Cellular, 600 MHz - 6 GHz Antenna.
- C. Power adapter:
 - 1. One of the following or equal:
 - a. Cradlepoint Power Supply, 12 V, 5.5 A, 170648-001 for IBR 900 Series cellular modem.
- D. Transmission cables:
 - 1. Provide the manufacturer's recommended transmission cable.
- E. Surge protectors:
 - 1. One of the following or equal:
 - a. CommScope:
 - 1) Gas Tube Surge Arrestors.
 - 2) T Series Surge Arrestors.
 - b. Phoenix Contact, Trabtech Series.
 - 2. As specified in Section 40_67_01 - Control Systems: Panels, Enclosures, and Panel Components.

2.04 MANUFACTURED UNITS

- A. Cellular communication system:
 - 1. General:
 - a. Wireless cellular system comprises the following:
 - 1) Cellular modem with dual SIM card(s).
 - 2) Omni antenna.
 - 3) Software/documentation and other accessories as specified in the accessories article in this Section.

- b. Performance requirements:
 - 1) Cellular modem and omni antenna to operate in quad-band range: 850/900/1,800/1,900 MHz.
 - 2) Operating temperature range: -25 to 60 degrees Celsius.
- 2. Cellular modem:
 - a. Transmission power:
 - 1) 1 W at 850 MHz.
 - 2) 2 W at 1,900 MHz.
 - b. LTE enabled.
 - c. Provide 1 SIM card for each cellular modem.
 - d. Communication with equipment to be monitored:
 - 1) Ethernet RJ-45.
 - 2) Serial RS-485.
 - e. Power supply: 24 or 54 VDC.
 - f. LED indication for status and alarm.
 - g. Mounting:
 - 1) DIN rail.
 - 2) As indicated on the Drawings.
 - h. Housing:
 - 1) ABS (acrylonitrile butadiene styrene).
 - 2) NEMA 4X.
 - i. Antenna connection: 3 SMA connectors (primary, diversity, gps).
 - j. Network and routing:
 - 1) Network address translation.
 - 2) Port forwarding.
 - 3) IPsec and OpenVPN with up to 5 tunnels.
 - k. Shall be capable of connecting an antenna with SMA type connector.
 - l. Remote authentication: LDAP.
 - m. Port, IP, and MAC filtering.
 - n. Network management: SNMP.
 - o. Discrete I/O: 1 input, minimum.
 - p. Device shall support stateful inspection firewall. Firewall rules shall be configurable by the user and include inspection on source/destination IP address, protocols and/or source/destination TCP/UDP port.
 - q. Support virtual private network (VPN) functionality up to 3 licenses with ability to act as client or server of VPN requests:
 - 1) IPsec and OpenVPN shall be the supported VPN protocols with encryption meeting the military standard of AES-256.
 - 2) Capable of initiating VPN via hard-wired contact or remotely through SMS text message.
 - r. Support static routing between 2 or more networks, port forwarding and IP masquerading.
 - s. Support one-to-one network address translation (NAT) routing.
- 3. Antenna:
 - a. Omni-directional type antenna.
 - b. Mounting: Remote.
 - c. Rated for outdoor installation.
- 4. Cable between cellular modem and antenna: Manufacturer's standard and rated for outdoor installation if the modem is installed outdoors.
- 5. Software and documentation: Manufacturer's standard.

2.05 COMPONENTS (NOT USED)

2.06 ACCESSORIES

- A. Mounting accessories:
 - 1. Provide accessories required for antenna mounting, such as clamps, brackets adapters, and related hardware for a complete installation.
 - 2. Mounting guidelines shall be provided as indicated on the Drawings and as recommended by the manufacturer.
 - 3. Terminal blocks, cellular modem/antenna, and associated wiring shall be clearly tagged, as indicated on the Drawings, and labeled for providing easy reference.
- B. Provide lightning surge arrestors for cellular modems/antennas located outdoors.
- C. Provide antenna connectors, cable fittings, and related hardware as necessary for installation.
- D. Provide din-rail mounting adapters required for installation of cellular modems in control panels/communication cabinets, as needed for each application.
- E. Software:
 - 1. Provide software package for cellular diagnostic testing.
 - 2. Provide cellular modem configuration via a secured wireless or wired ethernet network.
- F. PoE injectors:
 - 1. Manufacturer:
 - a. Suitable for the selected cellular modem model, based on manufacturer recommendation.
 - 2. Performance:
 - a. Output power: as required for the modem model selected.
 - b. Built-in surge protection capabilities.
 - c. Mounting: DIN rail mountable.
- G. Ethernet extender/long range Ethernet connector:
 - 1. Manufacturer:
 - a. Veracity LongSpan Connector.
 - 2. Performance:
 - a. Input power: 24 VDC.
 - b. Output power: as required for the cellular modem model selected.
 - c. Mounting: DIN rail mountable.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 INSTALLATION

- A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.
- B. Tag and label terminal blocks, cellular system components and associated wiring as indicated on the Drawings and as specified in Section 26_05_53 - Identification for Electrical Systems.

3.03 TESTING

- A. As specified in Section 40_80_01 - Commissioning for Instrumentation and Controls.
- B. Functional Testing:
 - 1. Hardware and communications testing:
 - 2. Perform tests to show that the integrated system hardware and software is fully operational and in accordance with the requirements specified in the Contract Documents.
 - 3. Engineer approval of the FAT communication testing activities is required before proceeding to FAT platform testing.
 - 4. Failure testing: Demonstrate how the system responds to and recovers from abnormal conditions, including, but not limited to:
 - a. Equipment failure.
 - b. Operator error.
 - c. Communications subsystem error.
 - d. Communications failure.
 - e. Simulated/forced software lockups.
 - f. Power failure (both utility power and power to HMI and/or SCADA hardware).
 - g. High system loading conditions.

3.04 OWNER TRAINING

- A. Perform Owner Training as specified in Section 01_75_17 - Commissioning.

3.05 FIELD QUALITY CONTROL

- A. Verify using field-collected data that the installed equipment is in accordance with reliability benchmarks developed as part of the field testing.
- B. Submit a report to document field-verified transmit and receive signal strength and any RF interference after installation of final communication elements:
 - 1. Troubleshoot issues and assist the Owner if interference is detected during startup and Commissioning.
- C. Installation shall follow the cellular equipment manufacturer's recommended installation practices and be in accordance with applicable codes.

- D. Upon completion of installation, provide the services of a factory-certified local service technician to perform start-up testing.
 - 1. Record test results and compare to factory testing to confirm proper operation of equipment.
 - 2. Submit test results with operation and maintenance manuals.

3.06 ADJUSTING

- A. Orient directional antennas as required for maximum receive strength signal intensity during startup.
- B. Orient directional antennas as required for maximum receive strength signal intensity (RSSI) during startup.

END OF SECTION

SECTION 40_67_01

CONTROL SYSTEMS: PANELS, ENCLOSURES, AND PANEL COMPONENTS

TABLE OF CONTENTS

PART 1	GENERAL	2
1.01	SUMMARY	2
1.02	REFERENCES	2
1.03	TERMINOLOGY	3
1.04	DELEGATED DESIGN	3
1.05	SUBMITTALS	3
1.06	QUALITY ASSURANCE	4
1.07	PROJECT OR SITE CONDITIONS	4
1.08	ADMINISTRATIVE REQUIREMENTS (NOT USED)	4
1.09	WARRANTY	4
PART 2	PRODUCTS	4
2.01	GENERAL	4
2.02	DESIGN AND PERFORMANCE CRITERIA	4
2.03	MANUFACTURERS (NOT USED)	5
2.04	EXISTING PRODUCTS	5
2.05	MATERIALS	5
2.06	MANUFACTURED UNITS	5
2.07	ACCESSORIES	24
2.08	FINISHES	25
PART 3	EXECUTION	26
3.01	PREPARATION	26
3.02	INSTALLATION	26
3.03	TESTING	27

1.01 SUMMARY

A. Section includes:

1. Design, fabrication and assembly of instrumentation enclosures, control panels and components provided under this Contract, including, but not limited to:
 - a. Custom built instrumentation and control panels, including enclosures for hand stations controllers, low voltage power distribution and marshalling panels.
 - b. Control panels furnished as part of equipment systems specified in other Divisions, such as vendor control panels (VCPs) and chemical feed panels.
 - c. Control components.
 - d. Control panel installation.

A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.

1. Institute of Electrical and Electronics Engineers (IEEE):

- a. C62.41.1 - Guide on the Surge Environment in Low-Voltage (1,000 V and less) AC Power Circuits.
 - b. 802.3af - Standard for Information Technology Telecommunications and Information Exchange Between Systems - Local and Metropolitan Area Networks - Specific Requirements Part 3: Carrier Sense Multiple Access with Collision Detection (CSMA/CD) Access Method and Physical Layer Specifications.
 - c. 802.3at - Standard for Information Technology -- Local and Metropolitan area networks -- Specific requirements -- Part 3: CSMA/CD Access Method and Physical Layer Specifications Amendment 3: Data Terminal Equipment (DTE) Power via the Media Dependent Interface (MDI) Enhancements.
2. International Electrotechnical Commission (IEC):
- a. 61643-11 - Low-Voltage Surge Protective Devices - Part 11: Surge Protective Devices Connected to Low-Voltage Power Systems - Requirements and test methods.
 - b. 61643-21 - Low-Voltage Surge Protective Devices - Part 21: Surge Protective Devices Connected to Telecommunications and Signaling Networks - Performance Requirements and Testing Methods.
3. National Fire Protection Association (NFPA):
- a. 70 - National Electrical Code (NEC).
4. Underwriters Laboratories Inc. (UL):
- a. 248-14 - Low-Voltage Fuses - Part 14: Supplemental Fuses.
 - b. 497B - Standard for Protectors for Data Communications and Fire-Alarm Circuits.
 - c. 508 - Standard for Industrial Control Equipment.
 - d. 508A - Standard for Industrial Control Panel.
 - e. 698A - Standard for Industrial Control Panels Relating to Hazardous (Classified) Locations.

- f. 1077 - Standard for Supplementary Protectors for Use in Electrical Equipment.
- g. 1283 - Standard for Electromagnetic Interference Filters.
- h. 1310 - Standard for Class 2 Power Units.
- i. 1449 - Standard for Surge Protective Devices.

1.03 TERMINOLOGY

- A. The words and terms listed below are not defined terms that require initial capital letters, but, when used in this Section, have the indicated meaning.
 - 1. The term “panel” in this Section is interchangeable with the term “enclosure”.

1.04 DELEGATED DESIGN

- A. As specified in Section 01_35_73 - Delegated Design Procedures.
- B. Anchoring and bracing.

1.05 SUBMITTALS

- A. Provide Submittals as specified in Section 01_33_00 - Submittal Procedures and Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.
- B. Provide a control panel hardware Submittal for each control panel/enclosure being provided on this Project, including, but not limited to:
 - 1. Product data:
 - a. Enclosure construction details and NEMA type.
 - b. Manufacturer’s literature and specification datasheets for each type of equipment to be installed within or on the panel or enclosure.
 - 2. Shop Drawings:
 - a. Scaled, detailed exterior panel (front and side views) and interior panel layout showing equipment arrangement and dimensional information:
 - 1) Provide draft for review and approval by the Engineer. Engineer has the authority to substantially alter initial panel layouts.
 - b. Complete nameplate engraving schedule.
 - c. Structural details of fabricated panels.
 - 3. Calculations:
 - a. Cooling calculations, including, but not limited to:
 - 1) Highest expected ambient temperature for the enclosure’s location.
 - 2) Internal heat load.
 - 3) Exposure to direct sunlight.
 - 4) Dimensions of the enclosure in inches.
 - 5) Maximum allowable temperature inside the enclosure, based on the lowest operating temperature limit of the installed components.

- C. Delegated Design Submittals:
 - 1. Anchoring and bracing: Provide project-specific calculations based on support conditions and requirements to resist loads specified in Section 01_81_50 - Design Criteria:
 - a. To structures for equipment installed in structures designated as seismic design category C, D, E, or F.
 - b. For equipment installed outdoors.
 - c. For wall mounted equipment weighing 125 pounds or more.

1.06 QUALITY ASSURANCE

- A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.
- B. Assemble panels, enclosures, and rack systems along with internal and external devices, wiring, equipment, and materials in a facility that is recognized by UL to assemble and certify UL-labeled control panels:
 - 1. Provide components and equipment with UL 508 listing.
 - 2. Control panels shall be UL 508A labeled, unless the equipment in the panel and the design in the Contract Documents cannot be reasonably modified to meet the requirements for UL 508A labeling:
 - 3. Provide fuses for equipment that is not UL or UR listed.
 - 4. Install intrinsically safe circuits and equipment in accordance with UL 698A.

1.07 PROJECT OR SITE CONDITIONS

- A. As specified in Section 01_81_50 - Design Criteria.

1.08 ADMINISTRATIVE REQUIREMENTS (NOT USED)

1.09 WARRANTY

- A. As specified in Section 01_78_36 - Warranties and Bonds.

PART 2 PRODUCTS

2.01 GENERAL

- A. Provide control panels identified in the Contract Documents.

2.02 DESIGN AND PERFORMANCE CRITERIA

- A. Panel dimensions:
 - 1. Minimum dimensions are scalable from or as indicated on the Drawings and are based upon the manufacturer's non-certified information. It is the responsibility of the Contractor or manufacturer to design and size panels:
 - a. Size panels to provide space for equipment, wiring, terminations, and other items in the panel, including 20 percent of the total back panel area shall remain empty.

- b. Panel sizes that substantially deviate (within 3 inches in any dimension) from the sizes indicated on the Drawings must be approved by the Engineer.
 - c. Maximum panel depth: 32 inches, unless otherwise indicated.
- B. Provide equipment and components that are fully rated for the Site elevation and operating environment where the equipment will be installed as specified in Section 01_81_50 - Design Criteria and as indicated on the Drawings.
- C. Non-conditioned spaces and outdoor installations:
 - 1. Provide additional temperature conditioning equipment to maintain the equipment temperature within a band of 10 degrees Fahrenheit above the minimum operating temperature and 10 degrees Fahrenheit below maximum operating temperature.
- D. As listed below in the individual component paragraphs.
 - 1. Provide conditioning equipment incorporated into the equipment to maintain the enclosures within the equipment manufacturer's specified operating ranges.

2.03 MANUFACTURERS (NOT USED)

2.04 EXISTING PRODUCTS

2.05 MATERIALS

- A. Construct and finish enclosures using materials capable of withstanding the mechanical, electrical, and thermal stresses, as well as the effects of humidity and corrosion that are likely to be encountered in normal service:
 - 1. Enclosures shall have the following properties:
 - a. NEMA Type 1: Steel.
 - b. NEMA Type 4: Steel with gasketed door, raintight.
 - c. NEMA Type 4X: Type 316 stainless steel (unless Type 304 is indicated on the Drawings).
 - d. NEMA Type 4X: Polycarbonate or fiberglass reinforced polyester (FRP) in corrosive areas where stainless steel is incompatible.
 - e. NEMA Type 12: Steel with gasketed door, dusttight.
 - f. NEMA Type 7: Cast aluminum.
- B. Bolting material:
 - 1. Commercial quality 1/2-inch diameter, stainless steel hex-head Grade 5 bolts, nuts, and washers, with unified coarse (UNC) threads.
 - 2. Carriage bolts for attaching end plates.
 - 3. Other bolted joints shall have S.A.E. standard lock washers.

2.06 MANUFACTURED UNITS

- A. Panels/enclosures:
 - 1. Manufacturers: One of the following or equal:
 - a. nVent/Hoffman.
 - b. Rittal.
 - c. Saginaw Control & Engineering.

2. Panel assembly:
 - a. General guidelines for panel fabrication include:
 - 1) Continuous welds ground smooth.
 - 2) Exposed surfaces free of burrs and sharp edges.
 - 3) Base formed of heavy channel iron, either galvanized or powder coated, minimum 1/2-inch holes at 12-inch spacing to accommodate anchoring of freestanding enclosures to floor.
 - b. Construct enclosure and mounting panel using stretcher-level quality sheet metal having minimum thickness not less than the following sizes (U.S. Standard Gauge):

Enclosure Height (inches)	Minimum Enclosure Steel Thickness (gauge)	Minimum Back Mounting Panel Thickness (gauge)
Wall-mounted up to 48	14	14
Up to 57	12	12
57 to 69	12	10
69 to 82	12, except 10 on back	10
82 or more	10	10

- 1) Use heavier sheet metal to meet seismic requirements at the Project Site or when required due to equipment requirements.
- c. For Rittal or engineer-approved equal free-standing modular enclosure, construct enclosure and mounting panel using stretcher-level quality sheet metal having minimum thickness not less than the following sizes (U.S. Standard Gauge):

Enclosure Height (inches)	Minimum Enclosure Steel Thickness (gauge)	Minimum Back Mounting Panel Thickness (gauge)
Wall-mounted up to 48	16	14
Up to 57	14	13
57 or more	16	11

- d. Construct supporting frame structure with angled, channeled, or folded rigid section of sheet metal, rigidly attached to and having essentially the same outer dimensions as the enclosure surface and having sufficient torsional rigidity to resist the bending moments applied via the enclosure surface when it is deflected.
- e. Provide stiffeners for back mounting or C folded back panels in enclosures larger than 4 feet. In addition, secure the panels in place by collar studs welded to the enclosure.
- f. Door construction:
 - 1) Turned-back edges suitably braced and supported to maintain alignment and rigidity without sagging.
 - 2) Sufficient width to permit door opening without interference with rear projection of flush-mounted instruments.
 - 3) Heavy-gauge stainless steel hinges.
 - 4) For NEMA Type 12, Type 4, and Type 4X, provide oil-resistant neoprene sealing gasket and adhesive to seal cover to enclosure.
 - 5) Gasket installed to seal against roll lip on the enclosure opening.

- g. Latches:
 - 1) For panels, provide each door with an oil tight 3-point latching mechanism and locking handle with rollers on the ends of the latch rods. Latch rods shall be connected to a common door handle, hold doors securely, and form a compressed seal between door and gasket, at the top, side, and bottom.
 - a) Provide padlock for each enclosure with padlock provisions.
 - b) Provide 2 keys per panel.
 - c) All locks keyed alike.
 - 2) For Rittal or engineer-approved equal free-standing modular enclosure, provide each door with a 4-point latching mechanism, if available, or a 2-point latching mechanism if a 4-point is not available.
 - 3) For cabinets not available with 3-point latching hardware, provide multiple clips and padlock hasps.
- h. Panel cut-outs:
 - 1) Cut, punch, or drill cutouts for instruments, devices, and windows. Smoothly finish with rounded edges.
 - 2) Allow a minimum of 3-inch envelope around displays, controllers, and monitors.
 - 3) Reinforce around cut-outs with steel angles or flat bars for the following:
 - a) Large panel cutouts; for example, openings for local operator interfaces.
 - b) Pilot device groupings, where the removed metal exceeds 50 percent of the available metal.
- 3. In addition to the requirements specified above, the following requirements for NEMA Type 4X powder coated stainless steel enclosures apply:
 - a. Minimum 16-gauge, Type 304 stainless steel.
 - b. Captive stainless steel cover screws threaded into sealed wells.
 - c. Inside finish: White polyester powder coating.
 - d. Specifically designed for use with flange-mounted disconnect handles where required or as indicated on the Drawings.
 - e. NEMA Type 4X powder-coated stainless steel enclosures are not an acceptable substitute for stainless steel unless indicated on the Drawings.
- 4. Outdoor panels. Supplementary requirements for panels located outdoors are as follows:
 - a. Enclosures located outdoors shall be explicitly designed and rated for outdoor service by the manufacturer.
 - b. Door hardware: Stainless steel.
 - c. Provide factory installed rain canopy and sun shield for enclosures with operator interface panels.
 - d. Bases: Heavy channel, gasketed stainless steel bases, flanges up, for anchoring to pad.

B. Arrangement of components:

- 1. Arrange panel internal components for external conduit and piping to enter into panel either from above or below.
- 2. Arrange panel instruments and control devices in a logical configuration, associating pushbutton and selector switches with related readout devices, or as indicated on the Drawings.

3. Mount internal control components on an internal back panel. Devices may be mounted on the side panel only by special permission from the Engineer.
 4. Control panel mounted operator interface devices shall be mounted between 3 feet and 5 feet above finished floor.
- C. Overcurrent protection:
1. Main overcurrent device:
 - a. Where the electrical power supply voltage to the control panel is more than 120 VAC, provide the panel with a flange-mounted disconnect handle operating a molded-case circuit breaker and provide a control power transformer for 120-VAC circuits:
 - 1) Door-mounted disconnect handles are not acceptable.
 - 2) Mechanically interlock the disconnect switch with the control enclosure doors so that no door can be opened unless the power is disconnected, and the disconnect switch cannot be closed until all doors are closed.
 - 3) Provide means to defeat the interlock.
 - 4) Lockable in the off position.
 - b. Control panels supplied with 120 VAC:
 - 1) Provide an internal breaker with the line side terminals covered by a barrier.
 - 2) Provide a nameplate prominently positioned on the control panel identifying the location of the power source and a warning statement requiring the source to be disconnected before opening the door to the enclosure.
 - 3) Provide a nameplate prominently positioned on the control panel stating "CAUTION Risk of Electric Shock - UPS equipment outputs remain energized with main disconnect in off position" for any panel containing a UPS.
 2. Provide circuit breakers as specified in Section 26_28_01 - Low Voltage Molded Case Circuit Breakers.
 3. Selection and ratings of protective devices:
 - a. Interrupting ratings: Not less than the system maximum available fault current at the point of application.
 - b. Voltage rating: Not less than the voltage of the application.
 - c. Select current rating and trip characteristics to be suitable for:
 - 1) Maximum normal operating current.
 - 2) Inrush characteristics.
 - 3) Coordination of the protective devices to each other and to the source breaker feeding the panel.
 - d. Circuit breakers, fuses, and motor overcurrent protection devices used for branch circuit protection must be UL 508A compliant.
 - 1) Circuit breakers listed under UL 1077 Standard for Supplementary Protectors that do not comply with UL 508A requirements are not acceptable.
 - 2) Miscellaneous, miniature, and micro fuses listed under UL 248, Part 14, that do not comply with UL 508A requirements are not acceptable.
 - 3) Manual motor controllers provided with an instantaneous-trip overcurrent mechanism listed under UL 508 that do not comply with UL 508A requirements are not acceptable.

4. Provide a separate protective device for each powered electrical device:
 - a. An individual circuit breaker for each 120-VAC instrument installed within its respective control panel and clearly identified for function.
 - b. Provide fuse external of the I/O card.
 - c. Individual discrete output:
 - 1) Individual fuse for each PLC discrete output.
 - 2) Size external fuse to open before any I/O-card-mounted fuses.
 - d. Individual discrete input:
 - 1) Individual fuse for each PLC discrete input.
 - 2) 1/2-amp fuse.
 - e. Individual analog input:
 - 1) Individual fuse for each PLC analog input powered from the control panel.
 - 2) 1/4-amp fuse.
 - f. Individual analog output:
 - 1) Individual fuse for each PLC analog output powered from the control panel.
 - 2) 1/4-amp fuse.
 - g. Install protective devices on the back mounting panel and identify by a service nameplate in accordance with the wiring diagrams.
5. Fuses for analog and discrete control loops:
 - a. Provide durable, readily visible label for each fuse, clearly indicating the correct type, size, and ratings of replacement fuse:
 - 1) Label shall not cover or interfere with the equipment manufacturer's instructions.
 - b. Provide fuses rated for the voltage and available short-circuit current at which they are applied.
 - c. Manufacturers: One of the following or equal:
 - 1) Bussmann.
 - 2) Ferraz Shawmut.
 - 3) Littelfuse.
6. Fuse holders:
 - a. Modular type:
 - 1) DIN rail mounting on 35-millimeter rail.
 - 2) Touch-safe design: Connection terminals to be protected against accidental touch.
 - 3) Incorporates blown-fuse indicator.
 - 4) Plug-in style fuse terminals and fuse plugs are not acceptable.
 - b. Provide nameplate identifying each fuse:
 - 1) As specified in Section 26_05_53 - Identification for Electrical Systems.
 - c. Manufacturers: One of the following or equal:
 - 1) Allen-Bradley, 1492-FB Series B.
 - 2) Phoenix Contact, UT4-HESI Series.
7. Control circuit breakers:
 - a. DIN rail mounting on 35-millimeter rail.
 - b. Manual OPEN-CLOSE toggle switch.
 - c. Rated for 250 VAC.
 - d. Interrupting rating: 10 kA or available fault current at the line terminal, whichever is higher.
 - e. Current ratings: As required for the application.

- f. Provide nameplate identifying each circuit breaker:
 - 1) As specified in Section 26_05_53 - Identification for Electrical Systems.
- g. Manufacturers: One of the following or equal:
 - 1) ABB.
 - 2) Allen-Bradley.
 - 3) Phoenix Contact, TMC Series.
 - 4) Square D.
- 8. Electronic circuit protectors:
 - a. Used where a NEC Class 2 power circuit is required.
 - b. Confirms to NEC Class 2 according to UL 1310.
 - c. DIN rail mounting on 35-millimeter rail.
 - d. Power source:
 - 1) Operating voltage: 24 VDC.
 - 2) Output current ratings: As required for the application.
 - 3) Maximum output current: 4 A.
 - 4) Maximum nameplate rating: 100 VA.
 - e. LED for status indication.
 - f. Remote status contact.
 - g. When using multi-channel electronic circuit protectors, distribute devices such that a failure is limited to a single network or segment.
 - h. Provide nameplate identifying each circuit electronic circuit protector module:
 - 1) As specified in Section 26_05_53 - Identification for Electrical Systems.
 - i. Manufacturers: One of the following or equal:
 - 1) Single channel:
 - a) Allen-Bradley, 1694 series.
 - b) Phoenix Contact, PTCB E1 series.
 - 2) Multi-channel:
 - a) Phoenix Contact, CBMC series.
 - b) Puls PISA11 series.
- D. Conductors and cables:
 - 1. Power and control wiring:
 - a. Materials: Stranded, soft annealed copper.
 - b. Insulation: 600 VAC type MTW.
 - c. Minimum sizes:
 - 1) Primary power distribution: 12 AWG.
 - 2) Secondary power distribution: 14 AWG.
 - 3) Control: 16 AWG.
 - d. Color:
 - 1) AC power (line and load): Black.
 - 2) AC power (neutral): White.
 - 3) AC control: Red.
 - 4) AC control: Orange for foreign voltages.
 - 5) DC power and control (ungrounded): Blue.
 - 6) DC power and control (grounded): White with Blue stripe.
 - 7) Ground: Green.

2. Signal cables:
 - a. Materials: Stranded, soft annealed copper.
 - b. Insulation: 600 VAC, PVC outer jacket.
 - c. Minimum size: 18 AWG paired triad.
 - d. Overall aluminum shield (tape).
 - e. Copper drain wire.
 - f. Color:
 - 1) 2-conductor:
 - a) Positive (+): Black.
 - b) Negative (-): White and red.
 - 2) 3-conductor:
 - a) Positive (+): Black.
 - b) Negative (-): Red.
 - c) Signal: White.
 - g. Insulate the foil shielding and exposed drain wire for each signal cable with heat-shrink tubing.
- E. Conductor identification:
 1. Identify each conductor and cable with unique wire numbers as specified in Section 26_05_53 - Identification for Electrical Systems.
 2. Readily identified without twisting the conductor.
- F. General wiring requirements:
 1. Wiring methods: Wiring methods and materials for panels shall be in accordance with the NEC requirements for general purpose (no open wiring) unless otherwise specified.
 2. Install components in accordance with the manufacturer's instructions included in the listing and labeling.
 3. Provide a nameplate on the cover of the control panel identifying sources of power supply and foreign voltages within the control panel.
 4. Provide transformers, protective devices, and power supplies required to convert the supply voltage to the needed utilization voltage.
 5. Provide power surge protection for control panels.
 6. Provide signal surge protection within control panels for each analog I/O, discrete I/O, and data line (copper ethernet, coax, fieldbus signals) that originates from outdoor devices.
 7. Provide non-metallic ducts for routing and organization of conductors and cables:
 - a. Provide wiring separation plan.
 - b. Size ducts for ultimate build-out of the panel, or for 20 percent spare, whichever is greater.
 - c. Provide separate ducts for signal and low voltage wiring from power and 120 VAC control wiring:
 - 1) 120 VAC: Grey colored ducts.
 - 2) 24 VDC: White colored ducts.
 8. Cables shall be fastened with cable-mounting clamps or with cable ties supported by any of the following methods:
 - a. Screw-on cable tie mounts.
 - b. Hammer-on cable-tie mounting clips.
 - c. Fingers of the nonmetallic duct.

9. Wire ties:
 - a. No wire ties inside wire duct.
 - b. Use Panduit cable tie installation tool, with tension control/cutoff.
 - c. Verify cut ends are cut flush filed smooth after installed.
 10. Provide supports at the ends of cables to prevent mechanical stresses at the termination of conductors.
 11. Support panel conductors where necessary to keep them in place.
 12. Wiring to rear terminals on panel-mount instruments shall be run in nonmetallic duct secured to horizontal brackets run adjacent to the instruments.
 13. Conductors and cables shall be run from terminal to terminal without splice or joints. Exceptions:
 - a. Factory-applied connectors molded onto cables shall be permitted. Such connectors shall not be considered as splices or joints.
 14. Control panel shall be the source of power for 120 VAC devices interconnected with the control panel, including, but not limited to:
 - a. Solenoid valves.
 - b. Instruments both mounted in the control panel and remotely connected to the control panel.
- G. Provide power circuits for Contractor- and vendor-furnished PLC cabinets in accordance with the PLC and instrument power wiring diagrams indicated on the Drawings or as specified.
- H. Thermal management:
1. Provide heating, cooling, and dehumidifying devices in order to maintain instrumentation and control devices to within a range as specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation.
 2. Heating:
 - a. Provide panels located in areas that are not climate controlled with thermostatically controlled strip heaters, except where all of the following conditions apply:
 - 1) Panel is not supplied with 120 VAC power.
 - 2) There are no electronics or moisture-sensitive devices in the enclosure.
 - 3) Panel is smaller than 38 inches high.
 3. Heat exchanger:
 - a. Closed-loop design ensuring separation of ambient air and clean air inside the cabinet.
 - b. Filterless design to facilitate easy cleaning of the core.
 - c. Mounting: As indicated on the Drawings.
 - d. Manufacturers: One of the following or equal:
 - 1) ICEcube, Blade series.
 - 2) Noren, CC Series.
 4. Enclosure temperature sensor as indicated on the Drawings:
 - a. Provide wall mounted RTD transmitter (to measure internal cabinet temperature) in enclosures containing electrical components such as PLCs, RTUs, RIO, and VFDs.
 - b. Platinum RTD.
 - c. 4 to 20 mA DC output.
 - d. Sensor and electronic enclosure.

- e. Accuracy: Within 2 degrees Fahrenheit.
- f. Manufacturers: One of the following or equal:
 - 1) Omega, EWS Series.
 - 2) TCS Basys Controls, TS Series as indicated on the Drawings.
- 5. Enclosure temperature switch:
 - a. Provide wall-mounted bimetallic switch transmitter (to measure internal cabinet temperature in enclosures) containing electrical components such as PLCs, RTUs, RIO, and VFDs.
 - b. Sensor and electronic enclosure.
 - c. Accuracy: Within 2 degrees Fahrenheit.
 - d. Single contact:
 - 1) Manufacturers: One of the following or equal:
 - a) nVent/Hoffman ATEMNC.
 - b) Pfannenberger FLZ.
 - c) Rittal.
 - e. Dual contact:
 - 1) Manufacturers: One of the following or equal:
 - a) nVent/Hoffman ADLTEMP.
 - b) Rittal.
- 6. Status relays and discrete inputs for switches, power supplies, and fieldbus devices (if applicable):
 - a. Provide as indicated on the Drawings or as specified.
- 7. Fan ventilation:
 - a. Provide nVent/Hoffman or Rittal fan speed control:
 - 1) Provide 2 door/cabinet-mounted vent fans for every 72 inches of cabinet width.
 - 2) Provide finger-guard kit.
 - 3) Filter kit with 2 spare filters for each intake fan.
 - 4) Provide bezel and gasket kit.
 - 5) Provide fan shroud.
 - 6) Automatically adjust fan speed depending on remote temperature sensor input.
 - 7) 120 VAC, 60 hertz.
 - 8) NEMA Type 5-15R cord connections.
- I. Panel meters:
 - 1. Pointer type:
 - a. Suitable for panel mounting.
 - b. Minimum scale length: 3 inches.
 - c. Calibrated in engineering units.
 - d. Accuracy: Within 2 percent of span.
 - e. NEMA Type 4/IP65 sealed front metal bezel.
 - f. Manufacturers: One of the following or equal:
 - 1) Red Lion.
 - 2) Yokogawa.
 - 2. Digital process indicators:
 - a. General:
 - 1) Integral provisions for scaling.
 - 2) Scale to process engineering units.
 - 3) Switch-programmable decimal points.
 - 4) NEMA Type 4/IP65 sealed front bezel.

- b. Current and voltage indicators:
 - 1) 3-1/2-digit minimum.
 - 2) Minimum character height: 0.5 inches.
 - 3) Accuracy:
 - a) AC/DC volts: Within 0.1 percent of reading plus 2 digits.
 - b) DC current: 4 to 20 mA; within 0.1 percent of reading plus 1 digit.
 - c) DC voltage: 0 to 10 volts; within 0.1 percent of reading plus 1 digit.
 - c. Operating voltage: 120 VAC.
 - d. Operating temperature: 32 degrees to 140 degrees Fahrenheit.
 - 1) Manufacturers: One of the following or equal:
 - a) Action Instruments, Visipak.
 - b) Red Lion.
 - 3. Digital bar graph meter:
 - a. Self-contained instruments that display process signals directly in engineering units, both in decimal format and as a bar graph display.
 - b. Suitable for panel mounting.
 - c. LED display:
 - 1) Not less than 3 decimal digits.
 - 2) Not less than a 101-segment LED bar graph.
 - d. Input signal:
 - 1) Conventional current loops and voltage control signals.
 - e. Minimum sample rate of once per second.
 - f. Provisions for field-adjustable scaling and/or offset.
 - g. Accuracy shall be within 1 least-significant digit.
 - h. Manufacturers: One of the following or equal:
 - 1) Ametek Dixson.
 - 2) Weschler Instruments.
 - 3) Yokogawa.
 - 4. Counters:
 - a. 6 digits.
 - b. Switch-selectable inputs:
 - 1) Switch contacts.
 - 2) CMOS.
 - 3) TTL.
 - 4) Magnetic pickup.
 - 5) RLC sensors.
 - c. Selectable up/down control via external signal.
 - d. Remote reset.
 - e. Remote inhibit to prevent accumulating counts.
 - f. Programmable to enable or disable front panel reset.
 - g. Non-volatile memory to retain all data upon loss of supply power.
 - h. Sunlight readable.
 - i. Operating temperature: 32 degrees to 122 degrees Fahrenheit.
 - j. Manufacturers: The following or equal:
 - 1) Red Lion, PAX Series.
- J. Pilot devices:
 - 1. General:
 - a. Provide operator pushbuttons, switches, and pilot lights from a single manufacturer.

- b. Size:
 - 1) 30.5 millimeters.
 - c. Heavy duty.
 - d. Pushbuttons:
 - 1) Contacts rated:
 - a) NEMA Type A600.
 - 2) Furnish 1 spare normally open contact and normally closed contact with each switch.
 - 3) Equipment shutdown (ESD): Palm or mushroom-head type with self-latching feature. ESD device will remain in the actuated position until deliberately reset.
 - e. Selector switches:
 - 1) Contacts rated:
 - a) NEMA Type A600.
 - b) Knob type.
 - 2) Furnish 1 spare normally open contact and normally closed contact with each switch.
 - 3) Provisions for locking in the OFF position where lockout provisions are indicated on the Drawings.
 - f. Pilot lights:
 - 1) Type:
 - a) LED for interior installations.
 - 2) Push to test.
 - 3) Lamp color:
 - a) On/Running/Start: Red.
 - b) Off/Stop: Green.
 - c) Power: White.
 - d) Alarm: Amber.
 - e) Status or normal condition: White.
 - f) Opened: Red.
 - g) Closed: Green.
 - h) Failure: Red.
2. Indoor and outdoor areas:
- a. NEMA Type 4/13.
 - b. Manufacturers: One of the following or equal:
 - 1) Allen-Bradley, Type 800T.
 - 2) General Electric, Type CR104P.
 - 3) IDEC, TWND Series.
 - 4) Schneider Electric, Class 9001, Type K.
3. Corrosive areas:
- a. NEMA Type 4X.
 - b. Corrosion resistant.
 - c. Exterior parts of high-impact strength fiberglass-reinforced polyester or multiple-layer epoxy-coated zinc.
 - d. Manufacturers: One of the following or equal:
 - 1) Allen-Bradley, Type 800H.
 - 2) Cutler Hammer, Type E34.
 - 3) IDEC, TWND Series.
 - 4) Schneider Electric, Class 9001, Type SK.

4. Hazardous (classified) areas/Class I, Division 2:
 - a. NEMA Type 4X.
 - b. Corrosion resistant.
 - c. Exterior parts of high-impact strength fiberglass-reinforced polyester or multiple-layer epoxy-coated zinc:
 - 1) Contacts contained within a hermetically sealed chamber:
 - a) Pushbuttons.
 - b) Selector switches.
 - c) Push-to-test contacts on pilot lights.
 - 2) UL listed and labeled for Class I, Division 2 areas.
 - d. Manufacturers: One of the following or equal:
 - 1) Allen-Bradley, Type 800H.
 - 2) Cutler Hammer, Type E34.
- K. Potentiometer and slidewire transmitters:
 1. Provide a DC output in proportion to a potentiometer input.
 2. Potentiometer input:
 - a. 100 ohms to 100 K ohms.
 - b. Impedance greater or equal to 1 M ohms.
 - c. Zero turn-up: 80 percent of full-scale input.
 - d. Span turn-down: 80 percent of full-scale input.
 3. Field-configurable output:
 - a. Voltage and current: Conventional current loops and voltage control signals.
 4. Accuracy, including linearity and hysteresis, within 0.1 percent maximum at 77 degrees Fahrenheit.
 5. Operating temperature: 32 degrees to 131 degrees Fahrenheit.
 6. Supply power: 9 to 30 VDC.
 7. Manufacturers: One of the following or equal:
 - a. Allen-Bradley, Type 800T-U29.
 - b. Phoenix Contact, Mini Analog Pro.
- L. Signal isolators and converters:
 1. Furnish signal isolators that provide complete isolation of input, output, and power input:
 - a. Minimum isolation level: 1.0 kilovolts AC/50 hertz for at least 1 minute.
 - b. Adjustable span and zero.
 - c. Accuracy: Within 1.0 percent of span.
 - d. Ambient temperature range: -4 degrees to 149 degrees Fahrenheit.
 2. Manufacturers: One of the following or equal:
 - a. Acromag, 1500, 600T, 800T, Flat Pack, or ACR Series.
 - b. Action Instruments, Q500 Series or Ultra SlimPak II.
 - c. AGM Electronics, Model TA-4000.
 - d. Moore Industries, MIT 4-Channel.
 - e. Phoenix Contact, Mini Analog Pro.
- M. Relays:
 1. General:
 - a. For all types of 120-VAC relays, provide surge protection across the coil of each relay.

- b. For all types of 24-VDC relays, provide a free-wheeling diode across the coil of each relay.
 - c. For plug in type relays, provide a relay base from the same manufacturer as the relay manufacturer.
2. Control:
- a. Magnetic style.
 - b. For use as standard control relay for motor and starter relay logic.
 - c. NEMA ratings:
 - 1) 300 volts.
 - 2) 10 amps thermal continuous test current.
 - 3) 60 amps make.
 - 4) 6 amps break.
 - d. Plug-in type.
 - e. LED indication for energization status.
 - f. Coil voltages: As required for the application.
 - g. Minimum poles: DPDT.
 - h. Touch-safe design: Connection terminals to be protected against accidental touch.
 - i. Enclose each relay in a clear plastic heat and shock-resistant dust cover.
 - j. Quantity and type of contact shall be as indicated on the Drawings or as needed for system compatibility.
 - k. Relays with screw-type socket terminals.
 - l. Provide additional relays when the following occurs:
 - 1) Number or type of contacts shown exceeds the contact capacity of the specified relays.
 - 2) Higher contact rating is required in order to interface with starter circuits or other equipment.
 - m. DIN rail mounting on 35-millimeter rail.
 - n. Ice-cube-type relays with retainer clips to secure relay in socket.
 - o. Integrated label holder for device labeling.
 - p. Manufacturers: One of the following or equal:
 - 1) Allen-Bradley: Type 700 HC.
 - 2) IDEC: R* Series (* = H, J, R, S, U).
 - 3) Potter and Brumfield: Type KRP or KUP.
 - 4) Square D: Type K.
3. Isolation:
- a. Electromechanical style.
 - b. For use as an interposing relay for PLC based discrete I/O signals.
 - c. NEMA ratings:
 - 1) Switching voltage: 250 volts AC/DC.
 - 2) Limiting current: 6 amps continuous.
 - 3) Interrupt: 1,500 volt-amperes.
 - d. Plug-in type.
 - e. LED indication for energization status.
 - f. Coil voltages: As required for the application.
 - g. Minimum poles: SPDT.
 - h. Touch-safe design: Connection terminals to be protected against accidental touch.
 - i. Quantity and type of contact shall be as indicated on the Drawings or as needed for system compatibility.
 - j. Relays with screw-type socket terminals.

- k. DIN rail mounting on 35-millimeter rail.
- l. Integrated label holder for device labeling.
- m. Manufacturers: One of the following or equal:
 - 1) Allen-Bradley, Type 700 HL TBR Series.
 - 2) Eaton, XR TBR Series.
 - 3) IDEC, RV8H Series.
 - 4) Phoenix Contact, PLC-INTERFACE Series.
- 4. Latching:
 - a. Magnetic-latching control relays.
 - b. NEMA ratings:
 - 1) 300 volts.
 - 2) 5 amps continuous.
 - 3) 360 volt-amperes make.
 - 4) 320 volt-amperes break.
 - c. Plug-in type.
 - d. DIN rail mounting on 35-millimeter rail.
 - e. Coil voltage: As required for the application.
 - f. Minimum contacts: DPDT; as required for the application. Plus 1 spare contact.
 - g. Touch-safe design: Connection terminals to be protected against accidental touch.
 - h. Clear cover for visual inspection.
 - i. Provide retainer clip to secure relay in socket.
 - j. Manufacturers: One of the following or equal:
 - 1) IDEC, RR2KP Series.
 - 2) Square D, 8501, Type K.
- 5. Time delay:
 - a. Provide time-delay relays to control contact transition time.
 - b. Contact rating:
 - 1) 240 volts.
 - 2) 10 amps continuous.
 - 3) 3,600 volt-amperes make.
 - 4) 360 volt-amperes break.
 - c. Coil voltage: As required for the application.
 - d. Provide pneumatic or electronic type with on-delay, off-delay, and on/off-delay:
 - 1) For off-delay, use true power-off time-delay relays. Where the required timing range exceeds capability of the off-delay relay use, signal off-delay where power loss will not cause undesirable operation or pneumatic time-delay relays.
 - e. Minimum contacts: DPDT.
 - f. Units include adjustable dial with graduated scale covering the time range in each case.
 - g. Minimum timing range: 0.1 second to 10 minutes, or as required for the application.
 - h. Manufacturers: One of the following or equal:
 - 1) Allen-Bradley, Type 700-HR.
 - 2) IDEC, RTE Series.
 - 3) Tyco Electronics, Agastat 7000 Series (pneumatic).

- N. Terminal blocks:
1. DIN rail mounting on 35-millimeter rail.
 2. Rated for 15 amps at 600 volts.
 3. Screw terminal type.
 4. Provide mechanism to prevent wire connection from loosening in environments where vibration is present. This mechanism shall not cause permanent deformation to the metal body.
 5. Finger-safe protection for terminals for conductors.
 6. Construction: Polyamide insulation material capable of withstanding temperature extremes from -40 degrees to 221 degrees Fahrenheit.
 7. Terminals: Plainly identified to correspond with markings on the diagrams:
 - a. Permanent machine-printed terminal identification.
 8. Disconnect-type field signal conductor terminals with socket/screw for testing.
 9. Identify terminals suitable for use with more than 1 conductor.
 10. Position:
 - a. So that the internal and external wiring does not cross.
 - b. To provide unobstructed access to the terminals and their conductors.
 11. Manufacturers: One of the following or equal:
 - a. Allen-Bradley, 1492 Series.
 - b. Phoenix Contact, UT4 Series.
- O. DIN rail grounding:
1. Grounding terminal blocks used exclusively for bonding each DIN rail section to panel grounding busbar shall:
 - a. Mount to DIN rail via grounding foot with mounting screw.
 - b. Connect to the panel grounding busbar shall be via a green insulated conductor sized in accordance with NEC.
 - c. Not be used for grounding signal cable shields.
 2. Screw terminal type.
 3. DIN rail mounting on 35-millimeter rail.
 4. Provide mechanism to prevent wire connection from loosening in environments where vibration is present. This mechanism shall not cause permanent deformation to the metal body.
 5. Finger-safe protection for terminals for conductors.
 6. Terminals: Plainly identified to correspond with markings on the diagrams:
 - a. Permanent machine-printed terminal identification.
 7. Manufacturers: One of the following or equal:
 - a. Allen-Bradley, 1492-JG Series.
 - b. Phoenix Contact, USKLG Series.
- P. Wire duct:
1. Provide flame retardant plastic wiring duct, slotted with dust cover.
 2. Type:
 - a. Wide slot.
 - b. Narrow slot.
 - c. Round hole.
 3. Manufacturers: One of the following or equal:
 - a. ABB.
 - b. Iboco.
 - c. Panduit.
 - d. Phoenix Contact.

- Q. DIN rail:
1. Perforated steel.
 2. 35-mm width.
 3. 15-mm deep.
 4. Provide 2-inch offset using one of the following:
 - a. Offset brackets.
 - b. Preformed standoff DIN Rail Channel.
- R. Surge protection devices (SPD):
1. 120 VAC control panel power SPD:
 - a. Provide SPD for panel 120 VAC power entrances:
 - 1) Non-faulting and non-interrupting design.
 - 2) Provide line to neutral and neutral to ground surge protection.
 - b. Provide surge protection at secondary of main circuit breaker:
 - 1) Surge protection is not required for 120 VAC circuits that are only used for panel lights and receptacles.
 - 2) For panels receiving power at 480 VAC, provide surge protection on the 120 VAC control power transformer secondary.
 - c. DIN rail mounting.
 - d. Attach wiring to the SPD by means of a screw-type cable-clamping terminal block:
 - 1) Gastight connections.
 - 2) Visual status indication of MOV status on the input and output circuits.
 - 3) Dry contact rated for remote status indication.
 - e. Approvals:
 - 1) Tested in accordance with IEC 61643-11.
 - 2) Tested in accordance with UL 1283.
 - 3) Tested in accordance with UL 1449.
 - 4) Surge protection minimum requirements: Withstand a minimum 10-kA test current of an 8/20 μ s waveform in accordance with IEEE C62.41.1, Category C Area.
 - f. Manufacturers: One of the following or equal:
 - 1) ASCO, Model 277.
 - 2) Phoenix Contact, Type SFP Filter.
 - 3) Rockwell, 4983-DC series.
 - 4) Sola HD, STFE Elite series.
 2. 24 VDC control panel power SPD:
 - a. Provide SPD for 24 VDC power circuits.
 - b. Provide surge protection at DC power supply output.
 - c. DIN rail mounting.
 - d. Attach wiring to the SPD by means of a screw-type cable clamping terminal block:
 - 1) Optical status indicator.
 - 2) Dry contact rated for remote status indication.
 - e. Approvals:
 - 1) Tested in accordance with IEC 61643-11.
 - f. Manufacturers: One of the following or equal:
 - 1) Field instruments that require auxiliary power:
 - a) Emerson, Model 265 (SLAC) series.
 - b) Phoenix Contact, Plugtrab PLT--SEC-T3-24-FM-UT.

- 2) Loop powered field instruments:
 - a) Emerson/Edco, Model SS65-036-2.
3. Panel mounted control, signal, and data line SPD:
 - a. General:
 - 1) This section applies to SPD located in a control panel, field panel, network junction box, or marshalling panel.
 - 2) Approvals:
 - a) Tested in accordance with IEC 61643-21.
 - b) Tested in accordance with UL 497B.
 - 3) SPD shall consist of 2 parts:
 - a) Base module:
 - (1) DIN rail mounting.
 - (a) Grounded to DIN rail via mounting rail foot.
 - b) Plug protection module:
 - (1) Replacing a plug shall not require the removal of any wires nor interrupt the signal.
 - 4) Provide indirect shield ground style SPD unless otherwise noted.
 - 5) Provide ability to locally identify and indicate SPD health.
 - 6) SPD shall be provided with controller module with dry contact for remote status monitoring of SPD device health.
 - 7) SPD modules shall be compatible with signal, communication bus type, data type, or control power being protected.
 - 8) Provide dedicated SPD for each signal, communication bus type, or data line being protected.
 - b. Manufacturers: One of the following or equal:
 - 1) Dehn, Blitzductor XTU Series.
 - 2) Phoenix Contact, Plugtrab PT-IQ Series.
4. Copper Ethernet SPD:
 - a. Protects network equipment from lightning or other surge events.
 - b. Suitable for Gigabit networks.
 - c. Shielded RJ-45 ports.
 - d. In accordance with PoE standards IEEE 802.3af and 802.3at.
 - e. Nominal discharge surge current: 10 kA.
 - f. Approvals:
 - 1) Tested in accordance with IEC 61643-21.
 - 2) Tested in accordance with UL 497B.
 - g. Manufacturers: One of the following or equal:
 - 1) Citel, MJ8-C6A.
 - 2) Eaton/MTL, ZoneBarrier High Energy Ethernet.
 - 3) Phoenix Contact, DT-LAN-CAT6+.
 - 4) Weidmuller, VDATA CAT6.
5. Field device mounted SPD:
 - a. Conduit entry mounting.
 - 1) Provide parallel or through wiring configurations as required by the application.
 - a) Use parallel wiring configuration if there is an available cable gland at the device.
 - b) Use through wiring configuration if there is no available cable gland at the device.
 - 2) Provide screw connections compatible with field device.

- b. NEMA 4X stainless steel material housing.
 - c. Approvals:
 - 1) Tested in accordance with IEC 61643-21.
 - d. 4-wire field device:
 - 1) Module shall provide simultaneous protection of signal cable, communication bus, or data line, and power supply line.
 - a) Maximum continuous voltage:
 - (1) DC:
 - (a) Signal: 32 VDC.
 - (b) Power supply: 255 VDC.
 - (2) AC:
 - (a) Signal: 22.6 VAC.
 - (b) Power supply: 255 VAC.
 - 2) Manufacturers: The following; Engineer knows of no equal:
 - a) Endress+Hauser, HAW569-CB2C.
 - e. 2-wire or 3-wire field device:
 - 1) Module shall provide protection for the signal cable, communication bus or data line.
 - 2) Manufacturers: One of the following or equal:
 - a) Eaton/MTL, TP Series.
 - b) Endress+Hauser, HAW569 Series.
 - c) Phoenix Contact, Surgetrab S-PT Series.
- S. Horns and beacons:
- 1. Beacons/horn combination units:
 - a. Manufacturers: One of the following or equal:
 - 1) Edwards, Multi-Status LED 108i with tone module.
 - 2) Federal Signals, AV1ST Strobe Combination Audible/Visual Signal.
 - b. LED colors: Red, green, and amber.
 - c. Power: 120 VAC.
 - d. Provide accessories such as pipe mount flange, pipe extensions, corner mount brackets, or wall mount brackets as needed.
 - e. Horn rated 80 dB minimum at 10 feet.
 - 2. Dedicated beacon unit:
 - a. Manufacturers: One of the following or equal:
 - 1) Allen-Bradley, 855 B *-* 10 Series.
 - 2) Edwards, 102 Series.
 - 3) Federal Signal Corp., Starfire Series.
 - 3. Dedicated horn unit:
 - a. Electromechanical:
 - 1) Manufacturers: One of the following or equal:
 - a) Edwards, 878EX or 879EX Series.
 - b) Federal Signal, 350 or 31X Series.
 - b. Electronic:
 - 1) Manufacturers: One of the following or equal:
 - a) Allen-Bradley, 855H or 855XH Series.
 - b) Edwards, 5530M or 5533MD Series.
 - c) Federal Signal, 300GCX or 300X Series.
 - c. Rated for 80 dB minimum at 10 feet.

T. Power supplies:

1. Configure power supply system so that either the primary or backup supply can be removed, repaired or replaced, and returned to service without disrupting the system operation.
2. Convert 120 VAC to 24-volt DC or other DC voltages required or as required for the application.
3. Provide redundant backup 24 VDC power supply units to automatically supply the load upon failure of the primary supply.
4. Provide power supply arrangement that is configured with several modules to supply adequate power in the event of a single module failure in either a 1+1 or N+1 configuration as required:
 - a. Provide automatic switchover upon module failure.
 - b. Alarm contacts monitored by the PLC.
5. Provide protective isolation between power supply units either by means of Diodes, Diode Modules, MOSFET Modules, or use power supplies with built in redundancy. Power supplies with built in redundancy must actively isolate each power supply and be designed as such.
6. Sized to provide 40-percent excess rated capacity.
7. UL 508 listed to allow full-rated output without de-rating.
8. Provide fuse or short-circuit protection.
9. Provide a minimum of 1 set of dry contacts for each power supply configured to change state on failure for monitoring and signaling purposes.
10. Output regulation: Within 0.05 percent for a 10-percent line change or a 50-percent load change.
11. Operating temperature range: 32 degrees to 140 degrees Fahrenheit.
12. Touch-safe design: Connection terminals to be protected against accidental touch.
13. DIN rail mounting on 35-millimeter rail:
 - a. Mount the power supply in the proper orientation as recommended by the manufacturer to ensure adequate thermal dispersion without derating the power supply.
14. Provide self-protecting power supplies with a means of limiting DC current in case of short circuit.
15. Manufacturers: One of the following or equal:
 - a. Fully redundant:
 - 1) IDEC, PS5R Series:
 - 2) Phoenix Contact, Quint Power Supply with SFB technology.
 - a) Phoenix Contact, Quint.
 - 3) PULS.
 - 4) Sola.
 - b. Redundancy module:
 - 1) Phoenix Contact, O-ring redundancy module.

U. Limit switches:

1. NEMA Type 4X.
2. AC contact rating 120 volts, 10 A.
3. DC contact rating 125 volts, 0.4 A.
4. Provide robust actuation mechanism not prone to degradation.
5. Provide complete actuator mechanism with required hardware.
6. Allows for contact opening even during contact weld condition.
7. UL approved.

8. Operating temperature range: 0 degrees to 230 degrees Fahrenheit).
 9. Manufacturers: One of the following or equal:
 - a. ABB.
 - b. Allen-Bradley, 802 Series.
 - c. Eaton, E47, E49, E50.
 - d. Honeywell, HDLS Series.
 - e. Omron, D4 Series.
- V. Current switches:
1. Power supply: 120 VAC supply voltage.
 2. 1 normally open and normally closed contacts.
 3. Adjustable current setting.
 4. Manufacturers: One of the following or equal:
 - a. Phoenix Contact, EMD Series.
 - b. Zelio®, RM35.

2.07 ACCESSORIES

- A. Provide panels with an inside protective pocket to hold the panel drawings.
 1. Ship panels with 1 copy of accepted Shop Drawings, including, but not limited to, schematic diagram, connection diagram, and layout drawing of control wiring and components in a sealed plastic bag stored in the panel drawing pocket.
- B. Provide floor stands or legs with a minimum height of 12 inches where needed or as indicated on the Drawings.
- C. Provide a folding shelf for enclosures that contain programmable controllers. Shelf shall be mounted on the inside surface of the door, capable of supporting a laptop computer.
- D. Provide nameplate to each panel as indicated on the Drawings:
 1. As specified in Section 26_05_53 - Identification for Electrical Systems on internal and external instruments and devices.
 2. With the following markings that is plainly visible after installation:
 - a. Manufacturer's name, trademark, or other descriptive marking by which the organization responsible for the panel can be identified.
 - b. Supply voltage, phase, frequency, and full-load current.
 - c. Power source or circuit ID.
 - d. Short-circuit current rating of the panel based on one of the following:
 - 1) A listed and labeled assembly.
 - 2) Established utilizing an approved method.
- E. Provide a window kit where indicated on the Drawings or where a transmitter with display is mounted inside a control panel. Window shall meet the following requirements:
 1. Safety plate glass.
 2. Secured by rubber locking seal.
 3. Allow full viewing of devices issuing visual process data or diagnostics.

- F. Lighting:
1. Provide 1 luminaire for each section, on the interior of the panel, spaced evenly along the top-front of the enclosure door opening(s):
 - a. Covered or guarded.
 - b. Provide On-Off door-activated switches where indicated on the Drawings.
 - c. 120-volt, single-phase, 15-amp style plug.
 - d. Provide 4,000 K, 900 lumens LED fixture.
 - 1) Provide additional fixtures for every 36 inches of width.
- G. Receptacles:
1. Provide 1 duplex receptacle located every 6 feet of enclosure width, spaced evenly along the back mounting panels.
 2. GFCI, 120-volt, single-phase, 15-amp style plug.
 3. Provide circuit breaker or fuse to limit receptacle draw to 5 amps.
- H. Grounding:
1. Provide the following:
 - a. Grounding strap between enclosure doors and the enclosure.
 - b. Equipment grounding conductor terminals.
 - c. Provide equipment grounding busbar with lugs for connection of equipment grounding wires.
 - d. Bond multi-section panels together with an equipment grounding conductor or an equivalent grounding busbar.
 2. Identify equipment grounding conductor terminals with the word "GROUND," the letters "GND", the letter "G", or the color green.
 3. Signal cable shields shall only be grounded at a single point in the loop. Unless otherwise noted, ground signal cable shields at the control panel.
 4. Ensure the continuity of the equipment grounding system by effective connections through conductors or structural members.
 5. Design so that removing a device does not interrupt the continuity of the equipment-grounding circuit.
 6. Provide an equipment-grounding terminal for each incoming power circuit, near the phase conductor terminal.
 7. Size ground wires in accordance with NEC and UL Standards, unless noted otherwise.
 8. Unless otherwise noted, connect exposed, noncurrent-carrying conductive parts, devices, and equipment to the equipment-grounding circuit.
 9. Connect the door stud on the enclosures to an equipment-grounding terminal within the enclosure using an equipment-bonding jumper.
 - a. Control panel ground lugs and ground bar shall be copper mechanical or compression connection type. Aluminum connectors or lugs are not acceptable for use with copper conductors.

2.08 FINISHES

- A. Finishes:
1. Metallic (non-stainless):
 - a. Metal surfaces of panels shall be prepared by chemical cleaning and mechanical abrasion in accordance with the finish manufacturer's recommendations to achieve a smooth, well-finished surface.

- b. Scratches or blemishes shall be filled before finishing. 1 coat of zinc phosphate shall be applied according to the manufacturer's recommended dry-film thickness and allowed to dry before applying the finish coat.
 - c. Finish coat shall be a baked polyester-urethane powder, aliphatic air-dry polyurethane, or epoxy enamel to meet NEMA rating specified application.
 - d. Exterior of enclosures located outdoors shall be UV-resistant polyester powder coating. Total dry film thickness shall be 3 mils, minimum.
 - 2. Stainless steel:
 - a. Stainless enclosures shall be provided with a No. 4 brushed finish, not painted.
- B. Colors:
 - 1. Exterior color of panels mounted indoors shall be the manufacturer's standard light gray.
 - 2. Exterior of panels mounted outdoors shall be the manufacturer's standard white.
 - 3. Panel interiors shall be the manufacturer's standard white.

PART 3 EXECUTION

3.01 PREPARATION

- A. Equipment support and anchoring to structures:
 - 1. As specified in Section 01_81_50 - Design Criteria, including, but not limited to:
 - a. Anchor bolt layout.
 - b. Equipment templates.
 - c. Anchor installation.

3.02 INSTALLATION

- A. Install enclosures so that their surfaces are plumb and level within 1/8 inch over the entire surface of the panel: Anchor securely to wall and structural supports at each corner, minimum. Direct attachment to drywall is not permitted.
- B. Install the equipment in accordance with the accepted installation instructions and anchorage details.
- C. Provide floor stand kits for wall-mounted enclosures larger than 48 inches high.
- D. Provide concrete housekeeping pads for freestanding enclosures.
 - 1. Refer to the structural typical details.
- E. Install gasket and sealing material under panels with floor slab cutouts for conduit:
 - 1. Undercoat floor-mounted panels.
- F. Provide a full-size equipment-grounding conductor in accordance with NEC included with the power feeder. Terminate to the incoming power circuit-grounding terminal.

- G. Holes for field conduits, etc., shall be cut in the field. No additional holes, factory cut holes, or hole closers allowed. Incorrect holes, additional holes, or miscut holes shall require that the entire enclosure be replaced.
- H. Protect wiring from sharp edges and corners.
- I. Control panels that are adjacent to motor control centers shall be fully wired to the motor control centers using wireways integral to the motor control center or additional conduits as needed. These interconnections are not shown or reflected on the Conduit Schedule but shall be shown on the loop drawings prepared by the Contractor.
- J. Provide individually fused analog input module points with blown-fuse indicator lights, mounted external of the module on the output terminal strip.
- K. Side panels:
 - 1. Side panels shall be kept free of control equipment and devices. Any deviation must be sent to the Engineer in writing asking for a deviation.
- L. Doors:
 - 1. Provide snake-skin cable management sleeve or spiral wire-wrap on wires where they pass from the interior of the cabinet past the door hinge to door-mounted devices.

3.03 TESTING

- A. As specified in Section 40_80_01 - Commissioning for Instrumentation and Controls.

END OF SECTION

SECTION 40_67_26

CONTROL SYSTEMS: UNINTERRUPTIBLE POWER SUPPLIES 10 KVA AND BELOW

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Single-phase double conversion uninterruptible power supplies rated 10 kVA and below.

1.02 REFERENCES

- A. As specified in Section 26_05_00 - Common Work Results for Electrical and Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.
- B. Standards:
 - 1. Federal Communications Commission (FCC):
 - a. FCC Part 15:
 - 1) Class A.
 - 2) Class B.
 - b. C62.41 - IEEE Recommended Practice for Surge Voltages in Low-Voltage AC Power Circuits.
 - 2. National Electrical Manufacturers Association (NEMA):
 - a. 250 - Enclosures for Electrical Equipment (1,000 V Maximum).
 - 3. Underwriters Laboratories, Inc. (UL):
 - a. UL 1778 - Standard for Uninterruptible Power Supply Systems and Equipment.

1.03 TERMINOLOGY

- A. The words and terms listed below are not defined terms that require initial capital letters, but, when used in this Section, have the indicated meaning.
 - 1. Critical load: Load supplied by the UPS.

1.04 SUBMITTALS

- A. Furnish Submittals as specified in Section 01_33_00 - Submittal Procedures and Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.
- B. Product data:
 - 1. Manufacturer and model number.
 - 2. Catalog data.
 - 3. Dimensions:
 - a. Height.
 - b. Width.

- c. Depth.
 - d. Weight.
 - 4. Ratings:
 - a. Input voltage.
 - b. Output voltage.
 - c. Input/output power factor.
 - d. Efficiency.
 - e. Harmonic distortion.
 - f. Runtime.
 - 5. Noise specifications.
 - 6. Heat dissipation.
 - 7. Warranties and maintenance contracts:
 - 8. Communications requirements such as software, cards, etc.
 - 9. Alarms and status available for remote monitoring and system health.
- C. Shop Drawings:
- 1. Power distribution block diagrams.
 - 2. Front and rear views of equipment enclosures:
 - a. Front elevation, including control and indicating devices.
 - 3. Support points and weight of overall equipment.
 - 4. Schematic and control wiring diagrams, including, but not limited to:
 - a. Line and load terminals.
 - b. Alarm and status terminals.
 - c. Manual maintenance bypass switch terminals.
 - d. External battery or step-down/step-up transformers, if any.
 - e. External wiring requirements for communication signals.
 - 5. Switching and overcurrent protective devices.
- D. Calculations:
- 1. Include derating for temperature and elevation as necessary.
 - 2. UPS sizing computation:
 - a. Apply safety factors as specified in this Section.
 - b. Provide itemized list of critical loads, including individual VA and watt ratings.
 - 3. Battery time calculation based on specified runtime for total load with the safety factor multiplied to it. Table/graph for back-up time calculation.
 - 4. Load calculation shall include power for all shown in the power distribution drawing, which includes, but is not limited to, PLC power supply, field instruments (120 VAC and 24 VDC), instrument power, Ethernet switches, and I/O modules. Refer to network drawings for additional information and notes.
 - 5. Total battery recharge time as a function of capacity utilized.
- E. Design data:
- 1. Design mounting and anchorage for seismic design criteria specified in Section 01_81_50 - Design Criteria:
 - a. Provide seismic kits as required to meet design criteria.
- F. Record documents:
- 1. Provide record drawings of installed unit(s), including layout and wiring.
- G. Manufacturer's field reports.

- H. Operation and maintenance manuals:
 - 1. As specified in Section 01_78_24 - Operation and Maintenance Manuals.
 - 2. System instruction manuals that describe troubleshooting, installation, operations, and safety procedures.
 - 3. Recommendations for maintenance procedures and intervals.
 - 4. Battery data/replacement information.
 - 5. Parts list.

1.05 QUALITY ASSURANCE

- A. Manufacturer qualifications:
 - 1. A minimum of 10 years' experience in the design, manufacture, and testing of solid-state UPS systems.
 - 2. ISO 9001 certified.
- B. Regulatory requirements for complete UPS system:
 - 1. UL listed in accordance with UL 1778.
 - 2. IEEE C62.41, Category B.
 - 3. FCC 15:
 - a. Greater than 2,000 VA - Class A.
 - b. Less than 2,000 VA - Class B.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.

1.07 PROJECT OR SITE CONDITIONS

- A. As specified in Section 01_81_50 - Design Criteria.

1.08 ADMINISTRATIVE REQUIREMENTS (NOT USED)

1.09 WARRANTY

- A. As specified in Section 01_78_36 - Warranties and Bonds.

PART 2 PRODUCTS

2.01 GENERAL

- A. Provide complete, factory-assembled, wired, and tested, true on-line double conversion UPS equipment, including, but not limited to, rectifier, DC bus, inverter, battery charger, batteries, automatic bypass, and ancillary components as specified in this Section and as indicated on the Drawings.

2.02 DESIGN AND PERFORMANCE CRITERIA

- A. Critical loads as indicated on the Drawings.

2.03 MANUFACTURERS

- A. Double conversion true online UPS system:
 - 1. One of the following or equal:
 - a. Eaton, 9PX Series.
 - b. Vertiv, Liebert GXT5 Series.

2.04 EXISTING PRODUCTS (NOT USED)

2.05 MATERIALS (NOT USED)

2.06 MANUFACTURED UNITS

- A. Design requirements:
 - 1. Minimum VA rating of the UPS shall be greater than or equal to the safety factor (as indicated in the UPS schedule) times the connected load or 700 VA, whichever is greater.
 - 2. UPS system input:
 - a. Voltage:
 - 1) Less than or equal to 3 kVA UPS:
 - a) 120 VAC within 3 percent, single-phase, 2-wire plus ground (L1, N, G).
 - 2) Greater than 3 kVA UPS:
 - a) 208 VAC within 5 percent, single-phase, 3-wire plus ground (L1, L2, N, G).
 - 3) Frequency: 60 hertz:
 - a) Auto sensing on initial power up.
 - b) User configurable.
 - b. Current harmonic distortion (THDi%):
 - 1) Less than or equal to 5 percent at full load operation.
 - c. Power factor:
 - 1) Greater than or equal to 0.99 lagging at rated load.
 - d. Connections:
 - 1) As specified and as indicated on the Drawings.
 - 3. UPS inverter:
 - a. Output voltage:
 - 1) Less than or equal to 3 kVA UPS:
 - a) Standard:
 - (1) 120 VAC.
 - b) User selectable:
 - (1) 100 VAC, 110 VAC, 120 VAC, 125 VAC.
 - 2) Greater than 3 kVA UPS:
 - a) Standard:
 - (1) 208 VAC.
 - b) User selectable: A.
 - (1) 200 VAC, 208 VAC, 220 VAC, 230 VAC, 240 VAC.
 - b. AC-AC efficiency:
 - 1) Greater than or equal to 89 percent at full rated resistive linear load.
 - c. Transient recovery time:
 - 1) To nominal voltage within 100 milliseconds.

- d. Voltage regulation:
 - 1) Within 1 percent steady state.
- e. Output voltage distortion (THDV%):
 - 1) Linear load: Less than 2 percent.
 - 2) Non-linear load: Less than 5 percent.
- f. Output power factor:
 - 1) Load power factor range shall be 0.65 lagging to 1.0 (unity) leading without power derating.
- g. Current overload capability:
 - 1) UPS shall attempt to clear overloads while maintaining normal operation before transferring to bypass.
 - 2) Bypass transfer thresholds shall follow inverse time-current characteristic that operates when the load exceeds the nameplate rating of the UPS.
 - 3) Transfer load to bypass when overload capacity is exceeded.
- 4. Batteries:
 - a. Internal battery shall utilize lithium-ion cells.
 - b. UPS shall have capability for connection of external battery modules to extend total available run time. External batteries shall match the UPS in aesthetics and color.
- 5. Mounting:
 - a. Configurable for rack and tower mounting applications.
 - b. Provide manufacturer's standard mounting kit as required by the application.
- 6. Cooling:
 - a. UPS shall have integral forced air cooling.
- 7. Output connections:
 - a. Receptacles:
 - 1) Less than or equal to 3 kVA UPS:
 - a) Provide a minimum of four NEMA Type 5-15R or Type 5-20R receptacles.
 - b) Provide at least one NEMA Type L5-30R receptacle.
 - 2) Greater than 3 kVA UPS:
 - a) Provide a minimum of four NEMA Type 5-20R receptacles.
 - b) Provide at least one NEMA Type L14-30R receptacle.
 - 3) Provide hardwired connections as required and as indicated on the Drawings.
- B. Environmental requirements:
 - 1. Operating ambient temperature:
 - a. UPS module: 50 degrees Fahrenheit to 104 degrees Fahrenheit (10 degrees Celsius to 40 degrees Celsius).
 - b. Battery: 68 degrees Fahrenheit to 86 degrees Fahrenheit (20 degrees Celsius to 30 degrees Celsius).
 - 2. Operating altitude:
 - a. Project Site conditions as specified in Section 01_81_50 - Design Criteria.
 - 3. Surge protection:
 - a. UPS shall be accordance with IEEE C62.41, Category B.
 - 4. Audible noise:
 - a. Less than 46 dB at 1 meter.

- C. Communications:
 - 1. Relay outputs:
 - a. Provide low voltage signals for On Battery, Low Battery, Any Mode Shutdown, and Battery Mode Shutdown.
 - b. Connections on a terminal block on the rear panel.
 - 2. Ethernet:
 - a. UPS shall include 1 communication slot that will allow the operator to field install a network communication card.
 - b. Network protocol: HTTP.
 - c. Network interface: RJ45.
 - 3. Serial:
 - a. RS-232 serial connection.
 - 4. USB:
 - a. Provide a USB connection that is HID compliant for network connection.

2.07 ACCESSORIES

- A. External maintenance bypass:
 - 1. Manufacturers: One of the following or equal:
 - a. Eaton, HotSwap MBP Series.
 - b. Vertiv, Liebert Micropod Series.
 - 2. Properties:
 - a. Provides isolation of the UPS for maintenance purposes.
 - b. Provide maintenance bypass from the same manufacturer as the UPS manufacturer.
 - c. UL 1778 listed.
 - d. Provide manufacturer's recommended mounting kit as required by the application.
 - e. Make-before-break design so that UPS can be isolated from the critical loads by placing these loads on source power without interruption of operation.
 - f. Utility and UPS status indications.
 - g. Rated to carry the full input current of the UPS.
 - h. Connections to match UPS connections and as indicated on the Drawings.
 - i. Supply necessary input/output cords and receptacles for connections with power source and UPS.
- B. External batteries:
 - 1. Manufacturers: One of the following or equal:
 - a. Eaton, 9PX EBM Series.
 - b. Vertiv, Liebert GXT5 EBC Series.
 - 2. Properties:
 - a. To provide extended runtime capabilities.
 - b. Provide batteries from the same manufacturer as the UPS manufacturer.
 - c. UL listed.
 - d. Housing shall match the appearance of the UPS.
 - e. Provide manufacturer's recommended mounting kit as required by the application.

- f. Connections to match UPS connections and as indicated on the Drawings.
- g. Supply necessary cords and cables for connection to UPS.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 INSTALLATION

- A. Install equipment in accordance with the manufacturer's instructions.
- B. Do not utilize extension cords, adapters, or other electrical connectors for UPS input.

3.03 FIELD QUALITY CONTROL

- A. Perform inspections and test procedures before UPS startup:
 - 1. Inspect equipment for signs of damage.
 - 2. Verify installation as indicated on the Drawings and specified in the Specifications.
 - 3. Inspect cabinets for foreign objects.
 - 4. Verify neutral and ground conductors are properly sized and terminated.
 - 5. Inspect battery cases.
 - 6. Inspect batteries for proper polarity.
 - 7. Check power and control wiring for tightness.
 - 8. Check terminal connectors for tightness.
 - 9. Ensure connection and voltage of the battery string(s).

3.04 SCHEDULES

Tag	Minimum Runtime	Input Voltage/Connection	Safety Factor	Notes
UPS-SW	3 hours	120 VAC	25% or greater	Need to provide continual power for at least 3 hours for the network cabinet, cameras, doors, and PCM cabinet

END OF SECTION

SECTION 40_71_15

FLOW MEASUREMENT: MAGNETIC FLOWMETERS

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Full-body magnetic flowmeters.

1.02 REFERENCES

- A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.
- B. Standards:
 - 1. International Organization for Standardization (ISO):
 - a. 9000 - Quality management systems - Fundamentals and vocabulary.
 - b. 17025 - General requirements for the competence of testing and calibration laboratories.
 - 2. National Institute of Standards and Technology (NIST).
 - 3. NSF International (NSF).

1.03 SUBMITTALS

- A. Furnish Submittals as specified in Section 01_33_00 - Submittal Procedures and Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.
- B. Include sizing information from the manufacturer that includes:
 - 1. Chart of the measurement error from zero to maximum measured volumetric flow range indicated in datasheets.
 - 2. Indication of input parameters and their values used in the calculations.
- C. Quality Control Submittals:
 - 1. Manufacturer's representative qualifications as specified in Section 01_75_17 - Commissioning.
- D. Owner Training Submittals:
 - 1. As specified in Section 01_75_17 - Commissioning.

1.04 QUALITY ASSURANCE

- A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.
- B. Examine the complete set of Contract Documents and verify that the instruments are compatible with the installed conditions, including:
 - 1. Process conditions: Fluids, pressures, temperatures, flows, materials, etc.

- 2. Physical conditions:
 - a. Installation and mounting requirements.
 - b. Location within the process.
 - c. Accessories: Verify that required accessories are provided and are compatible with the process conditions and physical installation.
- C. Manufacture instrument facilities certified to the quality standards of ISO 9001 - Quality Systems - Model for Quality Assurance in Design/Development, Production, Installation and Servicing.

1.05 DELIVERY, STORAGE, AND HANDLING

- A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.

1.06 PROJECT OR SITE CONDITIONS

- A. As specified in Section 01_81_50 - Design Criteria.

1.07 ADMINISTRATIVE REQUIREMENTS

- A. Coordination:
 - 1. Notify the Engineer if any installation condition does not meet the instrument manufacturer's recommendations or specifications.

1.08 WARRANTY

- A. As specified in Section 01_78_36 - Warranties and Bonds.

PART 2 PRODUCTS

2.01 GENERAL

- A. Provide instruments identified in the Contract Documents.

2.02 DESIGN AND PERFORMANCE CRITERIA

- A. Provide instruments suitable for the installed Site conditions, including, but not limited to, material compatibility, Site altitude, Site seismic conditions, humidity, and process and ambient temperatures.

2.03 MANUFACTURERS

- A. One of the following or approved equal:
 - 1. Endress+Hauser:
 - a. Promag W flowtube with 400 series transmitter.
 - 2. Krohne:
 - a. Optiflux 2300 with IFC 300 series transmitter.

2.04 MANUFACTURED UNITS

- A. As specified in this Section, including Attachment A - ISA Datasheet - Flow Measurement: Magnetic Flowmeters.
- B. Magnetic flowmeter:
 - 1. General:
 - a. Magnetic flowmeters obtain the flow velocity by measuring the changes of induced voltage of the conductive fluid passing across a controlled magnetic field.
 - b. Complete zero stability shall be an inherent characteristic of the flowmeter system.
 - c. Include for each magnetic flow metering system:
 - 1) A metering tube with electrodes (sensor).
 - 2) Fully welded flanges that are rated for the full pressure class of the piping.
 - 3) Signal cable if remote mounted.
 - 4) Provide zero diameter/0 x DN full bore option flow meter as indicated in the Data Sheet – Flow Measurement Magnetic Flowmeters.
 - 5) Transmitter integral or remote as indicated on the Drawings.
 - 6) Flowmeter grounding rings.
 - 2. Performance requirements:
 - a. Accuracy:
 - 1) 0.25 percent of flow rate from 10 to 100 percent of full-scale for velocities ranging between 1.9 to 10 feet per second.
 - b. Repeatability:
 - 1) 0.25 percent of rate.
 - 3. Element:
 - a. Metering tube:
 - 1) Constructed of Type 304 or 316 stainless steel (unless specifically noted otherwise in the instrument datasheet) with flanged connections to match with piping material.
 - a) Carbon steel cannot be used when coils are on the outside of the metering tube, it will not pass the magnetic field.
 - b) Coils that are embedded in the liner are not permitted.
 - 2) Liner material in conformance with:
 - a) Manufacturer's recommendations for the intended service.
 - b) NSF certified for drinking water applications.
 - 3) Electrodes type and material in conformance with:
 - a) Manufacturer's recommendations for the intended service.
 - b) Utilize a minimum of 2 self-cleaning electrodes.
 - 4) As indicated in the datasheets.
 - 5) Meter terminal housing NEMA Type 4X, unless installed in locations such as vaults that will experience submergence. In those applications NEMA 6P is required.
 - 6) Meter coating consisting of epoxy painted finish.
 - 7) Components:
 - a) 2 grounding rings:
 - (1) Which are in conformance with the manufacturer's bore and material recommendation for the meter's intended service.

4. Transmitter:
 - a. Power supply:
 - 1) As indicated in the datasheets.
 - b. Outputs:
 - 1) As indicated in the instrument datasheet.
 - 2) For instruments with 4 to 20 mA HART or digital bus protocol, provide a Device Type Manager (DTM) certification by FDT group.
 - c. Microprocessor-based signal converter/transmitter.
 - d. Utilize DC pulse technique to drive flux-producing coils.
 - e. Contain a 6-digit display for flow rate, percent of span, and totalizer.
 - f. Operator keypad interface.
 - g. Integral zero return to provide consistent zero output signals in response to an external dry contact closure.
 - h. Integral low flow cut-off zero return.
 - i. Programmable parameters, including:
 - 1) Meter size.
 - 2) Full-scale flow rate.
 - 3) Magnetic field frequency.
 - 4) Time constant.
 - j. Data retention for a minimum of 5 years without auxiliary main or battery power.
 - k. Self-diagnostics and automatic data checking.
 - l. Protected terminals and fuses in a separate compartment which isolates field connection from electronics.
 - m. Ambient operating temperature limits of -5 to 140 degrees Fahrenheit (-20 to 60 degrees Celsius).
 - n. Enclosure:
 - 1) As indicated in the instrument datasheet.
 - o. Transmitter should retain all setup parameters and accumulated measurements internally in non-volatile memory in the event of power failure.

2.05 ACCESSORIES

- A. Provide stainless steel tags for each instrument. Tags shall be labeled as specified in the Contract Documents.
- B. Provide sunshades for transmitters located outdoors.
- C. Provide galvanic isolation gaskets, nylon/Teflon™ flange bolt insulation bushings, and nylon washers on meters installed on pipes with cathodic protection.
- D. Furnish 1 spool piece for every size of magnetic flow tube being provided.

2.06 FINISHES (NOT USED)

2.07 SOURCE QUALITY CONTROL

- A. Factory calibrate each flow metering system at a facility that is traceable to the NIST.
 - 1. ISO 17025 accredited test facility with certified accuracy traceable to NIST.
 - 2. Suggestion, the calibration facility be traceable to international standards and ILAC, International Laboratory Accreditation Committee MRA, Mutual Recognition Agreement.
 - 3. This ensures worldwide accreditation of calibration laboratories.
- B. Evidence of accreditation shall originate from a national verification agency such as A2LA ILAC.
- C. FM approval certification or equal when installed in classified areas.
- D. A real-time computer-generated printout of the actual calibration date indication actual velocities and as read values of the flow tube.
 - 1. Flow calibration report of the manufacturers flow lab calibration procedure shall be shipped with the meter system.
 - 2. Minimum calibration shall be a 3-point calibration, including 1, 3, and 10 feet per second velocities for every meter and transmitter system. 2 points at 15 to 20 percent and 80 to 100 percent are statistically proven to be sufficient calibration points.
 - 3. Manufacturer shall archive calibration reports for future reference.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 INSTALLATION

- A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.
- B. For instruments located outdoors or where instrument elements and transmitters are separated by conduit located outside the building envelope, provide surge protection devices at the transmitters.

3.03 CALIBRATION AND TESTING

- A. As specified in Section 40_80_01 - Commissioning for Instrumentation and Controls.
- B. Calibration verification:
 - 1. Verify factory calibration of instruments in accordance with the manufacturer's instructions.
 - a. Verify flow meter performance to the original manufacturer specifications.
 - 2. Verification shall be traceable to factory calibration using a third party, attested onboard system pursuant to ISO standards.

3. Verification report in accordance with common quality systems such as ISO 9000 to prove the reliability of the meter-specified accuracy.
4. Return factory calibrated devices to the factory if they do not meet the field verification requirements for calibration.

3.04 OWNER TRAINING

- A. Not required.

3.05 SCHEDULES

- A. Instrument datasheets included in this Section.
- B. The provided information does not necessarily include all required instruments.
- C. Provide all instruments identified in the Contract Documents:
 1. Instruments may be indicated on the Drawings, specified in the Specifications, or both.

END OF SECTION

ATTACHMENT A - ISA DATASHEET - FLOW MEASUREMENT: MAGNETIC FLOWMETERS

PROJECT INFORMATION

PLANT
PROJECT 203505

CUSTOMER CITY OF THORNTON
LOCATION

GENERAL NOTE: FIELDS SHOWN WITH THE [*] SYMBOL ARE NOT SHOWN ON THE DATASHEET BUT MAY BE REQUIRED BY THE CONTRACT DOCUMENTS. THE CONTRACTOR SHALL SUBMIT COMPLETE ISA DATASHEETS FOR EACH INSTRUMENT PER ALL SPECIFIED REQUIREMENTS.

GENERAL

TAG FIT-300 (FE-300)
SPECIFICATION NUMBER 17302
DRAWING NUMBER 30N30
SERVICE PUMP STATION FLOW METER

MEASURING PRINCIPLE MAGNETIC
PLC PLC-SW
POWER LOCATION PCM-SW
TYPICAL DETAIL(S) NF133

CONNECTION

LINE SIZE 42
LINE MATERIAL [*]

PROCESS CONNECTION ANSI 150
PROCESS CONN. MATERIAL [*]

FLUID

FLUID RAW WATER
NOMINAL FLOW [*]
FLOW RANGE 0-45 MGD

PRESSURE 125 PSI
TEMPERATURE N/A
VISCOSITY N/A
CONDUCTIVITY N/A

ELEMENT

ELEMENT TAG NO. FE-300
ENCLOSURE CLASS NEMA 4X
HAZARDOUS APPROVALS N/A
TUBE SIZE 42
TUBE MATERIAL MFR. STD.

PROCESS CONNECTION ANSI 150
LINER MATERIAL HARD RUBBER
VACUUM POSSIBILITY NO
ELECTRODE TYPE MFR. STD.
ELECTRODE MATERIAL 316 SST

TRANSMITTER

TRANSMITTER TAG NO. FIT-300
MOUNTING INT
ENCLOSURE CLASS NEMA 4X
POWER 120VAC-1P
AMBIENT TEMPERATURE 30-90 DEG F
OUTPUT 4-20 MA
SURGE PROTECTION NO

HAZARDOUS APPROVALS N/A
EMPTY PIPE DETECTION YES
BI DIRECTIONAL FLOW NO
PULSE OUTPUT NO
RELAY OPTIONS YES
POTTED ELECTRONICS NO
CATHODIC PROT. LINE NO

NOTES

PROVIDE ZERO DIAMETER FLOW METER

PROJECT INFORMATION

PLANT
PROJECT 203505

CUSTOMER CITY OF THORNTON
LOCATION

GENERAL NOTE: FIELDS SHOWN WITH THE [*] SYMBOL ARE NOT SHOWN ON THE DATASHEET BUT MAY BE REQUIRED BY THE CONTRACT DOCUMENTS. THE CONTRACTOR SHALL SUBMIT COMPLETE ISA DATASHEETS FOR EACH INSTRUMENT PER ALL SPECIFIED REQUIREMENTS.

GENERAL

TAG FIT-311 (FE-311)
SPECIFICATION NUMBER 17302
DRAWING NUMBER 30N30
SERVICE PUMP STATION FLOW METER

MEASURING PRINCIPLE MAGNETIC
PLC PLC-SW
POWER LOCATION PCM-SW
TYPICAL DETAIL(S) NF133

CONNECTION

LINE SIZE 18
LINE MATERIAL [*]

PROCESS CONNECTION ANSI 150
PROCESS CONN. MATERIAL [*]

FLUID

FLUID RAW WATER
NOMINAL FLOW [*]
FLOW RANGE 0-13 MGD

PRESSURE 125 PSI
TEMPERATURE N/A
VISCOSITY N/A
CONDUCTIVITY N/A

ELEMENT

ELEMENT TAG NO. FE-311
ENCLOSURE CLASS NEMA 4X
HAZARDOUS APPROVALS N/A
TUBE SIZE 18
TUBE MATERIAL MFR. STD.

PROCESS CONNECTION ANSI 150
LINER MATERIAL HARD RUBBER
VACUUM POSSIBILITY NO
ELECTRODE TYPE MFR. STD.
ELECTRODE MATERIAL 316 SST

TRANSMITTER

TRANSMITTER TAG NO. FIT-311
MOUNTING INT
ENCLOSURE CLASS NEMA 4X
POWER 120VAC-1P
AMBIENT TEMPERATURE 30-90 DEG F
OUTPUT 4-20 MA
SURGE PROTECTION NO

HAZARDOUS APPROVALS N/A
EMPTY PIPE DETECTION YES
BI DIRECTIONAL FLOW NO
PULSE OUTPUT NO
RELAY OPTIONS YES
POTTED ELECTRONICS NO
CATHODIC PROT. LINE NO

NOTES

PROVIDE ZERO DIAMETER FLOW METER

SECTION 40_71_79

FLOW MEASUREMENT: SWITCHES

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Thermal dispersion flow switches.

1.02 REFERENCES

- A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.

1.03 SUBMITTALS

- A. Furnish Submittals as specified in Section 01_33_00 - Submittal Procedures and Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.
- B. Provide complete documentation covering the traceability of calibration instruments.

1.04 QUALITY ASSURANCE

- A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.
- B. Examine the complete set of Contract Documents and verify that the instruments are compatible with the installed conditions, including:
 - 1. Process conditions: Fluids, pressures, temperatures, flows, materials, etc.
 - 2. Physical conditions:
 - a. Installation and mounting requirements.
 - b. Location within the process.
 - c. Accessories: Verify that required accessories are provided and are compatible with the process conditions and physical installation.

1.05 DELIVERY, STORAGE, AND HANDLING

- A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.

1.06 PROJECT OR SITE CONDITIONS

- A. As specified in Section 01_81_50 - Design Criteria.

1.07 ADMINISTRATIVE REQUIREMENTS

- A. Coordination:
 - 1. Notify the Engineer if any installation condition does not meet the instrument manufacturer's recommendations or specifications.

1.08 WARRANTY

- A. As specified in Section 01_78_36 - Warranties and Bonds.

1.09 MAINTENANCE

- A. Furnish parts, materials, fluids, etc., necessary for operation, maintenance, and calibration purposes throughout the warranty period. Deliver these supplies before Project Substantial Completion.

PART 2 PRODUCTS

2.01 GENERAL

- A. Provide instruments identified in the Contract Drawings.

2.02 DESIGN AND PERFORMANCE CRITERIA

- A. Provide instruments suitable for the installed Site conditions, including, but not limited to, material compatibility, Site altitude, Site seismic conditions, humidity, and process and ambient temperatures.

2.03 MANUFACTURERS

- A. One of the following or equal:
 - 1. Thermal dispersion type:
 - a. Fluid Components International LLC, FLT93.
 - b. Kayden.

2.04 MANUFACTURED UNITS

- A. As specified in this Section, including Attachment A - ISA Datasheet - Flow Measurement: Switches.
- B. Thermal dispersion type:
 - 1. General:
 - a. Instrument uses a heated probe and a reference probe.
 - 1) Deviation in the amount of heat measured by the reference probe deviates beyond the setpoint and adjustable relay closes.
 - 2) Switch:
 - a) Micro-processor based with continuous self-diagnostics, "Smart Heater" to prevent sensor failure, no mechanical jumpers or trim pots, and a 3-year warranty.
 - 2. Performance requirements:
 - a. Accuracy: Within 2 degrees Fahrenheit.

- b. Repeatability: Within 1 percent of setpoint range.
- c. Response time: 0.5 to 2.5 seconds.
- d. Adjustable bypass delay timer.
- e. Adjustable range.
- 3. Switch characteristics:
 - a. Exposed parts: Powder coated aluminum housing.
 - b. Wetted parts:
 - 1) Materials as recommended by the manufacturer and approved by the Engineer.
 - c. Power supply:
 - 1) As indicated in the datasheets.
 - 2) 115 VAC.
 - d. Operating temperature range:
 - 1) As indicated in the datasheets.
 - 2) -40 degrees Fahrenheit to 140 degrees Fahrenheit.
 - e. Enclosure:
 - 1) As indicated in the datasheets.
 - 2) Non-hazardous area:
 - a) NEMA Type 4X.

2.05 ACCESSORIES

- A. Provide sunshades for outdoor installations.

2.06 FINISHES (NOT USED)

2.07 SOURCE QUALITY CONTROL

- A. Factory calibrate each instrument with a minimum 3-point calibration or according to the manufacturer's standard at a facility that is traceable to the NIST.
 - 1. Submit calibration datasheets to the Engineer at least 30 days before shipment of the instruments to the Project Site.
- B. Provide FM approval certification or equal when installed in classified areas.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Examine the installation location for the instrument and verify that the instrument will work properly when installed.

3.02 INSTALLATION

- A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.

3.03 CALIBRATION AND TESTING

- A. As specified in Section 40_80_01 - Commissioning for Instrumentation and Controls.

3.04 SCHEDULES

- A. The provided information does not necessarily include all required instruments.
Provide all instruments identified in the Contract Documents:
 - 1. Instruments may be indicated on the Drawings, specified in the Specifications or both.

END OF SECTION

ATTACHMENT A - ISA DATASHEET - FLOW MEASUREMENT: SWITCHES

Flow Switch

SPECIFICATION 17301

PROJECT INFORMATION

PLANT
PROJECT 203505

CUSTOMER CITY OF THORNTON
LOCATION

ELEMENT/SWITCH

GENERAL NOTE: FIELDS SHOWN WITH THE [*] SYMBOL ARE NOT SHOWN ON THE DATASHEET BUT MAY BE REQUIRED BY THE CONTRACT DOCUMENTS. THE CONTRACTOR SHALL SUBMIT COMPLETE ISA DATASHEETS FOR EACH INSTRUMENT PER ALL SPECIFIED REQUIREMENTS.

TAG FSL-302 FE-302	P&ID 30N25	SERVICE PUMP 2 LOW FLOW FLUID RAW WATER MEASURING PRINCIPLE THERMAL SET POINT ___ GPM PROCESS CONNECTION [*] CONNECTION MATERIAL [*] INSERTION LENGTH [*] TYPICAL DETAILS NF111	HAZARDOUS APP N/A ELEM. ENC. CLASS NEMA 4X SWITCH ENCL. CLASS NEMA 4X PRESSURE N/A TEMPERATURE N/A VISCOSITY N/A	POWER [*] POWER LOCATION LOOP OUTPUT [*] RELAY FORM SPDT PLC [NOT FOUND ON P&ID] SURGE PROTECTION NO
TAG FSL-303 FE-303	P&ID 30N26	SERVICE PUMP 3 LOW FLOW FLUID RAW WATER MEASURING PRINCIPLE THERMAL SET POINT ___ GPM PROCESS CONNECTION [*] CONNECTION MATERIAL [*] INSERTION LENGTH [*] TYPICAL DETAILS NF111	HAZARDOUS APP N/A ELEM. ENC. CLASS NEMA 4X SWITCH ENCL. CLASS NEMA 4X PRESSURE N/A TEMPERATURE N/A VISCOSITY N/A	POWER [*] POWER LOCATION LOOP OUTPUT [*] RELAY FORM SPDT PLC [NOT FOUND ON P&ID] SURGE PROTECTION NO
TAG FSL-305 FE-305	P&ID 30N28	SERVICE PUMP 5 LOW FLOW FLUID RAW WATER MEASURING PRINCIPLE THERMAL SET POINT ___ GPM PROCESS CONNECTION [*] CONNECTION MATERIAL [*] INSERTION LENGTH [*] TYPICAL DETAILS NF111	HAZARDOUS APP N/A ELEM. ENC. CLASS NEMA 4X SWITCH ENCL. CLASS NEMA 4X PRESSURE N/A TEMPERATURE N/A VISCOSITY N/A	POWER [*] POWER LOCATION LOOP OUTPUT [*] RELAY FORM SPDT PLC [NOT FOUND ON P&ID] SURGE PROTECTION NO

Flow Switch

SPECIFICATION 17301

PROJECT INFORMATION

PLANT
PROJECT 203505

CUSTOMER CITY OF THORNTON
LOCATION

ELEMENT/SWITCH

GENERAL NOTE: FIELDS SHOWN WITH THE [*] SYMBOL ARE NOT SHOWN ON THE DATASHEET BUT MAY BE REQUIRED BY THE CONTRACT DOCUMENTS. THE CONTRACTOR SHALL SUBMIT COMPLETE ISA DATASHEETS FOR EACH INSTRUMENT PER ALL SPECIFIED REQUIREMENTS.

TAG	P&ID	SERVICE PUMP 6 LOW FLOW	HAZARDOUS APP N/A	POWER 120VAC-1P
FSL-306	30N29	FLUID RAW WATER	ELEM. ENC. CLASS NEMA 4X	POWER LOCATION LOOP
FE-306		MEASURING PRINCIPLE [*]	SWITCH ENCL. CLASS NEMA 4X	OUTPUT 4-20 MA
		SET POINT ___ GPM	PRESSURE N/A	RELAY FORM SPDT
		PROCESS CONNECTION INSERTION	TEMPERATURE N/A	PLC [NOT FOUND ON P&ID]
		CONNECTION MATERIAL [*]	VISCOSITY N/A	SURGE PROTECTION NO
		INSERTION LENGTH [*]		
		TYPICAL DETAILS NF111		

SECTION 40_72_76

LEVEL MEASUREMENT: SWITCHES

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Conductivity level switch.
 - 2. Capacitance level switch.
 - 3. Tuning fork level switch.
 - 4. Ball float level switch.
 - 5. Displacement float level switch.
 - 6. Ultrasonic level switch.

1.02 REFERENCES

- A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.

1.03 SUBMITTALS

- A. Furnish Submittals as specified in Section 01_33_00 - Submittal Procedures and Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.
- B. Provide complete documentation covering the traceability of calibration instruments.

1.04 QUALITY ASSURANCE

- A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.
- B. Examine the complete set of Contract Documents and verify that the instruments are compatible with the installed conditions, including:
 - 1. Process conditions: Fluids, pressures, temperatures, flows, materials, etc.
 - 2. Physical conditions:
 - a. Installation and mounting requirements.
 - b. Location within the process.
 - c. Accessories: Verify that required accessories are provided and are compatible with the process conditions and physical installation.
- C. Manufacture instrument facilities certified to the quality standards of ISO 9001 - Quality Systems - Model for Quality Assurance in Design/Development, Production, Installation and Servicing.

1.05 DELIVERY, STORAGE, AND HANDLING

- A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.

1.06 PROJECT OR SITE CONDITIONS

- A. Project environmental conditions as specified in Section 01_81_50 - Design Criteria.

1.07 ADMINISTRATIVE REQUIREMENTS

- A. Coordination:
 - 1. Notify the Engineer if any installation condition does not meet the instrument manufacturer's recommendations or Specifications.

1.08 WARRANTY

- A. As specified in Section 01_78_36 - Warranties and Bonds.

1.09 MAINTENANCE

- A. Furnish parts, materials, fluids, etc., necessary for operation, maintenance, and calibration purposes throughout the warranty period. Deliver these supplies before Project Substantial Completion.

PART 2 PRODUCTS

2.01 GENERAL

- A. Provide instruments identified in the Contract Documents.

2.02 DESIGN AND PERFORMANCE CRITERIA

- A. Provide instruments suitable for the installed Site conditions, including, but not limited to, material compatibility, Site altitude, Site seismic conditions, humidity, and process and ambient temperatures.

2.03 MANUFACTURERS

- A. One of the following or equal:
 - 1. Displacement float level switch:
 - a. B/W, Unifloat.
 - b. Gems Sensors and Controls, Series LS-3.

2.04 MANUFACTURED UNITS

- A. As specified in this Section, including Attachment A - ISA Datasheet - Level Measurement: Switches.

- B. Displacement float level switch:
 - 1. Float with a permanent magnet encircles a stationary stem. A hermetically sealed magnetically operated latching reed switch(es) mounted in the stem:
 - a. Mercury switches are not acceptable.
 - 2. Lead wires: Mounted in flexible waterproof PVC cable from switch to junction box terminals without splices.
 - 3. Switch:
 - a. As indicated in the datasheets.
 - b. Single pole single throw (SPST).
 - 4. Rating:
 - a. As indicated in the datasheets.
 - b. on-hazardous area:
 - 5. NEMA Type 4X. Number of floats per level system shall be as indicated on the Drawings.

2.05 ACCESSORIES

- A. Provide sunshades for outdoor installation.

2.06 FINISHES (NOT USED)

2.07 SOURCE QUALITY CONTROL

- A. FM approval certification or equal when installed in classified areas.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Examine the installation location for the instrument and verify that the instrument will work properly when installed.

3.02 INSTALLATION

- A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.

3.03 CALIBRATION AND TESTING

- A. As specified in Section 40_80_01 - Commissioning for Instrumentation and Controls.

3.04 SCHEDULES

- A. The provided information does not necessarily include all required instruments. Provide all instruments identified in the Contract Documents:
 - 1. Instruments may be as indicated on the Drawings, as specified in the Specifications, or both.

END OF SECTION

ATTACHMENT A - ISA DATASHEET - LEVEL MEASUREMENT: SWITCHES

Level Switch

SPECIFICATION 17201

PROJECT INFORMATION

PLANT
PROJECT 203505

CUSTOMER CITY OF THORNTON
LOCATION

ELEMENT/SWITCH

GENERAL NOTE: FIELDS SHOWN WITH THE [*] SYMBOL ARE NOT SHOWN ON THE DATASHEET BUT MAY BE REQUIRED BY THE CONTRACT DOCUMENTS. THE CONTRACTOR SHALL SUBMIT COMPLETE ISA DATASHEETS FOR EACH INSTRUMENT PER ALL SPECIFIED REQUIREMENTS.

TAG	P&ID	SERVICE	LEVEL FLOATS	HAZARDOUS APP	POWER [*]
LSL-301	30N24		FLUID [*]	N/A	
LE-301		MEASURING PRINCIPLE	BALL FLOAT	ELEM. ENC. CLASS NEMA 4X	POWER LOCATION LOOP
		SET POINT [*]		ELEM. MATERIAL MFR. STD.	OUTPUT RELAY
		MOUNTING	INTEGRAL	SWITCH ENCL. CLASS NEMA 4X	RELAY FORM SPDT
		TYPICAL DETAILS	NL108	ENCL. MATERIAL MFR. STD.	PLC PLC-SW
		SURGE PROTECTION	NO		
TAG	P&ID	SERVICE	LEVEL FLOATS	HAZARDOUS APP	POWER [*]
LSLL-301	30N24		FLUID [*]	N/A	
LE-301		MEASURING PRINCIPLE	BALL FLOAT	ELEM. ENC. CLASS NEMA 4X	POWER LOCATION LOOP
		SET POINT [*]		ELEM. MATERIAL MFR. STD.	OUTPUT RELAY
		MOUNTING	INTEGRAL	SWITCH ENCL. CLASS NEMA 4X	RELAY FORM SPDT
		TYPICAL DETAILS	NL108	ENCL. MATERIAL MFR. STD.	PLC PLC-SW
		SURGE PROTECTION	NO		

SECTION 40_73_13

PRESSURE/VACUUM MEASUREMENT: GAUGES

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Pressure/vacuum gauges.

1.02 REFERENCES

- A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.
- B. Standards:
 - 1. American Society of Mechanical Engineers (ASME):
 - a. B40.100 - Pressure Gauges and Gauge Attachments.

1.03 SUBMITTALS

- A. Furnish Submittals as specified in Section 01_33_00 - Submittal Procedures and Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.
- B. Product data:
 - 1. Accessories.

1.04 QUALITY ASSURANCE

- A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.
- B. Examine the complete set of Contract Documents and verify that the instruments are compatible with the installed conditions, including:
 - 1. Process conditions: Fluids, pressures, temperatures, flows, materials, etc.
 - 2. Physical conditions:
 - a. Installation and mounting requirements.
 - b. Location within the process.
 - c. Accessories: Verify that required accessories are provided and are compatible with the process conditions and physical installation.

1.05 DELIVERY, STORAGE, AND HANDLING

- A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.

1.06 PROJECT OR SITE CONDITIONS

- A. As specified in Section 01_81_50 - Design Criteria.

1.07 ADMINISTRATIVE REQUIREMENTS

- A. Coordination:
 - 1. Notify the Engineer if any installation condition does not meet the instrument manufacturer's recommendations or specifications.

1.08 WARRANTY

- A. As specified in Section 01_78_36 - Warranties and Bonds.

PART 2 PRODUCTS

2.01 GENERAL

- A. Provide instruments specified in the Contract Documents.

2.02 DESIGN AND PERFORMANCE CRITERIA

- A. Provide instruments suitable for the installed Site conditions, including, but not limited to, material compatibility, Site altitude, Site seismic conditions, humidity, and process and ambient temperatures.

2.03 MANUFACTURERS

- A. One of the following or equal:
 - 1. Ametek U.S. Gauge.
 - 2. Ashcroft:
 - a. Maximum pressure less than 10 pounds per square inch: Model 1188
 - b. Maximum pressure greater than or equal to 10 pounds per square inch: Model 1279
 - 3. Wika, Model XSEL type 232.34.

2.04 MANUFACTURED UNITS

- A. General:
 - 1. Pressure gauge assembly shall include pressure sensing element, gauge case, and dial mechanism.
- B. Performance requirements:
 - 1. Pressure range:
 - a. As specified in the Contract Documents.
 - 2. Accuracy:
 - a. Grade 2A, as defined by ASME B40.100.
 - b. Within 1.0 percent of span after friction errors are eliminated by tapping or vibration.
 - c. Maximum allowable friction inaccuracy: Within 1.0 percent of span.

3. Element:
 - a. Where the maximum pressure is less than 10 pounds per square inch, provide socket and bellows; for all other pressure ranges, employ a Bourdon® tube.
 - b. Socket tips for bellows and Bourdon® tube:
 - 1) Materials: Type 316 stainless steel.
 - c. Overpressure: Minimum 130 percent of maximum range pressure without damage to gauge or sensing element.
 - d. Wetted materials:
 - 1) As indicated in the datasheets.
4. Dial gauge:
 - a. Dial size: 4-1/2 inches.
 - b. Dial case material:
 - 1) As indicated in the datasheets.
 - 2) Maximum pressure less than 10 pounds per square inch:
 - a) Phenolic.
 - 3) Maximum pressure greater than or equal to 10 pounds per square inch:
 - a) Phenolic.
 - c. Provide safety gauge with safety blow out through the back or top of the unit.
 - d. Dial face: Gasketed shatterproof glass or polycarbonate.
 - e. Provide gauge locks on pressure gauges directly connected to diaphragm seals.
 - f. Provide gauge locks where possible.
 - g. Connection and mounting:
 - 1) Direct mounted and suitable for outdoor installation.
 - 2) 1/2-inch NPT.
 - 3) Connection material:
 - a) As indicated in the datasheets.
 - h. Pointer: Externally adjustable.

2.05 ACCESSORIES

- A. Pulsation dampeners and snubbers:
 1. As indicated in the datasheets.
 2. Provide with each pressure gauge installed on discharge of positive displacement type pump.
 3. Provide piston-type snubber if pressure spikes will exceed 130 percent of gauge maximum range.
 4. Mount integrally to the pressure gauge.
 5. Connection: 1/2-inch NPT.
 6. Provide diaphragm seals as specified in the Contract Documents and/or as indicated in the datasheets.
 7. Diaphragm seal and pressure gauge shall be assembled by the manufacturer and shipped as an assembly.

- B. Furnish instrument isolation as indicated in the datasheets and specified in Section 40_73_64 - Pressure/Vacuum Measurement: Instrument Valves:
 - 1. Mount isolation device integrally to the instrument.
 - 2. Isolation device and instrument shall be assembled by the manufacturer and shipped as an assembly.
- C. Provide stainless steel tags for each instrument. Tags shall be labeled as specified in the Contract Documents.

2.06 FINISHES (NOT USED)

2.07 SOURCE QUALITY CONTROL

- A. Factory calibrate each pressure gauge at a facility that is traceable to the NIST.
- B. Provide complete documentation covering the traceability of calibration instruments.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Examine the installation location for the instrument and verify that the instrument will work properly when installed.

3.02 INSTALLATION

- A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.
- B. Coordinate the installation with trades to ensure that the mechanical system has necessary appurtenances, including weld-o-lets, valves, etc., for proper installation of instruments.

3.03 CALIBRATION AND TESTING

- A. As specified in Section 40_80_01 - Commissioning for Instrumentation and Controls.

3.04 ADJUSTING

- A. Verify factory calibration of instruments in accordance with the manufacturer's instructions:
 - 1. Return factory calibrated devices to the factory if they do not meet the field verification requirements for calibration.

3.05 SCHEDULES

- A. The provided information does not necessarily include all required instruments.
Provide all instruments identified in the Contract Documents:
 - 1. Instruments may be indicated on the Drawings, specified in the Specifications, or both.

END OF SECTION

ATTACHMENT A - ISA DATASHEET - PRESSURE/VACUUM MEASUREMENT: GAUGES

Pressure Gauge

SPECIFICATION 17404

PROJECT INFORMATION

PLANT
PROJECT 203505

CUSTOMER CITY OF THORNTON
LOCATION

ELEMENT/SWITCH

GENERAL NOTE: FIELDS SHOWN WITH THE [*] SYMBOL ARE NOT SHOWN ON THE DATASHEET BUT MAY BE REQUIRED BY THE CONTRACT DOCUMENTS. THE CONTRACTOR SHALL SUBMIT COMPLETE ISA DATASHEETS FOR EACH INSTRUMENT PER ALL SPECIFIED REQUIREMENTS.

TAG PI-302	P&ID 30N25	SERVICE PUMP 2 PRESSURE INDICATOR	FLUID [*] TEMPERATURE [*] MEASURING PRINCIPLE DIRECT PRESSURE RANGE: [*] GAUGE RANGE 0-400 PSI	CONNECTION TYPE 1/2 IN NPT ISOLATION SEALS N/A CASE MATERIAL PHENOLIC TYPICAL DETAILS [*] OPTIONS [*]	BOTT. HOUSING MAT. MFR. STD. INSTRUMENT VALVES INSTRUMENT VALVE TREE DIAPHRAGM MAT. MFR. STD. DIAL SIZE 4-1/2" AMBIENT TEMP 30-90 DEG F
TAG PI-303	P&ID 30N26	SERVICE PUMP 3 PRESSURE INDICATOR	FLUID [*] TEMPERATURE [*] MEASURING PRINCIPLE DIRECT PRESSURE RANGE: [*] GAUGE RANGE 0-400 PSI	CONNECTION TYPE 1/2 IN NPT ISOLATION SEALS N/A CASE MATERIAL PHENOLIC TYPICAL DETAILS [*] OPTIONS [*]	BOTT. HOUSING MAT. MFR. STD. INSTRUMENT VALVES INSTRUMENT VALVE TREE DIAPHRAGM MAT. MFR. STD. DIAL SIZE 4-1/2" AMBIENT TEMP 30-90 DEG F
TAG PI-310	P&ID 30N30	SERVICE PRESSURE INDICATOR	FLUID RAW WATER TEMPERATURE [*] MEASURING PRINCIPLE DIRECT PRESSURE RANGE: [*] GAUGE RANGE 0-400 PSI	CONNECTION TYPE 1/2 IN NPT ISOLATION SEALS N/A CASE MATERIAL PHENOLIC TYPICAL DETAILS [*] OPTIONS [*]	BOTT. HOUSING MAT. MFR. STD. INSTRUMENT VALVES INSTRUMENT VALVE TREE DIAPHRAGM MAT. MFR. STD. DIAL SIZE 4-1/2" AMBIENT TEMP 30-90 DEG F
TAG PI-341	P&ID 30N31	SERVICE PRESSURE INDICATOR	FLUID RAW WATER TEMPERATURE [*] MEASURING PRINCIPLE DIRECT PRESSURE RANGE: [*] GAUGE RANGE 0-400 PSI	CONNECTION TYPE 1/2 IN NPT ISOLATION SEALS N/A CASE MATERIAL PHENOLIC TYPICAL DETAILS NP502 OPTIONS [*]	BOTT. HOUSING MAT. MFR. STD. INSTRUMENT VALVES INSTRUMENT VALVE TREE DIAPHRAGM MAT. MFR. STD. DIAL SIZE 4-1/2" AMBIENT TEMP 30-90 DEG F

Pressure Gauge

SPECIFICATION 17404

PROJECT INFORMATION

PLANT
PROJECT 203505

CUSTOMER CITY OF THORNTON
LOCATION

ELEMENT/SWITCH

GENERAL NOTE: FIELDS SHOWN WITH THE [*] SYMBOL ARE NOT SHOWN ON THE DATASHEET BUT MAY BE REQUIRED BY THE CONTRACT DOCUMENTS. THE CONTRACTOR SHALL SUBMIT COMPLETE ISA DATASHEETS FOR EACH INSTRUMENT PER ALL SPECIFIED REQUIREMENTS.

TAG PI1-305	P&ID 30N28	SERVICE PUMP 5 PRESSURE INDICATOR	FLUID [*] TEMPERATURE [*] MEASURING PRINCIPLE DIRECT PRESSURE RANGE: [*] GAUGE RANGE 0-400 PSI	CONNECTION TYPE 1/2 IN NPT ISOLATION SEALS N/A CASE MATERIAL PHENOLIC TYPICAL DETAILS [*] OPTIONS [*]	BOTT. HOUSING MAT. MFR. STD. INSTRUMENT VALVES INSTRUMENT VALVE TREE DIAPHRAGM MAT. MFR. STD. DIAL SIZE 4-1/2" AMBIENT TEMP 30-90 DEG F
TAG PI1-306	P&ID 30N29	SERVICE PUMP 6 PRESSURE INDICATOR	FLUID [*] TEMPERATURE [*] MEASURING PRINCIPLE DIRECT PRESSURE RANGE: [*] GAUGE RANGE 0-400 PSI	CONNECTION TYPE 1/2 IN NPT ISOLATION SEALS N/A CASE MATERIAL PHENOLIC TYPICAL DETAILS [*] OPTIONS [*]	BOTT. HOUSING MAT. MFR. STD. INSTRUMENT VALVES INSTRUMENT VALVE TREE DIAPHRAGM MAT. MFR. STD. DIAL SIZE 4-1/2" AMBIENT TEMP 30-90 DEG F
TAG PI2-305	P&ID 30N28	SERVICE PRESSURE INDICATOR	FLUID RAW WATER TEMPERATURE [*] MEASURING PRINCIPLE DIRECT PRESSURE RANGE: [*] GAUGE RANGE 0-400 PSI	CONNECTION TYPE 1/2 IN NPT ISOLATION SEALS N/A CASE MATERIAL PHENOLIC TYPICAL DETAILS [*] OPTIONS [*]	BOTT. HOUSING MAT. MFR. STD. INSTRUMENT VALVES INSTRUMENT VALVE TREE DIAPHRAGM MAT. MFR. STD. DIAL SIZE 4-1/2" AMBIENT TEMP 30-90 DEG F
TAG PI2-306	P&ID 30N29	SERVICE PRESSURE INDICATOR	FLUID RAW WATER TEMPERATURE [*] MEASURING PRINCIPLE DIRECT PRESSURE RANGE: [*] GAUGE RANGE 0-400 PSI	CONNECTION TYPE 1/2 IN NPT ISOLATION SEALS N/A CASE MATERIAL PHENOLIC TYPICAL DETAILS [*] OPTIONS [*]	BOTT. HOUSING MAT. MFR. STD. INSTRUMENT VALVES INSTRUMENT VALVE TREE DIAPHRAGM MAT. MFR. STD. DIAL SIZE 4-1/2" AMBIENT TEMP 30-90 DEG F

SECTION 40_73_23

PRESSURE/VACUUM MEASUREMENT: DIRECT

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Pressure transmitters and indicators.

1.02 REFERENCES

- A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.

1.03 TERMINOLOGY

- A. The words and terms listed below are not defined terms that require initial capital letters, but, when used in this Section, have the indicated meaning.
 - 1. Calibrated range: Range that the pressure transmitter is configured to measure.
 - a. Low end of the calibrated range must be greater than the lower range value (LRV) of the transmitter.
 - b. High end of the calibrated range must be less than or equal to the upper range value (URV).
 - c. Calibrated range corresponds to the flow signal sent from the transmitter.
 - 2. Lower range value (LRV): Lowest pressure that the pressure transmitter is capable of measuring.
 - 3. Upper range value (URV): Highest pressure that the pressure transmitter is capable of measuring.

1.04 SUBMITTALS

- A. Furnish Submittals as specified in Section 01_33_00 - Submittal Procedures and Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.
- B. Provide complete documentation covering the traceability of calibration instruments.

1.05 QUALITY ASSURANCE

- A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.
- B. Examine the complete set of Contract Documents and verify that the instruments are compatible with the installed conditions, including:
 - 1. Process conditions: Fluids, pressures, temperatures, flows, materials, etc.

- 2. Physical conditions:
 - a. Installation and mounting requirements.
 - b. Location within the process.
 - c. Accessories: Verify that required accessories are provided and are compatible with the process conditions and physical installation.
- C. Provide instruments manufactured at facilities certified to the quality standards of ISO 9001.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.

1.07 PROJECT OR SITE CONDITIONS

- A. As specified in Section 01_81_50 - Design Criteria.

1.08 ADMINISTRATIVE REQUIREMENTS

- A. Coordination:
 - 1. Notify the Engineer if any installation condition does not meet the instrument manufacturer's recommendations or specifications.

1.09 WARRANTY

- A. As specified in Section 01_78_36 - Warranties and Bonds.

1.10 MAINTENANCE

- A. Furnish parts, materials, fluids, etc., necessary for operation, maintenance, and calibration purposes throughout the warranty period. Deliver these supplies before Project Substantial Completion.

PART 2 PRODUCTS

2.01 GENERAL

- A. Provide instruments identified in the Contract Documents.

2.02 DESIGN AND PERFORMANCE CRITERIA

- A. Provide instruments suitable for the installed Site conditions, including, but not limited to, material compatibility, Site altitude, Site seismic conditions, humidity, and process and ambient temperatures.

2.03 MANUFACTURERS

- A. One of the following or equal:
 - 1. ABB, 266 Series.
 - 2. Emerson, Rosemount 2051 Series with high performance option.

3. Emerson, Rosemount 3051 Series.
4. Endress & Hauser, Cerabar S Series.
5. Yokogawa, EJA Series.

2.04 MANUFACTURED UNITS

A. Pressure transmitters - direct:

1. General:
 - a. Pressure transmitter assembly shall include a diaphragm type pressure transducer and microprocessor-based transmitter for measurement of gauge, vacuum, or absolute pressure.
2. Performance requirements:
 - a. Maximum ratio of total instrument range to calibrated span: 10 to 1.
 - b. Accuracy:
 - 1) Reference accuracy: Within 0.075 percent of calibrated span, including effects of hysteresis, nonlinearity, and repeatability.
 - 2) Total performance accuracy: Within 0.30 percent of calibrated span, including reference accuracy effects, static pressure and ambient temperature effects.
 - 3) Stability: Within 0.15 percent of upper range limit over 5 years.
3. Element:
 - a. Diaphragm type transducer integral to pressure transmitter.
 - b. Diaphragm material: Stainless steel or ceramic.
 - c. Process material compatibility:
 - 1) Verify material compatibilities with the instrument manufacturer.
 - d. Process connection: As specified in Attachment A - ISA Datasheet - Pressure/Vacuum Measurement: Direct.
4. Transmitter:
 - a. Power supply:
 - 1) As indicated in the datasheets.
 - 2) 24 VDC - 2 wire loop powered.
 - b. Outputs:
 - 1) As indicated in the datasheets.
 - 2) Isolated 4-20 mA DC with HART communication protocol.
 - c. Provided with electronic microprocessor.
 - d. Adjustments: Adjustable electronic zero and span, with elevated or suppressed zero as required by application. Adjustment shall be possible without mechanical fulcrum points or handheld configurator.
 - e. Local display:
 - 1) 5-digit LCD.
 - 2) Scaled in engineering units.
 - f. Enclosure:
 - 1) As indicated in the datasheets.
 - 2) Non-hazardous area:
 - a) NEMA Type 4X.
 - g. Over range protection: To maximum process line pressure.
 - h. Conduit: 1/2-inch male NPT.
5. Components:
 - a. Transmitter mounting:
 - 1) As indicated in the datasheets.
 - 2) Provide necessary hardware for transmitter mounting.

2.05 ACCESSORIES

- A. Furnish instrument isolation as indicated in the datasheets and specified in Section 40_73_64 - Pressure/Vacuum Measurement: Instrument Valves:
 - 1. Mount isolation device integrally to the instrument.
 - 2. Isolation device and instrument shall be assembled by the manufacturer and shipped as an assembly.
- B. Provide remote or integral diaphragm seals as indicated on the Drawings or as indicated in the datasheets.
- C. Provide sunshades for outdoor installations.
- D. Provide stainless steel tags for each instrument. Tags shall be labeled as specified in the Contract Documents.

2.06 FINISHES (NOT USED)

2.07 SOURCE QUALITY CONTROL

- A. Factory calibrate each instrument with a minimum 3-point calibration or according to the manufacturer's standard at a facility that is traceable to the NIST.
 - 1. Submit calibration datasheets to the Engineer at least 30 days before shipment of the instruments to the Project Site.
- B. FM approval certification or equal when installed in classified areas.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Examine the installation location for the instrument and verify that the instrument will work properly when installed.

3.02 INSTALLATION

- A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.
- B. Coordinate the installation with trades to ensure that the mechanical system has necessary appurtenances, including weld-o-lets, valves, etc., for proper installation of instruments.

3.03 CALIBRATION AND TESTING

- A. As specified in Section 40_80_01 - Commissioning for Instrumentation and Controls.

3.04 SCHEDULES

- A. The provided information does not necessarily include all required instruments.
Provide all instruments identified in the Contract Documents:
 - 1. Instruments may be indicated on the Drawings, specified in the Specifications, or both.

END OF SECTION

ATTACHMENT A - ISA DATASHEET - PRESSURE/VACUUM MEASUREMENT: DIRECT

PROJECT INFORMATION

PLANT
PROJECT 203505

CUSTOMER CITY OF THORNTON
LOCATION

GENERAL NOTE: FIELDS SHOWN WITH THE [*] SYMBOL ARE NOT SHOWN ON THE DATASHEET BUT MAY BE REQUIRED BY THE CONTRACT DOCUMENTS. THE CONTRACTOR SHALL SUBMIT COMPLETE ISA DATASHEETS FOR EACH INSTRUMENT PER ALL SPECIFIED REQUIREMENTS.

GENERAL

TAG PIT-302 (PE-302)
SPECIFICATION NUMBER 17405
DRAWING NUMBER 30N25
SERVICE PUMP 2 PRESSURE TRANSMITTER

MEASURING PRINCIPLE DIRECT
PLC PLC-SW
TYPICAL DETAILS NP501

CONNECTION

CONNECTION TYPE M-NPT

INSTRUMENT VALVES BLOCK AND BLEED VALVE

FLUID

FLUID [*]
TEMPERATURE [*]

PRESSURE RANGE 0-400 PSIG

ELEMENT

ELEMENT TAG NO. PE-302
ENCLOSURE CLASS NEMA 4X
HAZARDOUS APPROVALS N/A

SEAL TYPE N/A
DIAPHRAGM MATERIAL MFR. STD.
BOTTOM HOUSING MAT. MFR. STD.

TRANSMITTER

TRANSMITTER TAG NO. PIT-302
MOUNTING INT
ENCLOSURE CLASS NEMA 4X

AMBIENT TEMPERATURE [*]
OUTPUT [*]
SURGE PROTECTION NO

NOTES

[*]

PROJECT INFORMATION

PLANT
PROJECT 203505

CUSTOMER CITY OF THORNTON
LOCATION

GENERAL NOTE: FIELDS SHOWN WITH THE [*] SYMBOL ARE NOT SHOWN ON THE DATASHEET BUT MAY BE REQUIRED BY THE CONTRACT DOCUMENTS. THE CONTRACTOR SHALL SUBMIT COMPLETE ISA DATASHEETS FOR EACH INSTRUMENT PER ALL SPECIFIED REQUIREMENTS.

GENERAL

TAG PIT-303 (PE-303)
SPECIFICATION NUMBER 17405
DRAWING NUMBER 30N26
SERVICE PUMP 3 PRESSURE TRANSMITTER

MEASURING PRINCIPLE DIRECT
PLC PLC-SW
TYPICAL DETAILS NP501

CONNECTION

CONNECTION TYPE M-NPT

INSTRUMENT VALVES BLOCK AND BLEED VALVE

FLUID

FLUID [*]
TEMPERATURE [*]

PRESSURE RANGE 0-400 PSIG

ELEMENT

ELEMENT TAG NO. PE-303
ENCLOSURE CLASS NEMA 4X
HAZARDOUS APPROVALS N/A

SEAL TYPE N/A
DIAPHRAGM MATERIAL MFR. STD.
BOTTOM HOUSING MAT. MFR. STD.

TRANSMITTER

TRANSMITTER TAG NO. PIT-303
MOUNTING INT
ENCLOSURE CLASS NEMA 4X

AMBIENT TEMPERATURE [*]
OUTPUT [*]
SURGE PROTECTION NO

NOTES

[*]

PROJECT INFORMATION

PLANT
PROJECT 203505

CUSTOMER CITY OF THORNTON
LOCATION

GENERAL NOTE: FIELDS SHOWN WITH THE [*] SYMBOL ARE NOT SHOWN ON THE DATASHEET BUT MAY BE REQUIRED BY THE CONTRACT DOCUMENTS. THE CONTRACTOR SHALL SUBMIT COMPLETE ISA DATASHEETS FOR EACH INSTRUMENT PER ALL SPECIFIED REQUIREMENTS.

GENERAL

TAG PIT-305 (PE1-305)
SPECIFICATION NUMBER 17405
DRAWING NUMBER 30N28
SERVICE PUMP 5 PRESSURE TRANSMITTER

MEASURING PRINCIPLE DIRECT
PLC PLC-SW
TYPICAL DETAILS NP501

CONNECTION

CONNECTION TYPE M-NPT

INSTRUMENT VALVES BLOCK AND BLEED VALVE

FLUID

FLUID [*]
TEMPERATURE [*]

PRESSURE RANGE 0-400 PSIG

ELEMENT

ELEMENT TAG NO. PE1-305
ENCLOSURE CLASS NEMA 4X
HAZARDOUS APPROVALS N/A

SEAL TYPE N/A
DIAPHRAGM MATERIAL MFR. STD.
BOTTOM HOUSING MAT. MFR. STD.

TRANSMITTER

TRANSMITTER TAG NO. PIT-305
MOUNTING INT
ENCLOSURE CLASS NEMA 4X

AMBIENT TEMPERATURE [*]
OUTPUT [*]
SURGE PROTECTION NO

NOTES

[*]

PROJECT INFORMATION

PLANT
PROJECT 203505

CUSTOMER CITY OF THORNTON
LOCATION

GENERAL NOTE: FIELDS SHOWN WITH THE [*] SYMBOL ARE NOT SHOWN ON THE DATASHEET BUT MAY BE REQUIRED BY THE CONTRACT DOCUMENTS. THE CONTRACTOR SHALL SUBMIT COMPLETE ISA DATASHEETS FOR EACH INSTRUMENT PER ALL SPECIFIED REQUIREMENTS.

GENERAL

TAG PIT-306 (PE1-306)
SPECIFICATION NUMBER 17405
DRAWING NUMBER 30N29
SERVICE PUMP 6 PRESSURE TRANSMITTER

MEASURING PRINCIPLE DIRECT
PLC PLC-SW
TYPICAL DETAILS NP501

CONNECTION

CONNECTION TYPE M-NPT

INSTRUMENT VALVES BLOCK AND BLEED VALVE

FLUID

FLUID [*]
TEMPERATURE [*]

PRESSURE RANGE 0-400 PSIG

ELEMENT

ELEMENT TAG NO. PE1-306
ENCLOSURE CLASS NEMA 4X
HAZARDOUS APPROVALS N/A

SEAL TYPE N/A
DIAPHRAGM MATERIAL MFR. STD.
BOTTOM HOUSING MAT. MFR. STD.

TRANSMITTER

TRANSMITTER TAG NO. PIT-306
MOUNTING INT
ENCLOSURE CLASS NEMA 4X

AMBIENT TEMPERATURE [*]
OUTPUT [*]
SURGE PROTECTION NO

NOTES

[*]

PROJECT INFORMATION

PLANT
PROJECT 203505

CUSTOMER CITY OF THORNTON
LOCATION

GENERAL NOTE: FIELDS SHOWN WITH THE [*] SYMBOL ARE NOT SHOWN ON THE DATASHEET BUT MAY BE REQUIRED BY THE CONTRACT DOCUMENTS. THE CONTRACTOR SHALL SUBMIT COMPLETE ISA DATASHEETS FOR EACH INSTRUMENT PER ALL SPECIFIED REQUIREMENTS.

GENERAL

TAG PIT-310 (PE1-310)
SPECIFICATION NUMBER 17405
DRAWING NUMBER 30N30
SERVICE PUMP STATION DISCHARGE
HEADER

MEASURING PRINCIPLE DIRECT
PLC PLC-SW
TYPICAL DETAILS NP502

CONNECTION

CONNECTION TYPE M-NPT

INSTRUMENT VALVES BLOCK AND BLEED VALVE

FLUID

FLUID [*]
TEMPERATURE [*]

PRESSURE RANGE 0-400 PSIG

ELEMENT

ELEMENT TAG NO. PE1-310
ENCLOSURE CLASS NEMA 4X
HAZARDOUS APPROVALS N/A

SEAL TYPE N/A
DIAPHRAGM MATERIAL MFR. STD.
BOTTOM HOUSING MAT. MFR. STD.

TRANSMITTER

TRANSMITTER TAG NO. PIT-310
MOUNTING INT
ENCLOSURE CLASS NEMA 4X

AMBIENT TEMPERATURE [*]
OUTPUT [*]
SURGE PROTECTION NO

NOTES

[*]

SECTION 40_73_63

PRESSURE/VACUUM MEASUREMENT: DIAPHRAGM AND ANNULAR SEALS

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Diaphragm seals.
 - 2. Annular seals.

1.02 REFERENCES

- A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.
- B. Standards:
 - 1. American National Standards Institute (ANSI).

1.03 SUBMITTALS

- A. Furnish Submittals as specified in Section 01_33_00 - Submittal Procedures and Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.
- B. Additional requirements:
 - 1. Product data:
 - a. Manufacturer's installation instructions.
 - b. Seal type.
 - c. Body materials.
 - d. Diaphragm material.
 - e. Fill fluid type.
 - f. Seal size.
 - g. Options.
 - h. Process connection.

1.04 QUALITY ASSURANCE

- A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.
- B. Examine the complete set of Contract Documents and verify the compatibility with the installed conditions, including:
 - 1. Process conditions: Fluids, pressures, temperatures, flows, materials, etc.

2. Physical conditions:
 - a. Installation and mounting requirements.
 - b. Location within the process.
 - c. Accessories: Verify that required accessories are provided and are compatible with the process conditions and physical installation.

1.05 DELIVERY, STORAGE, AND HANDLING

- A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.

1.06 PROJECT OR SITE CONDITIONS

- A. As specified in Section 01_81_50 - Design Criteria.

1.07 ADMINISTRATIVE REQUIREMENTS

- A. Coordination:
 1. Notify the Engineer if any installation condition does not meet the manufacturer's recommendations or specifications.

1.08 WARRANTY

- A. As specified in Section 01_78_36 - Warranties and Bonds.

1.09 MAINTENANCE

- A. Furnish a spare annular seal for every size provided in the Project.

PART 2 PRODUCTS

2.01 GENERAL

- A. Provide seals identified in the Contract Documents.

2.02 DESIGN AND PERFORMANCE CRITERIA

- A. Provide instruments suitable for the installed Site conditions, including, but not limited to, material compatibility, Site altitude, Site seismic conditions, humidity, and process and ambient temperatures.

2.03 MANUFACTURERS

- A. Diaphragm seals:
 1. For chemical applications, liquids containing solids, and liquids with pulsating flow having pressures less than or equal to 15 pounds per square inch gauge: One of the following or equal:
 - a. Ashcroft:
 - 1) Flushing connection: Type 741.
 - 2) Without flushing connection: Type 740.

- b. Mansfield and Green:
 - 1) Flushing connection: Type SGT.
 - 2) Without flushing connection: Type SBT.
- c. Wika, Type L990.40.

2.04 MANUFACTURED UNITS

- A. Diaphragm seals:
 - 1. General:
 - a. Diaphragm seal and pressure instrument shall be assembled by the pressure instrument manufacturer and shipped as an assembly.
 - 2. Requirements:
 - a. Seal type:
 - 1) Metallic diaphragm: Welded to upper housing.
 - 2) Elastomer diaphragm: Bonded to upper housing.
 - b. Process connection:
 - 1) As indicated in the instrument datasheets.
 - 2) 1-inch NPT.
 - c. Instrument connection: 1/2-inch NPT.
 - d. Material construction:
 - 1) As indicated in the instrument datasheets.
 - 2) Type 316 stainless steel.
 - e. Provide 1/4-inch flushing connection in diaphragm lower housing or provide flushing ring.
 - f. Flush port plug: Same material of construction as diaphragm lower housing.
 - g. Provide fill/bleed connection.
 - h. Mounting: As indicated in the Contract Documents.
 - i. Provide Type 316 stainless steel armored capillary for remote installations.
 - j. Nuts and bolts: Type 316 stainless steel.
 - k. Materials of construction:
 - 1) Sewage, sludge, liquids containing solids, and liquids with pulsating flow having pressures less than or equal to 15 pounds per square inch:
 - a) Diaphragm: Type 316 stainless steel.
 - b) Lower housing: Type 316 stainless steel.
 - c) Upper housing: Manufacturer's standard.
 - d) Fill fluid: Silicone oil.
 - 2) Sewage, sludge, liquids containing solids, and liquids with pulsating flow having pressures greater than 15 pounds per square inch:
 - a) Diaphragm: Type 316 stainless steel.
 - b) Lower housing: Type 316 stainless steel.
 - c) Upper housing: Manufacturer's standard.
 - d) Fill fluid: Silicone oil.
 - 3) Chlorine:
 - a) Diaphragm: Tantalum.
 - b) Lower housing: Hastelloy C.
 - c) Upper housing: Manufacturer's standard.
 - d) Fill fluid: Halocarbon.

- 4) Ferric chloride:
 - a) Diaphragm: PTFE or tantalum.
 - b) Lower housing: PVC or titanium.
 - c) Upper housing: Manufacturer's standard.
 - d) Fill fluid: Silicone oil.
- 5) Fluorosilicic acid:
 - a) Diaphragm: Viton™.
 - b) Lower housing: PVC.
 - c) Upper housing: Manufacturer's standard.
 - d) Fill fluid: Silicone oil.
- 6) Hydrochloric acid:
 - a) Diaphragm: PVDF or tantalum.
 - b) Lower housing: Hastelloy B2.
 - c) Upper housing: Manufacturer's standard.
 - d) Fill fluid: Fluorolube.
- 7) Ozone:
 - a) Diaphragm: Type 316 stainless steel.
 - b) Lower housing: Type 316 stainless steel.
 - c) Upper housing: Manufacturer's standard.
 - d) Fill fluid: Halocarbon.
- 8) Potassium permanganate:
 - a) Diaphragm: PTFE or tantalum.
 - b) Lower housing: PVDF or titanium.
 - c) Upper housing: Manufacturer's standard.
 - d) Fill fluid: Halocarbon.
- 9) Sodium permanganate:
 - a) Diaphragm: PTFE.
 - b) Lower housing: PVDF.
 - c) Upper housing: Manufacturer's standard.
 - d) Fill fluid: Halocarbon.
- 10) Sodium bisulfite:
 - a) Diaphragm: Tantalum.
 - b) Lower housing: Titanium.
 - c) Upper housing: Manufacturer's standard.
 - d) Fill fluid: Silicone oil.
- 11) Sodium hydroxide:
 - a) Diaphragm: Monel.
 - b) Lower housing: Monel.
 - c) Upper housing: Manufacturer's standard.
 - d) Fill fluid: Silicone oil.
- 12) Sodium hypochlorite:
 - a) Diaphragm: Tantalum.
 - b) Lower housing: Titanium.
 - c) Upper housing: Manufacturer's standard.
 - d) Fill fluid: Halocarbon.
- 13) Sulfur dioxide:
 - a) Diaphragm: PTFE or tantalum.
 - b) Lower housing: PVDF or titanium.
 - c) Upper housing: Manufacturer's standard.
 - d) Fill fluid: Halocarbon.

- 14) Sulfuric acid:
 - a) Diaphragm: PTFE or tantalum.
 - b) Lower housing: Hastelloy B2.
 - c) Upper housing: Manufacturer's standard.
 - d) Fill fluid: Halocarbon.
- 15) Engineer's approval.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 INSTALLATION

- A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation System.
- B. Coordinate the installation with trades to ensure that the mechanical system has necessary appurtenances, including weld-o-lets, valves, etc., for proper installation of instruments.
- C. Do not use Teflon™ thread seal tape on pressure instruments with silicone oil fill fluid.

3.03 CALIBRATION AND TESTING

- A. As specified in Section 40_80_01 - Commissioning for Instrumentation and Controls.

END OF SECTION

SECTION 40_73_64

PRESSURE/VACUUM MEASUREMENT: INSTRUMENT VALVES

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Instrument valve tree.
 - 2. Valve manifolds.
 - 3. Level sensor isolation valves.

1.02 REFERENCES

- A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.

1.03 SUBMITTALS

- A. Furnish Submittals as specified in Section 01_33_00 - Submittal Procedures and Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.
- B. Additional requirements:
 - 1. Product data:
 - a. Instrument valve type.
 - b. Body material.
 - c. Size.
 - d. Options.
 - 2. Shop Drawings:
 - a. Mounting details for instrument valves.

1.04 QUALITY ASSURANCE

- A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.
- B. Examine the complete set of Contract Documents and verify that the valves are compatible with the installed conditions, including:
 - 1. Process conditions: Fluids, pressures, temperatures, flows, materials, etc.
 - 2. Physical conditions:
 - a. Installation and mounting requirements.
 - b. Location within the process.
 - c. Accessories: Verify that required accessories are provided and are compatible with the process conditions and physical installation.
- C. Provide valves manufactured at facilities certified to the quality standards of ISO 9001.

1.05 DELIVERY, STORAGE, AND HANDLING

- A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.
- B. Protect valve manifolds and protective coatings from damage during handling and installation. Repair coating where damaged.

1.06 PROJECT OR SITE CONDITIONS

- A. As specified in Section 01_81_50 - Design Criteria.

1.07 ADMINISTRATIVE REQUIREMENTS

- A. Coordination:
 - 1. Notify the Engineer if any installation condition does not meet the manufacturer's recommendations or specifications.

1.08 WARRANTY

- A. As specified in Section 01_78_36 - Warranties and Bonds.

1.09 MAINTENANCE

- A. Furnish parts, materials, fluids, etc., necessary for operation, maintenance, and calibration purposes throughout the warranty period. Deliver these supplies before Project Substantial Completion.

PART 2 PRODUCTS

2.01 GENERAL

- A. Provide valves and valve manifolds identified in the Contract Documents.

2.02 DESIGN AND PERFORMANCE CRITERIA

- A. Provide valves and valve manifolds suitable for the installed Site conditions, including, but not limited to, material compatibility, process, and ambient temperatures.

2.03 MANUFACTURERS

- A. Instrument valve tree as indicated in the Contract Documents.
- B. Valve manifolds:
 - 1. One of the following or equal:
 - a. Anderson Greenwood.
 - b. Emerson, Rosemount.
 - c. Hex Valve.
 - d. Noshok.

- C. Level sensor isolation valves:
 - 1. One of the following or equal:
 - a. DeZURIK.
 - b. Indu-Tech.
 - c. PBM.

2.04 MANUFACTURED UNITS

- A. Instrument valve tree as indicated in the Contract Documents.
- B. Valve manifolds:
 - 1. General:
 - a. Provide 2-valve, 3-valve, blowdown type 5-valve, or metering type 5-valve manifolds, as indicated in the datasheets.
 - b. Valve manifolds shall have 1-piece bonnet with a metal-to-metal seal to the valve body below the bonnet threads.
 - 2. Requirements:
 - a. Bonnet lock pin to prevent accidental loosening.
 - b. Gas leak tested metal-to-metal hard seat design for hard seat valves.
 - c. Gas leak tested soft seat design with replaceable seat for soft seat valves.
 - d. Manifold valves shall have straight through portion for bi-directional flow and easy roddable cleaning.
 - e. Manifold valves shall allow for direct or remote instrument mounting.
 - f. Shall be able to withstand pressures up to 6,000 psi for soft seat valves and 10,000 psi for hard seat valves at maximum 200 degrees Fahrenheit.
 - g. Materials of construction:
 - 1) Body material: Type 316 stainless steel.
 - 2) O-ring: Teflon™.
 - h. 2-valve manifolds:
 - 1) 1 isolation valve and 1 drain/vent and calibration valve.
 - i. 3-valve manifolds:
 - 1) 2 isolation valves and 1 equalizing valve for differential pressure applications.
 - 2) Plugged vent connections used for vent/drain or calibration.
 - j. Blowdown 5-valve manifold:
 - 1) 2 isolation valves, 1 equalizing valve, 2 blowdown valves for differential pressure applications.
 - k. Metering 5-valve manifold:
 - 1) 2 isolation valves, 2 equalizing valves, 1 vent/drain and calibration valve for differential pressure applications.
- C. Level sensor isolation valves:
 - 1. General:
 - a. Valve shall provide process isolation from level diaphragm.
 - b. Gas leak tested, metal-to-metal hard seat design for hard seat valves.
 - c. Gas leak tested, soft seat design with replaceable seat for soft seat valves.
 - 2. Requirements:
 - a. Materials of construction:
 - 1) Body material: Type 316 stainless steel.
 - 2) Flange diameter size: 3 inches.

2.05 ACCESSORIES

- A. Provide tube fitting, female NPT, or pipe butt weld connections if necessary.
- B. Provide stainless steel concentric or eccentric pipe nipples when necessary.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Examine the installation location and verify the valve will work properly when installed.

3.02 INSTALLATION

- A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.
- B. Coordinate the installation with trades to ensure that the mechanical system has necessary appurtenances, including weld-o-lets, valves, etc., for proper installation of valves.

END OF SECTION

SECTION 40_73_65

PRESSURE MEASUREMENT: SUBMERSIBLE

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Submersible pressure transmitters.

1.02 REFERENCES

- A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.

1.03 SUBMITTALS

- A. Furnish Submittals as specified in Section 01_33_00 - Submittal Procedures and Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.
- B. Provide complete documentation covering the traceability of calibration instruments.

1.04 QUALITY ASSURANCE

- A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.
- B. Examine the complete set of Contract Documents and verify that the instruments are compatible with the installed conditions, including:
 - 1. Process conditions: Fluids, pressures, temperatures, flows, materials, etc.
 - 2. Physical conditions:
 - a. Installation and mounting requirements.
 - b. Location within the process.
 - c. Accessories: Verify that required accessories are provided and are compatible with the process conditions and physical installation.
- C. Provide instruments manufactured at facilities certified to the quality standards of ISO 9001.

1.05 DELIVERY, STORAGE, AND HANDLING

- A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.

1.06 PROJECT OR SITE CONDITIONS

- A. As specified in Section 01_81_50 - Design Criteria.

1.07 ADMINISTRATIVE REQUIREMENTS

- A. Coordination:
 - 1. Notify the Engineer if any installation condition does not meet the instrument manufacturer's recommendations or specifications.

1.08 WARRANTY

- A. As specified in Section 01_78_36 - Warranties and Bonds.

1.09 MAINTENANCE

- A. Furnish parts, materials, fluids, etc., necessary for operation, maintenance, and calibration purposes throughout the warranty period. Deliver these supplies before Project Substantial Completion.

PART 2 PRODUCTS

2.01 GENERAL

- A. Provide instruments identified in the Contract Documents.

2.02 DESIGN AND PERFORMANCE CRITERIA

- A. Provide instruments suitable for the installed Site conditions, including, but not limited to, material compatibility, Site altitude, Site seismic conditions, humidity, and process and ambient temperatures.

2.03 MANUFACTURERS

- A. Submersible level measurement with 2-wire integral transmitter:
 - 1. One of the following or equal:
 - a. Druck, PTX-1830.
 - b. Endress+Hauser, Deltapilot M FMB Series.
 - c. Endress+Hauser, Waterpilot FMX21
 - d. Siemens, SITRANS LH100.

2.04 MANUFACTURED UNITS

- A. As specified in this Section, including Attachment A - ISA Datasheet - Pressure Measurement: Submersible.
- B. Submersible level measurement with 2-wire integral transmitter:
 - 1. General:
 - a. Pressure is measured through a diaphragm-type measuring cell and converted to linear pressure measurement.
 - b. Each submersible pressure transmitter system shall include:
 - 1) Signal cable, including pressure compensation tube.
 - 2) Transducer probe with integral transmitter.
 - 3) Transmitter cable termination housing.

2. Performance requirements:
 - a. Accuracy:
 - 1) 0.3 percent of range.
 - b. Repeatability:
 - 1) 0.25 percent of full scale.
 - c. Rangeability:
 - 1) 3:1.
 - d. Range:
 - 1) As indicated on the Drawings or in the datasheet.
3. Element:
 - a. Sensor housing shall be Type 316L stainless steel or titanium with ceramic, Teflon™-coated, or titanium diaphragm.
 - b. Protective cap shall be the manufacturer's recommended material, chemically resistant to process fluid.
 - c. Pressure reference/compensation:
 - 1) Slip resistant extension cable with pressure compensation tube.
 - d. Enclosure for probe and transmitter assembly shall be NEMA Type 6P.
4. Transmitter:
 - a. Power supply:
 - 1) As indicated in the datasheets.
 - 2) 24 VDC: 2-wire loop powered.
 - b. Outputs:
 - 1) As indicated in the datasheets.
 - 2) Isolated 4 to 20 mA DC with HART communication protocol.
 - c. Ambient operating temperature limits of -10 to 70 degrees Celsius (14 to 158 degrees Fahrenheit).
5. Transmitter cable termination housing:
 - a. As indicated in the datasheets.
 - b. NEMA Type 4X.
 - c. Equipped with filter or desiccant chamber to eliminate moisture from the pressure compensation tube.
 - d. Termination for signal wires and/or pressure compensation tube.

2.05 ACCESSORIES

- A. Type 316L stainless steel mounting clamp with Type 304 stainless steel mounting screws.
- B. Provide guide tube for Stillwell mounting.
- C. Provide additional Type 316L stainless steel weight to prevent movement.
- D. Provide cable clamp and strain relief.

2.06 FINISHES (NOT USED)

2.07 SOURCE QUALITY CONTROL

- A. Factory calibrate each instrument with a minimum 3-point calibration or according to the manufacturer's standard at a facility that is traceable to the NIST.
 - 1. Submit calibration datasheet to the Engineer at least 30 days before shipment of the instruments to the Project Site.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Examine the installation location for the instrument and verify that the instrument will work properly when installed.

3.02 INSTALLATION

- A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.
- B. Coordinate the installation with trades to ensure that the mechanical system has necessary appurtenances, including weld-o-lets, valves, etc., for proper installation of instruments.

3.03 CALIBRATION AND TESTING

- A. As specified in Section 40_80_01 - Commissioning for Instrumentation and Controls.

3.04 SCHEDULES

- A. The provided information does not necessarily include all required instruments. Provide all instruments identified in the Contract Documents:
 - 1. Instruments may be indicated on the Drawings, specified in the Specifications, or both.

END OF SECTION

ATTACHMENT A - ISA DATASHEET - PRESSURE MEASUREMENT: SUBMERSIBLE

PROJECT INFORMATION

PLANT
PROJECT 203505

CUSTOMER CITY OF THORNTON
LOCATION

GENERAL NOTE: FIELDS SHOWN WITH THE [*] SYMBOL ARE NOT SHOWN ON THE DATASHEET BUT MAY BE REQUIRED BY THE CONTRACT DOCUMENTS. THE CONTRACTOR SHALL SUBMIT COMPLETE ISA DATASHEETS FOR EACH INSTRUMENT PER ALL SPECIFIED REQUIREMENTS.

GENERAL

TAG LT-302 (LE-302)
SPECIFICATION NUMBER 17407
DRAWING NUMBER 30N24
SERVICE WET WELL LEVEL

MEASURING PRINCIPLE DIRECT
PLC PLC-SW
TYPICAL DETAILS NL131, NL132

CONNECTION

CONNECTION TYPE FLANGED
ISOLATION SEALS N/A

INSTRUMENT VALVES [*]

FLUID

FLUID [*]
TEMPERATURE [*]

INSTRUMENT RANGE [*]

ELEMENT

ELEMENT TAG NO. LE-302
ENCLOSURE CLASS NEMA 4X
HAZARDOUS APPROVALS N/A

HOUSING MATERIAL MFR. STD.
MEMBRANE MATERIAL MFR. STD.
DIAPHRAGM MATERIAL MFR. STD.

TRANSMITTER

TRANSMITTER TAG NO. LT-302
ENCLOSURE CLASS NEMA 4X
TRANS. MOUNTING INT
SURGE PROTECTION NO

SIGNAL OUTPUT AI
OUTPUT 4-20 MA
AMBIENT TEMPERATURE [*]

NOTES

[*]

PROJECT INFORMATION

PLANT
PROJECT 203505

CUSTOMER CITY OF THORNTON
LOCATION

GENERAL NOTE: FIELDS SHOWN WITH THE [*] SYMBOL ARE NOT SHOWN ON THE DATASHEET BUT MAY BE REQUIRED BY THE CONTRACT DOCUMENTS. THE CONTRACTOR SHALL SUBMIT COMPLETE ISA DATASHEETS FOR EACH INSTRUMENT PER ALL SPECIFIED REQUIREMENTS.

GENERAL

TAG LT-340 (LE-340)
SPECIFICATION NUMBER 17407
DRAWING NUMBER 30N20
SERVICE UPPER INTAKE STRUCTURE LEVEL

MEASURING PRINCIPLE DIRECT
PLC PLC-SW
TYPICAL DETAILS [*]

CONNECTION

CONNECTION TYPE FLANGED
ISOLATION SEALS N/A

INSTRUMENT VALVES [*]

FLUID

FLUID [*]
TEMPERATURE [*]

INSTRUMENT RANGE 40 FT

ELEMENT

ELEMENT TAG NO. LE-340
ENCLOSURE CLASS NEMA 4X
HAZARDOUS APPROVALS N/A

HOUSING MATERIAL MFR. STD.
MEMBRANE MATERIAL MFR. STD.
DIAPHRAGM MATERIAL MFR. STD.

TRANSMITTER

TRANSMITTER TAG NO. LT-340
ENCLOSURE CLASS NEMA 4X
TRANS. MOUNTING INT
SURGE PROTECTION NO

SIGNAL OUTPUT AI
OUTPUT 4-20 MA
AMBIENT TEMPERATURE 30-90 DEG F

NOTES

[*]

PROJECT INFORMATION

PLANT
PROJECT 203505

CUSTOMER CITY OF THORNTON
LOCATION

GENERAL NOTE: FIELDS SHOWN WITH THE [*] SYMBOL ARE NOT SHOWN ON THE DATASHEET BUT MAY BE REQUIRED BY THE CONTRACT DOCUMENTS. THE CONTRACTOR SHALL SUBMIT COMPLETE ISA DATASHEETS FOR EACH INSTRUMENT PER ALL SPECIFIED REQUIREMENTS.

GENERAL

TAG LT-341 (LE-341)
SPECIFICATION NUMBER 17407
DRAWING NUMBER 30N20
SERVICE LOWER INTAKE STRUCTURE LEVEL

MEASURING PRINCIPLE DIRECT
PLC PLC-SW
TYPICAL DETAILS [*]

CONNECTION

CONNECTION TYPE FLANGED
ISOLATION SEALS N/A

INSTRUMENT VALVES [*]

FLUID

FLUID [*]
TEMPERATURE [*]

INSTRUMENT RANGE 40 FT

ELEMENT

ELEMENT TAG NO. LE-341
ENCLOSURE CLASS NEMA 4X
HAZARDOUS APPROVALS N/A

HOUSING MATERIAL MFR. STD.
MEMBRANE MATERIAL MFR. STD.
DIAPHRAGM MATERIAL MFR. STD.

TRANSMITTER

TRANSMITTER TAG NO. LT-341
ENCLOSURE CLASS NEMA 4X
TRANS. MOUNTING INT
SURGE PROTECTION NO

SIGNAL OUTPUT AI
OUTPUT 4-20 MA
AMBIENT TEMPERATURE 30-90 DEG F

NOTES

[*]

SECTION 40_75_13

ANALYZERS: PH

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. pH instruments.

1.02 REFERENCES

- A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.
- B. Standards:
 - 1. CSA International (CSA).

1.03 SUBMITTALS

- A. Furnish Submittals as specified in Section 01_33_00 - Submittal Procedures and Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.
- B. Provide complete documentation covering the traceability of calibration instruments.
- C. Quality Control Submittals:
 - 1. Manufacturer's representative qualifications as specified in Section 01_75_17 - Commissioning.
- D. Owner Training Submittals:
 - 1. As specified in Section 01_75_17 - Commissioning.

1.04 QUALITY ASSURANCE

- A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.
- B. Examine the complete set of Contract Documents and verify that the instruments are compatible with the installed conditions, including:
 - 1. Process conditions: Fluids, pressures, temperatures, flows, materials, etc.
 - 2. Physical conditions:
 - a. Installation and mounting requirements.
 - b. Location within the process.
 - c. Accessories: Verify that required accessories are provided and are compatible with the process conditions and physical installation.
- C. Provide instruments manufactured at facilities certified to the quality standards of ISO 9001.

1.05 DELIVERY, STORAGE, AND HANDLING

- A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.

1.06 PROJECT OR SITE CONDITIONS

- A. As specified in Section 01_81_50 - Design Criteria.

1.07 ADMINISTRATIVE REQUIREMENTS

- A. Coordination:
 - 1. Notify the Engineer if any installation condition does not meet the instrument manufacturer's recommendations or specifications.

1.08 WARRANTY

- A. As specified in Section 01_78_36 - Warranties and Bonds.

1.09 MAINTENANCE

- A. Furnish parts, materials, fluids, etc., necessary for operation, maintenance, and calibration purposes throughout the warranty period. Deliver these supplies before Project Substantial Completion.

PART 2 PRODUCTS

2.01 GENERAL

- A. Provide instruments identified in the Contract Documents.

2.02 DESIGN AND PERFORMANCE CRITERIA

- A. Provide instruments suitable for the installed Site conditions, including, but not limited to, material compatibility, Site altitude, Site seismic conditions, humidity, and process and ambient temperatures.

2.03 MANUFACTURERS

- A. The following or approved equal:
 - 1. Hach:
 - a. Sensor: DPD1P1 with flow cell assembly.
 - b. Flow cell assembly: 9180XXX series.
 - c. Transmitter: SC200.
- B. All instruments of similar nature must be furnished by the same manufacturer.

2.04 MANUFACTURED UNITS

- A. As specified in this Section, including Attachment A - ISA Datasheet - Analyzers: pH.

B. pH analyzers:

1. General:

- a. pH measurement shall use the potentiometric measurement method utilizing a glass electrode. pH sensitive glass membrane surface reacts to the acid content of the solution with a specific voltage, which is measured relative to a reference electrode.

2. Performance requirements:

- a. Accuracy: Within 0.01 pH.
- b. Stability: Within 0.01 pH/month.
- c. Repeatability: Within 0.01 pH.

3. Element:

a. Sensor material:

- 1) Glass pH sensor housed in a molded reinforced polypropylene body threaded for insertion, submersion, or flow-through installation as indicated on the Drawings and/or instrument datasheets.
- 2) Built in temperature sensor.
- 3) Reference electrode junction shall be capable of maintaining steady reference signal by resisting plugging in dirty applications.

b. pH measuring range: 2 to 12 pH.

c. Temperature measuring range: 0 to 70 degrees Celsius.

d. Operating temperature range: 0 to 80 degrees Celsius.

e. Operating pressure range: 0 to 87 pounds per square inch.

f. Connections:

- 1) Process: As specified in the instrument datasheets.

4. Transmitter:

a. Power supply:

- 1) 120 VAC.

b. Outputs:

- 1) 2 isolated 4 to 20 mA DC:
 - a) Proportional to pH and temperature.
- 2) As indicated in the instrument datasheets.

c. Display:

- 1) Backlit LCD digital.

d. Measurement ranges: 0 to 14 pH.

e. Temperature: 0 to 50 degrees Celsius.

f. Displayed resolution: Within 0.01 pH.

g. Ambient conditions:

- 1) Operable from 0 to 50 degrees Celsius.
- 2) Relative humidity: 0 to 95 percent.

h. Mechanical:

- 1) Enclosure rating:

(1) NEMA 4X.

- 2) Mounting:

- a) Panel mount suitable for mounting in an enclosure that includes gasket to maintain weather rating of the panel.
- b) Surface mount enclosures: Include self-tapping screws.
- c) Pipe mounting accessories shall be included for mounting enclosures to a 2-inch pipe.

- 3) Provide mounting hardware for proper installation and servicing of the sensor assembly.
 - i. Electrical certification: NRTL certified to UL and CSA standards, and CE approved.
- 5. Components:
 - a. Sensor cable:
 - 1) Shall be provided with watertight sensor-to-cable connector that prevents cable twisting and eliminates rewiring when replacing the sensor.
 - 2) Cable length: As required to connect sensor to transmitter plus 10 percent.

2.05 ACCESSORIES

- A. Sensor:
 - 1. Process assemblies:
 - a. Hach flow cell assembly.
 - 2. Cleaning:
 - a. Jet spray cleaner:
 - 1) 1/4-inch compression fitting for process stream.
 - 2) Manual ball valve shutoff.
 - 3. Low flow cell:
 - a. 1/4-inch NPT inlet and outlet tubing for connection to the process stream.
 - b. Flow rate: 2 to 5 gallons per hour.
 - c. Pressure range: 0 to 65 pounds per square inch gauge.
 - 4. Sensor cable:
 - a. Endress+Hauser CYK10.
 - 5. Power:
 - a. 120 VAC.
- B. Transmitter:
 - 1. Mounting kit:
 - a. Panel mounting kit.
 - 2. Stainless steel tag:
 - a. Marking specified in the instrument datasheets.
- C. Preamplifier:
 - 1. Use the manufacturer recommended preamplifier on coaxial cable runs longer than 15 feet. Review the Drawings and verify the need for a preamplifier.
- D. Provide sunshades for outdoor applications.

2.06 FINISHES (NOT USED)

2.07 SOURCE QUALITY CONTROL

- A. Factory calibrate each instrument with a minimum 3-point calibration or according to the manufacturer's standard at a facility that is traceable to the NIST:
 - 1. Submit calibration datasheets to the Engineer at least 30 days before shipment of the instruments to the Project Site.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Examine the installation location for the instrument and verify that the instrument will work properly when installed.

3.02 INSTALLATION

- A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.

3.03 CALIBRATION AND TESTING

- A. As specified in Section 40_80_01 - Commissioning for Instrumentation and Controls.

3.04 OWNER TRAINING

- A. Perform Owner Training as specified in Section 01_75_17 - Commissioning.

3.05 SCHEDULES

- A. The provided information does not necessarily include all required instruments. Provide all instruments identified in the Contract Documents:
 - 1. Instruments may be indicated on the Drawings, specified in the Specifications, or both.

END OF SECTION

ATTACHMENT A - ISA DATASHEET - ANALYZERS: PH

PROJECT INFORMATION

PLANT
PROJECT 203505

CUSTOMER CITY OF THORNTON
LOCATION

GENERAL NOTE: FIELDS SHOWN WITH THE [*] SYMBOL ARE NOT SHOWN ON THE DATASHEET BUT MAY BE REQUIRED BY THE CONTRACT DOCUMENTS. THE CONTRACTOR SHALL SUBMIT COMPLETE ISA DATASHEETS FOR EACH INSTRUMENT PER ALL SPECIFIED REQUIREMENTS.

GENERAL

TAG AIT-342 (AE-342)
SPECIFICATION NUMBER 17501
DRAWING NUMBER 30N31
SERVICE PH

POWER LOCATION PCM-SW
MEASURING PRINCIPLE PH ANALYZER
PLC PLC-SW
TYPICAL DETAILS NA013

FLUID

FLUID [*]
MEASUREMENT RANGE 2-12 PH

PRESSURE N/A
TEMPERATURE N/A

ELEMENT

ELEMENT TAG NO. AE-342
ENCLOSURE CLASS NEMA 4X
HAZARDOUS APPROVALS N/A
PROCESS CONN. MAT'L MFR. STD.

PROCESS CONNECTION IMMERSION
MOUNTING KIT POLE
HEAD ASSY FOR YES
CLEANING

TRANSMITTER

TRANSMITTER TAG NO. AIT-342
ENCLOSURE CLASS NEMA 4X
TRANS. MOUNTING REM
POWER 120VAC-1P
SURGE PROTECTION NO
RELAY OPTIONS YES
AMBIENT TEMPERATURE 30-90 DEG F

SIGNAL OUTPUT PRI AI
PRIMARY OUTPUT 4-20 MA
SIGNAL OUTPUT SEC AI
TEMPERATURE OUTPUT 4-20 MA
TRANS. HAZ APPROVALS N/A
AUTO. CLEANING RELAYS YES

NOTES

[*]

SECTION 40_75_14

ANALYZERS: ORP

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Oxidizing reducing potential (ORP) instruments.

1.02 REFERENCES

- A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.

1.03 SUBMITTALS

- A. Furnish Submittals as specified in Section 01_33_00 - Submittal Procedures and Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.
- B. Provide complete documentation covering the traceability of calibration instruments.
- C. Quality Control Submittals:
 - 1. Manufacturer's representative qualifications as specified in Section 01_75_17 - Commissioning.
- D. Owner Training Submittals:
 - 1. As specified in Section 01_75_17 - Commissioning.

1.04 QUALITY ASSURANCE

- A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.
- B. Examine the complete set of Contract Documents and verify that the instruments are compatible with the installed conditions, including:
 - 1. Process conditions: Fluids, pressures, temperatures, flows, materials, etc.
 - 2. Physical conditions:
 - a. Installation and mounting requirements.
 - b. Location within the process.
 - c. Verify that required accessories are provided and are compatible with the process conditions and physical installation.
- C. Provide instruments manufactured at facilities certified to the quality standards of ISO 9001.

1.05 DELIVERY, STORAGE, AND HANDLING

- A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.

1.06 PROJECT OR SITE CONDITIONS

- A. As specified in Section 01_81_50 - Design Criteria.

1.07 ADMINISTRATIVE REQUIREMENTS

- A. Coordination:
 - 1. Notify the Engineer if any installation condition does not meet the instrument manufacturer's recommendations or specifications.

1.08 WARRANTY

- A. As specified in Section 01_78_36 - Warranties and Bonds.

1.09 MAINTENANCE

- A. Furnish parts, materials, fluids, etc., necessary for operation, maintenance, and calibration purposes throughout the warranty period. Deliver these supplies before Project Substantial Completion.

PART 2 PRODUCTS

2.01 GENERAL

- A. Provide instruments identified in the Contract Documents.

2.02 DESIGN AND PERFORMANCE CRITERIA

- A. Provide instruments suitable for the installed Site conditions, including, but not limited to, material compatibility, Site altitude, Site seismic conditions, humidity, and process and ambient temperatures.
- B. Sensor probe and transmitter must be from the same manufacturer.

2.03 MANUFACTURERS

- A. The following or approved equal:
 - 1. Hach:
 - a. Sensor: DRD series.
 - b. Flow cell assembly: 9180XXX series.
 - c. Transmitter: SC200.
- B. Transmitter:
 - 1. Mounting kit:
 - a. Panel mounting kit.

2. Stainless steel tag:
 - a. Marking specified on Instrument Data Sheets.

2.04 MANUFACTURED UNITS

- A. As specified in this Section, including Attachment A - ISA Datasheet - Analyzers: ORP.
- B. ORP analyzer:
 1. General:
 - a. ORP is a unit of measurement for the state of equilibrium between oxidizing and reducing components of a media.
 - 1) A platinum or gold electrode shall be used with integrated noble metal reference system.
 - 2) Measuring electrode shall generate a voltage output relative to the oxidizing or reducing reactions.
 2. Performance requirements:
 - a. Accuracy: Within 1.0 millivolt.
 - b. Stability: Within 1.0 millivolt per month.
 - c. Repeatability: Within 1.0 millivolt.
 3. Element:
 - a. Sensor material:
 - 1) For general purpose applications and measurements above 500 millivolts, provide platinum ring electrode.
 - 2) For applications involving cyanide oxidation, zinc, cadmium, nickel, nitrite oxidation, ozone measurement, hydrogen superoxide measurements, or applications measuring below 500 millivolts provide gold pin or ring electrode.
 - 3) Glass sensor housed in a molded reinforced polypropylene threaded body. Installation as indicated on the Drawings and/or instrument datasheets.
 - 4) Built in temperature sensor.
 - 5) Reference electrode junction shall be capable of maintaining a steady reference signal by resisting plugging in dirty applications.
 - b. ORP measuring range: -1,500 to 1,500 millivolts.
 - c. Temperature measuring range: 0 to 100 degrees Celsius.
 - d. Operating temperature range: 0 to 100 degrees Celsius.
 - e. Operating pressure range: 0 to 87 pounds per square inch.
 - f. Process connections:
 - 1) As specified in the instrument datasheets.

2.05 ACCESSORIES

- A. Tagging:
 1. Provide stainless steel tag:
 - a. Marking specified on instrument datasheets.
- B. Sensor:
 1. Process assemblies:
 - a. Hach flow cell assembly.

- C. Transmitter:
 - 1. Mounting kit:
 - a. Panel mounting kit.
 - 2. Stainless steel tag:
 - a. Marking specified on Instrument Data Sheets.
- D. Preamplifier: Use manufacturer recommended.
 - 1. Required on coaxial cable runs longer than 15 feet.
- E. Provide sunshades for outdoor applications.

2.06 FINISHES (NOT USED)

2.07 SOURCE QUALITY CONTROL

- A. Factory calibrate each instrument with a minimum 3-point calibration or according to the manufacturer's standard at a facility that is traceable to the NIST.
 - 1. Submit calibration datasheets to the Engineer at least 30 days before shipment of the instruments to the Project Site.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Examine the installation location for the instrument and verify that the instrument will work properly when installed.

3.02 INSTALLATION

- A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.
- B. Coordinate the installation with trades to ensure that the mechanical system has necessary appurtenances, including weld-o-lets, valves, etc., for proper installation of instruments.

3.03 CALIBRATION AND TESTING

- A. As specified in Section 40_80_01 - Commissioning for Instrumentation and Controls.

3.04 OWNER TRAINING

- A. Perform Owner Training as specified in Section 01_75_17 - Commissioning.

3.05 SCHEDULES

- A. The provided information does not necessarily include all required instruments. Provide all instruments identified in the Contract Documents:
 - 1. Instruments may be indicated on the Drawings, specified in the Specifications, or both.

END OF SECTION

ATTACHMENT A - ISA DATASHEET - ANALYZERS: ORP

Analyzers: ORP

40_75_14-5

203505

CO/Thornton/203505-100000/04 Design/04 Specs/Carollo/SWPS/40_75_14 (IFB2)

Thornton Water Project (12-777XP)

Source Water Pump Station

May 2026

PROJECT INFORMATION

PLANT
PROJECT 203505

CUSTOMER CITY OF THORNTON
LOCATION

GENERAL NOTE: FIELDS SHOWN WITH THE [*] SYMBOL ARE NOT SHOWN ON THE DATASHEET BUT MAY BE REQUIRED BY THE CONTRACT DOCUMENTS. THE CONTRACTOR SHALL SUBMIT COMPLETE ISA DATASHEETS FOR EACH INSTRUMENT PER ALL SPECIFIED REQUIREMENTS.

GENERAL

TAG AIT-343 (AE-343)
SPECIFICATION NUMBER 17502
DRAWING NUMBER 30N31
SERVICE ORP

POWER LOCATION PCM-SW
MEASURING PRINCIPLE ORP ANALYZER
PLC PLC-SW
TYPICAL DETAILS NA013

FLUID

FLUID [*]
MEASUREMENT RANGE -1500-1500 MV

PRESSURE N/A
TEMPERATURE N/A

ELEMENT

ELEMENT TAG NO. AE-343
ENCLOSURE CLASS NEMA 4X
HAZARDOUS APPROVALS N/A
PROCESS CONN. MAT'L MFR. STD.

PROCESS CONNECTION IMMERSION
MOUNTING KIT POLE
HEAD ASSY FOR YES
CLEANING

TRANSMITTER

TRANSMITTER TAG NO. AIT-343
ENCLOSURE CLASS NEMA 4X
TRANS. MOUNTING REM
POWER 120VAC-1P
SURGE PROTECTION NO
RELAY OPTIONS YES
AMBIENT TEMPERATURE 30-90 DEG F

SIGNAL OUTPUT PRI AI
PRIMARY OUTPUT 4-20 MA
SIGNAL OUTPUT SEC AI
TEMPERATURE OUTPUT 4-20 MA
TRANS. HAZ APPROVALS N/A
AUTO. CLEANING RELAYS YES

NOTES

[*]

SECTION 40_75_53
ANALYZERS: TURBIDITY

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Turbidity analyzers (turbidimeters).

1.02 REFERENCES

- A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.
- B. Standards:
 - 1. United States Environmental Protection Agency (USEPA):
 - a. Federal Register Vol. 82, No. 143.
 - 1) 40 CFR, Part 141 - National Primary Drinking Water Regulations.
 - b. Method 180.1 - Determination of Turbidity by 360-degree Nephelometry.

1.03 SUBMITTALS

- A. Furnish Submittals as specified in Section 01_33_00 - Submittal Procedures and Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.
- B. Provide complete documentation covering the traceability of calibration instruments.
- C. Quality Control Submittals:
 - 1. Manufacturer's representative qualifications as specified in Section 01_75_17 - Commissioning.
- D. Owner Training Submittals:
 - 1. As specified in Section 01_75_17 - Commissioning.

1.04 QUALITY ASSURANCE

- A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.
- B. Examine the complete set of Contract Documents and verify that the instruments are compatible with the installed conditions, including:
 - 1. Process conditions: Fluids, pressures, temperatures, flows, materials, etc.

- 2. Physical conditions:
 - a. Installation and mounting requirements.
 - b. Location within the process.
 - c. Accessories: Verify that required accessories are provided and are compatible with the process conditions and physical installation.
- C. Provide instruments manufactured at facilities certified to the quality standards of ISO 9001.

1.05 DELIVERY, STORAGE, AND HANDLING

- A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.

1.06 PROJECT OR SITE CONDITIONS

- A. As specified in Section 01_81_50 - Design Criteria.

1.07 ADMINISTRATIVE REQUIREMENTS

- A. Coordination:
 - 1. Notify the Engineer if any installation condition does not meet the instrument manufacturer's recommendations or specifications.

1.08 WARRANTY

- A. As specified in Section 01_78_36 - Warranties and Bonds.

1.09 MAINTENANCE

- A. Furnish parts, materials, fluids, etc., necessary for operation, maintenance, and calibration purposes throughout the warranty period. Deliver these supplies before Project Substantial Completion.

PART 2 PRODUCTS

2.01 GENERAL

- A. Provide instruments identified in the Contract Documents.

2.02 DESIGN AND PERFORMANCE CRITERIA

- A. Provide instruments suitable for the installed Site conditions, including, but not limited to, material compatibility, Site altitude, Site seismic conditions, humidity, and process and ambient temperatures.
- B. Sensor probe and transmitter must be from the same manufacturer.

2.03 MANUFACTURERS

- A. Probe:
 - 1. Low range turbidimeters:
 - a. Hach, TU5300.
 - b. Lovibond, PTV 2000 Series.
 - 2. Low range, high precision turbidimeters:
 - a. Hach, TU5400.
 - b. Lovibond, PTV 6000 Series.
 - 3. High range turbidimeters:
 - a. Hach, Surface Scatter 7.
- B. Transmitter:
 - 1. As specified in Section 40_75_88 - Process Analyzer Transmitters.

2.04 MANUFACTURED UNITS

- A. As specified in this Section, including Attachment A - ISA Datasheet - Analyzers: Turbidity.
- B. Low range turbidimeters:
 - 1. General:
 - a. Microprocessor-based, continuous-reading, on-line nephelometric instrument utilizing a 4-beam radiometric measurement.
 - 1) Each turbidity system shall consist of a 1 sensor and 1 transmitter.
 - 2. Performance requirements:
 - a. Accuracy:
 - 1) Within 2 percent of reading or within 0.012 NTU (whichever is greater) over the range of regulation.
 - b. Resolution: 0.0001 NTU.
 - c. Repeatability: Better than 1 percent at 1 NTU.
 - d. Response time:
 - 1) Initial response in 30 seconds.
 - 2) 9.5 seconds with internal bubble trap.
 - e. Sample flow:
 - 1) Required flow: 30 to 500 mL/min (0.5 to 8 gallons per hour).
 - 2) Optimal flow: 50 to 80 mL/min.
 - f. Storage temperature: -20 to 60 degrees Celsius.
 - g. Operating temperature: 0 to 50 degrees Celsius.
 - h. Operating humidity: 5 to 95 percent non-condensing.
 - 3. Element:
 - a. Light sources shall be emitted by a LED source.
 - b. Method of measuring turbidity will be nephelometric.
 - c. Light will be directed into the sample in the turbidimeter body.
 - d. Light scattered at 90 degrees will be sensed by a submerged detector in the measuring chamber.

- C. Low range, high precision turbidimeters:
1. General:
 - a. Microprocessor-based, continuous-reading, on-line nephelometric instrument with predictive diagnostics, meeting design and performance criteria in accordance with acceptable USEPA testing methods for contaminants listed at 40 CFR 141.74(a)(1).
 - 1) Each turbidity system shall consist of a 1 sensor and 1 transmitter.
 - b. Optical components shall be mounted in a sealed head assembly that can be removed easily for calibration/service.
 - c. Body shall be corrosion-resistant and shall include an internal bubble trap to vent entrained air from the sample stream.
 2. Performance requirements:
 - a. Range: 0.0001 to 700 NTU.
 - b. Accuracy:
 - 1) Within 2 percent of reading within 0.01 NTU from 0 to 40 NTU based on Formazin primary standard at 25 degrees Celsius.
 - 2) Within 10 percent of reading from 40 to 1,000 NTU based on Formazin primary standard at 25 degrees Celsius.
 - c. Resolution: 0.0001 NTU.
 - d. Repeatability: Within 1 percent of reading or 0.002 NTU, whichever is greater based on Formazin primary standard at 25 degrees Celsius.
 - e. Sample flow required: 100 to 1,000 mL/min. Optimal flow rate 200 to 500 mL/min.
 3. Element:
 - a. Low range online laser turbidimeter consists of a Class 1 650 nanometer (EPA) laser light source and 360 degrees by 90 degrees detection system with predictive diagnostics designed to continuously monitor turbidity in a sample stream.
- D. High range (surface scatter) turbidimeters:
1. General:
 - a. Microprocessor-based, continuous-reading, on-line nephelometric instrument.
 - 1) Each turbidity system shall consist of 1 sensor and 1 transmitter.
 - 2) Design shall meet or exceed performance criteria in accordance with USEPA Method 180.1.
 2. Performance requirements:
 - a. Range: 1 to 9,999 NTU.
 - b. Accuracy:
 - 1) Within 5 percent of reading from 0 to 2,000 NTU.
 - 2) Within 10 percent of reading from 2,000 to 10,000 NTU.
 - c. Resolution: 0.01 NTU.
 - d. Repeatability: Better than within 1 percent of reading or within 0.04 NTU, whichever is greater.
 - e. Sample flow required: 15 to 30 gallons per hour.
 - f. Storage temperature: -20 to 60 degrees Celsius (-4 to 140 degrees Fahrenheit).
 - g. Operating temperature: 0 to 40 degrees Celsius (32 to 104 degrees Fahrenheit).

- h. Operating humidity: 5 to 95 percent non-condensing.
- i. Sample temperature: 0 to 50 degrees Celsius (32 to 122 degrees Fahrenheit).
- 3. Element:
 - a. Light shall be reflected off the surface of the sample thus preventing fouling.
 - b. Optical components shall be mounted in a sealed head assembly that can be removed easily for calibration/service, without disturbing sample flow.
 - c. Body shall be constructed of corrosion-resistant PVC.
 - d. Offer the choice of Formazin-based or instrument comparison-based calibration methods.

2.05 ACCESSORIES

- A. Mounting brackets as required or as indicated on the Drawings.
- B. Provide sunshades for outdoor installations.
- C. Flushing solenoids for cleaning the probe as recommended by the manufacturer.
- D. Low pressure kit: 0 to 50 pounds per square inch gauge at 68 degrees Fahrenheit.

2.06 FINISHES (NOT USED)

2.07 SOURCE QUALITY CONTROL

- A. Factory calibrate each instrument with a minimum 3-point calibration or according to manufacturer's standard at a facility that is traceable to the NIST.
 - 1. Submit calibration datasheets to the Engineer at least 30 days before shipment of the instruments to the Project Site.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Examine the installation location for the instrument and verify that the instrument will work properly when installed.

3.02 INSTALLATION

- A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.
- B. Coordinate the installation with trades to ensure that the mechanical system has necessary appurtenances, including weld-o-lets, valves, etc., for proper installation of instruments.

3.03 CALIBRATION AND TESTING

- A. As specified in Section 40_80_01 - Commissioning for Instrumentation and Controls.

3.04 OWNER TRAINING

- A. Perform Owner Training as specified in Section 01_75_17 - Commissioning.

3.05 SCHEDULES

- A. The provided information does not necessarily include all required instruments. Provide all instruments identified in the Contract Documents:
 - 1. Instruments may be indicated on the Drawings, specified in the Specifications, or both.

END OF SECTION

ATTACHMENT A - ISA DATASHEET - ANALYZERS: TURBIDITY

PROJECT INFORMATION

PLANT
PROJECT 203505

CUSTOMER CITY OF THORNTON
LOCATION

GENERAL NOTE: FIELDS SHOWN WITH THE [*] SYMBOL ARE NOT SHOWN ON THE DATASHEET BUT MAY BE REQUIRED BY THE CONTRACT DOCUMENTS. THE CONTRACTOR SHALL SUBMIT COMPLETE ISA DATASHEETS FOR EACH INSTRUMENT PER ALL SPECIFIED REQUIREMENTS.

GENERAL

TAG AIT-341 (AE-341)
SPECIFICATION NUMBER 17509
DRAWING NUMBER 30N31
SERVICE TURBIDITY

POWER LOCATION PCM-SW
MEASURING PRINCIPLE [*]
PLC PLC-SW
TYPICAL DETAILS NA030

FLUID

FLUID [*]
MEASUREMENT RANGE 0-100 NTU
SAMPLE FLOW [*]
SAMPLE pH 1-14

PRESSURE [*]
TEMPERATURE [*]
SAMPLE TEMPERATURE 40 - 80 DEG F

ELEMENT

ELEMENT TAG NO. AE-341
ENCLOSURE CLASS NEMA 4X
CLEANING APPARATUS NO

PROCESS CONNECTION INSERTION
HAZARDOUS APPROVALS N/A
ELEMENT MOUNTING KIT FLOW ASSEMBLY

TRANSMITTER

TRANSMITTER TAG NO. AIT-341
ENCLOSURE CLASS NEMA 4X
TRANS. MOUNTING REM
POWER 120VAC-1P
SURGE PROTECTION NO
AIR CLEANING SYSTEM NO

SIGNAL OUTPUT AI
OUTPUT 4-20 MA
TRANS. HAZ APPROVALS N/A
RELAY OPTIONS YES
AMBIENT TEMPERATURE [*]

NOTES

[*]

SECTION 40_80_01

COMMISSIONING FOR INSTRUMENTATION AND CONTROLS

TABLE OF CONTENTS

PART 1	GENERAL.....	2
1.01	SUMMARY	2
1.02	REFERENCES	2
1.03	TERMINOLOGY	2
1.04	SUBMITTALS	2
1.05	QUALITY ASSURANCE.....	4
PART 2	PRODUCTS (NOT USED)	4
PART 3	EXECUTION	4
3.01	EXAMINATION (NOT USED).....	4
3.02	INSTALLATION.....	4
3.03	COMMISSIONING.....	4
3.04	SCHEDULES.....	28
ATTACHMENT A - FACTORY ACCEPTANCE TEST - CONTROL PANELS		
ATTACHMENT B - INSTALLATION AND CERTIFICATION CHECKLIST DOCUMENTATION		
ATTACHMENT C - SWITCHES INSTALLATION AND CALIBRATION CHECKLIST		
ATTACHMENT D - TRANSMITTER/CONTROLLER/INDICATOR INSTALLATION AND CALIBRATION CHECKLIST		
ATTACHMENT E - ANALYZERS INSTALLATION AND CALIBRATION CHECKLIST		
ATTACHMENT F - CONTROL VALVES INSTALLATION AND CALIBRATION CHECKLIST		
ATTACHMENT G - DEVICENET INSTALLATION TESTING		
ATTACHMENT H - PROFIBUS INSTALLATION QUALIFICATION AND TESTING		

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Testing requirements that apply to process control and instrumentation systems for the entire Project.

1.02 REFERENCES

- A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.
- B. Abbreviations:
 - 1. PTO: Profibus Trade Organization.
- C. Standards:
 - 1. Telecommunications Industry Association (TIA).

1.03 TERMINOLOGY

- A. The words and terms listed below are not defined terms that require initial capital letters, but, when used in this Section, have the indicated meaning.
 - 1. Complete end-to-end testing (CEET) - Signals are tested from the field device through the PLC program, the network, and all the way to the operator's HMI graphic screens.
 - 2. Loop validation tests - Signals are tested from the field device to the PLC.
 - 3. Permanent link: Fixed portion of cabling installed between an equipment outlet and its immediate distributor or between 2 distributors.
 - 4. Platform testing: Testing of the PLC and SCADA/HMI at the manufacturer's shop to demonstrate the program's functionality based upon specified and designed control requirements.

1.04 SUBMITTALS

- A. Furnish Submittals as specified in Section 01_33_00 - Submittal Procedures.
- B. General:
 - 1. Reference additional detailed test Submittal scheduling and prerequisite requirements as specified in the sequencing article of Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.
- C. Overall test plan:
 - 1. Develop the PCIS system test Submittals in consultation and cooperation with applicable Subcontractors.
 - 2. Develop and submit an overall testing plan for the PCIS. Overall test plan to be reviewed and approved by the Engineer before detailed test plans, procedures, and forms will be reviewed.
 - 3. Describe the test phases as they apply specifically to this Project and each process system.

4. Provide a preliminary testing schedule to show the sequence of tests and commissioning as they apply to each process system and each PLC.
 5. Provide a description of factory tests. Describe what equipment will be included, what testing equipment will be used, and the simulator that will be used.
 6. Provide examples of proposed forms and checklists.
- D. Test procedures:
1. Develop and submit detailed test procedures to show that the integrated SCADA system hardware and software is fully operational and in compliance with the requirements specified in the Contract Documents.
 2. Provide a statement of test objectives for each test.
 3. Prepare specific procedures for each process system.
 4. Describe sequentially the steps to be followed in verifying the correct operation of each process system, including features described in the loop descriptions, control strategies, and shown in the P&IDs. Implied or generic test procedures are not acceptable.
 5. Specify who will perform the tests, specifically what testing equipment will be used (including serial numbers and NIST-traceable calibration), and how the testing equipment will be used.
 6. Describe the expected role of the Engineer, as well as any requirements for assistance from the Owner's staff.
 7. Provide the forms and checklists to be used.
- E. Test forms:
1. Submit completed calibration forms, test forms, and checklists.
 - a. Test forms shall include the detailed test procedures or shall include clear references to separate pages containing the complete test procedure applicable to each form. If references to procedures are used, the complete procedure shall be included with each test binder.
 - b. Every page of each test form shall include Project name, date, time, name of person conducting the test, signature of person conducting the test, and for witnessed tests, place for signature of person (Engineer and Owner) witnessing the test.
 - c. Sample test forms at the end of this Section show the minimum required content:
 - 1) Sample test forms have not been customized for this Project.
 - 2) Develop and submit test forms customized for the Project and meeting the specified test and Submittal requirements.
- F. FAT procedure additional minimal requirements:
1. Prepare and submit a FAT procedure which includes:
 - a. Control system testing block diagram.
 - b. Estimated test duration.
 - c. Details on the simulator construction, components, and operation.
- G. Testing binders:
1. Sub-system to be tested: Provide and submit a test binder containing test procedures and individual forms for the test. References to other documents for test procedures and requirements are not acceptable.
 2. Fill out in advance, headings and all other information known before the test.

3. Include applicable test plan information, as well as a list of test prerequisites, test personnel, and equipment.
 4. Include or list reference material and provide separately at the time of the test.
 5. Record test results and verify that all test requirements and conditions have been met.
- H. Furnish Commissioning Submittals listed below, as specified in this Section, and Section 01_75_17 - Commissioning:
1. Manufacturer's representative qualifications.
 2. Owner Training.
- I. Test reports:
1. At the conclusion of each test, submit a complete test report, including test results and certifications.
 2. Include completed test binders, forms, and checklists.
 3. Submission, review, and acceptance of each test report is required before the start of the sub-system.
- J. Furnish 4 CD/DVD copies of the following:
1. Application software:
 - a. Finalized fully annotated copy of programmed PLC logic in its native format.
 - b. Cross-referenced index of PLC registers or points.

1.05 QUALITY ASSURANCE

- A. Test personnel:
1. Furnish qualified technical personnel to perform calibration, testing, and verification. Test personnel are required to be familiar with this Project and the equipment, software, and systems before being assigned to the test program.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 INSTALLATION

- A. Installation supervision:
1. Provide as specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.

3.03 COMMISSIONING

- A. As specified in Section 01_75_17 - Commissioning.

B. Testing and training phase:

1. Source Testing:

a. Manufacturer services: Provide as specified in the table below.

Section Number	Section Title	Source Testing (Witnessed or Non-Witnessed)
40_61_16.10 - Specific Control Strategies	Specific Control Strategies	Witnessed
40_67_01 - Control Systems - Panels, Enclosures, and Panel Components	Control Systems - Panels, Enclosures, and Panel Components	Witnessed
40_80_01 - Commissioning for Instrumentation and Controls	Commissioning for Instrumentation and Controls	Witnessed

b. Prerequisite requirements:

- 1) Engineer approval of the hardware and equipment Source Testing Submittal is required before proceeding to preliminary FAT.

c. Preliminary FAT (pre-FAT):

- 1) The purpose of the pre-FAT is to provide assurance that the HMI/SCADA system is ready for the full, witnessed FAT, in terms of both stability and functionality:
 - a) Debugging of software and troubleshooting of hardware shall occur during and before the pre-FAT, not during the FAT.
 - b) Fully test the HMI/SCADA system and fix deficiencies found before the FAT.
- 2) Conduct utilizing test procedures approved by the Engineer.
- 3) Owner shall have the right to witness any or all of the pre-FAT testing and shall be notified in writing 20 days before the start of the pre-FAT.
- 4) Submit a letter, signed by the Contractor's Project Manager or company officer, certifying that integrated system hardware and software has been tested and confirmed to be fully operational and in compliance with the requirements specified in the Contract Documents and is fully ready for the full, witnessed FAT:
 - a) Attach the completed pre-FAT test forms, signed by the Contractor's staff.
- 5) Engineer approval of the pre-FAT Submittal is required before proceeding to FAT.

d. FAT hardware and communications testing:

- 1) Perform tests to show that the integrated system hardware and software is fully operational and in compliance with the requirements specified in the Contract Documents.
- 2) Complete PCIS system, including operator stations, servers, network equipment, printers, PCMs, PLCs, RTUs, LCPs, CCS, peripherals, communications equipment, and other HMI/SCADA equipment, shall be assembled, connected, and software loaded for a fully functional FAT of the integrated system.
- 3) For any fault tolerant networks such as ring topology networks, disconnect each segment of the network individually to demonstrate proper failover and alarming at the HMI.

- 4) Testing simulation:
 - a) Inputs and outputs shall be simulated, and proper control and system operation shall be validated.
 - b) Whenever supplied equipment is available, such as devices internal to the control panel, test input and output signals using the equipment. Simulation is not acceptable.
 - c) FAT shall make use of simulators that contain switches, pilot lights, variable analog signal generators, and analog signal level displays, which shall be connected to the I/O points within the HMI/SCADA system:
 - (1) Use of jumper wires, terminal block mounted pilot lights, and loose meters to act as or supply the functionality of a simulator shall not be allowed.
 - (2) Simulator may consist of a PLC, operating under an HMI/SCADA software package, or other approved software that has its I/O points wired to the PLC's I/O points.
 - (3) Software operating on a PC may then act as the switches, pilot lights, variable analog signal generators, and analog signal level displays.
- 5) Additional source tests are specified in other sections of the instrumentation and control Specifications.
- 6) Owner shall have the right to witness any or all of the FAT testing and shall be notified in writing 20 days before the start of the FAT.
- 7) Verify communications between the hardware and the programmer's software comply with specified requirements:
 - a) For systems that contain RTUs or remote communications with other devices, the complete communications system must be factory tested, including actual interfacing with telephone company equipment and/or the actual radios used for radio-based telemetry systems.
- 8) Panel inspections:
 - a) Engineer will inspect each control panel for completeness, workmanship, fit and finish, and compliance with the Contract Documents and the accepted Shop Drawings:
 - (1) Inspection to include, as a minimum: Layout, mounting, wire and data cable routing, wire tags, power supply, components and wiring, I/O components layout (including terminals, wiring and relays), device layout on doors and front panels, and proper ventilation operation.
 - b) Inspection forms:
 - (1) Provide panel inspection forms as part of the FAT procedures Submittal.
 - (2) A sample FAT control panel form has been provided at the end of this Section.
- 9) I/O test:
 - a) Engineer will verify that I/O is properly wired to field terminals and is properly mapped into the PLC and the rest of the SCADA system, including operator interface devices.

- b) Test methodology:
 - (1) Discrete inputs:
 - (a) Apply appropriate input from simulator at panel terminal, observe input card indicator, observe data value at each indicated data address, and observe data received at field wiring terminals or operator interface screen.
 - (2) Discrete outputs:
 - (a) Issue commands from operator interface screen or PLC, verify output card indicator light, and measure response at field wiring terminals or multimeter.
 - (3) Analog inputs:
 - (a) Apply appropriate analog input signal at panel terminals on simulator, observe data value at each indicated data address, and observe data properly received at field wiring terminals or operator interface screen.
 - (b) Check each point at 0 percent, 50 percent, and 100 percent of scale.
 - (4) Analog outputs:
 - (a) Enter scaled values in the output buffer file, observe the output data file value, and measure appropriate response at field wiring terminals or multimeter.
 - (b) Check each point at 0 percent, 50 percent, and 100 percent of scale.
- c) Test forms to include, but not be limited to, the following data:
 - (1) PLC and panel number.
 - (2) I/O type.
 - (3) I/O tag name.
 - (4) Rack/slot/number of I/O point.
 - (5) Check-off for correct response for each I/O point.
 - (6) Comments field.
 - (7) Initials of individual performing test.
 - (8) Date test was performed.
 - (9) Witness signature lines.
- 10) System configuration test:
 - a) Demonstrate and test the setup and configuration of operator stations, servers, development stations, and peripherals.
 - b) Demonstrate utility software and functions, such as virus protection, backup, optical drive burning, network monitoring, etc.
 - c) Demonstrate the proper operation of peripheral hardware.
 - d) Demonstrate general HMI/SCADA functions.
 - e) Demonstrate proper operation of log-on and other security access functions.
 - f) Demonstrate the proper operation of historical data storage, trend, display, backup, and report functions.
 - g) Test automatic fail over of redundant equipment.
 - h) Demonstrate the proper operation of the alarm display and acknowledgement functions.
 - i) For any fault tolerant networks, such as ring topology networks, disconnect each segment of the network individually to demonstrate proper failover and alarming.

- j) Test forms:
 - (1) For each test, list the specification page and paragraph of the function demonstrated, and provide a description of the function.
 - (2) List the specific tests and steps to be conducted.
 - (3) For each function, list all of the different sub-functions or ways the function can be used, and provide a test check-off for each:
 - (a) Include signature and date lines.
 - 11) Engineer approval of the FAT Communication Testing activities is required before proceeding to FAT Platform Testing.
- e. FAT Platform Testing - Control logic test:
 - 1) Verify the PLC, HMI, and SCADA, provides monitoring and control functionality based upon specified and designed control requirements.
 - 2) Testing requirements:
 - a) Demonstrate each function described in the Control Strategies.
 - b) Demonstrate in detail how each function operates under a variety of operating scenarios:
 - (1) Test to verify the application of each general control strategy function to each specific control strategy or loop description.
 - c) Demonstrate the proper operation of the programming and configuration for each control strategy or loop description:
 - (1) Test each strategy or loop description on a sentence by sentence and function by function basis.
 - (2) Loops with similar or identical logic must each be tested individually.
 - (3) Test the boundaries of each numeric operator input by entering values outside of the allowable range.
 - d) Demonstrate the proper operation of digital communication links and networks.
 - (1) Verify each digital communication I/O point.
 - e) Failure testing: Demonstrate how the system responds to and recovers from abnormal conditions, including, but not limited to, equipment failure, operator error, communications subsystem error, communications failures, simulated/forced software lockups, power failure (both utility power and power to HMI and/or SCADA hardware), process equipment failure, and high system loading conditions.
 - 3) Test forms:
 - a) Submit completed test forms for each loop, including, but not limited to, the fully revised and approved control strategy.
 - b) Identify the cause and effect as each I/O point is toggled through the simulator:
 - (1) Identify and track proper and/or improper operation of the loop.
 - c) Note any deficiencies or operational changes on the forms for correction and documentation:
 - (1) Include signature and date lines.
 - 4) Engineer approval of the FAT Submittal is required prior to shipment of system components.

2. Owner Training:
 - a. Perform Owner Training as specified in Section 01_75_17 - Commissioning.

Course Title	Minimum Course Length (Hours per Session)	Personnel (Estimated Number of Students)	Minimum Number of Sessions
System Overview	8	5	1
Operator Training - Basic	8	5	2
Operator Training - Advanced	16	5	2
Network Equipment	8	4	1
Follow-Up Training	8	5	5

3. Training course requirements:
 - a. System overview training:
 - 1) Furnish training courses that give the Owner's supervisory level personnel and overview of all elements of the PCIS system that focus on the overall functional aspect of elements of the control system and provide an understanding of the interaction of the various components.
 - 2) Furnish a training course that gives the Owner's supervisory level personnel and overview of the new Contractor-provided elements of the PCIS system. Focus on the overall functional aspects of each new elements of the control system, particularly the mechanical system vendor-provided control packages.
 - b. Operator training:
 - 1) Furnish training courses that instruct system operators in the efficient operation of all aspects of the PCIS that include not only the general operation of the control system but also the operation of specific system features.
 - 2) Furnish training courses that instruct system operators in the efficient operation of Contractor-provided aspects of the PCIS that include not only the general operation of each control system but also the operation of specific system features.
 - 3) Operator's training shall include the following for each vendor package and programmable device:
 - a) Control system overview: Architecture, equipment functions, software components, etc.
 - b) Display navigation, overview, and types of displays.
 - c) Process and equipment monitoring and control: Basic principles and operation.
 - d) Logging ON and OFF the system and description of the security and access system.
 - e) Alarm subsystem.
 - f) Trending: Provide a thorough session on how to use trending functions.
 - g) Reports: How to access, print, and review content.

- h) Control strategies: Present an average 15-minute review of each control strategy, including a hands-on demonstration of screens and operator functions for each.
 - i) Instruction on the use of operational functionality alarm logging, trending, displays, database, reports, and control software developed for the Project and incorporated in the installed PCIS system.
- c. Network equipment training:
 - 1) configuration and software, and network monitoring software.
 - 2) Furnish basic training on network hardware, switch and router. Include a detailed description and explanation of the installed network architecture, media, and functions.
 - 3) Furnish an overview of the function and operation of each piece of network equipment.
 - 4) Furnish training on network maintenance troubleshooting and repair.
 - 5) Furnish training on how to install spare or off-line backup equipment.
 - 6) Basic network overview:
 - a) Discuss a basic network overview for each site.
 - b) Discuss the architecture (loop, star, etc.), media redundancy, and items that are not readily apparent to staff.
 - c) Discuss how to monitor the network health through the HMI network screen.
 - d) Discuss both enterprise level networks, the PCS communications network, and the field network.
 - 7) Ethernet switches:
 - a) Discuss the various types of switches (Layer 2, Layer 3, etc.).
 - b) Discuss switch health monitoring through the HMI.
 - c) Discuss the VLAN configuration (what ports should be used for what network, etc.).
 - d) Discuss testing procedures.
 - 8) Field networks:
 - a) General:
 - (1) Discuss general principles behind likely device failures and actions to take to resolve such failures for each type of field network.
 - b) Modbus networks:
 - (1) Discuss Modbus TCP/IP and Modbus TCP connections.
 - (2) Discuss Modbus RTU converters.
- d. Follow-up training:
 - 1) Provide a series of on-site follow-up training classes beginning after process Start-up of the SCADA/PCIS system. The intent for these classes is to provide the Owner's personnel the opportunity for a review and "refresher" of the training topics and material after they have had some experience using the system.
 - 2) Mutually schedule and develop the content of these classes with the Owner no later than 1 month before the beginning of the first session:
 - a) Schedule at the Owner's discretion on non-consecutive days spaced out over the process Start-up and warranty period.
- 4. Installation testing:
 - a. Calibration:
 - 1) Performed by the Contractor and ICSC.

- 2) Calibrate and adjust instruments, devices, valves, and systems, in accordance with the component manufacturer's instructions and as specified in these Contract Documents.
- 3) Replace either individually or within a system, defective elements that cannot achieve proper calibration or accuracy.
 - a) Discrete devices:
 - (1) Calibrate and adjust devices for reliable operation and to avoid nuisance tripping.
 - b) Ultrasonic and radar level devices:
 - (1) Provide echo transmission and signal quality on level transmitters, including guided and unguided units.
 - (a) Submit printout of the actual transmission and parameters.
 - (2) Adjust mounting as required to obtain accurate readings.
 - (3) Post mounting: Provide any additional calibration required by the manufacturer.
 - c) Analog transmitters:
 - (1) Components having adjustable features are to be set accurately for the specific conditions and applications of this installation.
 - (2) Test and verify that components and/or systems are within the specified limits of accuracy.
 - (3) Calibration points:
 - (a) Calibrate each analog instrument at 0 percent, 25 percent, 50 percent, 75 percent, and 100 percent of span, using test instruments with accuracies traceable to NIST.
 - (4) Field verify calibration of instruments, including units that have been factory-calibrated to determine whether any of the calibrations are in need of adjustment.
 - d) Analyzer:
 - (1) Calibrate and test each analyzer system as a workable system after installation. Follow the testing procedures directed by the manufacturers' technical representatives.
 - (2) Submit completed instrument calibration sheets for every field instrument and analyzer.
 - (3) Calibration tags:
 - (a) Attach a calibration and testing tag to each instrument, piece of equipment, or system.
 - (b) Sign the tag when calibration is complete.
 - e) Industrial networking test equipment:
 - (1) Submit calibration documentation.
- b. Loop check:
 - 1) Performed by the Contractor.
 - 2) Cabling installed, terminated, and labeled.
 - 3) Perform continuity check of wiring to each field device through intermediate devices to field terminals in the cabinet.
 - 4) Complete loop check form for each device.
 - 5) Submit loop check test results before proceeding to the next step.

- c. Loop validation tests:
 - 1) Performed by the Contractor, ICSC, and the manufacturer's representative, working together, and witnessed by the Owner or Owner's representative.
 - 2) Perform tests on the signal from each field device through intermediate devices to the I/O module on the PLC.
 - a) PLC may or may not be connected to the network.
 - 3) Engineer approval of the loop validation test Submittal is required before proceeding to CEET.
- d. Copper Ethernet cable acceptance testing:
 - 1) Testing procedures and field-test instruments shall be in accordance with applicable requirements of:
 - a) TIA-1152 - Requirements for Field Test Instruments and Measurements for Balanced Twisted-Pair Cabling.
 - b) TIA-568.0-E - Generic Telecommunications Cabling for Customer Premises.
 - c) TIA-568.1-E - Commercial Building Telecommunications Infrastructure Standard.
 - d) TIA-568.2-D - Balanced Twisted-Pair Telecommunications Cabling and Components Standard.
 - e) Copper Ethernet cable installation testing as specified in Section 26_08_50 - Field Electrical Acceptance Tests.
 - 2) Testing shall be performed by trained technicians who have successfully completed an appropriate training program and have obtained a certificate as proof thereof shall execute the tests. These certificates may have been issued by any of the following organizations or an equivalent organization:
 - a) Manufacturer of the connectors or cable.
 - b) Manufacturer of the test equipment used for the field certification.
 - c) Training organizations (e.g., BICSI).
 - 3) Submit the following information before testing begins:
 - a) Manufacturer's catalog sheets, specifications, and the most recent calibration report for the test equipment.
 - b) Certificate of testing technician's training.
 - c) A schedule of balanced twisted-pair copper links to be tested, including:
 - (1) Cable identification as it appears on the cable records.
 - (2) Cable identification as it appears on the individual test reports.
 - (3) Cable identification as specified in Section 26_05_53 - Identification for Electrical Systems.
 - d) Sample test reports.
 - e) Installed cabling Permanent Links shall be field-tested and pass the test requirements and analysis as described below:
 - (1) Any Permanent Link that fails these requirements shall be diagnosed and corrected.
 - (2) Any corrective action that must take place shall be documented and followed with a new test to prove that the corrected Permanent Link meets performance requirements.

- (3) Final and passing result of the tests for Permanent Links shall be provided in the test results documentation in accordance with the testing requirements.
- f) Acceptance of the test results shall be given in writing after the Project is fully completed and tested in accordance with the Contract Documents and to the satisfaction of the Engineer.
- 4) Cable field-test instruments:
 - a) Field-test instrument shall be within the calibration period recommended by the manufacturer, typically 12 months.
 - b) Certification tester requirements:
 - (1) Level III in accordance with TIA-1152.
 - (2) Independent verification of accuracy.
 - (3) Must be capable of storing more than 10,000 results for all required measurements.
 - (4) Manufacturers: The following or equal:
 - (a) Fluke CableAnalyzer Industrial Ethernet Kit, DSX2-5-IE-K1.
 - c) Permanent Link adapters:
 - (1) Use the manufacturer's adapter for connecting to tested equipment.
 - (a) Patch cables shall not be used for testing.
 - (2) RJ45 plug must meet the requirements for NEXT, FEXT, and return loss in accordance with TIA-568.2-D Annex C.
 - d) Measurement capabilities:
 - (1) Wire map.
 - (2) Length.
 - (3) Propagation delay.
 - (4) Delay skew.
 - (5) DC loop resistance.
 - (6) DC resistance unbalance.
 - (7) Insertion loss.
 - (8) NEXT (near-end crosstalk).
 - (9) PS NEXT (power sum near-end crosstalk).
 - (10) ACR-N (attenuation to crosstalk ratio near-end).
 - (11) PS ACR-N (power sum attenuation to crosstalk ratio near-end).
 - (12) ACR-F (attenuation to crosstalk ratio far-end).
 - (13) PS ACR-F (power sum attenuation to crosstalk ratio far-end).
 - (14) Return loss.
 - (15) TCL (transverse conversion loss).
 - (16) ELTCTL (equal level transverse conversion transfer loss).
 - (17) Time domain reflectometer.
 - (18) Time domain crosstalk analyzer.
- 5) Testing requirements:
 - a) Field test instruments shall have the latest software and firmware installed.

- b) Permanent Link test results, including the individual frequency measurements from the tester shall be recorded in the test instrument upon completion of each test for subsequent uploading to a PC in which the administrative documentation (reports) may be generated.
- c) Testing shall be performed on each cabling segment from connector to connector:
 - (1) Sampling is not acceptable.
- d) Installer shall build a reference link:
 - (1) Components shall be anchored so it is not possible to disturb them.
 - (2) Technician is to conduct a Permanent Link test each day, for each type of category cable used, to ensure no degradation of the tester or its Permanent Link adapters.
- e) Unless noted otherwise tests shall use the following frequency resolution:
 - (1) 1 to 31.25 MHz: 150 kHz.
 - (2) 31.25 to 100 MHz: 250 kHz.
 - (3) 100 to 250 MHz: 500 kHz.
- f) Wire map measurement:
 - (1) Wire map test is intended to verify pin-to-pin termination at each end and check for installation connectivity errors. For each of the 8 conductors in the cabling, the wire map indicates:
 - (a) Continuity to the remote end.
 - (b) Shorts between any 2 or more conductors.
 - (c) Reversed pairs.
 - (d) Split pairs.
 - (e) Transposed pairs.
 - (f) Distance to open on shield.
 - (g) Any other miss-wiring.
 - (h) Correct connectivity of telecommunications outlets/connectors is defined in TIA-568.2-D:
 - 2 color schemes are permitted.
 - User shall define which scheme is to be used.
 - Field tester shall document which color scheme was used.
- g) Length measurement:
 - (1) Record the length of each cable. Use the physical length of the link calculated using the pair with the shortest electrical delay for reporting and to determine pass/fail.
 - (2) Pass or fail criteria is based on the maximum length allowed for the Permanent Link as specified in TIA-568.2-D plus the nominal velocity of propagation (NVP) uncertainty of 10 percent. For a Permanent Link, the length measurement can be 325 feet before a fail is reported.
- h) Propagation delay measurement:
 - (1) Is the time it takes for a signal to reach the end of the link.
 - (2) Measurement shall be made at 10 MHz in accordance with TIA-1152.

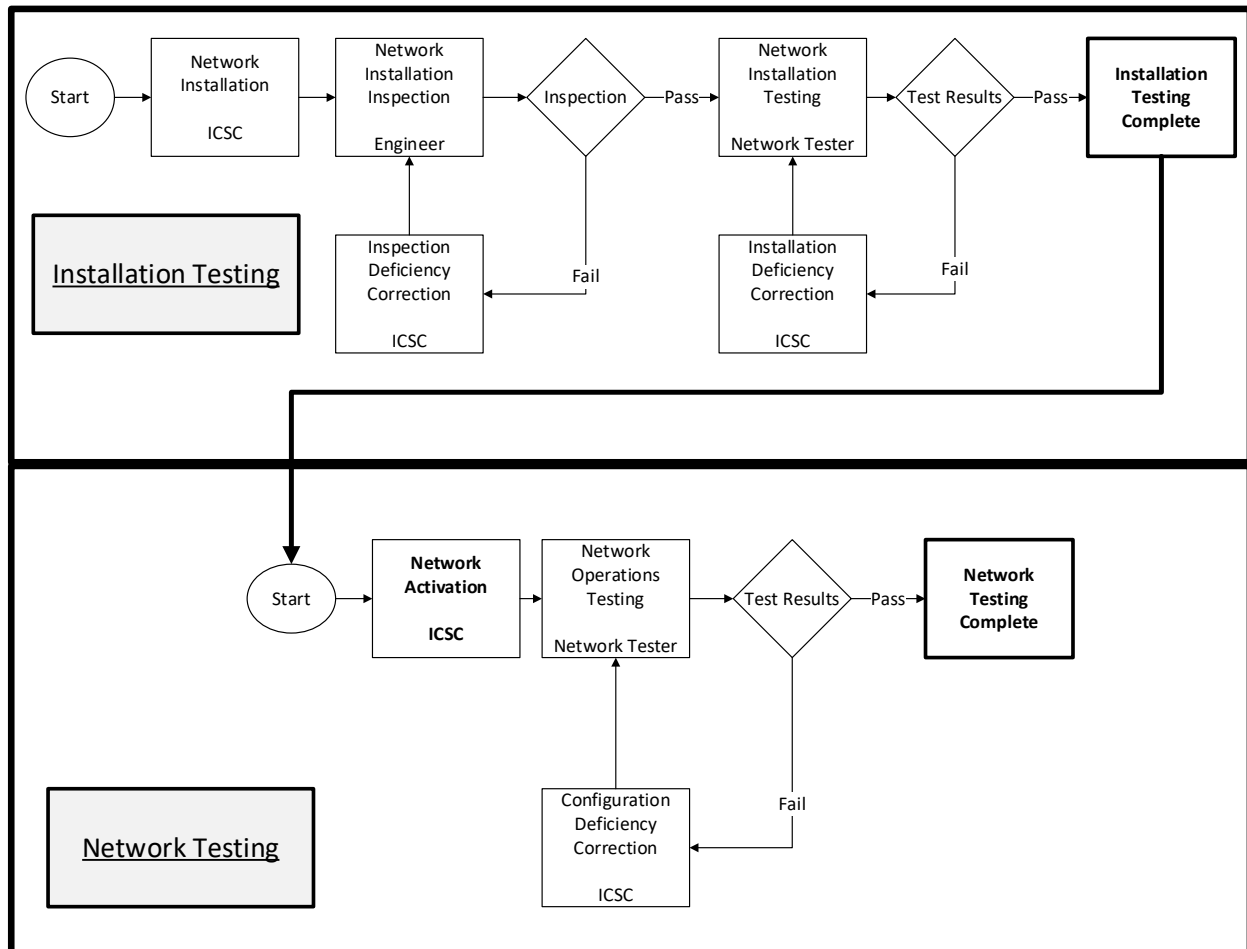
- (3) Propagation delay of each balanced twisted pair shall be recorded.
 - (4) Not to exceed 498 nanoseconds in accordance with TIA-568.2-D Section 6.4.21.
- i) Delay skew measurement:
 - (1) Is the difference in propagation delay at 10 MHz between the shortest delay and the delays of the other wire pairs.
 - (2) Delay skew of each balanced twisted pair shall be recorded.
 - (3) Not to exceed 44 nanoseconds in accordance with TIA-568.2-D Section 6.4.22.
- j) DC resistance:
 - (1) Often reported as resistance, is the loop resistance of both conductors in the pair.
 - (2) Not specified in TIA-1152 but shall be recorded for all 4 pairs.
- k) DC resistance unbalance:
 - (1) Often reported as resistance unbalance, is the difference in resistance of the 2 wires within the pair.
 - (2) Not specified in TIA-1152 for a Permanent Link but shall be recorded for all 4 pairs.
- l) Insertion loss:
 - (1) The loss of signal strength over the cabling (in dB).
 - (2) Worst case shall be reported for all 4 pairs in one direction only.
 - (3) Reported margins found to be within the accuracy of the field tester shall be marked with an asterisk.
 - (4) Not to exceed the Category 6 Permanent Link limits in accordance with TIA-568.2-D Section 6.4.10.
- m) NEXT (near-end crosstalk):
 - (1) Is the difference in amplitude (in dB) between a transmitted signal and the crosstalk received on other wire pairs at the same end of the cabling.
 - (2) Shall be measured in both directions (12 pair to pair possible combinations).
 - (3) Both worst case and worst margins shall be reported.
 - (4) Is not to exceed the Category 6 Permanent Link limits in accordance with TIA-568.2-D Section 6.4.11.
 - (5) Reported margins found to be within the accuracy of the field tester shall be marked with an asterisk (*).
 - (6) Time domain crosstalk data shall be stored for any marginal or failing NEXT results.
- n) PS NEXT (power sum near-end crosstalk):
 - (1) Is the difference (in dB) between the test signal and the crosstalk from the other pairs received at the same end of the cabling.
 - (2) Shall be measured in both directions (8 pair possible combinations).
 - (3) Both worst case and worst margins shall be reported.
 - (4) Not to exceed the Category 6 Permanent Link limits in accordance with TIA-568.2-D Section 6.4.12.

- (5) Reported margins found to be within the accuracy of the field tester shall be marked with an asterisk (*).
- (6) Time domain crosstalk data shall be stored for any marginal or failing PS NEXT results.
- o) ACR-N (attenuation crosstalk ratio near-end):
 - (1) Is a calculation of NEXT minus insertion loss of the disturbed pair in dB.
 - (2) Shall be calculated in both directions.
 - (3) Is not specified in TIA-1152 but shall be recorded for all 12 possible combinations.
- p) PS ACR-N (power sum attenuation crosstalk ratio near-end):
 - (1) Is a calculation of PS NEXT minus insertion loss of the disturbed pair in dB.
 - (2) Shall be calculated in both directions.
 - (3) Is not specified in TIA-1152 but shall be recorded for all 8 possible combinations.
- q) ACR-F (attenuation crosstalk ratio far-end):
 - (1) Is a calculation of FEXT minus insertion loss of the disturbed pair in dB.
 - (2) Shall be measured in both directions (24 pair to pair possible combinations).
 - (3) Both worst case and worst margins shall be reported.
 - (4) Is not to exceed the Category 6 Permanent Link limits in accordance with TIA-568.2-D Section 6.4.14.
 - (5) Reported margins found to be within the accuracy of the field tester shall be marked with an asterisk (*).
- r) PS ACR-F (power sum attenuation crosstalk ratio far-end):
 - (1) Is a calculation of PS FEXT minus insertion loss of the disturbed pair in dB.
 - (2) Shall be measured in both directions (8 pair possible combinations).
 - (3) Both worst case and worst margins shall be reported.
 - (4) Is not to exceed the Category 6 Permanent Link limits in accordance with TIA-568.2-D Section 6.4.16.
 - (5) Reported margins found to be within the accuracy of the field tester shall be marked with an asterisk (*).
- s) Return loss:
 - (1) Is the difference (in dB) between the power of a transmitted signal and the power of the signals reflected back.
 - (2) Shall be measured in both directions (8 pair possible combinations).
 - (3) Both worst case and worst margins shall be reported.
 - (4) Shall be ignored at all frequencies where the insertion loss is less than 3 dB for that pair.
 - (5) Is not to exceed the Category 6 Permanent Link limits in accordance with TIA-568.2-D Section 6.4.9.
 - (6) Reported margins found to be within the accuracy of the field tester shall be marked with an asterisk (*).
 - (7) Time domain reflectometer data shall be stored for any marginal or failing return loss results.

- t) TCL (transverse conversion loss):
 - (1) Is the ratio (in dB) between a differential mode signal inject at the near-end and the common-mode signal measured at the near-end on the same wire pair.
 - (2) Shall be measured in both directions.
 - (3) Is not specified in TIA-1152 for a Permanent Link but shall be recorded for all 8 possible combinations.
- u) ELTCTL (equal level transverse conversion transfer loss):
 - (1) Is the ratio (in dB) between a differential mode signal inject at the near-end and the common-mode signal measured at the far end on the same wire pair minus the insertion loss of that pair.
 - (2) Shall be measured in both directions.
 - (3) Is not specified in TIA-1152 for a Permanent Link but shall be recorded for all 8 possible combinations.
- 6) Test results documentation:
 - a) Detailed test results documentation data is to be provided in an electronic database for each tested balance twisted pair and shall contain the following information:
 - (1) Overall pass/fail evaluation of the link-under-test.
 - (2) Date and time the test results were saved in the memory of the tester.
 - (3) Identification of the customer site as specified by the end user.
 - (4) Name of the test limit selected to execute the stored test results.
 - (5) Name of the personnel performing the test.
 - (6) Version of the test software and the version of the test limit database held within the test instrument.
 - (7) Manufacturer, model, and serial number of the field-test instrument.
 - (8) Adapters used.
 - (9) Factory calibration date.
 - (10) Wire map.
 - (11) Propagation delay values, for all 4 pairs.
 - (12) Delay skew values, for all 4 pairs.
 - (13) DC resistance values, for all 4 pairs.
 - (14) DC resistance unbalance, values for all 4 pairs.
 - (15) Insertion loss, worst case values for all 4 pairs.
 - (16) NEXT, worst case margin and worst case values, both directions.
 - (17) PS NEXT, worst case margin and worst case values, both directions.
 - (18) ACR-F, worst case margin and worst case values, both directions.
 - (19) PS ACR-F, worst case margin and worst case values, both directions.
 - (20) Return loss, worst case margin and worst case values, both directions.
 - (21) TCL, worst case values both directions.
 - (22) ELTCTL, worst case values, both directions.

- (23) Time domain crosstalk data if the link is marginal or fails.
 - (24) Time domain reflectometer data if the link is marginal or fails.
 - b) Maintain a set of “red-line” throughout during construction:
 - (1) Drawings shall be available for review at any time as requested by the Owner or Engineer.
 - (2) Provide record copy drawings at the end of the Project.
 - (a) Shall be in CAD format and include notations reflecting the as-built conditions of any additions to or variation from the drawings provided, such as, but not limited to, cable paths and termination point.
 - (3) As-built drawings shall include, but are not limited to, block diagrams, frame and cable labeling, cable termination points, equipment room layouts and frame installation details.
 - (4) As-builts shall include field changes made up to construction completion:
 - (a) Field directed changes to pull schedule.
 - (b) Horizontal cable routing changes.
 - 7) Associated detail drawings. Engineer approval of the copper Ethernet cable acceptance-testing Submittal is required before proceeding to CEET.
- e. Industrial network testing:
 - 1) General test requirements:
 - a) Contractor will hire a network tester who is a Certified Profibus Installer for testing for the proper installation and operation of the Profibus network.
 - b) Provide necessary components and labor required to address changes required to bring the network into compliance.
 - c) Personnel shall be available at the time of network inspection and testing to address network deficiencies.
 - d) Before commencing any network inspection or testing activities:
 - (1) Verify that network segments and nodes are in their final installed condition:
 - (a) Network node devices installed.
 - (b) Field devices physically disconnected from the network.
 - (2) Process and process equipment is not dependent on operation of the network.
 - (3) Inspect network components and deficiencies addressed.
 - (4) Manufacturer’s data and specifications for installed network components, available on site for use by the network testing firm.
 - (5) A complete set of Contract Documents included addenda and change orders are available on site for use by the network testing firm.
 - e) Network operation may be interrupted for inspection and testing.
 - f) Figure 1, Network Test Sequence and Responsibilities, defines the general test sequence.

Figure 1. Network Test Sequence and Responsibilities



- 2) Test equipment:
 - a) Use the following:
 - (1) Network line analyzer: ProfiTrace v1.6 or equivalent.
 - (2) Oscilloscope: Fluke Scopemeter Series 190 or equivalent.
 - (3) Digital VOM: Fluke 87 Multimeter or equivalent.
 - (4) Network bus monitor, ProfiTrace v1.6 or equivalent.
- 3) Network installation testing:
 - a) Performed by the Contractor/ICSC, network tester, and the Owner's representative working together.
 - b) This activity focuses on the physical media and its installation.
 - c) Conduct a physical inspection to establish the network configuration as indicated on the Drawings:
 - (1) Validate the node type and quantity.
 - (2) Identify improper installation and damaged components.
 - d) Validate integrity of cables and connectors via a physical media test to confirm the signal propagation capabilities of the network media using visual and mechanical inspection:
 - (1) Compare network devices nameplate data with Drawings and Specifications.
 - (2) Confirm network components are PTO compliant.

- (3) Verify labeling of trunk cables.
 - (4) Confirm permissible cable length.
 - (5) Confirm correct cable type.
 - (6) Verify the presence/absence of stub lines.
 - (7) Verify network terminators are in place.
 - (8) Verify power supply source and connections for active terminations.
 - (9) Verify total network node count.
 - (10) Verify power supply specifications, including quantity, ratings, locations, and configuration. Verify power supply source of supply location, conductor size, and rating.
 - (11) Inspect accessible network cabling for adherence to specified installation practices:
 - (a) Cable installed in conduit or protective raceway.
 - (b) Cable proximity to high voltage wiring.
 - (c) Exposure to extreme temperatures, shock, vibration, chemicals, or moisture.
 - (d) Bend radius.
 - (12) Inspect cable and conductor terminations for adherence to specified installation practices.
 - (13) Check accessible components for evidence of physical damage.
 - (14) Check grounding techniques, including ground conductor sizes and termination points.
 - (15) Eliminate signal reflections.
- e) Electrical tests:
- (1) Measure total network resistance.
 - (2) Cable length and configuration evaluation:
 - (a) Confirm the network cable topology (length and configuration) does not exceed data rate limitations.
 - (b) Confirm total stub length (if required by design) does not exceed data rate limitations.
 - (c) Calculate spare trunk length for the specified data rate.
 - (3) Line analysis for the following conditions:
 - (a) Short circuit between signal lines A and B.
 - (b) Short circuit between signal lines A and B and the cable shield.
 - (c) Shield continuity.
 - (d) Cross-wired signals lines.
 - (e) Terminator installed in wrong position.
 - (f) Poor transmission or reception levels.
 - (g) Non-permissible stub line.
 - (4) Examine the data traffic between the controller and each agent device.
 - (5) Verify baud rate meets specified requirements.
 - (6) Confirm signal level meets specified requirements.
 - (7) Verify network cycle time meets specified requirements.
 - (8) Generate agent device list.
 - (9) Verify and record scanner diagnostic data, including node status and error codes.

- (10) Monitor and capture network waveform.
- (11) Measure and record power supply voltage at active terminations.
- f) Submit corrective measures recommendations based on the results of the inspections and testing.
- g) Engineer approval of the network installation validation and testing Submittal is required before proceeding to network operations validation and testing.
- 4) Network operations testing:
 - a) Performed by the Contractor/ICSC, network tester, and the Owner's representative working together.
 - b) General requirements:
 - (1) Network performance is monitored and measured using non-intrusive test equipment and procedures in accordance with the referenced standards:
 - (a) Profibus networks.
 - (2) Modifications required as a result of network operations validation and shall be in accordance with the applicable standards from Profibus organization, North America, PTO.
 - c) Online evaluation:
 - (1) Confirm specified agent devices appear on the live list.
 - (2) Evaluate data traffic between controller and each agent to confirm proper agent configuration and performance.
 - (3) Inspect waveform capture for evidence of excessive noise.
 - (4) Evaluate and report any failed or questionable network tests.
 - (5) Evaluate and report network error codes and related symptoms.
 - d) Network operations validation and testing report:
 - (1) Prepare a report that documents the results of the qualification and testing activities, including, but not limited to, the following:
 - (a) Document the installed condition of the network and provide baseline values for future network maintenance and testing activities.
 - (b) Executive summary for each network, including the following:
 - Inspection and test results for each network.
 - Calculated network parameters.
 - Recommendations.
 - Description of test procedures and required test equipment.
 - Network agency specifications.
 - (c) Manufacturer's specifications and guidelines:
 - Include applicable manufacturer's specifications and guidelines.
 - May supersede the specifications of the applicable governing body for the associated network but at a minimum must meet the governing body's requirements.

- e) Submit final report of the industrial network testing to the Engineer upon successful completion of the testing.
- 5) Engineer approval of the industrial network testing Submittals is required before proceeding to CEET.
- f. Complete End-to-End Testing (CEET):
 - 1) Performed by the Contractor, ICSC, and the manufacturer's representative working together, with assistance from the Owner or the inspection staff, as needed:
 - a) Participants need to be dedicated full-time to CEET.
 - b) ICSC will provide staff to verify input signals at, and create output signals from, an HMI or engineering workstation.
 - c) Contractor and ICSC will be responsible for creating field signals and verifying proper operation of final control elements.
 - 2) Prerequisites:
 - a) CEET cannot begin until the successful completion of the preceding tests:
 - (1) Calibration.
 - (2) Loop check.
 - (3) Loop validation tests.
 - (4) Copper Ethernet cable acceptance testing.
 - (5) Industrial network testing.
 - 3) Testing description:
 - a) This testing is to ensure I/O signals operate to the intent of the design from the field device to the HMI and all other auxiliary controls and indicators in the PCS.
 - b) Connect PLC to the network to test signals from the field device through the PLC program, the network, and to the operator's HMI graphic screens. Outputs will be energized for a duration long enough to verify proper operation of the final control element.
 - c) SCADA screens:
 - (1) Test and record operator commands and signal readouts to each operator device where there is more than one operator interface point.
 - (2) For each signal, perform separate tests for SCADA computer screens, local operator interface (LOI) screens, and local control panels.
 - (3) Retest any loop following any necessary corrections.
 - 4) Check control loops under simulated operating conditions by causing a range of input signals at the primary control elements and observing appropriate responses of the respective control and monitoring elements, final control elements, and the graphic displays associated with the HMI/SCADA system:
 - a) Use actual process inputs wherever available.
 - b) Issue commands from the HMI/SCADA system and verify proper responses of field devices:
 - (1) Test SCADA system inputs from field device to SCADA system operator workstations:
 - (a) Track responses through trend charts in the HMI/SCADA system.
 - (2) Test SCADA system outputs from SCADA operator workstations to field devices and equipment.

- 5) Discrete device testing:
 - a) Exercise each field device providing a discrete input to the HMI/SCADA system in the field and observe the proper operation shall be observed at the operator workstation:
 - (1) Test limit switches, set limits mechanically, and observe proper operation at the operator workstation.
 - (2) Exercise starters, relay contacts, switch contacts, and observe proper operation.
 - (3) Calibrate and test instruments supplying discrete inputs and observe proper operation.
 - b) Test each device accepting a discrete output signal from the HMI/SCADA. Perform the appropriate operator action at the SCADA operator stations (including LOIs, if present) and confirm the proper operation of the field device:
 - (1) Stroke valves through outputs from the HMI/SCADA system and confirm proper directional operation. Confirm travel limits and any feedback signals to the HMI/SCADA system.
 - (2) Exercise motors starters from the HMI/SCADA system and verify proper operation through direct field observation.
 - (3) Exercise solenoids and other field devices from the HMI/SCADA system and verify proper operation through direct field observation.
- 6) Analog device testing:
 - a) Apply continuously variable up and down analog inputs to verify the proper operation and setting of discrete devices (signal trips, etc.).
 - b) Apply provisional settings on controllers and alarm setpoints.
- 7) Analog input:
 - a) Exercise each field device monitoring the analog signal, through the HMI/SCADA system:
 - (1) Apply simulated sensor inputs corresponding to 0 percent, 25 percent, 50 percent, 75 percent, and 100 percent of span for networks that incorporate analog elements and monitor the resulting outputs to verify compliance to accuracy tolerance requirements.
- 8) Analog output:
 - a) Exercise each field device requiring an analog command signal, through the HMI/SCADA system:
 - (1) Vary the output from the PLC HMI/SCADA system and measure the end device position, speed, etc., to confirm the proper operation of the device for the supplied analog signal.
 - (2) Manually set the output from the HMI/SCADA screen at 0 percent, 25 percent, 50 percent, 75 percent, and 100 percent and measure the response at the final device and at any intermediate devices.
- 9) Submit completed test forms:
 - a) Discrete instrument input devices:
 - (1) Switch setting, contact action, and dead band.

- (2) Valve position switches:
 - (a) Response in the PLC as the valve is stroked from the PLC.
 - (b) Field observed actual valve position, and valve indicator position as the valve is stroked from the PLC.
 - (3) Operator interface switches (control stations and other pilot devices) and associated response.
 - (4) Starter and drive auxiliary device contact response.
 - (5) Response of all other discrete inputs to the PLC.
 - (6) Test equipment used and associated serial numbers.
 - b) Discrete output devices:
 - (1) Observed response of field device to the discrete output from the PLC.
 - (2) Observe the proper operation of Open, Close, Start, Stop, On, Off, etc.
 - (3) Test equipment used and associated serial numbers.
 - c) Analog input devices:
 - (1) Calibration range.
 - (2) Calibration data: Input, output, and error at each test value.
 - (3) Analog input associated PLC register address.
 - (4) Value in PLC register at each test point.
 - (5) Value displayed at each operator interface station (local operator interface displays and SCADA workstations).
 - (6) Test equipment used and associated serial numbers.
 - d) Analog output devices:
 - (1) Calibration range.
 - (2) Test value at each test point.
 - (3) Analog output associated PLC register address.
 - (4) Control variable value at field device at each test point.
 - (5) Physical device response at each test point:
 - (a) Response to be actual valve position, or motor speed, etc.
 - (6) Test equipment used and associated serial numbers.
 - 10) Failure testing:
 - a) Demonstrate how the system reacts and recovers from abnormal conditions, including, but not limited to:
 - (1) Equipment failure.
 - (2) Communications sub-system error.
 - (3) Power failure.
 - (4) Process equipment failure.
 - (5) High system loading conditions.
 - 11) Engineer approval of the CEET Submittals is required before proceeding to Functional Testing.
5. Functional Testing:
- a. General:
 - 1) Testing to demonstrate proper operation of systems with process equipment operating over full operating ranges under conditions as closely resembling actual operating conditions as possible.
 - 2) Performed by the Contractor, ICSC, and the manufacturer's representative working together, with assistance from the Owner or the inspection staff, as needed.

- 3) Additional tests are specified in other instrumentation and control Sections.
- 4) Follow approved detailed test procedures and check lists for Functional test activities.
- b. Control logic operational validation:
 - 1) The purpose of control logic validation is to field test the operation of the complete control system, including all parts of the HMI/SCADA system, control panels (including vendor control panels), control circuits, control stations, monitored/controlled equipment, and final control elements.
 - 2) Demonstrate control functionality shown on the P&IDs, control schematics, and other drawings, and specified in the loop descriptions, control strategies, electrical Specifications, and mechanical equipment Specifications.
 - 3) Test in detail on a function-by-function and sentence-by-sentence basis.
 - 4) Thoroughly test hardware and software functions, including hardwired and software control circuit interlocks and alarms.
 - 5) Test final control elements, controlled equipment, control panels, and ancillary equipment under startup, shut down, and steady-state operating conditions to verify logic and control is achieved.
 - 6) Control logic validation tests to include, but not be limited to, a repeat of control logic tests from the FAT, modified and expanded to include field instruments, control panels, circuits, and equipment.
- c. Loop tuning:
 - 1) Optimally tune electronic control stations and software control logic incorporating proportional, integral, or derivative control. Apply control signal disturbances at various process variable levels and adjusting the gain, reset, or rate settings as required to achieve proper response.
 - 2) Verify the transient stability of final control elements operating over the full range of operating conditions, by applying control signal disturbances, monitoring the amplitude and decay rate of control parameter oscillations and making necessary controller adjustments as required to eliminate excessive oscillatory amplitudes and decay rates.
 - a) As a minimum, achieve 1/4-wave amplitude decay ratio damping (subsidence ratio of 4) under the full range of operating conditions.
 - 3) If excessive oscillations or system instability occur, as determined by the Engineer, continue tuning and parameter adjustments, or develop and implement any additional control algorithms needed to achieve satisfactory control loop operation.
 - 4) Functional validation sheets:
 - a) Document each Functional test on an approved test form.
 - b) Document loop tuning with a report for each loop, including 2-pen chart recordings showing the responses to step disturbance at a minimum of 3 setpoints or process rates approved by the Engineer. Show tuning parameters on the charts, along with time, date, and sign-off by the Contractor and Engineer.

- c) Include on the form, functions which can be demonstrated on a loop-by-loop basis:
 - (1) Loop number and P&ID number.
 - (2) Control strategy, or reference to specification tested.
 - (3) Test procedures: Where applicable, use the FAT function-by-function, sentence-by-sentence loop test checklist forms modified to meet the requirements of the Functional test. Otherwise, create new forms.
 - d) For functions that cannot be demonstrated on a loop-by-loop basis (such as overall plant power failure), include on the test form a listing of the specific steps and tests to be conducted. Include with each test description the following information:
 - (1) Specification page and paragraph of function demonstrated.
 - (2) Description of function and/or text from specification.
 - (3) Test procedures: Use the FAT loop test checklist forms modified to meet the specific testing conditions of the Functional test.
 - 5) Functional certification:
 - a) Including test forms with test data entered, submitted to the Engineer with a clear and unequivocal statement that Functional test requirements have been satisfied.
- C. Process Start-up Phase:
 - 1. Process Start-up:
 - 1) ICSC shall be available as needed.
 - b. ICSC shall be on site to support process Start-up activities and provide functional changes as required.
 - 2. Process operation period:
 - 1) ICSC shall be available as needed.
 - 3. PCIS optimization and fine-tuning:
 - a. General:
 - 1) After the process operational period, test PCIS system for additional 60 days as specified in this Section to identify issues and make corrections, as needed.
 - 2) This is part of the Work that must be completed as a condition of Substantial Completion and final completion for the entire Project.
 - 3) Complete PLC control and HMI/SCADA system must run continuously for the duration of the PCIS optimization and fine-tuning.
 - 4) Test and use the entire process control system under standard operating conditions.
 - 5) Exercise system functions.
 - 6) Log failure, any system interruption and accompanying component, subsystem, or program failure, including time of occurrence, duration of each failure, failure classification, and cause:
 - a) Provide a competently trained technician or programmer on call for the Project Site during normal working days and hours from the start of the PCIS optimization and fine-tuning until final acceptance of the system:
 - (1) Response time to the Project Site: 24 hours or less, for a major failure.

- b. SCADA system testing:
- 1) Exercise each system function, e.g., status report, alarms, logs, and displays several times at a minimum, and in a manner that approximates "normal" system operation.
 - 2) Failure of the HMI/SCADA system during testing shall be considered as indicating that the programs and operating system do not meet the requirements of the specifications:
 - a) Corrective action is required before restarting the PCIS optimization and fine-tuning.
 - 3) Only those components, sub-systems, and systems covered in this Section and supplied under this Contract shall be considered for this acceptance test. Problems and failures of other systems shall not be considered as part of this test, except as they display the capabilities of this system to detect failures.
 - 4) Failures:
 - a) Classify failures as either major or minor:
 - (1) Minor failure:
 - (a) A small and non-critical component failure or software problem that can be corrected by the Owner's operators.
 - (b) Log this occurrence but this is not a reason for stopping the test and is not grounds for non-acceptance.
 - (c) Should the same or similar component failure occur repeatedly, this may be considered as grounds for non-acceptance.
 - (d) Failure of 1 printer or operator station is considered a minor failure providing all functions can be provided by backup equipment, i.e., alternate printers and operator station, and repairs can be made, and equipment returned to service within 3 working days.
 - (2) Major failure:
 - (a) Considered to have occurred when a component, subsystem, software control, or program fault causes a halt in or improper operation of the system and/or when a technician's work is required to make a repair or to re-initiate operation of the system.
 - (b) Cause termination of the PCIS optimization and fine-tuning.
 - (c) Start a new acceptance test when the causes of a major failure have been corrected.
 - (d) A failure is also considered major when failure of any control system that results in an overflow, underflow, overdose, or underdose condition occurs.
 - 5) Technician report:
 - a) Each time a technician is required to respond to a system malfunction, they must complete a report, which includes details concerning the nature of the complaint or malfunction and the resulting repair action required and taken.
 - b) If a malfunction occurs which clears itself or which the operator on duty is able to correct, no report is required or logged as specified above.

- c) If a technician has performed work but no report is written, then a major failure is considered to have occurred.
- d) Each report shall be submitted within 24 hours to the Engineer and the Owner, or its representative.

3.04 SCHEDULES

- A. Example test forms:
 - 1. Attached at the end of this Section. They may be used as a starting point for the development of project-specific test forms for this Project.
 - 2. Not intended to be complete or comprehensive. Edit and supplement the forms to meet the requirements for testing and test forms specified in this Section and other Contract Documents.

END OF SECTION

ATTACHMENT A - FACTORY ACCEPTANCE TEST - CONTROL PANELS

	FACTORY ACCEPTANCE TEST - CONTROL PANELS	
1. GENERAL INSPECTION A. Structural Inspection ☐ Verify lifting lugs installed. ☐ Verify enclosure has lock and lock is functional. ☐ Confirm that seismic bracing components are provided in accordance with manufacturer's installation instructions. B. Exterior Inspection ☐ Cabinet exterior is clean, scratch, and dent free. ☐ Inspect externally for corrosion and damage. ☐ Verify enclosure door opens and closes easily. ☐ Verify enclosure has a 3-point latch. ☐ Verify enclosure has a flange mounted disconnect (where voltages greater than 120 VAC enter the cabinet). ☐ Verify enclosure has the appropriate NEMA rating (1, 1G, 12, 3R, 4, 4X, etc.). ☐ Verify enclosure is the appropriate size (not grossly larger than design, and will still fit in the plant). Nameplates ☐ Cabinet has identification nameplate. ☐ All door labels are straight, spelled correctly, and match the tagging defined in the Contract. ☐ Cabinet has a nameplate that includes the following: ☐ Power source(s). ☐ Integrator's logo. ☐ Circuit ID(s). ☐ Short Circuit KAIC ratings. ☐ If labels are screwed to door, silicone was utilized to cover screw holes. (Labels screwed to the door of a NEMA 4/4X panel technically violates the NEMA rating.) Door Devices ☐ All devices penetrating the outside of panel have gaskets, silicone or both. ☐ All door devices are installed (HMIs, Pilot Devices, etc.). ☐ Door mounted equipment is mounted straight and square. ☐ All exterior or door mounted equipment present and accounted for, installed and securely fastened. ☐ NEMA classification has not been violated due to penetrations. ☐ Door mounted equipment has the same NEMA rating as the panel. ☐ All door mounted equipment installed at the correct height. ☐ All door mounted equipment installed in the correct positions and order (layout of door mounted equipment is grouped properly and in a logical manner). ☐ Doors with multiple penetrations have adequate bracing (if needed). ☐ Visually check condition of indicators, controllers, and annunciators. ☐ Check that pilot lights illuminate correctly. ☐ Check the Push-To-Test function. ☐ Ensure correct pilot light color. Peripheral Devices ☐ Horn/Beacon is installed (where required). ☐ Silence and Reset pushbutton.		
PROJECT NAME: _____ FACILITY NAME: _____ PROCESS AREA: _____ NETWORK ID: _____ WITNESSED BY: _____		TEST DATE: _____ TESTED BY: _____ COMPANY: _____ PAGE: _____ SIGNATURE: _____

	FACTORY ACCEPTANCE TEST - CONTROL PANELS			
1. GENERAL INSPECTION (continued) C. Interior Inspection ☐ Cabinet is cleaned of marks and dirt. ☐ Inspect internally for corrosion and damage. ☐ Back panel is clean of marks and dirt. ☐ Interior of panel vacuumed and shall be free of all debris. ☐ Check that the panel roof is clean and clear of foreign materials. ☐ Bottom of panel has been cut out (where bottom entry is required), with angle iron welded around the bottom perimeter. Re-painting has been performed. ☐ If internal light door limit switch is provided, ensure the light automatically turns "on" when the doors are open. ☐ Check that a document pocket has been provided. ☐ Intrusion alarms (where required). Interior Labeling ☐ All panel mounted equipment has identification labeling, by using either a Brothers or Phenolic type tags. ☐ Verify that door mounted components are mounted square and symmetrical. ☐ Verify that nameplates are straight, legible, and spelled correctly. ☐ All terminal blocks are identified/labeled with permanent labels, including tight end blocks and caps. ☐ All wiring shrink labeled and or phased correctly to the specifications. ☐ All wire labels shrunk completely rotated and aligned alike for easy identification. ☐ All fuses and circuit breakers are labeled with ID and current rating. ☐ System Integrator's label or labels installed on door. ☐ Panel manufacturer model/serial number tag is present. ☐ All required safety/warning tags installed and straight. ☐ Correct UL (typically UL 508) or cUL tag installed and registered and all other associated tags installed and straight. (The UL tag might not be installed in the panel at the factory test. If the panel is modified due to changes during the factory test or a punch list generated from the factory test, the UL labeling would need to be re-applied. Some UL shops do not apply the UL label until the panel is released to be shipped.) Wireways ☐ Plastic wire way covers installed properly. ☐ Plastic wireways have no sharp edges. ☐ No wire ties inside the wireways. ☐ No sharp edges on wire ties. ☐ Separation: White duct is used for DC voltages; Gray duct is used for AC voltages. ☐ Ensure wiring duct is not over-full, includes provision for 20% more wiring and the cover may easily be installed. Panduit recommends 50% duct fill, but 40% is a better practice.				
<table style="width: 100%; border: none;"> <tr> <td style="width: 50%; vertical-align: top;"> PROJECT NAME: _____ FACILITY NAME: _____ PROCESS AREA: _____ NETWORK ID: _____ WITNESSED BY: _____ </td> <td style="width: 50%; vertical-align: top;"> TEST DATE: _____ TESTED BY: _____ COMPANY: _____ PAGE: _____ SIGNATURE: _____ </td> </tr> </table>			PROJECT NAME: _____ FACILITY NAME: _____ PROCESS AREA: _____ NETWORK ID: _____ WITNESSED BY: _____	TEST DATE: _____ TESTED BY: _____ COMPANY: _____ PAGE: _____ SIGNATURE: _____
PROJECT NAME: _____ FACILITY NAME: _____ PROCESS AREA: _____ NETWORK ID: _____ WITNESSED BY: _____	TEST DATE: _____ TESTED BY: _____ COMPANY: _____ PAGE: _____ SIGNATURE: _____			

	FACTORY ACCEPTANCE TEST - CONTROL PANELS											
1. GENERAL INSPECTION (continued) C. Interior Inspection (continued) Wiring ☐ Visually check terminals and condition of internal wirings. ☐ Verify that the control panel has been assembled and wired as designed. ☐ Verify that all components are operational and perform the functions intended. ☐ Verify that all components are sized appropriately for the application. ☐ Verify that equipment control circuits function as intended. ☐ Back of door wiring is labeled and neatly formed. ☐ Back panel to door wiring has sufficient bending radius with spiral wrap. ☐ Wire connection has been verified wired to correct points within the panel. ☐ Individual wires have been given a pull test to verify a good terminal connection. ☐ Wire and cable minimum bending radius have not been violated. ☐ All equipment installed straight and square to back panel. ☐ Wire colors are correct: ☐ Black and White > AC hot and neutral, respectively. ☐ Red > AC control signals. ☐ Blue > DC power and control. ☐ White w/Blue stripes > DC ground. ☐ Yellow > Foreign voltages (those still present when panel power is disconnected). ☐ Green > AC equipment ground. ☐ Black > TSP (+). ☐ White > TSP(-). ☐ Analog wiring shields are continuous (connected by a dedicated terminal block for such shields). ☐ Analog shield wires are grounded within the panel, where not otherwise grounded at the transmitter itself. ☐ Discrete inputs are separately fused or protected by a circuit breaker on a "per loop" basis. ☐ Intrinsic Safety Wiring. ☐ Ensure wiring associated with intrinsic safety circuits or intrinsic safety barriers is kept away from all other wiring by UL minimum distances or by a physical (grounded metal) barrier preventing non-intrinsically safe wiring from coming in contact with intrinsically safe circuits or wiring. ☐ Verify all spare terminals are installed according to the percentage listed in the specifications. Grounding ☐ Equipped with "Blackburn" or other grounding type lug. ☐ Lug is securely fastened to the panel structure. ☐ Verify grounding bar is installed. ☐ Verify isolated ground bar is installed.												
<table style="width: 100%; border: none;"> <tr> <td style="width: 50%; border: none;">PROJECT NAME: _____</td> <td style="width: 50%; border: none;">TEST DATE: _____</td> </tr> <tr> <td style="border: none;">FACILITY NAME: _____</td> <td style="border: none;">TESTED BY: _____</td> </tr> <tr> <td style="border: none;">PROCESS AREA: _____</td> <td style="border: none;">COMPANY: _____</td> </tr> <tr> <td style="border: none;">NETWORK ID: _____</td> <td style="border: none;">PAGE: _____</td> </tr> <tr> <td style="border: none;">WITNESSED BY: _____</td> <td style="border: none;">SIGNATURE: _____</td> </tr> </table>			PROJECT NAME: _____	TEST DATE: _____	FACILITY NAME: _____	TESTED BY: _____	PROCESS AREA: _____	COMPANY: _____	NETWORK ID: _____	PAGE: _____	WITNESSED BY: _____	SIGNATURE: _____
PROJECT NAME: _____	TEST DATE: _____											
FACILITY NAME: _____	TESTED BY: _____											
PROCESS AREA: _____	COMPANY: _____											
NETWORK ID: _____	PAGE: _____											
WITNESSED BY: _____	SIGNATURE: _____											

FACTORY ACCEPTANCE TEST - CONTROL PANELS	
2. POWER TEST A. AC Power ☐ AC power is routed correctly within the panel and is isolated from DC and network wiring. ☐ All fuses are installed and sized properly. ☐ All breakers are installed and sized properly. ☐ 24 VDC Power Supplies are functional. ☐ 24 VDC Power fail contacts are functional. ☐ 24 VDC power supplies are redundant and have diode modules enabling the hot swap-over between supplies. ☐ 24 VDC supplies are equipped with dry contact failure alarms, wired as PLC inputs to signal failure of any DC power supply. Such alarm inputs to the PLC have been tested as being functional. ☐ Dedicated receptacle is wired to receive a dedicated AC supply. ☐ Verify continuity for all DC commons, ground and AC neutrals. ☐ Verify that the CP temporary input power is connected correctly and is the correct voltage. ☐ Close the CP main circuit breaker(s). ☐ Verify that voltages at subsequent circuit breakers are correct. ☐ Close circuit breakers. ☐ Verify that power feeding interruptible and uninterruptible power supplies is correct. ☐ Turn on power supplies if they are not already on. ☐ Verify that voltages at distribution terminals are correct. ☐ Energize any remaining hardware such as the PLC. B. Uninterruptible Power Supply (UPS) ☐ Mounted appropriately within the cabinet, on a dedicated shelf, or rear of a swing-out sub panel. ☐ Is equipped with maintenance bypass switch (or at least plug/receptacle means for bypassing the unit). ☐ Test all UPS alarms (on inverter, failure, battery failure etc.). ☐ Turn off the AC power supply and verify that the UPS will be switched on to supply the designated vital loads in the control panel. 3. CONTROLS & AUXILIARY DEVICES TEST ☐ Verify all interposing and auxiliary relays are functioning. ☐ Verify panel lights are functioning. Ventilation and Heating ☐ If ventilation fans are fitted, check the fans operate correctly any associated air filters are clean and not blocked. ☐ Verify components are installed in the correct orientation for proper air flow. 4. HARDWIRED INTERLOCK AND SAFETY TEST ☐ Verify that hardwired interlocks through the control panel as shown on schematic drawings are functioning. For example, outlet high pressure switch interlock to a pump. ☐ Verify that all hardwired safety devices through the control panel is functioning. For example, the pull cord emergency stops of conveyors.	
PROJECT NAME: _____ FACILITY NAME: _____ PROCESS AREA: _____ NETWORK ID: _____ WITNESSED BY: _____	TEST DATE: _____ TESTED BY: _____ COMPANY: _____ PAGE: _____ SIGNATURE: _____

FACTORY ACCEPTANCE TEST - CONTROL PANELS	
5. PLC TEST A. Components ☐ PLC interior High Temperature alarm is installed, wired to the PLC, and is shown to be functional. ☐ Relays have transient suppression across their coils. This is particularly important for DC coil relays, where diodes in reverse polarity are often used. ☐ TVSS is installed across the main incoming 120 VAC. PLC and PLC Rack ☐ Verify all cards are securely seated. ☐ Ensure clearance around PLC rack has been met, such that convective heat transfer is not impeded by devices erroneously mounted in the "no encroachment" area. Confirm with manufacturer clearance recommendations. B. PLC I/O Test ☐ Furnish I/O test forms and test all the listed input and output points as follows: ☐ Discrete Inputs: Simulate a field contact closure by "shorting" across the appropriate terminal blocks. Observe the transition between a logical "0" and "1" in the PLC software. ☐ Discrete Outputs: Force the output bit to toggle between logical "0" and logical "1" using the PLC software. Measure contact resistance at the wired terminal blocks using a digital meter selected for the "ohms" setting. ☐ Analog Inputs: Connect a signal generator to the appropriate terminal blocks. Tailor the connection depending on whether a 2-wire or 4-wire simulation is required. Modulate the 4-20mA signal. Observe the associated PLC internal memory register to transition between 0-65535 or if scaled in engineering units, between 0 and the maximum scaled engineering unit. The latter method is preferred. ☐ Analog Outputs: Force the output register to a value between 0-65535 or 0-100%, if the scaling block can be manipulated. Observe the measured 4-20mA value increment and decrement using a digital ammeter. C. Redundant Controllers (where required) Test ☐ Remove Communication cable from primary PLC to verify switching to backup PLC. ☐ Remove Communication cable from backup PLC to verify switching back to primary PLC. ☐ Remove Power cable from primary PLC to verify switching to backup PLC. ☐ Remove Power cable from backup PLC to verify switching back to primary PLC. D. PLC Control Logic Verification ☐ The PLC control strategy is verified by following the Control Logic Verification Form based on the specifications. Each control strategy will be verified by simulating the process and checking the state or value of PLC outputs. The results of equipment status and alarms and process instrument values and trends shall also be verified on the Plant SCADA graphic screens stored in a temporary SCADA computer. Since all PLC input and output wiring has been verified and some field devices are not available during Factory Acceptance Testing, certain inputs will be simulated either by means of additional hardware and/or software as described below. ☐ ☐ ☐ DI states are either simulated by hardwired switches or forced inputs using a programming terminal. ☐ For example, when starters and drives are not provided as part of the Contract, jumpers may be installed from the output call relays to the running confirmation inputs to simulate the running state of the motors.	
PROJECT NAME: _____ FACILITY NAME: _____ PROCESS AREA: _____ NETWORK ID: _____ WITNESSED BY: _____	TEST DATE: _____ TESTED BY: _____ COMPANY: _____ PAGE: _____ SIGNATURE: _____

	FACTORY ACCEPTANCE TEST - CONTROL PANELS											
5. PLC TEST (continued) D. PLC Control Logic Verification (continued) Typical Fault Logic ☐ If the fault input is high and the disable (if applicable) for the fault is not high and the common disable (if applicable) is not high begin timing. If any of these conditions changes, stop timing and reset the timer. If the timer reaches its preset, activate the alarm output. If the fault alarm is a shutdown alarm stop the associated motor and latch the alarm so that it remains present even if the condition clears. ☐ The fault condition must return to normal and the alarm must be reset for a latched alarm to clear. Typical Fail to Start Logic ☐ If the motor is called to run (call output high) and no running feedback is received (running input is low) and the fail to start and common alarm disables (if applicable) are not high start timing. If any of these conditions changes, stop timing and reset the timer. If the timer reaches its preset, activate the alarm output, stop calling the motor and latch the alarm. 6. HMI OR OIT TEST HMI/OIT Functionality ☐ Communication with PLC. ☐ Screen Layouts. ☐ Screen Navigation. ☐ Set Point Entry. ☐ Animation. ☐ Color Correctness (Green=Run, Red=Off, Amber=Alarm, or the agreed upon convention). ☐ Alarms. ☐ Acknowledge and Reset. ☐ Security/Access Levels/Passwords. 7. NETWORK COMMUNICATION TEST A. Network Components ☐ Fiber optic cabling terminates in a patch panel. ☐ Media converters are installed and functional. ☐ Terminating resistors have been installed for trunk/tap topologies or where required. ☐ Wire and cable bending limitations have not been violated. B. Networking Functions ☐ Verify data transfer via the network to different PLCs as shown on the Network Block Diagrams. ☐ Verify network traffic rate and error margin is acceptable.												
<table style="width: 100%; border: none;"> <tr> <td style="width: 50%; border: none;">PROJECT NAME: _____</td> <td style="width: 50%; border: none;">TEST DATE: _____</td> </tr> <tr> <td style="border: none;">FACILITY NAME: _____</td> <td style="border: none;">TESTED BY: _____</td> </tr> <tr> <td style="border: none;">PROCESS AREA: _____</td> <td style="border: none;">COMPANY: _____</td> </tr> <tr> <td style="border: none;">NETWORK ID: _____</td> <td style="border: none;">PAGE: _____</td> </tr> <tr> <td style="border: none;">WITNESSED BY: _____</td> <td style="border: none;">SIGNATURE: _____</td> </tr> </table>			PROJECT NAME: _____	TEST DATE: _____	FACILITY NAME: _____	TESTED BY: _____	PROCESS AREA: _____	COMPANY: _____	NETWORK ID: _____	PAGE: _____	WITNESSED BY: _____	SIGNATURE: _____
PROJECT NAME: _____	TEST DATE: _____											
FACILITY NAME: _____	TESTED BY: _____											
PROCESS AREA: _____	COMPANY: _____											
NETWORK ID: _____	PAGE: _____											
WITNESSED BY: _____	SIGNATURE: _____											

	FACTORY ACCEPTANCE TEST - CONTROL PANELS			
8. FAT DOCUMENTATION AND RECORD Panel Documentation ☐ As-built panel drawings showing actual panel construction and devices arrangement and c/w Bill of Material. ☐ Panel schematic and interconnection drawings. ☐ P&ID drawings and schematic drawings for the process area controlled by the panel that is to be tested. ☐ I/O list test forms of the process area to be tested. ☐ FAT procedure of the process area to be tested. ☐ Test record forms of the process area to be tested. Forms shall include area for signature of responsible test personnel. ☐ Hard copy of the PLC application program of the process area to be tested. ☐ Hard copy of the HMI/OIT graphic screens of the process area to be tested. 9. FAT TOOLS AND SOFTWARE ☐ Simulation software if required. ☐ Digital volt meter Fluke 87. ☐ Process meter Fluke 787. ☐ Laptop computer with PLC application program. ☐ Temporary SCADA computer with HMI software and applicable graphic screens. ☐ Jumper wires.				
<table style="width: 100%; border: none;"> <tr> <td style="width: 50%; vertical-align: top;"> PROJECT NAME: _____ FACILITY NAME: _____ PROCESS AREA: _____ NETWORK ID: _____ WITNESSED BY: _____ </td> <td style="width: 50%; vertical-align: top;"> TEST DATE: _____ TESTED BY: _____ COMPANY: _____ PAGE: _____ SIGNATURE: _____ </td> </tr> </table>			PROJECT NAME: _____ FACILITY NAME: _____ PROCESS AREA: _____ NETWORK ID: _____ WITNESSED BY: _____	TEST DATE: _____ TESTED BY: _____ COMPANY: _____ PAGE: _____ SIGNATURE: _____
PROJECT NAME: _____ FACILITY NAME: _____ PROCESS AREA: _____ NETWORK ID: _____ WITNESSED BY: _____	TEST DATE: _____ TESTED BY: _____ COMPANY: _____ PAGE: _____ SIGNATURE: _____			

ATTACHMENT B - INSTALLATION AND CERTIFICATION CHECKLIST DOCUMENTATION

	INSTALLATION AND CERTIFICATION CHECKLIST DOCUMENTATION	

INSTRUMENT LOOP NO. _____

SERVICE DESCRIPTION _____

A COPY OF LATEST ISSUE OF THE FOLLOWING DOCUMENTS ARE INCLUDED IN THIS INSTRUMENT INSTALLATION CERTIFICATION FILE:

- ☐ INSTRUMENT SPECIFICATION SHEETS (FOR ALL INSTRUMENTS IN THE LOOP)
- ☐ INSTRUMENT INSTALLATION DETAILS (FOR ALL INSTRUMENTS IN THE LOOP)
- ☐ INSTRUMENT LOOP WIRING DIAGRAMS
- ☐ INSTRUMENT INSTALLATION CERTIFICATION CHECKLIST
- ☐ SIZING CALCULATIONS
- ☐ INSTRUMENT INSTALLATION SCHEDULE (APPLICABLE PART)
- ☐ NAMEPLATE SCHEDULE (APPLICABLE PART)
- ☐ VENDOR LITERATURE CALIBRATION INFORMATION

INSTRUMENT LOOP IS PART OF EQUIPMENT START-UP/SHUTDOWN INTERLOCKS? ☐ No ☐ Yes

REMARKS: _____

CHECKED BY (COMPANY) _____ ACCEPTED BY (COMPANY) _____

SIGNATURE _____ SIGNATURE _____

DATE _____ DATE _____

ATTACHMENT C - SWITCHES INSTALLATION AND CALIBRATION CHECKLIST

	SWITCHES INSTALLATION AND CALIBRATION CHECKLIST	

INSTRUMENT LOOP NO. _____

SERVICE DESCRIPTION _____

CHECK BELOW, WHEN COMPLETED:

- ☐ BENCH CALIBRATED PER SPECIFICATION SHEET NO. _____
- ☐ VERIFIED PER P&ID NO. _____
- ☐ CORRESPONDS TO SPECIFICATION SHEET NO. _____
- ☐ WIRING CORRECT PER INSTRUMENT LOOP DRAWING NO. _____
- ☐ INSTALLATION CORRECT PER DETAIL NO. _____
- ☐ ACCESSORIES ARE PRESENT AND PROPERLY INSTALLED
- ☐ INSTRUMENT IS ACCESSIBLE FOR MAINTENANCE OR REMOVAL
- ☐ ENGRAVED LAMINATED NAMEPLATE (NO SPELLING ERRORS) PERMANENTLY INSTALLED

☐ ☐

INSTRUMENT LOOP IS PART OF EQUIPMENT START-UP/SHUTDOWN INTERLOCKS?

No Yes

FIELD CALIBRATION CHECK						
CONTACT NO.	FUNCTION	FOR SIGNAL	CONTACT IS TO	AT SPECIFIED VALUE FOR	ACTUAL TRIP POINT WAS	
1	☐ ALARM	☐ INCR	☐ OPEN	SET PT = _____	SET PT = _____	
	☐ S/D PERM	☐ DECR	☐ CLOSE	RESET = _____	RESET = _____	
2	☐ ALARM	☐ INCR	☐ OPEN	SET PT = _____	SET PT = _____	
	☐ S/D PERM	☐ DECR	☐ CLOSE	RESET = _____	RESET = _____	
3	☐ ALARM	☐ INCR	☐ OPEN	SET PT = _____	SET PT = _____	
	☐ S/D PERM	☐ DECR	☐ CLOSE	RESET = _____	RESET = _____	
4	☐ ALARM	☐ INCR	☐ OPEN	SET PT = _____	SET PT = _____	
	☐ S/D PERM	☐ DECR	☐ CLOSE	RESET = _____	RESET = _____	

NOTE: PERM IS ABBREVIATION FOR PERMISSIVE

**ATTACHMENT D - TRANSMITTER/CONTROLLER/INDICATOR
INSTALLATION AND CALIBRATION CHECKLIST**

	TRANSMITTER/CONTROLLER/INDICATOR INSTALLATION AND CALIBRATION CHECKLIST	

INSTRUMENT LOOP IS PART OF EQUIPMENT START-UP/SHUTDOWN INTERLOCKS? ☐ No ☐ Yes

INSTRUMENT TYPE ☐ TRANSMITTER ☐ CONTROLLER ☐ INDICATOR ☐ OTHER DESCRIPTION _____

INSTRUMENT TAG NO. _____ SERIAL NO. _____

SERVICE DESCRIPTION _____

BENCH CALIBRATION CHECK				
INPUT RANGE = _____		OUTPUT RANGE = _____		
HEAD CORRECTION = _____		☐ LINEAR		
CALIBRATED SPAN = _____		☐ SQUARE ROOT		
% CALIB SPAN	DESIRED VALUE	ACTUAL VALUE	EXPECTED VALUE	ACTUAL VALUE
0				
50				
100				

CHECK BELOW, WHEN COMPLETED:

- ☐ BENCH CALIBRATED PER SPECIFICATION SHEET NO. _____
- ☐ VERIFIED PER P&ID NO. _____
- ☐ CORRESPONDS TO SPECIFICATION SHEET NO. _____
- ☐ WIRING CORRECT PER INSTRUMENT LOOP DRAWING NO. _____
- ☐ INSTALLATION CORRECT PER DETAIL NO. _____
- ☐ ACCESSORIES ARE PRESENT AND PROPERLY INSTALLED
- ☐ INSTRUMENT IS ACCESSIBLE FOR MAINTENANCE OR REMOVAL
- ☐ ENGRAVED LAMINATED NAMEPLATE (NO SPELLING ERRORS) PERMANENTLY INSTALLED

FIELD CALIBRATION CHECK				
INPUT RANGE = _____		OUTPUT RANGE = _____		
% CALIB SPAN	DESIRED VALUE	ACTUAL VALUE	EXPECTED VALUE	ACTUAL VALUE
0				
50				
100				

ATTACHMENT E - ANALYZERS INSTALLATION AND CALIBRATION CHECKLIST

	ANALYZERS INSTALLATION AND CALIBRATION CHECKLIST	

INSTRUMENT LOOP IS PART OF EQUIPMENT START-UP/SHUTDOWN INTERLOCKS? ☐ No ☐ Yes

TYPE OF INSTRUMENT _____

INSTRUMENT TAG NO. _____ SERIAL NO. _____

SERVICE DESCRIPTION _____

CHECK BELOW, IF TRUE

- ☐ BENCH CALIBRATED PER SPECIFICATION SHEET NO. _____
- ☐ VERIFIED PER P&ID NO. _____
- ☐ CORRESPONDS TO SPECIFICATION SHEET NO. _____
- ☐ WIRING CORRECT PER INSTRUMENT LOOP DRAWING NO. _____
- ☐ INSTALLATION CORRECT PER DETAIL NO. _____
- ☐ ACCESSORIES ARE PRESENT AND PROPERLY INSTALLED
- ☐ INSTRUMENT IS ACCESSIBLE FOR MAINTENANCE OR REMOVAL
- ☐ ENGRAVED LAMINATED NAMEPLATE (NO SPELLING ERRORS) PERMANENTLY INSTALLED

REMARKS _____

CHECKED BY (COMPANY) _____	ACCEPTED BY (COMPANY) _____
SIGNATURE _____	SIGNATURE _____
DATE _____	DATE _____

**ATTACHMENT F - CONTROL VALVES
INSTALLATION AND CALIBRATION CHECKLIST**

	CONTROL VALVES INSTALLATION AND CALIBRATION CHECKLIST	

INSTRUMENT LOOP IS PART OF EQUIPMENT START-UP/SHUTDOWN INTERLOCKS? ☐ No ☐ Yes

- ☐ VALVE TAG NO. _____ SERIAL NO. _____
- ☐ TRANSDUCER TAG NO. _____ SERIAL NO. _____
- ☐ SOLENOID TAG NO. _____ SERIAL NO. _____
- ☐ VOLUME BOOSTER TAG NO. _____ SERIAL NO. _____
- ☐ POSITIONER _____ SERIAL NO. _____

SERVICE DESCRIPTION _____

TRANSDUCER CHECK					
INPUT RANGE =			OUTPUT RANGE =		
CALIBRATED SPAN =			CALIBRATED SPAN =		
BENCH					
SPAN	DESIRED	ACTUAL	SPAN	EXPECTED	ACTUAL
0%			0%		
50%			50%		
100%			100%		
FIELD					
SPAN	DESIRED	ACTUAL	SPAN	EXPECTED	ACTUAL
0%			0%		
50%			50%		
100%			100%		

CHECK BELOW, IF TRUE:

- ☐ BENCH CALIBRATED PER ABOVE _____
- ☐ VERIFIED PER P&ID NO. _____
- ☐ CORRESPONDS TO SPECIFICATION SHEET NO. _____
- ☐ VALVE SPECIFICATION NO. _____
- ☐ TRANSDUCER SPECIFICATION NO. _____
- ☐ SOLENOID SPECIFICATION NO. _____
- ☐ WIRING CORRECT PER INSTRUMENT LOOP DRAWING NO. _____
- ☐ INSTALLATION CORRECT PER INSTRUMENT INSTALLATION DETAILS _____
- ☐ VALVE DETAIL NO. _____
- ☐ TRANSDUCER DETAIL NO. _____
- ☐ SOLENOID DETAIL NO. _____

	CONTROL VALVES INSTALLATION AND CALIBRATION CHECKLIST	

- ☐ ACCESSORIES ARE PRESENT AND PROPERLY INSTALLED
- ☐ INSTRUMENT IS ACCESSIBLE FOR MAINTENANCE OR REMOVAL
- ☐ ENGRAVED LAMINATED NAMEPLATE (NO SPELLING ERRORS) PERMANENTLY INSTALLED

VALVE CHECK			
FLOW CHECK	☐ PROCESS FLOW DIRECTION THROUGH THE VALVE IS CORRECT		
SAFETY CHECK	ON LOSS OF AIR VALVE FAILS ☐ OPEN ☐ CLOSE	ON LOSS OF POWER SOLENOID FAILS ☐ TO VENT ☐ TO VALVE	
TRAVEL CHECK	FULL OPEN AT _____ PSI	FULL CLOSED AT _____ PSI	MEASURED TRAVEL _____ INCHES
SEATING CHECK	☐ ON BENCH ☐ IN-LINE	RESULTS	ACTUATOR BENCH SET
POSITIONER CHECK			
VALVE FULL OPEN AT _____ PSI TO POSITIONER _____			
VALVE FULL CLOSED AT _____ PSI TO POSITIONER _____			
VOLUME BOOSTER CHECK			
BYPASS VALVE (GAIN) ADJUSTING SCREW BACKED OUT _____ TURNS FROM CLOSED TO ENSURE QUICK BUT STABLE OPERATION (TYPICALLY 1-1/2 TO 2 TURNS)			

REMARKS _____

CHECKED BY (COMPANY) _____	ACCEPTED BY (COMPANY) _____
SIGNATURE _____	SIGNATURE _____
DATE _____	DATE _____

ATTACHMENT G - DEVICENET INSTALLATION TESTING

	DEVICENET INSTALLATION TESTING	
DeviceNet Network _____		
Network Installation Characteristics		
<u>Architecture</u>	<u>Baud Rate</u>	<u>Trunk Media</u>
☐ Single Controller	☐ 125 kBaud	☐ Thick Round
or		☐ Thick Round, Unshielded
☐ Multi Controller	☐ 250 kBaud	☐ Thin Round
☐ Redundant Power Supplies	☐ 500 kBaud	☐ Thin Round, Shielded
☐ Per Network		☐ Thick Round, Shielded
<u>Installed Node List</u>		
☐ 0 ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10 ☐ 11 ☐ 12 ☐ 13 ☐ 14 ☐ 15 ☐ 16 ☐ 17 ☐ 18 ☐ 19 ☐ 20 ☐ 21 ☐ 22 ☐ 23 ☐ 24 ☐ 25 ☐ 26 ☐ 27 ☐ 28 ☐ 29 ☐ 30 ☐ 31 ☐ 32 ☐ 33 ☐ 34 ☐ 35 ☐ 36 ☐ 37 ☐ 38 ☐ 39 ☐ 40 ☐ 41 ☐ 42 ☐ 43 ☐ 44 ☐ 45 ☐ 46 ☐ 47 ☐ 48 ☐ 49 ☐ 50 ☐ 51 ☐ 52 ☐ 53 ☐ 54 ☐ 55 ☐ 56 ☐ 57 ☐ 58 ☐ 59 ☐ 60 ☐ 61 ☐ 62 ☐ 63		
☐ All nodes present and in accordance with network drawings/specifications ☐ ODVA approved devices ☐ Nodes/devices accessible for inspection and maintenance ☐ Nodes/devices properly addressed		
Comments: _____		

Media Inspection		
<u>Trunk Cable</u>	<u>Drop Cable</u>	<u>Installation</u>
☐ ODVA approved	☐ ODVA approved	☐ No evidence of physical damage
☐ Labeling complete	☐ Labeling complete	☐ Installed in protective raceway
☐ Cable/conductor terminations	☐ Cable/conductor terminations	☐ Bending radius not exceeded
☐ Terminating resistors at ends	☐ Maximum drop length < 20 ft.	☐ Cable supports in place
		☐ V- and shield are grounded
		☐ Clearance from high temperature/voltage sources
		☐ No installation subject to vibration
Comments: _____		

	DEVICENET INSTALLATION TESTING	
Network Power Supplies		
<u>Power Supply Equipment</u>	<u>Supply Source (120 VAC)</u>	<u>Network Power Tap (24 VDC)</u>
☐ ODVA compliant	☐ Overcurrent protection	☐ Overcurrent protection
☐ Quantity and ratings	☐ Conductor size	☐ Conductor size
Comments: _____		

CHECKED BY (COMPANY) _____	ACCEPTED BY (COMPANY) _____
SIGNATURE _____	SIGNATURE _____
DATE _____	DATE _____

ATTACHMENT H - PROFIBUS INSTALLATION QUALIFICATION AND TESTING

PROFIBUS INSTALLATION QUALIFICATION AND TESTING																																																																																																																																	
General Network Description The Profibus network serves the RO pretreatment, blended water, and concentrate processes and consists of both DP and PA agent devices. The controller is located in programmable logic controller, PLC-900. Profibus DP repeaters are deployed in the network to essentially support a radial network topology from each process control panel.																																																																																																																																	
Network Design Characteristics																																																																																																																																	
ARCHITECTURE	BAUD RATE (KBITS/SEC)																																																																																																																																
CONTROLLER ☐ SINGLE ☐ REDUNDANT	☐ 9.6 ☐ 187.5 ☐ 3,000																																																																																																																																
TOTAL NODE COUNT ≤ 126 ☐	☐ 19.2 ☐ 50 ☐ 6,000																																																																																																																																
REPEATER COUNT _____	☐ 93.75 ☐ 1,500 ☐ 12,000																																																																																																																																
CASCADED REPEATER COUNT <9 _____																																																																																																																																	
NODE COUNT PER DP SEGMENT <32 ☐																																																																																																																																	
DP/PA SEGMENT COUPLERS _____																																																																																																																																	
REDUNDANCY (DP/PA COUPLERS) _____																																																																																																																																	
ACTIVE TERMINATORS ☐																																																																																																																																	
PROFIBUS DIAGNOSTICS ☐ PA ONLY ☐ DP & PA																																																																																																																																	
SURGE PROTECTION FOR AGENTS LOCATED OUTSIDE ☐																																																																																																																																	
SURGE PROTECTION FOR MEDIA ENTERING THE CONTROLLER CABINET ☐																																																																																																																																	
INTRINSIC SAFETY WIRING: REQUIRED FOR ANY PA NETWORK ☐																																																																																																																																	
INSTALLED NODE LIST																																																																																																																																	
<table style="width: 100%; border-collapse: collapse;"> <tr> <td>☐ 0</td><td>☐ 1</td><td>☐ 2</td><td>☐ 3</td><td>☐ 4</td><td>☐ 5</td><td>☐ 6</td><td>☐ 7</td><td>☐ 8</td><td>☐ 9</td><td>☐ 10</td><td>☐ 11</td><td>☐ 12</td><td>☐ 13</td><td>☐ 14</td><td>☐ 15</td> </tr> <tr> <td>☐ 16</td><td>☐ 17</td><td>☐ 18</td><td>☐ 19</td><td>☐ 20</td><td>☐ 21</td><td>☐ 22</td><td>☐ 23</td><td>☐ 24</td><td>☐ 25</td><td>☐ 26</td><td>☐ 27</td><td>☐ 28</td><td>☐ 29</td><td>☐ 30</td><td>☐ 31</td> </tr> <tr> <td>☐ 32</td><td>☐ 33</td><td>☐ 34</td><td>☐ 35</td><td>☐ 36</td><td>☐ 37</td><td>☐ 38</td><td>☐ 39</td><td>☐ 40</td><td>☐ 41</td><td>☐ 42</td><td>☐ 43</td><td>☐ 44</td><td>☐ 45</td><td>☐ 46</td><td>☐ 47</td> </tr> <tr> <td>☐ 48</td><td>☐ 49</td><td>☐ 50</td><td>☐ 51</td><td>☐ 52</td><td>☐ 53</td><td>☐ 54</td><td>☐ 55</td><td>☐ 56</td><td>☐ 57</td><td>☐ 58</td><td>☐ 59</td><td>☐ 60</td><td>☐ 61</td><td>☐ 62</td><td>☐ 63</td> </tr> <tr> <td>☐ 64</td><td>☐ 65</td><td>☐ 66</td><td>☐ 67</td><td>☐ 68</td><td>☐ 69</td><td>☐ 70</td><td>☐ 71</td><td>☐ 72</td><td>☐ 73</td><td>☐ 74</td><td>☐ 75</td><td>☐ 76</td><td>☐ 77</td><td>☐ 78</td><td>☐ 79</td> </tr> <tr> <td>☐ 80</td><td>☐ 81</td><td>☐ 82</td><td>☐ 83</td><td>☐ 84</td><td>☐ 85</td><td>☐ 86</td><td>☐ 87</td><td>☐ 88</td><td>☐ 89</td><td>☐ 90</td><td>☐ 91</td><td>☐ 92</td><td>☐ 93</td><td>☐ 94</td><td>☐ 95</td> </tr> <tr> <td>☐ 96</td><td>☐ 97</td><td>☐ 98</td><td>☐ 99</td><td>☐ 100</td><td>☐ 101</td><td>☐ 102</td><td>☐ 103</td><td>☐ 104</td><td>☐ 105</td><td>☐ 106</td><td>☐ 107</td><td>☐ 108</td><td>☐ 109</td><td>☐ 110</td><td>☐ 111</td> </tr> <tr> <td>☐ 112</td><td>☐ 113</td><td>☐ 114</td><td>☐ 115</td><td>☐ 116</td><td>☐ 117</td><td>☐ 118</td><td>☐ 119</td><td>☐ 120</td><td>☐ 121</td><td>☐ 122</td><td>☐ 123</td><td>☐ 124</td><td>☐ 125 R</td><td>☐ 126 R</td><td>☐ 127</td> </tr> </table>		☐ 0	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7	☐ 8	☐ 9	☐ 10	☐ 11	☐ 12	☐ 13	☐ 14	☐ 15	☐ 16	☐ 17	☐ 18	☐ 19	☐ 20	☐ 21	☐ 22	☐ 23	☐ 24	☐ 25	☐ 26	☐ 27	☐ 28	☐ 29	☐ 30	☐ 31	☐ 32	☐ 33	☐ 34	☐ 35	☐ 36	☐ 37	☐ 38	☐ 39	☐ 40	☐ 41	☐ 42	☐ 43	☐ 44	☐ 45	☐ 46	☐ 47	☐ 48	☐ 49	☐ 50	☐ 51	☐ 52	☐ 53	☐ 54	☐ 55	☐ 56	☐ 57	☐ 58	☐ 59	☐ 60	☐ 61	☐ 62	☐ 63	☐ 64	☐ 65	☐ 66	☐ 67	☐ 68	☐ 69	☐ 70	☐ 71	☐ 72	☐ 73	☐ 74	☐ 75	☐ 76	☐ 77	☐ 78	☐ 79	☐ 80	☐ 81	☐ 82	☐ 83	☐ 84	☐ 85	☐ 86	☐ 87	☐ 88	☐ 89	☐ 90	☐ 91	☐ 92	☐ 93	☐ 94	☐ 95	☐ 96	☐ 97	☐ 98	☐ 99	☐ 100	☐ 101	☐ 102	☐ 103	☐ 104	☐ 105	☐ 106	☐ 107	☐ 108	☐ 109	☐ 110	☐ 111	☐ 112	☐ 113	☐ 114	☐ 115	☐ 116	☐ 117	☐ 118	☐ 119	☐ 120	☐ 121	☐ 122	☐ 123	☐ 124	☐ 125 R	☐ 126 R	☐ 127
☐ 0	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7	☐ 8	☐ 9	☐ 10	☐ 11	☐ 12	☐ 13	☐ 14	☐ 15																																																																																																																		
☐ 16	☐ 17	☐ 18	☐ 19	☐ 20	☐ 21	☐ 22	☐ 23	☐ 24	☐ 25	☐ 26	☐ 27	☐ 28	☐ 29	☐ 30	☐ 31																																																																																																																		
☐ 32	☐ 33	☐ 34	☐ 35	☐ 36	☐ 37	☐ 38	☐ 39	☐ 40	☐ 41	☐ 42	☐ 43	☐ 44	☐ 45	☐ 46	☐ 47																																																																																																																		
☐ 48	☐ 49	☐ 50	☐ 51	☐ 52	☐ 53	☐ 54	☐ 55	☐ 56	☐ 57	☐ 58	☐ 59	☐ 60	☐ 61	☐ 62	☐ 63																																																																																																																		
☐ 64	☐ 65	☐ 66	☐ 67	☐ 68	☐ 69	☐ 70	☐ 71	☐ 72	☐ 73	☐ 74	☐ 75	☐ 76	☐ 77	☐ 78	☐ 79																																																																																																																		
☐ 80	☐ 81	☐ 82	☐ 83	☐ 84	☐ 85	☐ 86	☐ 87	☐ 88	☐ 89	☐ 90	☐ 91	☐ 92	☐ 93	☐ 94	☐ 95																																																																																																																		
☐ 96	☐ 97	☐ 98	☐ 99	☐ 100	☐ 101	☐ 102	☐ 103	☐ 104	☐ 105	☐ 106	☐ 107	☐ 108	☐ 109	☐ 110	☐ 111																																																																																																																		
☐ 112	☐ 113	☐ 114	☐ 115	☐ 116	☐ 117	☐ 118	☐ 119	☐ 120	☐ 121	☐ 122	☐ 123	☐ 124	☐ 125 R	☐ 126 R	☐ 127																																																																																																																		
☐ ALL NODES PRESENT IN ACCORDANCE WITH NETWORK DESIGN DOCUMENTS.																																																																																																																																	
LEGEND																																																																																																																																	
M	CONTROLLER NODE PRESENT AT THIS ADDRESS																																																																																																																																
D	PROFIBUS DP NODE PRESENT AT THIS ADDRESS																																																																																																																																
P	PROFIBUS PA NODE PRESENT AT THIS ADDRESS																																																																																																																																
R	RESERVED ADDRESS																																																																																																																																
☐	NO DEVICE PRESENT AT THIS ADDRESS																																																																																																																																
COMMENTS <i>(Comments referenced by number. refer to the comments, observations, and recommendations summary.)</i>																																																																																																																																	
<table style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 20px; height: 20px;"></td> <td style="width: 20px; height: 20px;"></td> <td style="width: 20px; height: 20px;"></td> <td style="width: 20px; height: 20px;"></td> <td style="width: 20px; height: 20px;"></td> <td style="width: 20px; height: 20px;"></td> <td style="width: 20px; height: 20px;"></td> <td style="width: 20px; height: 20px;"></td> <td style="width: 20px; height: 20px;"></td> <td style="width: 20px; height: 20px;"></td> <td style="width: 20px; height: 20px;"></td> <td style="width: 20px; height: 20px;"></td> <td style="width: 20px; height: 20px;"></td> <td style="width: 20px; height: 20px;"></td> <td style="width: 20px; height: 20px;"></td> <td style="width: 20px; height: 20px;"></td> </tr> </table>																																																																																																																																	
<table style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 50%;">PROJECT NAME: _____</td> <td style="width: 50%;">TEST DATE: _____</td> </tr> <tr> <td>FACILITY NAME: _____</td> <td>TESTED BY: _____</td> </tr> <tr> <td>PROCESS AREA: _____</td> <td>COMPANY: _____</td> </tr> <tr> <td>NETWORK ID: _____</td> <td>PAGE: _____</td> </tr> <tr> <td>WITNESSED BY: _____</td> <td>SIGNATURE: _____</td> </tr> </table>		PROJECT NAME: _____	TEST DATE: _____	FACILITY NAME: _____	TESTED BY: _____	PROCESS AREA: _____	COMPANY: _____	NETWORK ID: _____	PAGE: _____	WITNESSED BY: _____	SIGNATURE: _____																																																																																																																						
PROJECT NAME: _____	TEST DATE: _____																																																																																																																																
FACILITY NAME: _____	TESTED BY: _____																																																																																																																																
PROCESS AREA: _____	COMPANY: _____																																																																																																																																
NETWORK ID: _____	PAGE: _____																																																																																																																																
WITNESSED BY: _____	SIGNATURE: _____																																																																																																																																

		PROFIBUS INSTALLATION QUALIFICATION AND TESTING					
Media Inspection							
Cabling				DP Network	PA Network Segments		
PI COMPLIANT				☐	☐	☐	☐
LABELING COMPLETE				☐	☐	☐	☐
GROUNDING				☐	☐	☐	☐
CABLE AND CONDUCTOR TERMINATIONS				☐	☐	☐	☐
NO STUB LINES (DP ONLY)				☐	☐	☐	☐
TERMINATING RESISTORS (IN PLACE)				☐	☐	☐	☐
DEDICATED DIAGNOSTICS BUS				☐	☐	☐	☐
INSTALLATION							
NO EVIDENCE OF PHYSICAL DAMAGE				☐	☐	☐	☐
INSTALLATION IN PROTECTIVE RACEWAY				☐	☐	☐	☐
CLEARANCES FROM HIGH TEMPERATURE SOURCES				☐	☐	☐	☐
CLEARANCES FROM HIGH VOLTAGE SOURCES				☐	☐	☐	☐
BEND RADIUS				☐	☐	☐	☐
NO INSTALLATION SUBJECT TO VIBRATION, SHOCK, HIGH FLEX, CHEMICALS, OR MOISTURE				☐	☐	☐	☐
TERMINATING RESISTORS TURNED ON AT CORRECT LOCATION				☐	☐	☐	☐
COMMENTS (Comments referenced by number. refer to the comments, observations, and recommendations summary.)							
Device Inspection							
DEVICE QUANTITY/TYPE				INSTALLATION			
☐ TOTAL AGENT COUNT				☐ NO EVIDENCE OF PHYSICAL DAMAGE			
☐ MOST UPDATED DEVICE DRIVER INSTALLED?				☐ ACCESSIBLE FOR INSPECTION AND MAINTENANCE			
☐ INSTALLED DEVICES COMPLY WITH DRAWINGS AND SPECIFICATIONS				☐ FDT COMPLIANT DEVICES			
☐ PI COMPLIANCE DEVICES							
☐ DIAGNOSTICS MODULE INSTALLED							
COMMENTS (Comments referenced by number. refer to the comments, observations, and recommendations summary.)							
Power Supplies							
ACTIVE TERMINATIONS			COUPLERS			REPEATERS	
☐ SOURCE LOCATION			☐ SOURCE LOCATION			☐ SOURCE LOCATION	
☐ OVERCURRENT PROTECTION			☐ OVERCURRENT PROTECTION			☐ OVERCURRENT PROTECTION	
☐ CONDUCTOR SIZE			☐ CONDUCTOR SIZE			☐ CONDUCTOR SIZE	
☐ GROUNDING			☐ GROUNDING			☐ GROUNDING	
COMMENTS (Comments referenced by number. refer to the comments, observations, and recommendations summary.)							
PROJECT NAME: _____				TEST DATE: _____			
FACILITY NAME: _____				TESTED BY: _____			
PROCESS AREA: _____				COMPANY: _____			
NETWORK ID: _____				PAGE: _____			
WITNESSED BY: _____				SIGNATURE: _____			

SECTION 40_96_15

SCHEDULES: I/O LIST

PART 1 GENERAL

1.01 SUMMARY

- A. The I/O List is not a take-off list.
 - 1. Additional information is as indicated on the Drawings and specified in the Contract Documents.
 - 2. Where any discrepancies between this list and the P&ID drawings arise, the P&ID shall govern.
- B. Abbreviations used in the I/O List are indicated on the Drawings.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 I/O LIST

- A. As specified in Attachment A - I/O List.

END OF SECTION

ATTACHMENT A - I/O LIST



PLC I/O Listing for PLC-SW



Drawing	Tag	I/O	Location	Description	Service	(E/F)
30N24	MPR-301		PLC-SW		MOTOR PROTECTION RELAY	F
30N24	PMP-301		PLC-SW		PUMP 1	F
30N25	MPR-302		PLC-SW		MOTOR PROTECTION RELAY	
30N25	PMP-302		PLC-SW		PUMP 2	
30N26	MPR-303		PLC-SW		MOTOR PROTECTION RELAY	
30N26	PMP-303		PLC-SW		PUMP 3	
30N27	MPR-304		PLC-SW		MOTOR PROTECTION RELAY	F
30N27	PMP-304		PLC-SW		PUMP 4	F
30N28	MPR-305		PLC-SW		MOTOR PROTECTION RELAY	
30N28	PMP-305		PLC-SW		PUMP 5	
30N29	MPR-306		PLC-SW		MOTOR PROTECTION RELAY	
30N29	PMP-306		PLC-SW		PUMP 6	
30N33	ATS-SW		PLC-SW		AUTOMATIC TRANSFER SWITCH	
30N33	UPS-SW		PLC-SW		UNINTERRUPTIBLE POWER SUPPLY	
30N34	SWBD-SW		PLC-SW		MAIN SWITCHBOARD	
30N34	SWGR-SW		PLC-SW		MAIN SWITCHGEAR	
30N34	SWGR-UT1		PLC-SW		UTILITY SWITCHGEAR 1	
30N34	SWGR-UT2		PLC-SW		UTILITY SWITCHGEAR 2	F
PLC-SW		Total Points = 18				



PLC I/O Listing for PLC-SW



Drawing	Tag	I/O	Location	Description	Service	(E/F)
30N20	L-340	AI	PLC-SW		UPPER INTAKE STRUCTURE LEVEL	
30N20	L-341	AI	PLC-SW		LOWER INTAKE STRUCTURE LEVEL	
30N20	Z-340	AI	PLC-SW	POSITION	RESERVOIR UPPER INTAKE HYDRAULIC GATE	
30N20	Z-341	AI	PLC-SW	POSITION	RESERVOIR LOWER INTAKE HYDRAULIC GATE	
30N24	L-302	AI	PLC-SW		WET WELL LEVEL	
30N24	P-301	AI	PLC-SW		PUMP 1 PRESSURE TRANSMITTER	F
30N24	SPDF-301	AI	PLC-SW	SPEED FBK	PUMP 1	F
30N24	Z-301	AI	PLC-SW	POSITION	PUMP 1 DISCH VALVE	F
30N25	P-302	AI	PLC-SW		PUMP 2 PRESSURE TRANSMITTER	
30N25	SPDF-302	AI	PLC-SW	SPEED FBK	PUMP 2	
30N25	Z-302	AI	PLC-SW	POSITION	PUMP 2 DISCH VALVE	
30N26	P-303	AI	PLC-SW		PUMP 3 PRESSURE TRANSMITTER	
30N26	SPDF-303	AI	PLC-SW	SPEED FBK	PUMP 3	
30N26	Z-303	AI	PLC-SW	POSITION	PUMP 3 DISCH VALVE	
30N27	P-304	AI	PLC-SW		PUMP 4 PRESSURE TRANSMITTER	F
30N27	SPDF-304	AI	PLC-SW	SPEED FBK	PUMP 4	F
30N28	P-305	AI	PLC-SW		PUMP 5 PRESSURE TRANSMITTER	
30N28	SPDF-305	AI	PLC-SW	SPEED FBK	PUMP 5	
30N29	P-306	AI	PLC-SW		PUMP 6 PRESSURE TRANSMITTER	
30N29	SPDF-306	AI	PLC-SW	SPEED FBK	PUMP 6	
30N30	F-300	AI	PLC-SW		PUMP STATION FLOW METER	
30N30	F-311	AI	PLC-SW		PUMP STATION FLOW METER	
30N30	PI-310	AI	PLC-SW	PRESS	PUMP STATION DISCHARGE HEADER	
30N31	A-341	AI	PLC-SW	TURB	TURBIDITY	
30N31	A-342	AI	PLC-SW	pH	PH	
30N31	A-343	AI	PLC-SW	ORP	ORP	
30N31	T-342	AI	PLC-SW		PH	



PLC I/O Listing for PLC-SW



Drawing	Tag	I/O	Location	Description	Service	(E/F)
30N31	T-343	AI	PLC-SW		ORP	
30N32	L-320	AI	PLC-SW		HYDROPNEUMATIC TANK LEVEL	
30N33	T-SW	AI	PLC-SW	RACK TEMP	SOURCE WATER PUMP STATION NETWORK RACK	
PLC-SW	Total AI Points = 30					
30N20	ZC-340	AO	PLC-SW	POSITION	RESERVOIR UPPER INTAKE HYDRAULIC GATE	
30N20	ZC-341	AO	PLC-SW	POSITION	RESERVOIR LOWER INTAKE HYDRAULIC GATE	
30N24	SPDC-301	AO	PLC-SW	SPEED CMD	PUMP 1	F
30N25	SPDC-302	AO	PLC-SW	SPEED CMD	PUMP 2	
30N26	SPDC-303	AO	PLC-SW	SPEED CMD	PUMP 3	
30N27	SPDC-304	AO	PLC-SW	SPEED CMD	PUMP 4	F
30N28	SPDC-305	AO	PLC-SW	SPEED CMD	PUMP 5	
30N29	SPDC-306	AO	PLC-SW	SPEED CMD	PUMP 6	
PLC-SW	Total AO Points = 8					



PLC I/O Listing for PLC-SW

Drawing	Tag	I/O	Location	Description	Service	(E/F)
30N20	YA-340	DI	PLC-SW	TROUBLE	RESERVOIR UPPER INTAKE HYDRAULIC GATE	
30N20	YA-341	DI	PLC-SW	TROUBLE	RESERVOIR LOWER INTAKE HYDRAULIC GATE	
30N20	ZSC-340	DI	PLC-SW	CLOSED	RESERVOIR UPPER INTAKE HYDRAULIC GATE	
30N20	ZSC-341	DI	PLC-SW	CLOSED	RESERVOIR LOWER INTAKE HYDRAULIC GATE	
30N20	ZSO-340	DI	PLC-SW	OPENED	RESERVOIR UPPER INTAKE HYDRAULIC GATE	
30N20	ZSO-341	DI	PLC-SW	OPENED	RESERVOIR LOWER INTAKE HYDRAULIC GATE	
30N24	LSL-301	DI	PLC-SW		LEVEL FLOATS	
30N24	LSLL-301	DI	PLC-SW		LEVEL FLOATS	
30N24	RDY-301	DI	PLC-SW	READY	PUMP 1	F
30N24	REM1-301	DI	PLC-SW	REMOTE	PUMP 1 DISCH VALVE	F
30N24	REM-301	DI	PLC-SW	REMOTE	PUMP 1	F
30N24	RNG-301	DI	PLC-SW	RUNNING	PUMP 1	F
30N24	YA1-301	DI	PLC-SW	VFD OK	PUMP 1	F
30N24	ZSC1-301	DI	PLC-SW	CLOSED	LIMIT SWITCH	F
30N24	ZSC-301	DI	PLC-SW	CLOSED	PUMP 1 DISCH VALVE	F
30N24	ZSO1-301	DI	PLC-SW	OPENED	LIMIT SWITCH	F
30N24	ZSO-301	DI	PLC-SW	OPENED	PUMP 1 DISCH VALVE	F
30N25	RDY-302	DI	PLC-SW	READY	PUMP 2	
30N25	REM1-302	DI	PLC-SW	REMOTE	PUMP 2 DISCH VALVE	
30N25	REM-302	DI	PLC-SW	REMOTE	PUMP 2	
30N25	RNG-302	DI	PLC-SW	RUNNING	PUMP 2	
30N25	YA1-302	DI	PLC-SW	VFD OK	PUMP 2	
30N25	ZSC1-302	DI	PLC-SW	CLOSED	LIMIT SWITCH	
30N25	ZSC-302	DI	PLC-SW	CLOSED	PUMP 2 DISCH VALVE	
30N25	ZSO1-302	DI	PLC-SW	OPENED	LIMIT SWITCH	
30N25	ZSO-302	DI	PLC-SW	OPENED	PUMP 2 DISCH VALVE	
30N26	RDY-303	DI	PLC-SW	READY	PUMP 3	



PLC I/O Listing for PLC-SW



Drawing	Tag	I/O	Location	Description	Service	(E/F)
30N26	REM1-303	DI	PLC-SW	REMOTE	PUMP 3 DISCH VALVE	
30N26	REM-303	DI	PLC-SW	REMOTE	PUMP 3	
30N26	RNG-303	DI	PLC-SW	RUNNING	PUMP 3	
30N26	YA1-303	DI	PLC-SW	VFD OK	PUMP 3	
30N26	ZSC1-303	DI	PLC-SW	CLOSED	LIMIT SWITCH	
30N26	ZSC-303	DI	PLC-SW	CLOSED	PUMP 3 DISCH VALVE	
30N26	ZSO1-303	DI	PLC-SW	OPENED	LIMIT SWITCH	
30N26	ZSO-303	DI	PLC-SW	OPENED	PUMP 3 DISCH VALVE	
30N27	PSH-304	DI	PLC-SW	HIGH PRESSURE	PRESSURE SWITCH HIGH	F
30N27	RDY-304	DI	PLC-SW	READY	PUMP 4	F
30N27	REM-304	DI	PLC-SW	REMOTE	PUMP 4	F
30N27	RNG-304	DI	PLC-SW	RUNNING	PUMP 4	F
30N27	YA1-304	DI	PLC-SW	VFD OK	PUMP 4	F
30N27	ZSC1-304	DI	PLC-SW	CLOSED	LIMIT SWITCH	F
30N27	ZSO1-304	DI	PLC-SW	OPENED	LIMIT SWITCH	F
30N28	PSH-305	DI	PLC-SW	HIGH PRESSURE	PRESSURE SWITCH HIGH	
30N28	RDY-305	DI	PLC-SW	READY	PUMP 5	
30N28	REM-305	DI	PLC-SW	REMOTE	PUMP 5	
30N28	RNG-305	DI	PLC-SW	RUNNING	PUMP 5	
30N28	YA1-305	DI	PLC-SW	VFD OK	PUMP 5	
30N28	ZSC1-305	DI	PLC-SW	CLOSED	LIMIT SWITCH	
30N28	ZSO1-305	DI	PLC-SW	OPENED	LIMIT SWITCH	
30N29	PSH-306	DI	PLC-SW	HIGH PRESSURE	PRESSURE SWITCH HIGH	
30N29	RDY-306	DI	PLC-SW	READY	PUMP 6	
30N29	REM-306	DI	PLC-SW	REMOTE	PUMP 6	
30N29	RNG-306	DI	PLC-SW	RUNNING	PUMP 6	
30N29	YA1-306	DI	PLC-SW	VFD OK	PUMP 6	



PLC I/O Listing for PLC-SW

Drawing	Tag	I/O	Location	Description	Service	(E/F)
30N29	ZSC1-306	DI	PLC-SW	CLOSED	LIMIT SWITCH	
30N29	ZSO1-306	DI	PLC-SW	OPENED	LIMIT SWITCH	
30N30	PSH-310	DI	PLC-SW	HIGH PRESSURE	PRESSURE SWITCH HIGH	
30N30	REM-310	DI	PLC-SW	REMOTE	PS DISCH VALVE 2	
30N30	REM-311	DI	PLC-SW	REMOTE	PS DISCH VALVE 1	
30N30	ZSC-310	DI	PLC-SW	CLOSED	PS DISCH VALVE 2	
30N30	ZSC-311	DI	PLC-SW	CLOSED	PS DISCH VALVE 1	
30N30	ZSO-310	DI	PLC-SW	OPENED	PS DISCH VALVE 2	
30N30	ZSO-311	DI	PLC-SW	OPENED	PS DISCH VALVE 1	
30N32	FAIL-322	DI	PLC-SW	FAIL	SOLENOID	
30N32	FAIL-331A	DI	PLC-SW	FAULT	AIR COMREPSSOR 1	
30N32	FAIL-331B	DI	PLC-SW	FAULT	AIR COMREPSSOR 2	
30N32	RNG-331A	DI	PLC-SW	RUNNING	AIR COMREPSSOR 1	
30N32	RNG-331B	DI	PLC-SW	RUNNING	AIR COMREPSSOR 2	
30N33	JS10-SW	DI	PLC-SW	PWR SUP OK	POWER SUPPLY	
30N33	JS13-SW	DI	PLC-SW	REDUNDANCY OK	POWER SUPPLY	
30N33	JS14-SW	DI	PLC-SW	ACB OK	POWER SUPPLY	
30N33	JS1-SW	DI	PLC-SW	PWR SUP OK	SOURCE WATER PUMP STATION PCM	
30N33	JS4-SW	DI	PLC-SW	PWR SUP OK	SOURCE WATER PUMP STATION PCM	
30N33	JS5-SW	DI	PLC-SW	REDUNDANCY OK	SOURCE WATER PUMP STATION PCM	
30N33	JS7-SW	DI	PLC-SW	ACB OK	SOURCE WATER PUMP STATION PCM	
30N33	JS8-SW	DI	PLC-SW	PWR SUP OK	POWER SUPPLY	
30N33	TSH-SW	DI	PLC-SW	HIGH CABINET TEMP	SOURCE WATER PUMP STATION PCM	
30N33	XA1-SW	DI	PLC-SW	SPD1 FAIL	SOURCE WATER PUMP STATION PCM	
30N33	XA2-SW	DI	PLC-SW	SPD2 FAIL	SOURCE WATER PUMP STATION PCM	
30N33	XA3-SW	DI	PLC-SW	SPD1 FAIL	SURGE PROTECTION DEVICE	
30N33	XA4-SW	DI	PLC-SW	SPD2 FAIL	SURGE PROTECTION DEVICE	



PLC I/O Listing for PLC-SW

Drawing	Tag	I/O	Location	Description	Service	(E/F)
30N33	XA5-SW	DI	PLC-SW	ESP FAIL	SOURCE WATER PUMP STATION PCM	
30N33	XA6-SW	DI	PLC-SW	ESF FAIL	SOURCE WATER PUMP STATION PCM	
30N33	XA7-SW	DI	PLC-SW	ECP FAIL	SOURCE WATER PUMP STATION PCM	
30N33	XA8-SW	DI	PLC-SW	ECP FAIL	SOURCE WATER PUMP STATION PCM	
30N33	XA9-SW	DI	PLC-SW	SPD3 FAIL	SURGE PROTECTION DEVICE	
30N33	ZS1-SW	DI	PLC-SW	INTRUSION	SOURCE WATER PUMP STATION PCM	
30N33	ZS2-SW	DI	PLC-SW	INTRUSION	SOURCE WATER PUMP STATION NETWORK RACK	
PLC-SW	Total DI Points = 88					
30N24	RUN-301	DO	PLC-SW	RUN	PUMP 1	F
30N24	ZCC-301	DO	PLC-SW	JOG CLOSE	PUMP 1 DISCH VALVE	F
30N24	ZCO-301	DO	PLC-SW	JOG OPEN	PUMP 1 DISCH VALVE	F
30N25	RUN-302	DO	PLC-SW	RUN	PUMP 2	
30N25	ZCC-302	DO	PLC-SW	JOG CLOSE	PUMP 2 DISCH VALVE	
30N25	ZCO-302	DO	PLC-SW	JOG OPEN	PUMP 2 DISCH VALVE	
30N26	RUN-303	DO	PLC-SW	RUN	PUMP 3	
30N26	ZCC-303	DO	PLC-SW	JOG CLOSE	PUMP 3 DISCH VALVE	
30N26	ZCO-303	DO	PLC-SW	JOG OPEN	PUMP 3 DISCH VALVE	
30N27	RUN-304	DO	PLC-SW	RUN	PUMP 4	F
30N28	RUN-305	DO	PLC-SW	RUN	PUMP 5	
30N29	RUN-306	DO	PLC-SW	RUN	PUMP 6	
30N30	ZCC-310	DO	PLC-SW	CLOSE	PS DISCH VALVE 2	
30N30	ZCC-311	DO	PLC-SW	CLOSE	PS DISCH VALVE 1	
30N30	ZCO-310	DO	PLC-SW	OPEN	PS DISCH VALVE 2	
30N30	ZCO-311	DO	PLC-SW	OPEN	PS DISCH VALVE 1	
PLC-SW	Total DO Points = 16					



PLC I/O Listing for PLC-SW



Drawing	Tag	I/O	Location	Description	Service	(E/F)
30N24	MPR-301	MODBUS TCP	PLC-SW	W DEMAND	MOTOR PROTECTION RELAY	F
30N24	MPR-301	MODBUS TCP	PLC-SW	3 PH AVG DEMAND CURRENT	MOTOR PROTECTION RELAY	F
30N24	MPR-301	MODBUS TCP	PLC-SW	A PH CURRENT	MOTOR PROTECTION RELAY	F
30N24	MPR-301	MODBUS TCP	PLC-SW	A PH CURRENT %THD	MOTOR PROTECTION RELAY	F
30N24	MPR-301	MODBUS TCP	PLC-SW	A PH DEMAND CURRENT	MOTOR PROTECTION RELAY	F
30N24	MPR-301	MODBUS TCP	PLC-SW	A PH V	MOTOR PROTECTION RELAY	F
30N24	MPR-301	MODBUS TCP	PLC-SW	AB PH V %THD	MOTOR PROTECTION RELAY	F
30N24	MPR-301	MODBUS TCP	PLC-SW	AN PH V %THD	MOTOR PROTECTION RELAY	F
30N24	MPR-301	MODBUS TCP	PLC-SW	B PH CURRENT	MOTOR PROTECTION RELAY	F
30N24	MPR-301	MODBUS TCP	PLC-SW	B PH CURRENT %THD	MOTOR PROTECTION RELAY	F
30N24	MPR-301	MODBUS TCP	PLC-SW	B PH DEMAND CURRENT	MOTOR PROTECTION RELAY	F
30N24	MPR-301	MODBUS TCP	PLC-SW	B PH V	MOTOR PROTECTION RELAY	F
30N24	MPR-301	MODBUS TCP	PLC-SW	BC PH V %THD	MOTOR PROTECTION RELAY	F
30N24	MPR-301	MODBUS TCP	PLC-SW	BN PH V %THD	MOTOR PROTECTION RELAY	F
30N24	MPR-301	MODBUS TCP	PLC-SW	C PH CURRENT	MOTOR PROTECTION RELAY	F
30N24	MPR-301	MODBUS TCP	PLC-SW	C PH CURRENT %THD	MOTOR PROTECTION RELAY	F
30N24	MPR-301	MODBUS TCP	PLC-SW	C PH DEMAND CURRENT	MOTOR PROTECTION RELAY	F
30N24	MPR-301	MODBUS TCP	PLC-SW	C PH V	MOTOR PROTECTION RELAY	F
30N24	MPR-301	MODBUS TCP	PLC-SW	CA PH V %THD	MOTOR PROTECTION RELAY	F
30N24	MPR-301	MODBUS TCP	PLC-SW	CN PH V %THD	MOTOR PROTECTION RELAY	F
30N24	MPR-301	MODBUS TCP	PLC-SW	ENERGY	MOTOR PROTECTION RELAY	F
30N24	MPR-301	MODBUS TCP	PLC-SW	FREQUENCY	MOTOR PROTECTION RELAY	F
30N24	MPR-301	MODBUS TCP	PLC-SW	POWER FACTOR	MOTOR PROTECTION RELAY	F
30N24	MPR-301	MODBUS TCP	PLC-SW	RTD 1 TEMP	MOTOR PROTECTION RELAY	F
30N24	MPR-301	MODBUS TCP	PLC-SW	RTD 2 TEMP	MOTOR PROTECTION RELAY	F
30N24	MPR-301	MODBUS TCP	PLC-SW	RTD 3 TEMP	MOTOR PROTECTION RELAY	F
30N24	MPR-301	MODBUS TCP	PLC-SW	RTD 4 TEMP	MOTOR PROTECTION RELAY	F



PLC I/O Listing for PLC-SW



Drawing	Tag	I/O	Location	Description	Service	(E/F)
30N24	MPR-301	MODBUS TCP	PLC-SW	RTD 5 TEMP	MOTOR PROTECTION RELAY	F
30N24	MPR-301	MODBUS TCP	PLC-SW	RTD 6 TEMP	MOTOR PROTECTION RELAY	F
30N24	MPR-301	MODBUS TCP	PLC-SW	RTD 7 TEMP	MOTOR PROTECTION RELAY	F
30N24	MPR-301	MODBUS TCP	PLC-SW	RTD 8 TEMP	MOTOR PROTECTION RELAY	F
30N24	MPR-301	MODBUS TCP	PLC-SW	VA	MOTOR PROTECTION RELAY	F
30N24	MPR-301	MODBUS TCP	PLC-SW	VA DEMAND	MOTOR PROTECTION RELAY	F
30N24	MPR-301	MODBUS TCP	PLC-SW	VAR5	MOTOR PROTECTION RELAY	F
30N24	MPR-301	MODBUS TCP	PLC-SW	VIBRATION 1 SWITCH HIGH	MOTOR PROTECTION RELAY	F
30N24	MPR-301	MODBUS TCP	PLC-SW	VIBRATION 2 SWITCH HIGH	MOTOR PROTECTION RELAY	F
30N24	MPR-301	MODBUS TCP	PLC-SW	WATTS	MOTOR PROTECTION RELAY	F
30N24	PMP-301	MODBUS TCP	PLC-SW	A PH CURRENT	PUMP 1	F
30N24	PMP-301	MODBUS TCP	PLC-SW	A PH V	PUMP 1	F
30N24	PMP-301	MODBUS TCP	PLC-SW	AVERAGE 3 PH CURRENT	PUMP 1	F
30N24	PMP-301	MODBUS TCP	PLC-SW	B PH CURRENT	PUMP 1	F
30N24	PMP-301	MODBUS TCP	PLC-SW	B PH V	PUMP 1	F
30N24	PMP-301	MODBUS TCP	PLC-SW	C PH CURRENT	PUMP 1	F
30N24	PMP-301	MODBUS TCP	PLC-SW	C PH V	PUMP 1	F
30N24	PMP-301	MODBUS TCP	PLC-SW	CURRENT ALARM HIGH	PUMP 1	F
30N24	PMP-301	MODBUS TCP	PLC-SW	DAILY RUN TIME	PUMP 1	F
30N24	PMP-301	MODBUS TCP	PLC-SW	DAILY STARTS	PUMP 1	F
30N24	PMP-301	MODBUS TCP	PLC-SW	ELAPSED TIME	PUMP 1	F
30N24	PMP-301	MODBUS TCP	PLC-SW	EQUIPMENT SHUTDOWN	PUMP 1	F
30N24	PMP-301	MODBUS TCP	PLC-SW	ESD OK	PUMP 1	F
30N24	PMP-301	MODBUS TCP	PLC-SW	FAIL TO RESPOND	PUMP 1	F
30N24	PMP-301	MODBUS TCP	PLC-SW	FAULT	PUMP 1	F
30N24	PMP-301	MODBUS TCP	PLC-SW	LOCAL	PUMP 1	F
30N24	PMP-301	MODBUS TCP	PLC-SW	LOW FLOW	PUMP 1	F



PLC I/O Listing for PLC-SW



Drawing	Tag	I/O	Location	Description	Service	(E/F)
30N24	PMP-301	MODBUS TCP	PLC-SW	LOW LOW LEVEL	PUMP 1	F
30N24	PMP-301	MODBUS TCP	PLC-SW	OFF	PUMP 1	F
30N24	PMP-301	MODBUS TCP	PLC-SW	OVERLOAD	PUMP 1	F
30N24	PMP-301	MODBUS TCP	PLC-SW	POWER FACTOR	PUMP 1	F
30N24	PMP-301	MODBUS TCP	PLC-SW	POWER KVA	PUMP 1	F
30N24	PMP-301	MODBUS TCP	PLC-SW	POWER KW	PUMP 1	F
30N24	PMP-301	MODBUS TCP	PLC-SW	REMOTE	PUMP 1	F
30N24	PMP-301	MODBUS TCP	PLC-SW	RESET ELAPSED TIME	PUMP 1	F
30N24	PMP-301	MODBUS TCP	PLC-SW	RUNNING	PUMP 1	F
30N24	PMP-301	MODBUS TCP	PLC-SW	SPEED	PUMP 1	F
30N24	PMP-301	MODBUS TCP	PLC-SW	SPEED FEEDBACK	PUMP 1	F
30N24	PMP-301	MODBUS TCP	PLC-SW	START	PUMP 1	F
30N24	PMP-301	MODBUS TCP	PLC-SW	STOP	PUMP 1	F
30N24	PMP-301	MODBUS TCP	PLC-SW	TOTAL STARTS	PUMP 1	F
30N25	MPR-302	MODBUS TCP	PLC-SW	W DEMAND	MOTOR PROTECTION RELAY	
30N25	MPR-302	MODBUS TCP	PLC-SW	3 PH AVG DEMAND CURRENT	MOTOR PROTECTION RELAY	
30N25	MPR-302	MODBUS TCP	PLC-SW	A PH CURRENT	MOTOR PROTECTION RELAY	
30N25	MPR-302	MODBUS TCP	PLC-SW	A PH CURRENT %THD	MOTOR PROTECTION RELAY	
30N25	MPR-302	MODBUS TCP	PLC-SW	A PH DEMAND CURRENT	MOTOR PROTECTION RELAY	
30N25	MPR-302	MODBUS TCP	PLC-SW	A PH V	MOTOR PROTECTION RELAY	
30N25	MPR-302	MODBUS TCP	PLC-SW	AB PH V %THD	MOTOR PROTECTION RELAY	
30N25	MPR-302	MODBUS TCP	PLC-SW	AN PH V %THD	MOTOR PROTECTION RELAY	
30N25	MPR-302	MODBUS TCP	PLC-SW	B PH CURRENT	MOTOR PROTECTION RELAY	
30N25	MPR-302	MODBUS TCP	PLC-SW	B PH CURRENT %THD	MOTOR PROTECTION RELAY	
30N25	MPR-302	MODBUS TCP	PLC-SW	B PH DEMAND CURRENT	MOTOR PROTECTION RELAY	
30N25	MPR-302	MODBUS TCP	PLC-SW	B PH V	MOTOR PROTECTION RELAY	
30N25	MPR-302	MODBUS TCP	PLC-SW	BC PH V %THD	MOTOR PROTECTION RELAY	



PLC I/O Listing for PLC-SW

Drawing	Tag	I/O	Location	Description	Service	(E/F)
30N25	MPR-302	MODBUS TCP	PLC-SW	BN PH V %THD	MOTOR PROTECTION RELAY	
30N25	MPR-302	MODBUS TCP	PLC-SW	C PH CURRENT	MOTOR PROTECTION RELAY	
30N25	MPR-302	MODBUS TCP	PLC-SW	C PH CURRENT %THD	MOTOR PROTECTION RELAY	
30N25	MPR-302	MODBUS TCP	PLC-SW	C PH DEMAND CURRENT	MOTOR PROTECTION RELAY	
30N25	MPR-302	MODBUS TCP	PLC-SW	C PH V	MOTOR PROTECTION RELAY	
30N25	MPR-302	MODBUS TCP	PLC-SW	CA PH V %THD	MOTOR PROTECTION RELAY	
30N25	MPR-302	MODBUS TCP	PLC-SW	CN PH V %THD	MOTOR PROTECTION RELAY	
30N25	MPR-302	MODBUS TCP	PLC-SW	ENERGY	MOTOR PROTECTION RELAY	
30N25	MPR-302	MODBUS TCP	PLC-SW	FREQUENCY	MOTOR PROTECTION RELAY	
30N25	MPR-302	MODBUS TCP	PLC-SW	POWER FACTOR	MOTOR PROTECTION RELAY	
30N25	MPR-302	MODBUS TCP	PLC-SW	RTD 1 TEMP	MOTOR PROTECTION RELAY	
30N25	MPR-302	MODBUS TCP	PLC-SW	RTD 2 TEMP	MOTOR PROTECTION RELAY	
30N25	MPR-302	MODBUS TCP	PLC-SW	RTD 3 TEMP	MOTOR PROTECTION RELAY	
30N25	MPR-302	MODBUS TCP	PLC-SW	RTD 4 TEMP	MOTOR PROTECTION RELAY	
30N25	MPR-302	MODBUS TCP	PLC-SW	RTD 5 TEMP	MOTOR PROTECTION RELAY	
30N25	MPR-302	MODBUS TCP	PLC-SW	RTD 6 TEMP	MOTOR PROTECTION RELAY	
30N25	MPR-302	MODBUS TCP	PLC-SW	RTD 7 TEMP	MOTOR PROTECTION RELAY	
30N25	MPR-302	MODBUS TCP	PLC-SW	RTD 8 TEMP	MOTOR PROTECTION RELAY	
30N25	MPR-302	MODBUS TCP	PLC-SW	VA	MOTOR PROTECTION RELAY	
30N25	MPR-302	MODBUS TCP	PLC-SW	VA DEMAND	MOTOR PROTECTION RELAY	
30N25	MPR-302	MODBUS TCP	PLC-SW	VAR5	MOTOR PROTECTION RELAY	
30N25	MPR-302	MODBUS TCP	PLC-SW	VIBRATION 1 SWITCH HIGH	MOTOR PROTECTION RELAY	
30N25	MPR-302	MODBUS TCP	PLC-SW	VIBRATION 2 SWITCH HIGH	MOTOR PROTECTION RELAY	
30N25	MPR-302	MODBUS TCP	PLC-SW	WATTS	MOTOR PROTECTION RELAY	
30N25	PMP-302	MODBUS TCP	PLC-SW	A PH CURRENT	PUMP 2	
30N25	PMP-302	MODBUS TCP	PLC-SW	A PH V	PUMP 2	
30N25	PMP-302	MODBUS TCP	PLC-SW	AVERAGE 3 PH CURRENT	PUMP 2	



PLC I/O Listing for PLC-SW

Drawing	Tag	I/O	Location	Description	Service	(E/F)
30N25	PMP-302	MODBUS TCP	PLC-SW	B PH CURRENT	PUMP 2	
30N25	PMP-302	MODBUS TCP	PLC-SW	B PH V	PUMP 2	
30N25	PMP-302	MODBUS TCP	PLC-SW	C PH CURRENT	PUMP 2	
30N25	PMP-302	MODBUS TCP	PLC-SW	C PH V	PUMP 2	
30N25	PMP-302	MODBUS TCP	PLC-SW	CURRENT ALARM HIGH	PUMP 2	
30N25	PMP-302	MODBUS TCP	PLC-SW	DAILY RUN TIME	PUMP 2	
30N25	PMP-302	MODBUS TCP	PLC-SW	DAILY STARTS	PUMP 2	
30N25	PMP-302	MODBUS TCP	PLC-SW	ELAPSED TIME	PUMP 2	
30N25	PMP-302	MODBUS TCP	PLC-SW	EQUIPMENT SHUTDOWN	PUMP 2	
30N25	PMP-302	MODBUS TCP	PLC-SW	ESD OK	PUMP 2	
30N25	PMP-302	MODBUS TCP	PLC-SW	FAIL TO RESPOND	PUMP 2	
30N25	PMP-302	MODBUS TCP	PLC-SW	FAULT	PUMP 2	
30N25	PMP-302	MODBUS TCP	PLC-SW	LOCAL	PUMP 2	
30N25	PMP-302	MODBUS TCP	PLC-SW	LOW FLOW	PUMP 2	
30N25	PMP-302	MODBUS TCP	PLC-SW	LOW LOW LEVEL	PUMP 2	
30N25	PMP-302	MODBUS TCP	PLC-SW	OFF	PUMP 2	
30N25	PMP-302	MODBUS TCP	PLC-SW	OVERLOAD	PUMP 2	
30N25	PMP-302	MODBUS TCP	PLC-SW	POWER FACTOR	PUMP 2	
30N25	PMP-302	MODBUS TCP	PLC-SW	POWER KVA	PUMP 2	
30N25	PMP-302	MODBUS TCP	PLC-SW	POWER KW	PUMP 2	
30N25	PMP-302	MODBUS TCP	PLC-SW	REMOTE	PUMP 2	
30N25	PMP-302	MODBUS TCP	PLC-SW	RESET ELAPSED TIME	PUMP 2	
30N25	PMP-302	MODBUS TCP	PLC-SW	RUNNING	PUMP 2	
30N25	PMP-302	MODBUS TCP	PLC-SW	SPEED	PUMP 2	
30N25	PMP-302	MODBUS TCP	PLC-SW	SPEED FEEDBACK	PUMP 2	
30N25	PMP-302	MODBUS TCP	PLC-SW	START	PUMP 2	
30N25	PMP-302	MODBUS TCP	PLC-SW	STOP	PUMP 2	



PLC I/O Listing for PLC-SW



Drawing	Tag	I/O	Location	Description	Service	(E/F)
30N25	PMP-302	MODBUS TCP	PLC-SW	TOTAL STARTS	PUMP 2	
30N26	MPR-303	MODBUS TCP	PLC-SW	W DEMAND	MOTOR PROTECTION RELAY	
30N26	MPR-303	MODBUS TCP	PLC-SW	3 PH AVG DEMAND CURRENT	MOTOR PROTECTION RELAY	
30N26	MPR-303	MODBUS TCP	PLC-SW	A PH CURRENT	MOTOR PROTECTION RELAY	
30N26	MPR-303	MODBUS TCP	PLC-SW	A PH CURRENT %THD	MOTOR PROTECTION RELAY	
30N26	MPR-303	MODBUS TCP	PLC-SW	A PH DEMAND CURRENT	MOTOR PROTECTION RELAY	
30N26	MPR-303	MODBUS TCP	PLC-SW	A PH V	MOTOR PROTECTION RELAY	
30N26	MPR-303	MODBUS TCP	PLC-SW	AB PH V %THD	MOTOR PROTECTION RELAY	
30N26	MPR-303	MODBUS TCP	PLC-SW	AN PH V %THD	MOTOR PROTECTION RELAY	
30N26	MPR-303	MODBUS TCP	PLC-SW	B PH CURRENT	MOTOR PROTECTION RELAY	
30N26	MPR-303	MODBUS TCP	PLC-SW	B PH CURRENT %THD	MOTOR PROTECTION RELAY	
30N26	MPR-303	MODBUS TCP	PLC-SW	B PH DEMAND CURRENT	MOTOR PROTECTION RELAY	
30N26	MPR-303	MODBUS TCP	PLC-SW	B PH V	MOTOR PROTECTION RELAY	
30N26	MPR-303	MODBUS TCP	PLC-SW	BC PH V %THD	MOTOR PROTECTION RELAY	
30N26	MPR-303	MODBUS TCP	PLC-SW	BN PH V %THD	MOTOR PROTECTION RELAY	
30N26	MPR-303	MODBUS TCP	PLC-SW	C PH CURRENT	MOTOR PROTECTION RELAY	
30N26	MPR-303	MODBUS TCP	PLC-SW	C PH CURRENT %THD	MOTOR PROTECTION RELAY	
30N26	MPR-303	MODBUS TCP	PLC-SW	C PH DEMAND CURRENT	MOTOR PROTECTION RELAY	
30N26	MPR-303	MODBUS TCP	PLC-SW	C PH V	MOTOR PROTECTION RELAY	
30N26	MPR-303	MODBUS TCP	PLC-SW	CA PH V %THD	MOTOR PROTECTION RELAY	
30N26	MPR-303	MODBUS TCP	PLC-SW	CN PH V %THD	MOTOR PROTECTION RELAY	
30N26	MPR-303	MODBUS TCP	PLC-SW	ENERGY	MOTOR PROTECTION RELAY	
30N26	MPR-303	MODBUS TCP	PLC-SW	FREQUENCY	MOTOR PROTECTION RELAY	
30N26	MPR-303	MODBUS TCP	PLC-SW	POWER FACTOR	MOTOR PROTECTION RELAY	
30N26	MPR-303	MODBUS TCP	PLC-SW	RTD 1 TEMP	MOTOR PROTECTION RELAY	
30N26	MPR-303	MODBUS TCP	PLC-SW	RTD 2 TEMP	MOTOR PROTECTION RELAY	
30N26	MPR-303	MODBUS TCP	PLC-SW	RTD 3 TEMP	MOTOR PROTECTION RELAY	



PLC I/O Listing for PLC-SW



Drawing	Tag	I/O	Location	Description	Service	(E/F)
30N26	MPR-303	MODBUS TCP	PLC-SW	RTD 4 TEMP	MOTOR PROTECTION RELAY	
30N26	MPR-303	MODBUS TCP	PLC-SW	RTD 5 TEMP	MOTOR PROTECTION RELAY	
30N26	MPR-303	MODBUS TCP	PLC-SW	RTD 6 TEMP	MOTOR PROTECTION RELAY	
30N26	MPR-303	MODBUS TCP	PLC-SW	RTD 7 TEMP	MOTOR PROTECTION RELAY	
30N26	MPR-303	MODBUS TCP	PLC-SW	RTD 8 TEMP	MOTOR PROTECTION RELAY	
30N26	MPR-303	MODBUS TCP	PLC-SW	VA	MOTOR PROTECTION RELAY	
30N26	MPR-303	MODBUS TCP	PLC-SW	VA DEMAND	MOTOR PROTECTION RELAY	
30N26	MPR-303	MODBUS TCP	PLC-SW	VAR5	MOTOR PROTECTION RELAY	
30N26	MPR-303	MODBUS TCP	PLC-SW	VIBRATION 1 SWITCH HIGH	MOTOR PROTECTION RELAY	
30N26	MPR-303	MODBUS TCP	PLC-SW	VIBRATION 2 SWITCH HIGH	MOTOR PROTECTION RELAY	
30N26	MPR-303	MODBUS TCP	PLC-SW	WATTS	MOTOR PROTECTION RELAY	
30N26	PMP-303	MODBUS TCP	PLC-SW	A PH CURRENT	PUMP 3	
30N26	PMP-303	MODBUS TCP	PLC-SW	A PH V	PUMP 3	
30N26	PMP-303	MODBUS TCP	PLC-SW	AVERAGE 3 PH CURRENT	PUMP 3	
30N26	PMP-303	MODBUS TCP	PLC-SW	B PH CURRENT	PUMP 3	
30N26	PMP-303	MODBUS TCP	PLC-SW	B PH V	PUMP 3	
30N26	PMP-303	MODBUS TCP	PLC-SW	C PH CURRENT	PUMP 3	
30N26	PMP-303	MODBUS TCP	PLC-SW	C PH V	PUMP 3	
30N26	PMP-303	MODBUS TCP	PLC-SW	CURRENT ALARM HIGH	PUMP 3	
30N26	PMP-303	MODBUS TCP	PLC-SW	DAILY RUN TIME	PUMP 3	
30N26	PMP-303	MODBUS TCP	PLC-SW	DAILY STARTS	PUMP 3	
30N26	PMP-303	MODBUS TCP	PLC-SW	ELAPSED TIME	PUMP 3	
30N26	PMP-303	MODBUS TCP	PLC-SW	EQUIPMENT SHUTDOWN	PUMP 3	
30N26	PMP-303	MODBUS TCP	PLC-SW	ESD OK	PUMP 3	
30N26	PMP-303	MODBUS TCP	PLC-SW	FAIL TO RESPOND	PUMP 3	
30N26	PMP-303	MODBUS TCP	PLC-SW	FAULT	PUMP 3	
30N26	PMP-303	MODBUS TCP	PLC-SW	LOCAL	PUMP 3	



PLC I/O Listing for PLC-SW



Drawing	Tag	I/O	Location	Description	Service	(E/F)
30N26	PMP-303	MODBUS TCP	PLC-SW	LOW FLOW	PUMP 3	
30N26	PMP-303	MODBUS TCP	PLC-SW	LOW LOW LEVEL	PUMP 3	
30N26	PMP-303	MODBUS TCP	PLC-SW	OFF	PUMP 3	
30N26	PMP-303	MODBUS TCP	PLC-SW	OVERLOAD	PUMP 3	
30N26	PMP-303	MODBUS TCP	PLC-SW	POWER FACTOR	PUMP 3	
30N26	PMP-303	MODBUS TCP	PLC-SW	POWER KVA	PUMP 3	
30N26	PMP-303	MODBUS TCP	PLC-SW	POWER KW	PUMP 3	
30N26	PMP-303	MODBUS TCP	PLC-SW	REMOTE	PUMP 3	
30N26	PMP-303	MODBUS TCP	PLC-SW	RESET ELAPSED TIME	PUMP 3	
30N26	PMP-303	MODBUS TCP	PLC-SW	RUNNING	PUMP 3	
30N26	PMP-303	MODBUS TCP	PLC-SW	SPEED	PUMP 3	
30N26	PMP-303	MODBUS TCP	PLC-SW	SPEED FEEDBACK	PUMP 3	
30N26	PMP-303	MODBUS TCP	PLC-SW	START	PUMP 3	
30N26	PMP-303	MODBUS TCP	PLC-SW	STOP	PUMP 3	
30N26	PMP-303	MODBUS TCP	PLC-SW	TOTAL STARTS	PUMP 3	
30N27	MPR-304	MODBUS TCP	PLC-SW	W DEMAND	MOTOR PROTECTION RELAY	F
30N27	MPR-304	MODBUS TCP	PLC-SW	3 PH AVG DEMAND CURRENT	MOTOR PROTECTION RELAY	F
30N27	MPR-304	MODBUS TCP	PLC-SW	A PH CURRENT	MOTOR PROTECTION RELAY	F
30N27	MPR-304	MODBUS TCP	PLC-SW	A PH CURRENT %THD	MOTOR PROTECTION RELAY	F
30N27	MPR-304	MODBUS TCP	PLC-SW	A PH DEMAND CURRENT	MOTOR PROTECTION RELAY	F
30N27	MPR-304	MODBUS TCP	PLC-SW	A PH V	MOTOR PROTECTION RELAY	F
30N27	MPR-304	MODBUS TCP	PLC-SW	AB PH V %THD	MOTOR PROTECTION RELAY	F
30N27	MPR-304	MODBUS TCP	PLC-SW	AN PH V %THD	MOTOR PROTECTION RELAY	F
30N27	MPR-304	MODBUS TCP	PLC-SW	B PH CURRENT	MOTOR PROTECTION RELAY	F
30N27	MPR-304	MODBUS TCP	PLC-SW	B PH CURRENT %THD	MOTOR PROTECTION RELAY	F
30N27	MPR-304	MODBUS TCP	PLC-SW	B PH DEMAND CURRENT	MOTOR PROTECTION RELAY	F
30N27	MPR-304	MODBUS TCP	PLC-SW	B PH V	MOTOR PROTECTION RELAY	F



PLC I/O Listing for PLC-SW



Drawing	Tag	I/O	Location	Description	Service	(E/F)
30N27	MPR-304	MODBUS TCP	PLC-SW	BC PH V %THD	MOTOR PROTECTION RELAY	F
30N27	MPR-304	MODBUS TCP	PLC-SW	BN PH V %THD	MOTOR PROTECTION RELAY	F
30N27	MPR-304	MODBUS TCP	PLC-SW	C PH CURRENT	MOTOR PROTECTION RELAY	F
30N27	MPR-304	MODBUS TCP	PLC-SW	C PH CURRENT %THD	MOTOR PROTECTION RELAY	F
30N27	MPR-304	MODBUS TCP	PLC-SW	C PH DEMAND CURRENT	MOTOR PROTECTION RELAY	F
30N27	MPR-304	MODBUS TCP	PLC-SW	C PH V	MOTOR PROTECTION RELAY	F
30N27	MPR-304	MODBUS TCP	PLC-SW	CA PH V %THD	MOTOR PROTECTION RELAY	F
30N27	MPR-304	MODBUS TCP	PLC-SW	CN PH V %THD	MOTOR PROTECTION RELAY	F
30N27	MPR-304	MODBUS TCP	PLC-SW	ENERGY	MOTOR PROTECTION RELAY	F
30N27	MPR-304	MODBUS TCP	PLC-SW	FREQUENCY	MOTOR PROTECTION RELAY	F
30N27	MPR-304	MODBUS TCP	PLC-SW	POWER FACTOR	MOTOR PROTECTION RELAY	F
30N27	MPR-304	MODBUS TCP	PLC-SW	RTD 1 TEMP	MOTOR PROTECTION RELAY	F
30N27	MPR-304	MODBUS TCP	PLC-SW	RTD 2 TEMP	MOTOR PROTECTION RELAY	F
30N27	MPR-304	MODBUS TCP	PLC-SW	RTD 3 TEMP	MOTOR PROTECTION RELAY	F
30N27	MPR-304	MODBUS TCP	PLC-SW	RTD 4 TEMP	MOTOR PROTECTION RELAY	F
30N27	MPR-304	MODBUS TCP	PLC-SW	RTD 5 TEMP	MOTOR PROTECTION RELAY	F
30N27	MPR-304	MODBUS TCP	PLC-SW	RTD 6 TEMP	MOTOR PROTECTION RELAY	F
30N27	MPR-304	MODBUS TCP	PLC-SW	RTD 7 TEMP	MOTOR PROTECTION RELAY	F
30N27	MPR-304	MODBUS TCP	PLC-SW	RTD 8 TEMP	MOTOR PROTECTION RELAY	F
30N27	MPR-304	MODBUS TCP	PLC-SW	VA	MOTOR PROTECTION RELAY	F
30N27	MPR-304	MODBUS TCP	PLC-SW	VA DEMAND	MOTOR PROTECTION RELAY	F
30N27	MPR-304	MODBUS TCP	PLC-SW	VARS	MOTOR PROTECTION RELAY	F
30N27	MPR-304	MODBUS TCP	PLC-SW	VIBRATION 1 SWITCH HIGH	MOTOR PROTECTION RELAY	F
30N27	MPR-304	MODBUS TCP	PLC-SW	VIBRATION 2 SWITCH HIGH	MOTOR PROTECTION RELAY	F
30N27	MPR-304	MODBUS TCP	PLC-SW	WATTS	MOTOR PROTECTION RELAY	F
30N27	PMP-304	MODBUS TCP	PLC-SW	A PH CURRENT	PUMP 4	F
30N27	PMP-304	MODBUS TCP	PLC-SW	A PH V	PUMP 4	F



PLC I/O Listing for PLC-SW



Drawing	Tag	I/O	Location	Description	Service	(E/F)
30N27	PMP-304	MODBUS TCP	PLC-SW	AVERAGE 3 PH CURRENT	PUMP 4	F
30N27	PMP-304	MODBUS TCP	PLC-SW	B PH CURRENT	PUMP 4	F
30N27	PMP-304	MODBUS TCP	PLC-SW	B PH V	PUMP 4	F
30N27	PMP-304	MODBUS TCP	PLC-SW	C PH CURRENT	PUMP 4	F
30N27	PMP-304	MODBUS TCP	PLC-SW	C PH V	PUMP 4	F
30N27	PMP-304	MODBUS TCP	PLC-SW	CURRENT ALARM HIGH	PUMP 4	F
30N27	PMP-304	MODBUS TCP	PLC-SW	DAILY RUN TIME	PUMP 4	F
30N27	PMP-304	MODBUS TCP	PLC-SW	DAILY STARTS	PUMP 4	F
30N27	PMP-304	MODBUS TCP	PLC-SW	ELAPSED TIME	PUMP 4	F
30N27	PMP-304	MODBUS TCP	PLC-SW	EQUIPMENT SHUTDOWN	PUMP 4	F
30N27	PMP-304	MODBUS TCP	PLC-SW	ESD OK	PUMP 4	F
30N27	PMP-304	MODBUS TCP	PLC-SW	FAIL TO RESPOND	PUMP 4	F
30N27	PMP-304	MODBUS TCP	PLC-SW	FAULT	PUMP 4	F
30N27	PMP-304	MODBUS TCP	PLC-SW	LOCAL	PUMP 4	F
30N27	PMP-304	MODBUS TCP	PLC-SW	LOW FLOW	PUMP 4	F
30N27	PMP-304	MODBUS TCP	PLC-SW	LOW LOW LEVEL	PUMP 4	F
30N27	PMP-304	MODBUS TCP	PLC-SW	OFF	PUMP 4	F
30N27	PMP-304	MODBUS TCP	PLC-SW	OVERLOAD	PUMP 4	F
30N27	PMP-304	MODBUS TCP	PLC-SW	POWER FACTOR	PUMP 4	F
30N27	PMP-304	MODBUS TCP	PLC-SW	POWER KVA	PUMP 4	F
30N27	PMP-304	MODBUS TCP	PLC-SW	POWER KW	PUMP 4	F
30N27	PMP-304	MODBUS TCP	PLC-SW	REMOTE	PUMP 4	F
30N27	PMP-304	MODBUS TCP	PLC-SW	RESET ELAPSED TIME	PUMP 4	F
30N27	PMP-304	MODBUS TCP	PLC-SW	RUNNING	PUMP 4	F
30N27	PMP-304	MODBUS TCP	PLC-SW	SPEED	PUMP 4	F
30N27	PMP-304	MODBUS TCP	PLC-SW	SPEED FEEDBACK	PUMP 4	F
30N27	PMP-304	MODBUS TCP	PLC-SW	START	PUMP 4	F



PLC I/O Listing for PLC-SW

Drawing	Tag	I/O	Location	Description	Service	(E/F)
30N27	PMP-304	MODBUS TCP	PLC-SW	STOP	PUMP 4	F
30N27	PMP-304	MODBUS TCP	PLC-SW	TOTAL STARTS	PUMP 4	F
30N28	MPR-305	MODBUS TCP	PLC-SW	W DEMAND	MOTOR PROTECTION RELAY	
30N28	MPR-305	MODBUS TCP	PLC-SW	3 PH AVG DEMAND CURRENT	MOTOR PROTECTION RELAY	
30N28	MPR-305	MODBUS TCP	PLC-SW	A PH CURRENT	MOTOR PROTECTION RELAY	
30N28	MPR-305	MODBUS TCP	PLC-SW	A PH CURRENT %THD	MOTOR PROTECTION RELAY	
30N28	MPR-305	MODBUS TCP	PLC-SW	A PH DEMAND CURRENT	MOTOR PROTECTION RELAY	
30N28	MPR-305	MODBUS TCP	PLC-SW	A PH V	MOTOR PROTECTION RELAY	
30N28	MPR-305	MODBUS TCP	PLC-SW	AB PH V %THD	MOTOR PROTECTION RELAY	
30N28	MPR-305	MODBUS TCP	PLC-SW	AN PH V %THD	MOTOR PROTECTION RELAY	
30N28	MPR-305	MODBUS TCP	PLC-SW	B PH CURRENT	MOTOR PROTECTION RELAY	
30N28	MPR-305	MODBUS TCP	PLC-SW	B PH CURRENT %THD	MOTOR PROTECTION RELAY	
30N28	MPR-305	MODBUS TCP	PLC-SW	B PH DEMAND CURRENT	MOTOR PROTECTION RELAY	
30N28	MPR-305	MODBUS TCP	PLC-SW	B PH V	MOTOR PROTECTION RELAY	
30N28	MPR-305	MODBUS TCP	PLC-SW	BC PH V %THD	MOTOR PROTECTION RELAY	
30N28	MPR-305	MODBUS TCP	PLC-SW	BN PH V %THD	MOTOR PROTECTION RELAY	
30N28	MPR-305	MODBUS TCP	PLC-SW	C PH CURRENT	MOTOR PROTECTION RELAY	
30N28	MPR-305	MODBUS TCP	PLC-SW	C PH CURRENT %THD	MOTOR PROTECTION RELAY	
30N28	MPR-305	MODBUS TCP	PLC-SW	C PH DEMAND CURRENT	MOTOR PROTECTION RELAY	
30N28	MPR-305	MODBUS TCP	PLC-SW	C PH V	MOTOR PROTECTION RELAY	
30N28	MPR-305	MODBUS TCP	PLC-SW	CA PH V %THD	MOTOR PROTECTION RELAY	
30N28	MPR-305	MODBUS TCP	PLC-SW	CN PH V %THD	MOTOR PROTECTION RELAY	
30N28	MPR-305	MODBUS TCP	PLC-SW	ENERGY	MOTOR PROTECTION RELAY	
30N28	MPR-305	MODBUS TCP	PLC-SW	FREQUENCY	MOTOR PROTECTION RELAY	
30N28	MPR-305	MODBUS TCP	PLC-SW	POWER FACTOR	MOTOR PROTECTION RELAY	
30N28	MPR-305	MODBUS TCP	PLC-SW	RTD 1 TEMP	MOTOR PROTECTION RELAY	
30N28	MPR-305	MODBUS TCP	PLC-SW	RTD 2 TEMP	MOTOR PROTECTION RELAY	



PLC I/O Listing for PLC-SW

Drawing	Tag	I/O	Location	Description	Service	(E/F)
30N28	MPR-305	MODBUS TCP	PLC-SW	RTD 3 TEMP	MOTOR PROTECTION RELAY	
30N28	MPR-305	MODBUS TCP	PLC-SW	RTD 4 TEMP	MOTOR PROTECTION RELAY	
30N28	MPR-305	MODBUS TCP	PLC-SW	RTD 5 TEMP	MOTOR PROTECTION RELAY	
30N28	MPR-305	MODBUS TCP	PLC-SW	RTD 6 TEMP	MOTOR PROTECTION RELAY	
30N28	MPR-305	MODBUS TCP	PLC-SW	RTD 7 TEMP	MOTOR PROTECTION RELAY	
30N28	MPR-305	MODBUS TCP	PLC-SW	RTD 8 TEMP	MOTOR PROTECTION RELAY	
30N28	MPR-305	MODBUS TCP	PLC-SW	VA	MOTOR PROTECTION RELAY	
30N28	MPR-305	MODBUS TCP	PLC-SW	VA DEMAND	MOTOR PROTECTION RELAY	
30N28	MPR-305	MODBUS TCP	PLC-SW	VAR5	MOTOR PROTECTION RELAY	
30N28	MPR-305	MODBUS TCP	PLC-SW	VIBRATION 1 SWITCH HIGH	MOTOR PROTECTION RELAY	
30N28	MPR-305	MODBUS TCP	PLC-SW	VIBRATION 2 SWITCH HIGH	MOTOR PROTECTION RELAY	
30N28	MPR-305	MODBUS TCP	PLC-SW	WATTS	MOTOR PROTECTION RELAY	
30N28	PMP-305	MODBUS TCP	PLC-SW	A PH CURRENT	PUMP 5	
30N28	PMP-305	MODBUS TCP	PLC-SW	A PH V	PUMP 5	
30N28	PMP-305	MODBUS TCP	PLC-SW	AVERAGE 3 PH CURRENT	PUMP 5	
30N28	PMP-305	MODBUS TCP	PLC-SW	B PH CURRENT	PUMP 5	
30N28	PMP-305	MODBUS TCP	PLC-SW	B PH V	PUMP 5	
30N28	PMP-305	MODBUS TCP	PLC-SW	C PH CURRENT	PUMP 5	
30N28	PMP-305	MODBUS TCP	PLC-SW	C PH V	PUMP 5	
30N28	PMP-305	MODBUS TCP	PLC-SW	CURRENT ALARM HIGH	PUMP 5	
30N28	PMP-305	MODBUS TCP	PLC-SW	DAILY RUN TIME	PUMP 5	
30N28	PMP-305	MODBUS TCP	PLC-SW	DAILY STARTS	PUMP 5	
30N28	PMP-305	MODBUS TCP	PLC-SW	ELAPSED TIME	PUMP 5	
30N28	PMP-305	MODBUS TCP	PLC-SW	EQUIPMENT SHUTDOWN	PUMP 5	
30N28	PMP-305	MODBUS TCP	PLC-SW	ESD OK	PUMP 5	
30N28	PMP-305	MODBUS TCP	PLC-SW	FAIL TO RESPOND	PUMP 5	
30N28	PMP-305	MODBUS TCP	PLC-SW	FAULT	PUMP 5	



PLC I/O Listing for PLC-SW

Drawing	Tag	I/O	Location	Description	Service	(E/F)
30N28	PMP-305	MODBUS TCP	PLC-SW	LOCAL	PUMP 5	
30N28	PMP-305	MODBUS TCP	PLC-SW	LOW FLOW	PUMP 5	
30N28	PMP-305	MODBUS TCP	PLC-SW	LOW LOW LEVEL	PUMP 5	
30N28	PMP-305	MODBUS TCP	PLC-SW	OFF	PUMP 5	
30N28	PMP-305	MODBUS TCP	PLC-SW	OVERLOAD	PUMP 5	
30N28	PMP-305	MODBUS TCP	PLC-SW	POWER FACTOR	PUMP 5	
30N28	PMP-305	MODBUS TCP	PLC-SW	POWER KVA	PUMP 5	
30N28	PMP-305	MODBUS TCP	PLC-SW	POWER KW	PUMP 5	
30N28	PMP-305	MODBUS TCP	PLC-SW	REMOTE	PUMP 5	
30N28	PMP-305	MODBUS TCP	PLC-SW	RESET ELAPSED TIME	PUMP 5	
30N28	PMP-305	MODBUS TCP	PLC-SW	RUNNING	PUMP 5	
30N28	PMP-305	MODBUS TCP	PLC-SW	SPEED	PUMP 5	
30N28	PMP-305	MODBUS TCP	PLC-SW	SPEED FEEDBACK	PUMP 5	
30N28	PMP-305	MODBUS TCP	PLC-SW	START	PUMP 5	
30N28	PMP-305	MODBUS TCP	PLC-SW	STOP	PUMP 5	
30N28	PMP-305	MODBUS TCP	PLC-SW	TOTAL STARTS	PUMP 5	
30N29	MPR-306	MODBUS TCP	PLC-SW	W DEMAND	MOTOR PROTECTION RELAY	
30N29	MPR-306	MODBUS TCP	PLC-SW	3 PH AVG DEMAND CURRENT	MOTOR PROTECTION RELAY	
30N29	MPR-306	MODBUS TCP	PLC-SW	A PH CURRENT	MOTOR PROTECTION RELAY	
30N29	MPR-306	MODBUS TCP	PLC-SW	A PH CURRENT %THD	MOTOR PROTECTION RELAY	
30N29	MPR-306	MODBUS TCP	PLC-SW	A PH DEMAND CURRENT	MOTOR PROTECTION RELAY	
30N29	MPR-306	MODBUS TCP	PLC-SW	A PH V	MOTOR PROTECTION RELAY	
30N29	MPR-306	MODBUS TCP	PLC-SW	AB PH V %THD	MOTOR PROTECTION RELAY	
30N29	MPR-306	MODBUS TCP	PLC-SW	AN PH V %THD	MOTOR PROTECTION RELAY	
30N29	MPR-306	MODBUS TCP	PLC-SW	B PH CURRENT	MOTOR PROTECTION RELAY	
30N29	MPR-306	MODBUS TCP	PLC-SW	B PH CURRENT %THD	MOTOR PROTECTION RELAY	
30N29	MPR-306	MODBUS TCP	PLC-SW	B PH DEMAND CURRENT	MOTOR PROTECTION RELAY	



PLC I/O Listing for PLC-SW



Drawing	Tag	I/O	Location	Description	Service	(E/F)
30N29	MPR-306	MODBUS TCP	PLC-SW	B PH V	MOTOR PROTECTION RELAY	
30N29	MPR-306	MODBUS TCP	PLC-SW	BC PH V %THD	MOTOR PROTECTION RELAY	
30N29	MPR-306	MODBUS TCP	PLC-SW	BN PH V %THD	MOTOR PROTECTION RELAY	
30N29	MPR-306	MODBUS TCP	PLC-SW	C PH CURRENT	MOTOR PROTECTION RELAY	
30N29	MPR-306	MODBUS TCP	PLC-SW	C PH CURRENT %THD	MOTOR PROTECTION RELAY	
30N29	MPR-306	MODBUS TCP	PLC-SW	C PH DEMAND CURRENT	MOTOR PROTECTION RELAY	
30N29	MPR-306	MODBUS TCP	PLC-SW	C PH V	MOTOR PROTECTION RELAY	
30N29	MPR-306	MODBUS TCP	PLC-SW	CA PH V %THD	MOTOR PROTECTION RELAY	
30N29	MPR-306	MODBUS TCP	PLC-SW	CN PH V %THD	MOTOR PROTECTION RELAY	
30N29	MPR-306	MODBUS TCP	PLC-SW	ENERGY	MOTOR PROTECTION RELAY	
30N29	MPR-306	MODBUS TCP	PLC-SW	FREQUENCY	MOTOR PROTECTION RELAY	
30N29	MPR-306	MODBUS TCP	PLC-SW	POWER FACTOR	MOTOR PROTECTION RELAY	
30N29	MPR-306	MODBUS TCP	PLC-SW	RTD 1 TEMP	MOTOR PROTECTION RELAY	
30N29	MPR-306	MODBUS TCP	PLC-SW	RTD 2 TEMP	MOTOR PROTECTION RELAY	
30N29	MPR-306	MODBUS TCP	PLC-SW	RTD 3 TEMP	MOTOR PROTECTION RELAY	
30N29	MPR-306	MODBUS TCP	PLC-SW	RTD 4 TEMP	MOTOR PROTECTION RELAY	
30N29	MPR-306	MODBUS TCP	PLC-SW	RTD 5 TEMP	MOTOR PROTECTION RELAY	
30N29	MPR-306	MODBUS TCP	PLC-SW	RTD 6 TEMP	MOTOR PROTECTION RELAY	
30N29	MPR-306	MODBUS TCP	PLC-SW	RTD 7 TEMP	MOTOR PROTECTION RELAY	
30N29	MPR-306	MODBUS TCP	PLC-SW	RTD 8 TEMP	MOTOR PROTECTION RELAY	
30N29	MPR-306	MODBUS TCP	PLC-SW	VA	MOTOR PROTECTION RELAY	
30N29	MPR-306	MODBUS TCP	PLC-SW	VA DEMAND	MOTOR PROTECTION RELAY	
30N29	MPR-306	MODBUS TCP	PLC-SW	VAR5	MOTOR PROTECTION RELAY	
30N29	MPR-306	MODBUS TCP	PLC-SW	VIBRATION 1 SWITCH HIGH	MOTOR PROTECTION RELAY	
30N29	MPR-306	MODBUS TCP	PLC-SW	VIBRATION 2 SWITCH HIGH	MOTOR PROTECTION RELAY	
30N29	MPR-306	MODBUS TCP	PLC-SW	WATTS	MOTOR PROTECTION RELAY	
30N29	PMP-306	MODBUS TCP	PLC-SW	A PH CURRENT	PUMP 6	



PLC I/O Listing for PLC-SW



Drawing	Tag	I/O	Location	Description	Service	(E/F)
30N29	PMP-306	MODBUS TCP	PLC-SW	A PH V	PUMP 6	
30N29	PMP-306	MODBUS TCP	PLC-SW	AVERAGE 3 PH CURRENT	PUMP 6	
30N29	PMP-306	MODBUS TCP	PLC-SW	B PH CURRENT	PUMP 6	
30N29	PMP-306	MODBUS TCP	PLC-SW	B PH V	PUMP 6	
30N29	PMP-306	MODBUS TCP	PLC-SW	C PH CURRENT	PUMP 6	
30N29	PMP-306	MODBUS TCP	PLC-SW	C PH V	PUMP 6	
30N29	PMP-306	MODBUS TCP	PLC-SW	CURRENT ALARM HIGH	PUMP 6	
30N29	PMP-306	MODBUS TCP	PLC-SW	DAILY RUN TIME	PUMP 6	
30N29	PMP-306	MODBUS TCP	PLC-SW	DAILY STARTS	PUMP 6	
30N29	PMP-306	MODBUS TCP	PLC-SW	ELAPSED TIME	PUMP 6	
30N29	PMP-306	MODBUS TCP	PLC-SW	EQUIPMENT SHUTDOWN	PUMP 6	
30N29	PMP-306	MODBUS TCP	PLC-SW	ESD OK	PUMP 6	
30N29	PMP-306	MODBUS TCP	PLC-SW	FAIL TO RESPOND	PUMP 6	
30N29	PMP-306	MODBUS TCP	PLC-SW	FAULT	PUMP 6	
30N29	PMP-306	MODBUS TCP	PLC-SW	LOCAL	PUMP 6	
30N29	PMP-306	MODBUS TCP	PLC-SW	LOW FLOW	PUMP 6	
30N29	PMP-306	MODBUS TCP	PLC-SW	LOW LOW LEVEL	PUMP 6	
30N29	PMP-306	MODBUS TCP	PLC-SW	OFF	PUMP 6	
30N29	PMP-306	MODBUS TCP	PLC-SW	OVERLOAD	PUMP 6	
30N29	PMP-306	MODBUS TCP	PLC-SW	POWER FACTOR	PUMP 6	
30N29	PMP-306	MODBUS TCP	PLC-SW	POWER KVA	PUMP 6	
30N29	PMP-306	MODBUS TCP	PLC-SW	POWER KW	PUMP 6	
30N29	PMP-306	MODBUS TCP	PLC-SW	REMOTE	PUMP 6	
30N29	PMP-306	MODBUS TCP	PLC-SW	RESET ELAPSED TIME	PUMP 6	
30N29	PMP-306	MODBUS TCP	PLC-SW	RUNNING	PUMP 6	
30N29	PMP-306	MODBUS TCP	PLC-SW	SPEED	PUMP 6	
30N29	PMP-306	MODBUS TCP	PLC-SW	SPEED FEEDBACK	PUMP 6	



PLC I/O Listing for PLC-SW



Drawing	Tag	I/O	Location	Description	Service	(E/F)
30N29	PMP-306	MODBUS TCP	PLC-SW	START	PUMP 6	
30N29	PMP-306	MODBUS TCP	PLC-SW	STOP	PUMP 6	
30N29	PMP-306	MODBUS TCP	PLC-SW	TOTAL STARTS	PUMP 6	
30N34	SWBD-SW	MODBUS TCP	PLC-SW	W DEMAND	MAIN SWITCHBOARD	
30N34	SWBD-SW	MODBUS TCP	PLC-SW	3 PH AVG DEMAND CURRENT	MAIN SWITCHBOARD	
30N34	SWBD-SW	MODBUS TCP	PLC-SW	A PH CURRENT	MAIN SWITCHBOARD	
30N34	SWBD-SW	MODBUS TCP	PLC-SW	A PH DEMAND CURRENT	MAIN SWITCHBOARD	
30N34	SWBD-SW	MODBUS TCP	PLC-SW	A PH V	MAIN SWITCHBOARD	
30N34	SWBD-SW	MODBUS TCP	PLC-SW	B PH CURRENT	MAIN SWITCHBOARD	
30N34	SWBD-SW	MODBUS TCP	PLC-SW	B PH DEMAND CURRENT	MAIN SWITCHBOARD	
30N34	SWBD-SW	MODBUS TCP	PLC-SW	B PH V	MAIN SWITCHBOARD	
30N34	SWBD-SW	MODBUS TCP	PLC-SW	BREAKER OPEN	MAIN SWITCHBOARD	
30N34	SWBD-SW	MODBUS TCP	PLC-SW	BREAKER TRIPPED	MAIN SWITCHBOARD	
30N34	SWBD-SW	MODBUS TCP	PLC-SW	C PH CURRENT	MAIN SWITCHBOARD	
30N34	SWBD-SW	MODBUS TCP	PLC-SW	C PH DEMAND CURRENT	MAIN SWITCHBOARD	
30N34	SWBD-SW	MODBUS TCP	PLC-SW	C PH V	MAIN SWITCHBOARD	
30N34	SWBD-SW	MODBUS TCP	PLC-SW	ENERGY	MAIN SWITCHBOARD	
30N34	SWBD-SW	MODBUS TCP	PLC-SW	FREQUENCY	MAIN SWITCHBOARD	
30N34	SWBD-SW	MODBUS TCP	PLC-SW	ON UTIL POWER	MAIN SWITCHBOARD	
30N34	SWBD-SW	MODBUS TCP	PLC-SW	POWER FACTOR	MAIN SWITCHBOARD	
30N34	SWBD-SW	MODBUS TCP	PLC-SW	POWER FAIL ON BUS	MAIN SWITCHBOARD	
30N34	SWBD-SW	MODBUS TCP	PLC-SW	VA	MAIN SWITCHBOARD	
30N34	SWBD-SW	MODBUS TCP	PLC-SW	VA DEMAND	MAIN SWITCHBOARD	
30N34	SWBD-SW	MODBUS TCP	PLC-SW	VARs	MAIN SWITCHBOARD	
30N34	SWBD-SW	MODBUS TCP	PLC-SW	WATTS	MAIN SWITCHBOARD	
30N34	SWGR-SW	MODBUS TCP	PLC-SW	W DEMAND	MAIN SWITCHGEAR	
30N34	SWGR-SW	MODBUS TCP	PLC-SW	3 PH AVG DEMAND CURRENT	MAIN SWITCHGEAR	



PLC I/O Listing for PLC-SW



Drawing	Tag	I/O	Location	Description	Service	(E/F)
30N34	SWGR-SW	MODBUS TCP	PLC-SW	A PH CURRENT	MAIN SWITCHGEAR	
30N34	SWGR-SW	MODBUS TCP	PLC-SW	A PH DEMAND CURRENT	MAIN SWITCHGEAR	
30N34	SWGR-SW	MODBUS TCP	PLC-SW	A PH V	MAIN SWITCHGEAR	
30N34	SWGR-SW	MODBUS TCP	PLC-SW	B PH CURRENT	MAIN SWITCHGEAR	
30N34	SWGR-SW	MODBUS TCP	PLC-SW	B PH DEMAND CURRENT	MAIN SWITCHGEAR	
30N34	SWGR-SW	MODBUS TCP	PLC-SW	B PH V	MAIN SWITCHGEAR	
30N34	SWGR-SW	MODBUS TCP	PLC-SW	BREAKER OPEN	MAIN SWITCHGEAR	
30N34	SWGR-SW	MODBUS TCP	PLC-SW	BREAKER TRIPPED	MAIN SWITCHGEAR	
30N34	SWGR-SW	MODBUS TCP	PLC-SW	C PH CURRENT	MAIN SWITCHGEAR	
30N34	SWGR-SW	MODBUS TCP	PLC-SW	C PH DEMAND CURRENT	MAIN SWITCHGEAR	
30N34	SWGR-SW	MODBUS TCP	PLC-SW	C PH V	MAIN SWITCHGEAR	
30N34	SWGR-SW	MODBUS TCP	PLC-SW	ENERGY	MAIN SWITCHGEAR	
30N34	SWGR-SW	MODBUS TCP	PLC-SW	FREQUENCY	MAIN SWITCHGEAR	
30N34	SWGR-SW	MODBUS TCP	PLC-SW	ON UTIL POWER	MAIN SWITCHGEAR	
30N34	SWGR-SW	MODBUS TCP	PLC-SW	POWER FACTOR	MAIN SWITCHGEAR	
30N34	SWGR-SW	MODBUS TCP	PLC-SW	POWER FAIL ON BUS	MAIN SWITCHGEAR	
30N34	SWGR-SW	MODBUS TCP	PLC-SW	VA	MAIN SWITCHGEAR	
30N34	SWGR-SW	MODBUS TCP	PLC-SW	VA DEMAND	MAIN SWITCHGEAR	
30N34	SWGR-SW	MODBUS TCP	PLC-SW	VARs	MAIN SWITCHGEAR	
30N34	SWGR-SW	MODBUS TCP	PLC-SW	WATTS	MAIN SWITCHGEAR	
30N34	SWGR-UT1	MODBUS TCP	PLC-SW	W DEMAND	UTILITY SWITCHGEAR 1	
30N34	SWGR-UT1	MODBUS TCP	PLC-SW	3 PH AVG DEMAND CURRENT	UTILITY SWITCHGEAR 1	
30N34	SWGR-UT1	MODBUS TCP	PLC-SW	A PH CURRENT	UTILITY SWITCHGEAR 1	
30N34	SWGR-UT1	MODBUS TCP	PLC-SW	A PH DEMAND CURRENT	UTILITY SWITCHGEAR 1	
30N34	SWGR-UT1	MODBUS TCP	PLC-SW	A PH V	UTILITY SWITCHGEAR 1	
30N34	SWGR-UT1	MODBUS TCP	PLC-SW	B PH CURRENT	UTILITY SWITCHGEAR 1	
30N34	SWGR-UT1	MODBUS TCP	PLC-SW	B PH DEMAND CURRENT	UTILITY SWITCHGEAR 1	



PLC I/O Listing for PLC-SW

Drawing	Tag	I/O	Location	Description	Service	(E/F)
30N34	SWGR-UT1	MODBUS TCP	PLC-SW	B PH V	UTILITY SWITCHGEAR 1	
30N34	SWGR-UT1	MODBUS TCP	PLC-SW	BREAKER OPEN	UTILITY SWITCHGEAR 1	
30N34	SWGR-UT1	MODBUS TCP	PLC-SW	BREAKER TRIPPED	UTILITY SWITCHGEAR 1	
30N34	SWGR-UT1	MODBUS TCP	PLC-SW	C PH CURRENT	UTILITY SWITCHGEAR 1	
30N34	SWGR-UT1	MODBUS TCP	PLC-SW	C PH DEMAND CURRENT	UTILITY SWITCHGEAR 1	
30N34	SWGR-UT1	MODBUS TCP	PLC-SW	C PH V	UTILITY SWITCHGEAR 1	
30N34	SWGR-UT1	MODBUS TCP	PLC-SW	ENERGY	UTILITY SWITCHGEAR 1	
30N34	SWGR-UT1	MODBUS TCP	PLC-SW	FREQUENCY	UTILITY SWITCHGEAR 1	
30N34	SWGR-UT1	MODBUS TCP	PLC-SW	ON UTIL POWER	UTILITY SWITCHGEAR 1	
30N34	SWGR-UT1	MODBUS TCP	PLC-SW	POWER FACTOR	UTILITY SWITCHGEAR 1	
30N34	SWGR-UT1	MODBUS TCP	PLC-SW	POWER FAIL ON BUS	UTILITY SWITCHGEAR 1	
30N34	SWGR-UT1	MODBUS TCP	PLC-SW	VA	UTILITY SWITCHGEAR 1	
30N34	SWGR-UT1	MODBUS TCP	PLC-SW	VA DEMAND	UTILITY SWITCHGEAR 1	
30N34	SWGR-UT1	MODBUS TCP	PLC-SW	VARS	UTILITY SWITCHGEAR 1	
30N34	SWGR-UT1	MODBUS TCP	PLC-SW	WATTS	UTILITY SWITCHGEAR 1	
30N34	SWGR-UT2	MODBUS TCP	PLC-SW	W DEMAND	UTILITY SWITCHGEAR 2	F
30N34	SWGR-UT2	MODBUS TCP	PLC-SW	3 PH AVG DEMAND CURRENT	UTILITY SWITCHGEAR 2	F
30N34	SWGR-UT2	MODBUS TCP	PLC-SW	A PH CURRENT	UTILITY SWITCHGEAR 2	F
30N34	SWGR-UT2	MODBUS TCP	PLC-SW	A PH DEMAND CURRENT	UTILITY SWITCHGEAR 2	F
30N34	SWGR-UT2	MODBUS TCP	PLC-SW	A PH V	UTILITY SWITCHGEAR 2	F
30N34	SWGR-UT2	MODBUS TCP	PLC-SW	B PH CURRENT	UTILITY SWITCHGEAR 2	F
30N34	SWGR-UT2	MODBUS TCP	PLC-SW	B PH DEMAND CURRENT	UTILITY SWITCHGEAR 2	F
30N34	SWGR-UT2	MODBUS TCP	PLC-SW	B PH V	UTILITY SWITCHGEAR 2	F
30N34	SWGR-UT2	MODBUS TCP	PLC-SW	BREAKER OPEN	UTILITY SWITCHGEAR 2	F
30N34	SWGR-UT2	MODBUS TCP	PLC-SW	BREAKER TRIPPED	UTILITY SWITCHGEAR 2	F
30N34	SWGR-UT2	MODBUS TCP	PLC-SW	C PH CURRENT	UTILITY SWITCHGEAR 2	F
30N34	SWGR-UT2	MODBUS TCP	PLC-SW	C PH DEMAND CURRENT	UTILITY SWITCHGEAR 2	F



PLC I/O Listing for PLC-SW

Drawing	Tag	I/O	Location	Description	Service	(E/F)
30N34	SWGR-UT2	MODBUS TCP	PLC-SW	C PH V	UTILITY SWITCHGEAR 2	F
30N34	SWGR-UT2	MODBUS TCP	PLC-SW	ENERGY	UTILITY SWITCHGEAR 2	F
30N34	SWGR-UT2	MODBUS TCP	PLC-SW	FREQUENCY	UTILITY SWITCHGEAR 2	F
30N34	SWGR-UT2	MODBUS TCP	PLC-SW	ON UTIL POWER	UTILITY SWITCHGEAR 2	F
30N34	SWGR-UT2	MODBUS TCP	PLC-SW	POWER FACTOR	UTILITY SWITCHGEAR 2	F
30N34	SWGR-UT2	MODBUS TCP	PLC-SW	POWER FAIL ON BUS	UTILITY SWITCHGEAR 2	F
30N34	SWGR-UT2	MODBUS TCP	PLC-SW	VA	UTILITY SWITCHGEAR 2	F
30N34	SWGR-UT2	MODBUS TCP	PLC-SW	VA DEMAND	UTILITY SWITCHGEAR 2	F
30N34	SWGR-UT2	MODBUS TCP	PLC-SW	VARS	UTILITY SWITCHGEAR 2	F
30N34	SWGR-UT2	MODBUS TCP	PLC-SW	WATTS	UTILITY SWITCHGEAR 2	F
PLC-SW	Total MODBUS TCP Points = 496					



PLC I/O Listing for PLC-SW

Drawing	Tag	I/O	Location	Description	Service	(E/F)
30N33	ATS-SW	SNMPv3	PLC-SW	START	AUTOMATIC TRANSFER SWITCH	
30N33	ATS-SW	SNMPv3	PLC-SW	STOP	AUTOMATIC TRANSFER SWITCH	
30N33	UPS-SW	SNMPv3	PLC-SW	AC POWER RESTORED	UNINTERRUPTIBLE POWER SUPPLY	
30N33	UPS-SW	SNMPv3	PLC-SW	COMMUNICATION WITH UPS LOST	UNINTERRUPTIBLE POWER SUPPLY	
30N33	UPS-SW	SNMPv3	PLC-SW	LOW BATTERY ALARM	UNINTERRUPTIBLE POWER SUPPLY	
30N33	UPS-SW	SNMPv3	PLC-SW	REPLACE BATTERY WARNING	UNINTERRUPTIBLE POWER SUPPLY	
30N33	UPS-SW	SNMPv3	PLC-SW	UPS BATTERY DISCHARGED	UNINTERRUPTIBLE POWER SUPPLY	
30N33	UPS-SW	SNMPv3	PLC-SW	UPS BATTERY TEST IN PROGRESS	UNINTERRUPTIBLE POWER SUPPLY	
30N33	UPS-SW	SNMPv3	PLC-SW	UPS BYPASS UNAVAILABLE	UNINTERRUPTIBLE POWER SUPPLY	
30N33	UPS-SW	SNMPv3	PLC-SW	UPS CIRCUIT BREAKER ALARM	UNINTERRUPTIBLE POWER SUPPLY	
30N33	UPS-SW	SNMPv3	PLC-SW	UPS FAULTED	UNINTERRUPTIBLE POWER SUPPLY	
30N33	UPS-SW	SNMPv3	PLC-SW	UPS HARDWARE FAILED	UNINTERRUPTIBLE POWER SUPPLY	
30N33	UPS-SW	SNMPv3	PLC-SW	UPS INTERNALLY BYPASSED	UNINTERRUPTIBLE POWER SUPPLY	
30N33	UPS-SW	SNMPv3	PLC-SW	UPS INVERTER FAILED	UNINTERRUPTIBLE POWER SUPPLY	
30N33	UPS-SW	SNMPv3	PLC-SW	UPS OUTPUT OFF	UNINTERRUPTIBLE POWER SUPPLY	
30N33	UPS-SW	SNMPv3	PLC-SW	UPS OUTPUT OVERLOADED	UNINTERRUPTIBLE POWER SUPPLY	
30N33	UPS-SW	SNMPv3	PLC-SW	UPS RETURNED TO UTILITY POWER	UNINTERRUPTIBLE POWER SUPPLY	
30N33	UPS-SW	SNMPv3	PLC-SW	UPS SHUTDOWN IMMINENT	UNINTERRUPTIBLE POWER SUPPLY	
30N33	UPS-SW	SNMPv3	PLC-SW	UPS SWITCHED TO BATTERY POWER	UNINTERRUPTIBLE POWER SUPPLY	
30N33	UPS-SW	SNMPv3	PLC-SW	UPS TEMPERATURE ALARM	UNINTERRUPTIBLE POWER SUPPLY	
30N33	UPS-SW	SNMPv3	PLC-SW	UTILITY POWER FAULTED	UNINTERRUPTIBLE POWER SUPPLY	
PLC-SW		Total SNMPv3 Points = 21				

SECTION 41_22_15

TOP RUNNING DOUBLE GIRDER BRIDGE CRANES

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Top running double girder bridge crane.

1.02 REFERENCES

- A. American Society of Civil Engineers (ASCE).
- B. Crane Manufacturers Association of America, Inc. (CMAA):
 - 1. Specification No. 70 - Specifications for Top Running Bridge and Gantry type Multiple Girder Electric Overhead Traveling Cranes.
 - 2. Specification No. 78 - Standards and Guidelines for Professional Services Performed on Overhead and Traveling Cranes and Associated Hoisting Equipment.
 - 3. Specification No. 79 - Crane Operator's Manual.
- C. Hoist Manufacturers Institute (HMI).
- D. National Electrical Manufacturers Association (NEMA):
 - 1. 250 - Enclosures for Electrical Equipment (1,000 V Maximum).
- E. Occupational Safety and Health Administration (OSHA).

1.03 DELEGATED DESIGN

- A. As specified in Section 01_35_73 - Delegated Design Procedures.
- B. Calculations.

1.04 SUBMITTALS

- A. Furnish Submittals as specified in Section 01_33_00 - Submittal Procedures.
- B. Product data:
 - 1. Parts, devices, and accessories, including special safety and control devices.
- C. Shop Drawings:
 - 1. Dimensional drawings and other construction details, including materials of construction, equipment weights, electrical connection diagrams, and schematics showing electrical control or power requirements.

- D. Delegated Design Submittals:
 - 1. Structural calculations for runway beams, hoists, rails, bridge beams, and anchorage.
- E. Installation instructions:
 - 1. Detail the complete installation of the equipment, including rigging, moving, and setting into place.
 - 2. Provide manufacturer's installation instructions.
- F. Quality Control Submittals:
 - 1. Manufacturer's representative qualifications.
 - 2. Manufacturer's Certificate of Source Testing as specified in Section 01_75_17 - Commissioning.
 - 3. Manufacturer's Certificate of Installation Verification as specified in Section 01_75_17 - Commissioning.
 - 4. Manufacturer's Certificate of Functional Compliance as specified in Section 01_75_17 - Commissioning.
 - 5. Certificate of tests conducted by the crane manufacturer in accordance with industry standards and federal regulations.
 - 6. Certificate of local authority having jurisdiction if required.
 - 7. Load test certificate.
- G. Owner Training Submittals:
 - 1. As specified in Section 01_75_17 - Commissioning.
- H. Operation and maintenance manuals:
 - 1. As specified in Section 01_78_24 - Operation and Maintenance Manuals.
 - 2. Include CMAA Specification No. 79.

1.05 DELIVERY, STORAGE, AND HANDLING

- A. As specified in Section 01_60_01 - Product Requirements, Section 46_05_10 - Common Work Results for Mechanical, and the manufacturer's instructions.
- B. Unload and store cranes under the manufacturer's supervision.

1.06 PROJECT OR SITE CONDITIONS

- A. As specified in Section 01_81_50 - Design Criteria.

1.07 WARRANTY

- A. As specified in Section 01_78_36 - Warranties and Bonds.

PART 2 PRODUCTS

2.01 GENERAL

- A. As specified in Section 46_05_10 - Common Work Results for Mechanical Equipment.
- B. Top running, double girder, bridge crane system as indicated on the Drawings.

2.02 MANUFACTURERS

- A. The following or equal:
 - 1. Kone Crane.
 - 2. Heco Pacific Manufacturing.

2.03 DESIGN AND PERFORMANCE CRITERIA

- A. Design in accordance with CMAA Specification No. 70.
- B. Cranes shall be in accordance with CMAA Service Class A2 for infrequent use.
- C. Top running, double girder, traveling bridge crane system with electric motor-driven bridge and electric motor-driven trolley, hoist, bridge crane girders, cross bracing, end trucks, runways, rails, end stops, complete electrification and reels, and accessories based on the following values:

Item	Requirement
Capacity	17.5 tons
Span (center to center crane runway)	30 feet
Approximate hoisting speed, (minimum/maximum for range of speed)	1.6/10 feet per minute
Approximate travel speed of trolley	65 feet per minute
Approximate travel speed of bridge	100 feet per minute
Nominal Power of Crane	18.1 horsepower

- D. Arrange working parts for convenient inspection, lubrication, adjustment, repair, and replacement.

2.04 MANUFACTURED UNITS

- A. Bridge:
 - 1. Top running, double girder type, supported by end trucks on crane rail.
 - a. End trucks: Structural steel members capable of distributing loading equally to each wheel.
 - b. Wheels: Minimum 6-inch diameter; double flanged with rotating axles and safety lugs; forged steel, hardened to 425 Brinell fitted with anti-friction bearings with seals and grease fittings.
 - c. Stops and bumpers: Capable of absorbing energy and stopping moving bridge at end of travel.

- B. Bridge drive unit:
1. Type: Single-speed, adjustable torque cushioned start, motor-driven CMAA units at ends of bridge.
 - a. Tractor type drives are not acceptable.
 2. End trucks: 6-inch minimum diameter wheels with safety lugs.
 3. Speed reducers: Oil-lubricated with oil tight cases.
 4. Shaft bearings: Anti-friction.
 5. Holding brakes: Cushioned stop.
 6. Motors:
 - a. Designed and constructed for crane service.
 - b. Revolutions per minute: 1,800 maximum.
 - c. Enclosure: TENV squirrel-cage induction type.
 - d. Electrical characteristics: 460-volt, 3 phase, 3 wire.
 - e. Class B or Class F insulation.
 7. Bumpers: Spring buffer.
- C. Trolley and hoist:
1. Trolley drive: Provided with adjustable torque cushioned start feature and single- or dual-speed motor, and direct current cushioned stop holding brakes. Tractor drive units are not acceptable.
 - a. Double-flanged wheels with rotating axles: Forged steel, hardened to 425 Brinell, and fitted with anti-friction bearings with seals and grease fittings.
 - b. Drive units: Separate for each runway or one that drives wheels on runway through a common shaft.
 - c. Trolley head wheels: Minimum 5-inch diameter wheels with safety lugs.
 2. Hoist: HMI Duty Service Classification H2 (Standard); single or dual-speed, electric motor-driven, with load break, lower limit switch, and an overload device.
 - a. Load brake:
 - 1) Mechanical Weston multiple disc type running in an oil bath and automatically holding loads indefinitely and permitting lowering without acceleration under full control.
 - 2) Direct current operated motor brake acting directly on the motor pinion shaft the instant power is shut off.
 - 3) Capable of sustaining a load equal to 125 percent of hoist capacity.
 - 4) Capable of at least 15 operations per minute and controlled smooth inching for both directions in vertical plane.
 - 5) Hoisting drum:
 - a) Steel or cast iron with machined grooves to depth equal to 1/2-rope diameter.
 - b) Capable of retaining at least 2 complete wraps of rope with hook in lowest position and accommodating full rope length without overlapping when hook is in highest position.
 - b. Hoisting rope: Specifically designed for specified service loads; preformed, improved plow steel with fiber core; double-reeved.
 - c. Hoisting block: Steel with hook supported on ball or roller bearings.
 - d. Hoisting block hook: Forged or rolled steel freely rotating on bearing support and with heavy-duty type safety latches.
 3. Drive speed reducers: Oil-lubricated heat-treated steel helical gears with oil tight cases, and shafts running in anti-friction bearings.

- 4. Drive motors:
 - a. Designed and constructed for crane service.
 - b. Revolutions per minute: 1,800 maximum.
 - c. Enclosure: TENV squirrel-cage induction type.
 - d. Electrical characteristics: 460-volt, 3 phase, 3 wire.
 - e. Class B or Class F insulation.
- D. Crane rails:
 - 1. ASCE crane rail: 60 pounds.
 - a. Splice using light splice joints by bolting.
 - 2. Rail:
 - a. Arranged so that joints on opposite sides of the runway will be staggered with respect to each other and with respect to the wheelbase of the crane.
 - b. Rail joints shall not occur at crane girder splices.
- E. Rail clamps:
 - 1. Use steel plates with eccentric fillers for adjustment of rail location.
 - 2. Double-hole fixed clamps at 2 feet apart on each side of rail in staggered position.

2.05 ELECTRICAL AND CONTROL

- A. Electrification:
 - 1. Electric power: 480-volt, 3 phase, 60 hertz electric service with junction boxes for connection of field services and ground pad.
 - 2. Runway: Insulated bar electrification 3 power, 1 ground.
 - 3. Bridge: Industrial rigid track festoon system.
 - 4. Control voltage: 120 volts alternating current, supplied from a transformer on the crane.
- B. Control:
 - 1. Capable of controlling hoist speed, trolley travel, and bridge travel.
 - 2. Unit type: Pendant, momentary-contact, maintain-pressure type, automatically de-energizing, 2-speed pushbutton stations hanging from hoist and attached to bridge, supported by a steel cable parallel to the control cable.
 - 3. Pushbuttons:
 - a. Start-stop.
 - b. 2 pushbuttons for hoisting: 1 for each direction.
 - c. 2 pushbuttons for trolley travel: 1 for each direction.
 - d. 2 pushbuttons for crane travel: 1 for each direction.
 - e. Directions of horizontal motions clearly marked on bridge or trolley and on control pendant.
 - 4. Pendant and electrical enclosures: NEMA Type 4.
 - 5. Limit switches: Set to limit the up and down travel of hook to stop hoist at highest safe point.
- C. Control and electrical enclosures: NEMA Type 4.

2.06 FINISHES

- A. Products with a factory or shop applied coating system:
 - 1. Coat products with the manufacturer's standard surface preparation and applied permanent coating system.
 - 2. Equipment subject to sunlight shall have an ultraviolet stable topcoat.
 - 3. Coating system shall provide 10-year corrosion free protection without significant defects in atmospheric exposure.
 - 4. Color and gloss: Manufacturer's standard.
 - 5. Unexposed surfaces that require coating, such as the interior of cabinets, enclosures, and equipment shall be given the manufacturer's standard permanent coated finish.
 - 6. The following shall not be coated:
 - a. Running surfaces of beams and wheels.

2.07 SOURCE QUALITY CONTROL

- A. Source Testing (Factory Acceptance Tests):
 - 1. Not witnessed.
 - 2. As specified in Section 01_75_17 - Commissioning.
 - 3. Tests required to comply with CMAA standards and federal regulations.
 - 4. Test as specified in Section 46_05_94 - Mechanical Equipment Testing.
 - 5. Furnish test reports and the Manufacturer's Certificate of Source Testing.

PART 3 EXECUTION

3.01 GENERAL

- A. Do not use cranes to handle loads until the load test certificate has been received.
- B. Do not use cranes for construction.

3.02 PREPARATION

- A. Anchoring and bracing to structures:
 - 1. Prepare equipment anchor setting template(s) and use to position anchors during construction of supporting structure(s).
 - 2. Install anchors of type and material indicated on approved anchoring designs.
 - 3. Install anchors with embedment indicated on approved anchoring designs.

3.03 INSTALLATION

- A. Install equipment as indicated on the Drawings and the manufacturer's written installation instructions.
- B. Tolerances:
 - 1. In accordance with CMAA Specification No. 70.
- C. Repair damaged areas of coated surfaces with compatible materials to equal thickness and color match of undamaged areas.

- D. Ensure overhead and lateral clearance between the crane and obstructions in accordance with CMAA Specification No. 70.
- E. Furnish Manufacturer's Certificate of Installation Verification.

3.04 FIELD QUALITY CONTROL

- A. Functional Testing:
 - 1. Witnessed by:
 - a. An OSHA certified representative from the equipment manufacturer.
 - 2. Testing requirements:
 - a. Test with not less than 110 percent nor more than 125 percent of rated load capacity.
 - b. Provide load and slings for tests. Remove loads and slings after tests are complete.
 - c. Operate crane through a full lift and lowering cycle, and travel of bridge and trolley to demonstrate functions of hoisting, braking, and traveling.
 - 1) Crane shall function quietly, smoothly, and safely.
 - 3. Furnish test reports and the Manufacturer's Certificate of Functional Compliance.

3.05 OWNER TRAINING

- A. Perform Owner Training as specified in Section 01_75_17 - Commissioning.
 - 1. Number of sessions:
 - a. Operations: 1.
 - b. Maintenance: 2.

END OF SECTION

SECTION 41_22_17
PORTABLE DAVIT CRANES

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Portable davit cranes with associated appurtenances.

1.02 DELEGATED DESIGN

- A. As specified in Section 01_35_73 - Delegated Design Procedures.
- B. Anchoring and bracing.

1.03 SUBMITTALS

- A. Furnish Submittals as specified in Section 01_33_00 - Submittal Procedures and Section 01_60_01 - Product Requirements.
- B. Delegated Design Submittals:
 - 1. Anchoring and bracing: Provide project-specific calculations based on support conditions and requirements to resist loads specified in Section 01_81_50 - Design Criteria.
 - a. To structures for equipment installed in structures designated as seismic design category C, D, E, or F.
 - b. For equipment installed outdoors.
 - c. For wall mounted equipment weighing 125 pounds or more.
- C. Product data:
 - 1. Dimensional drawings or other construction details, including materials of construction, equipment weights and equipment finishes.
 - 2. Manufacturer's installation instructions.
- D. Operation and maintenance manuals:
 - 1. As specified in Section 01_78_24 - Operation and Maintenance Manuals.

1.04 WARRANTY

- A. As specified in Section 01_78_36 - Warranties and Bonds.

PART 2 PRODUCTS

2.01 GENERAL

- A. As specified in Section 01_60_01 - Product Requirements and Section 46_05_10 - Common Work Results for Mechanical Equipment.
- B. Provide davit cranes as specified in Table 1 and as indicated on the Drawings.

2.02 DESIGN AND PERFORMANCE CRITERIA

- A. Design davit crane in accordance with the codes of the Steel Construction Manual.

Table 1 - Davit Crane Requirements						
Tag No	Maximum Load, pounds	Maximum Hook			Adjustable Boom Length	Mount Type
		Reach (inches)	Height above floor (inches)	Lift below floor (feet)		
1	1,000	As recommended by Manufacturer	As recommended by Manufacturer	50	As recommended by Manufacturer	Socket

2.03 MANUFACTURERS

- A. Manufacturers: One of the following or equal:
 - 1. DBI Sala, Model 5110M3SS.
 - 2. Thern.

2.04 PORTABLE DAVIT CRANES

- A. Boom to be capable of rotating 360 degrees under load.
- B. Locking pin adjustment: Boom angle to be vertically adjustable. Boom to lock in place at each position with a locking pin.
- C. Provide a locking device to prevent boom swivel when desired.
- D. Loads are lifted with a spur gear hand winch attached to the boom and equipped with a disk brake for load control.
- E. Steel gear covers protect gears and help prevent injuries.
- F. Crane and base to be constructed of stainless steel.

2.05 ACCESSORIES

- A. Provide 5/16 inch by 70-foot stainless steel cable with swivel hook. Hoisting cable shall be specifically designed for service loads specified:
 - 1. Manufacturers: One of the following or equal:
 - a. DBI Sala.
 - b. Thern.
- B. Provide mounting bases by the same manufacturer as the davit crane:
 - 1. Provide stainless steel base cover to keep water from collecting in base when crane is removed.

PART 3 EXECUTION

3.01 GENERAL

- A. Crane shall not be used by the Contractor for the installation of equipment.

3.02 PREPARATION

- A. Anchoring and bracing to structures:
 - 1. Prepare equipment anchor setting template(s) and use to position anchors during construction of supporting structure(s).
 - 2. Install anchors of type and material indicated on approved anchoring designs.
 - 3. Install anchors with embedment indicated on approved anchoring designs.

3.03 INSTALLATION

- A. Install the equipment in accordance with the accepted installation instructions and anchorage details.

3.04 FIELD QUALITY CONTROL

- A. After installation, test the crane to its rated capacity.
 - 1. Load and slings shall be provided by the crane manufacturer and removed when tests are complete.
 - 2. Operate the crane through 3 complete lift and lowering cycles.

END OF SECTION

SECTION 43_24_50.10

VERTICAL TURBINE SHORT SETTING CENTRIFUGAL PUMPS

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Pump systems, including vertical turbine pumps with radial, mixed flow, or axial (propeller) type impellers and drivers as scheduled.
 - 2. Requirements for installation and testing of pump tag numbers PMP-302, PMP-303, PMP-305, and PMP-306 that were previously procured by the Owner.
- B. Tag numbers: As specified in the Pump Schedule.

1.02 REFERENCES

- A. American Bearing Manufacturers Association (ABMA):
 - 1. 9 - Load Ratings and Fatigue Life for Ball Bearings.
 - 2. 11 - Load Ratings and Fatigue Life for Roller Bearings.
- B. American Society of Mechanical Engineers (ASME):
 - 1. B16.1 - Cast Iron Pipe Flanges and Flanged Fittings, Class 25, 125, and 250.
 - 2. B16.5 - Pipe Flanges and Flanged Fittings: NPS 1/2 through NPS 24, Metric/Inch Standard.
- C. American Water Works Association (AWWA):
 - 1. C205 - Standard for Cement-Mortar Protective Lining and Coating for Steel Water Pipe, 4 In. (100 mm) and Larger-Shop Applied.
- D. ASTM International (ASTM):
 - 1. A48 - Standard Specification for Gray Iron Castings.
 - 2. A53 - Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless.
 - 3. A108 - Standard Specification for Steel Bars, Carbon and Alloy, Cold-Finished.
 - 4. A276 - Standard Specification for Stainless Steel Bars and Shapes.
 - 5. A278 - Standard Specification for Gray Iron Castings for Pressure-Containing Parts for Temperatures Up to 650°F (350°C).
 - 6. A283 - Standard Specification for Low and Intermediate Tensile Strength Carbon Steel Plates.
 - 7. A516- Standard Specification for Pressure Vessel Plates, Carbon Steel, for Moderate-and Lower-Temperature Service.
 - 8. A582 - Standard Specification for Free-Machining Stainless Steel Bars.
 - 9. A743 - Standard Specification for Castings, Iron-Chromium, Iron-Chromium-Nickel, Corrosion Resistant, for General Application.
 - 10. B30 - Standard Specification for Copper Alloys in Ingot Form.
 - 11. B505 - Standard Specification for Copper Alloy Continuous Castings.

12. B584 - Standard Specification for Copper Alloy Sand Castings for General Applications.
 13. F593 - Standard Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs.
 14. F594 - Standard Specification for Stainless Steel Nuts.
- E. Hydraulic Institute (HI):
1. 9.1-9.5 - Pumps - General Guidelines for Types, Definitions, Application, Sound Measurement and Decontamination.
 2. 14.1-14.2 - Rotodynamic Pumps for Nomenclature and Definitions.
 3. 14.3 - Rotodynamic Pumps for Design and Application.
 4. 14.4 - Rotodynamic Pumps for Installation, Operation and Maintenance.
 5. 14.6 - Rotodynamic Pumps for Hydraulic Performance Acceptance Tests.

1.03 TERMINOLOGY

- A. The words and terms listed below are not defined terms that require initial capital letters, but, when used in this Section, have the indicated meaning.
1. Allowable operating region (AOR): Region over which the service life of the pump is not seriously compromised by hydraulic loads, vibration, or flow separation where the pump's vibration, noise, and cavitation are within acceptable limits.
 2. Preferred operating region (POR): Region over which the service life of the pump will not be significantly affected by hydraulic loads, vibration, or flow separation where the pump's vibration, noise, and cavitation are within acceptable limits.
 3. Pump head (total dynamic head, TDH), flow capacity, pump efficiency, net positive suction head available (NPSHa), and net positive suction head required (NPSHr): As defined in HI 9.1-9.5, 14.1-14.2, 14.3, 14.4, and 14.6, and as modified in the Specifications.
 - a. Pump head and efficiency are evaluated at the outlet of the discharge head and include the net losses in the pump column and discharge head, and barrel/can, intake basket or strainer (when specified).
 4. Suction head: Gauge pressure available at pump intake flange or bell in feet of fluid above atmospheric.
 5. Tolerances: This Section and related sections contain tolerances that may be more stringent than HI standard tolerances. Where tolerances are not specified, HI 9.1-9.5, 14.1-14.2, 14.3, and 14.4 shall apply.

1.04 DELEGATED DESIGN

- A. As specified in Section 01_35_73 - Delegated Design Procedures.
- B. Anchoring and bracing.

1.05 SUBMITTALS

- A. Furnish Submittals as specified in Section 01_33_00 - Submittal Procedures.
- B. Owner Training Submittals:
1. As specified in Section 01_75_17 - Commissioning.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. As specified in Section 01_60_01 - Product Requirements, Section 46_05_10 - Common Work Results for Mechanical, and the manufacturer's instructions.

1.07 WARRANTY

- A. As specified in Section 01_78_36 - Warranties and Bonds.

PART 2 PRODUCTS

2.01 SUPPORTS

- A. Strength: Design pump discharge head and driver (motor or engine) supports to withstand a minimum of 1.5 times the maximum imposed operating loads or the imposed seismic loads, whichever is greater.
- B. Resonant frequency: Design supports in conjunction with the pump, shafting, drivers, bearings, and other components to avoid natural resonant frequencies, either torsional, radial, or axial as specified in Section 46_05_94 - Mechanical Equipment Testing.
- C. Coordinate pump and drive system supports with the foundation designs as indicated on the Drawings.
- D. Anchor bolts: As specified in Section 05_05_24 - Mechanical Anchoring and Fastening to Concrete and Masonry.

PART 3 EXECUTION

3.01 PREPARATION

- A. Anchoring and bracing to structures:
 - 1. Prepare equipment anchor setting template(s) and use to position anchors during construction of supporting structure(s).
 - 2. Install anchors of type and material indicated on approved anchoring designs.
 - 3. Install anchors with embedment indicated on approved anchoring designs.
 - 4. Base plate shall be leveled to within 0.005 in/ft across entire baseplate.

3.02 INSTALLATION

- A. Install the equipment in accordance with the accepted installation instructions and anchorage details.

3.03 FIELD QUALITY CONTROL

- A. Functional Testing:
 - 1. Witnessed.

2. Test as specified in Section 46_05_94 - Mechanical Equipment Testing and the Pump Schedule.
3. Furnish test reports and the Manufacturer's Certificate of Functional Compliance.

3.04 OWNER TRAINING

- A. Perform Owner Training as specified in Section 01_75_17 - Commissioning.
 1. Number of sessions:
 - a. Operations: 2.
 - b. Maintenance: 2.

3.05 FUNCTIONAL TESTING REQUIREMENTS FOR PUMPS PMP-302, PMP-303, PMP-305, AND PMP-306

- A. Performance Test Level: 2.
- B. Vibration Test Level: 2.
- C. Noise Test Level: 2.

END OF SECTION

SECTION 43_25_00.10
SUBMERSIBLE SUMP PUMPS

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Requirements for submersible sump pump systems, including pumps, control panels, and level controls.
- B. Tag numbers: As specified in the Pump Schedule.

1.02 REFERENCES

- A. ASTM International (ASTM):
 - 1. A48 - Standard Specification for Gray Iron Castings.
 - 2. A276 - Standard Specification for Stainless Steel Bars and Shapes.
 - 3. D2000 - Standard Classification System for Rubber Products in Automotive Applications.
- B. Hydraulic Institute (HI):
 - 1. 9.1-9.5 - Pumps - General Guidelines.
 - 2. 11.6 - Rotodynamic Submersible Pump Tests.
 - 3. 14.1-14.2 - Rotodynamic Pumps for Nomenclature and Definitions.
 - 4. 14.3 - Rotodynamic Pumps for Design and Application.
- C. National Electrical Manufacturers Association (NEMA).

1.03 TERMINOLOGY

- A. The words and terms listed below are not defined terms that require initial capital letters, but, when used in this Section have the indicated meaning.
 - 1. Allowable operating region (AOR): Region over which the service life of the pump is not seriously compromised by hydraulic loads, vibration, or flow separation where the pump's vibration, noise, and cavitation are within acceptable limits.
 - 2. Preferred operating region (POR): Region over which the service life of the pump will not be significantly affected by hydraulic loads, vibration, or flow separation where the pump's vibration, noise, and cavitation are within acceptable limits.
 - 3. Pump head (total dynamic head, TDH), flow capacity, pump efficiency, net positive suction head available (NPSHa), and net positive suction head required (NPSHr): As defined in HI 9.1-9.5, 11.6, 14.1-14.2, 14.3, and as modified in this Section.
 - 4. Suction head: Gauge pressure available at pump intake flange or bell in feet of fluid above atmospheric; average when using multiple suction pressure taps, regardless of variation in individual taps.

1.04 DELEGATED DESIGN

- A. As specified in Section 01_35_73 - Delegated Design Procedures.
- B. Anchoring and bracing.
- C. Rotordynamic analysis.

1.05 SUBMITTALS

- A. Furnish Submittals as specified in Section 01_33_00 - Submittal Procedures.
- B. Product Submittals:
 - 1. As specified in Section 01_60_01 - Product Requirements.
 - 2. Product data.
 - a. Include pump curves.
 - 3. Shop Drawings.
 - 4. Manufacturer's instructions.
 - 5. Calculations.
 - 6. Schedules.
- C. Delegated Design:
 - 1. Anchoring and bracing: Provide project-specific calculations based on support conditions and requirements to resist loads specified in Section 01_81_50 - Design Criteria.
 - a. To structures for equipment installed in structures designated as seismic design category C, D, E, or F.
 - b. For equipment installed outdoors.
- D. Quality Control Submittals:
 - 1. Manufacturer's representative qualifications.
 - 2. Manufacturer's Certificate of Source Testing as specified in Section 01_75_17 - Commissioning.
 - 3. Manufacturer's Certificate of Installation Verification as specified in Section 01_75_17 - Commissioning.
- E. Operation and maintenance manuals:
 - 1. As specified in Section 01_78_24 - Operation and Maintenance Manuals.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. As specified in Section 01_60_01 - Product Requirements, Section 46_05_10 - Common Work Results for Mechanical, and the manufacturer's instructions.

1.07 PROJECT OR SITE CONDITIONS

- A. As specified in Section 01_81_50 - Design Criteria.

1.08 WARRANTY

- A. As specified in Section 01_78_36 - Warranties and Bonds.

PART 2 PRODUCTS

2.01 GENERAL

- A. As specified in Section 01_60_01 - Product Requirements.
- B. Factory finish:
 - 1. Exterior cast iron parts:
 - a. Water-thinned industrial enamel.
 - b. 3 to 4 mils.
 - 2. Manufacturer to supply touch-up paint for field use.

2.02 DESIGN AND PERFORMANCE CRITERIA

- A. As specified Section 01_81_50 - Design Criteria and in the Pump Schedule.
- B. Design working pressure: Minimum 1.5 times shut off pressure.

2.03 TYPE 1: SUMP PUMP, GENERAL SERVICE

- A. Suitable for continuous operation:
 - 1. With pump unit dry or unsubmerged at ambient temperature rating.
 - 2. When immersed in water up to 104 degrees Fahrenheit.
- B. Manufacturers: One of the following or equal:
 - 1. Barnes, SE series.
 - 2. ITT Goulds, WS series.
 - 3. Pentair Hydromatic, SKHS series.
- C. Housing:
 - 1. Cast iron: In accordance with ASTM A48, Class 30.
 - 2. Inlet: Open and clear, without screening, capable of passing 2-inch spheres.
 - 3. 3-inch NPT vertical discharge connection.
 - 4. External mating parts shall be machined and Buna-N, O-ring sealed.
 - 5. Fasteners exposed to the pumped liquid: Type 316 stainless steel.
- D. Impeller:
 - 1. Cast iron: In accordance with ASTM A48, Class 30.
 - 2. Two-vane, semi-open.
 - 3. Pump out vanes on backside.
 - 4. Mechanically locked to shaft.
- E. Bearings:
 - 1. Upper radial and lower thrust bearings required.
 - 2. Single row, oil lubricated.
 - 3. Permanently sealed.
 - 4. Shaft seal:
 - a. Type 21 mechanical seal.
 - 1) Carbon versus ceramic faces.
 - 2) Elastomer:
 - a) Buna-N in accordance with ASTM D2000.

- 3) Hardware:
 - a) Type 316 stainless steel in accordance with ASTM A276.
- F. Motor:
 - 1. Oil-filled, NEMA B with horsepower as scheduled.
 - a. 3-phase, 480 volts.
 - b. 1.15 service factor.
 - c. 3,450 revolutions per minute.
 - 2. Shaft: Type 416 stainless steel in accordance with ASTM A276.
 - 3. Insulation:
 - a. 1.5 horsepower and above: Class B.
 - b. Under 1.5 horsepower: Class F.
- G. Power cable:
 - 1. STW sized for motor and length requirements, 16 gauge minimum.
 - 2. Length to reach connection (control panel or junction box) indicated on the Drawings plus 10 feet.
 - a. 20 feet minimum.
- H. Source Quality Control (Factory Acceptance Tests):
 - 1. Visual inspect for imperfections.
 - 2. Check ground continuity.
 - 3. High potential test (Hipot).
 - 4. Air pressure test of housings for motor and volute.
 - 5. Test run to:
 - a. Monitor voltage and current.
 - b. Detect excessive noise.
 - 6. Furnish test reports and the Manufacturer's Certificate of Source Testing.

2.04 VENDOR CONTROL PANEL

- A. As specified in the Pump Schedule.
- B. Construction and components as specified in Section 40_67_01 - Control Systems: Panels, Enclosures, and Panel Components.
- C. Electrical components:
 - 1. Main circuit breaker:
 - a. As specified in Section 26_28_01 - Low Voltage Molded Case Circuit Breakers.
 - b. Flange-mounted operator:
 - 1) Pad-lockable in the off position.
 - 2) Disconnects all power to the panel.
 - 3) Interlock with the panel door.
 - 4) Defeat mechanism.
 - 2. Motor starter for each pump:
 - a. Motor circuit protector circuit breaker.
 - b. Full voltage non-reversing magnetic starter.
 - c. Thermal or electronic overloads.
 - 3. Control power transformer:
 - a. Primary voltage: 230/460 VAC, 3-phase, 60 hertz.

- b. Secondary voltages:
 - 1) Control and status points: 120 volts.
 - c. Sized for all panel components plus 10 percent spare capacity.
 - d. Primary and secondary fuses.
- 4. Control components:
 - a. Terminal strips:
 - 1) For landing all external wiring.
 - b. Relays, timers, and other components as required for the specified functionality and remote monitoring connections.
- 5. Simplex operation:
 - a. Front panel controls:
 - 1) HAND/OFF/AUTO switch.
 - 2) START pushbutton.
 - 3) STOP pushbutton.
 - 4) Momentary LOW-LEVEL OVERRIDE pushbutton.
 - 5) Running pilot light.
 - 6) Stopped pilot light.
 - 7) Power pilot light.
 - 8) Pump fault pilot light.
 - 9) High-High-level alarm.
 - b. Remote monitoring and control:
 - 1) Provide dry relay contact outputs for the following:
 - a) Pump fault alarm.
 - b) Pump run status.
 - c) High-High-Level Alarm.
 - c. Operation:
 - 1) HAND:
 - a) START pushbutton starts pump.
 - b) STOP pushbutton stops pump.
 - c) LOW-level switch activation stops pump.
 - (1) Momentary LOW-LEVEL OVERRIDE pushbutton overrides.
 - 2) OFF: Pump stops operation and alarm conditions are re-set.
 - 3) AUTO: Pump operates automatically in response to level switch signals.
 - a) Start when the HIGH-level switch is activated.
 - b) Stop when the LOW-level switch is activated.
 - d. Alarm: High-High alarm with activation of HIGH-HIGH-level switch.
- 6. Duplex operation:
 - a. Front panel controls:
 - 1) HAND/OFF/AUTO switch.
 - 2) LEAD-STANDBY selector switch:
 - a) Designates the lead pump automatic operation.
 - 3) START pushbutton for each pump.
 - 4) STOP pushbutton for each pump.
 - 5) Momentary LOW-LEVEL OVERRIDE pushbutton.
 - 6) Running pilot light for each pump.
 - 7) Stopped pilot light for each pump.
 - 8) Power pilot light.
 - 9) Pump fault pilot light for each pump.
 - 10) High-High-level alarm.

- b. Remote monitoring and control:
 - 1) Provide dry relay contact outputs for the following:
 - a) Pump fault alarm: Each pump.
 - b) Pump run status: Each pump.
 - c) High-High Level Alarm.
- c. Operation:
 - 1) HAND:
 - a) START pushbutton starts pump.
 - b) STOP pushbutton stops pump.
 - c) LOW-level activation stops pump:
 - (1) Momentary LOW-LEVEL OVERRIDE pushbutton overrides.
 - 2) OFF: Pump stops operation and alarm conditions are re-set.
 - 3) AUTO: Pumps operate automatically in response to level switch signals.
 - a) Lead pump starts when HIGH-level switch is activated.
 - b) Lead pump stops when LOW-level switch is activated.
 - c) When lead pump fault alarm is activated, standby pump becomes the lead pump.
 - d) Activation of HIGH-HIGH-level switch activates HIGH-HIGH-level alarm and standby pump becomes the lead pump.

2.05 LEVEL SWITCHES

- A. Type: Ball float as specified in Section 40_72_76 - Level Measurement: Switches.
- B. Cable length: Equal to sump depth to the VCP plus 5 feet.

2.06 ACCESSORIES

- A. Lifting cables:
 - 1. Material: Type 316 stainless steel.
 - 2. Attached to balance point of pump.
 - 3. Suitable for lifting pump from sump.
 - 4. Extend from pump attachment to hanger.
- B. Lifting hangars:
 - 1. Material: Type 316 stainless steel.
 - 2. Suitable to provide storage of extra lift cable and electrical cables at wall sump.

2.07 SPARE PARTS AND SPECIAL TOOLS

- A. As specified in Section 01_60_01 - Product Requirements.
- B. Special tools: For each type or size of pump, provide 1 set.
- C. Touch-up paint: 1 pint of finish coating paint.

PART 3 EXECUTION

3.01 PREPARATION

- A. Anchoring and bracing to structures:
 - 1. Prepare equipment anchor setting template(s) and use to position anchors during construction of supporting structure(s).
 - 2. Install anchors of type and material indicated on approved anchoring designs.
 - 3. Install anchors with embedment indicated on approved anchoring designs.

3.02 INSTALLATION

- A. Install the equipment in accordance with the accepted installation instructions and anchorage details.
- B. In accordance with the manufacturer's instructions.
- C. Install lifting hanger 3 feet-6 inches above floor.
- D. Remove any extra length of power and control cables at connection point (panel, junction box, or receptacle).
- E. Repair damaged finish with the manufacturer's supply of touch up paint.
- F. Furnish Manufacturer's Certificate of Installation Verification.

3.03 PUMP SCHEDULE

- A. Attributes:

Tag Numbers	PMP-311 AND PMP-312
<u>General Characteristics:</u>	
Sump Pump Type	Type 1
<u>Rated Performance:</u>	
Total Head, feet	30
Minimum flow, gpm	64
<u>Motor:</u>	
Maximum, hp	0.5
<u>Vendor Control Panel:</u>	
Enclosure	NEMA 4X
Operation	Duplex

END OF SECTION

SECTION 43_42_21.08

HYDROPNEUMATIC PRESSURE CONTROL SYSTEM INCLUDING TANK

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes: Pressure tank, air compressor, receiver, and accessories.

1.02 REFERENCES

- A. American Society of Mechanical Engineers (ASME):
 - 1. B31.1 - Power Piping.
 - 2. Boiler and Pressure Vessel Code (BPVC) Section VIII-Rules for Construction of Pressure Vessels, Division 1.
- B. ASTM International (ASTM):
 - 1. A269 - Standard Specification for Seamless and Welded Austenitic Stainless Steel Tubing for General Service.
 - 2. A516 - Specification for Pressure Vessel Plates, Carbon Steel, for Moderate and Lower Temperature Service.
- C. National Electrical Manufacturers Association (NEMA):
 - 1. 250 - Enclosures for Electrical Equipment (1000 V Maximum).
 - 2. MG-1 - Motors and Generators.
- D. NSF International (NSF):
 - 1. 61 - Drinking Water System Components - Health Effects.
- E. International Building Code (IBC).
- F. Underwriters Laboratories, Inc. (UL).

1.03 SUBMITTALS

- A. Submit as specified in Section 01_33_00 - Submittal Procedures and Section 46_05_10 - Common Work Results for Mechanical Equipment.
- B. Pressure tank:
 - 1. Product data: List of materials and coatings used:
 - a. Certification and ASME Code data reports in accordance with the ASME BPVC and other similar codes:
 - 1) The certification shall include certification of joint radiography, and hydrostatic testing.
 - 2. Shop drawings:
 - a. Detail drawings or manufacturer's literature to indicate compliance with the specified requirements.
 - b. Dimensional drawings indicating vessel dimensions, wall thickness, mounting, and anchorage requirements.

- c. ASME BPVC calculations.
 - d. Fabrication drawings.
 - e. Complete electrical diagrams.
- 3. Calculations:
 - a. Copy of structural, seismic, and wind loading calculations for the support system signed by a Structural Engineer registered in Colorado.
- C. Air compressor and receiver:
 - 1. Product data and shop drawings.
 - 2. Sizing calculations:
 - a. Signed by a Professional Engineer.
- D. Form U-1 "Manufacturers' Data Report for Unfired Pressure Vessels".
- E. Provide draft vendor operation and maintenance manual as specified in Section 01_78_24 - Operation and Maintenance Manuals
- F. Commissioning submittals:
 - 1. Provide Manufacturer's Certificate of Source Testing as specified in Section 01_75_17 - Commissioning.
 - 2. Provide Manufacturer's Certificate of Installation and Functionality Compliance as specified in Section 01_75_17 - Commissioning.
- G. Project closeout documents:
 - 1. Provide final vendor operation and maintenance manual as specified in Section 01_78_24 - Operation and Maintenance Manuals.
 - 2. Verify submittal of Form U-1 to the National Board of Boiler and Pressure Vessel Inspectors.

1.04 WARRANTY

- A. Provide warranty as specified in Section 01_78_36 - Warranties and Bonds.

PART 2 PRODUCTS

2.01 DESIGN AND PERFORMANCE CRITERIA

- A. Performance criteria:
 - 1. The hydropneumatic pressure control system shall include a pressure tank, air compressor, receiver tank, automatic water level control system, and all piping and accessories needed to assemble a complete working system at the job site.
 - 2. The hydropneumatic system shall be designed to maintain a discharged water pressure of 75 to 105 pounds per square inch gauge (psig).
- B. Design criteria:
 - 1. Tank size:
 - a. Nominal tank diameter: 144 inches.
 - b. Tank length: Approximately 760 inches.

- c. Minimum tank capacity: 50,000 gallons.
 - d. Orientation: horizontal.
- 2. Pressure rating: The new tank shall be fabricated in accordance with the ASME BPVC for unfired pressure vessels, for a design pressure rating of 150 psig.
- 3. Corrosion allowance: 1/16-inch corrosion allowance applied to shell, heads, and attachment thicknesses.
- 4. Seismic design criteria: Design tank restraint system for seismic design criteria as specified in Section 01_81_50 - Design Criteria.
- 5. Wind design criteria: Design tank restraint system of outdoor or exposed tanks to meet the wind design criteria as specified in Section 01_81_50 - Design Criteria.
- 6. The equipment to be provided under this Section shall be suitable for installation and operation under the following conditions:
 - a. Project site elevation: Colorado between 5125 and 5200 feet above sea level.
 - b. Indoor temperature and humidity:
 - 1) Outside ambient air temperatures range between 32 and 100 degrees Fahrenheit, with relative humidity ranging between 10 and 100 percent (noncondensing).
- 7. The tank shall contain 60 percent air under steady state conditions.
- 8. The system and anchorage of the tank shall conform to the IBC.

2.02 PRESSURE TANK

- A. Manufacturers:
 - 1. Pressure tank: One of the following or equal:
 - a. Pulsco.
 - b. Pressure Vessel Technologies/Wagner Plat Works West.
- B. Materials:
 - 1. Construct tank using ASTM A516 steel unless otherwise indicated on the Drawings.
- C. Components:
 - 1. Lifting lugs: Provide lifting lugs.
 - 2. Anchor bolts:
 - a. Anchor bolts shall have a nominal diameter of at least 3/4-inch, unless otherwise indicated on the Drawings, and shall be anchored to concrete foundations using methods designed to transfer the full ultimate strength of the anchor bolt to the concrete foundation.
 - b. Attach anchor bolts to the tank by use of anchor bolt chairs or rings, as required.
 - c. Chairs or rings shall be designed to transfer 125 percent of the ultimate strength of the bolt, or 150 percent of the calculated load; whichever is less, to the tank shell.
 - 3. Nameplate and code stamp:
 - a. Design, fabricate, and test tank in accordance with the ASME BPVC.
 - b. Tank shall bear a stainless steel ASME nameplate.

- c. Nameplate shall bear the applicable code symbol.
 - d. Manufacturer shall be authorized by ASME to apply the applicable code symbols.
 - 4. Fittings and attachments:
 - a. Fittings shall be as indicated on the Drawings.
 - b. Fittings larger than 1 inch shall be flanged.
 - c. Fittings 1 inch and smaller shall be National Pipe Thread.
 - d. Reinforce openings in accordance with the ASME BPVC.
 - 5. Attachments: Weld shell attachments for pipe supports, tank gages, instruments, and other items as indicated on the Drawings before application of the tank lining.
- D. Inspection openings:
- 1. Provide 24-inch diameter inspection opening on the tank.
 - 2. In accordance with ASME requirements.
 - 3. Provide bolted cover with neoprene or EPDM flange gasket.
 - 4. Weld lifting lugs to cover and to tank above centerline of opening to aid in cover removal.
- E. Ground lug:
- 1. Provide lug sized for 2/0 size electrical cable.
 - 2. Locate at bottom of tank.
- F. Appurtenances:
- 1. Appurtenances shall include mounting flanges, drain valves, and lifting lugs.
 - 2. Solenoid valves: As specified in Section 40_05_52 - Specialty Valves.
- G. Fabrication:
- 1. Welding:
 - a. Weld reinforcement shall be in accordance with ASME BPVC.
 - b. Excessive reinforcement shall be ground down to within the ASME BPVC requirements, and as required to install the lining systems.
 - c. All internal corners and edges shall be ground to a 1/8-inch radius, or a greater radius if required by the lining system.
 - 2. Protective coating:
 - a. Interior surfaces of the tank shall be factory-coated with High Solids Epoxy Coating in accordance with NSF 61 and as specified in Section 09_96_01 - High-Performance Coatings at a minimum dry film thickness of 10 to 12 mils.
 - b. Coat exterior as specified in Section 09_96_01 - High-Performance Coatings.
- H. Level control system:
- 1. Differential pressure transmitter as specified in Section 40_73_29 - Pressure/Vacuum Measurement: Differential.
- I. Pressure controls:
- 1. The tank pressure controls shall control the pump turn on points and add/vent air solenoid valves.

2. The components shall consist of a pressure transmitter with 4 to 20 milliamperes output.
 3. The pressure connection for the pressure transmitter shall be at the probe well or on the top of the tank.
- J. Vendor control panel (VCP):
1. The NEMA Type 4X VCP shall include all the components necessary for operation of the hydropneumatic system.
 - a. The VCP shall operate on 120-volt, 60 Hertz, 20-amp electrical service.
 - b. It shall be factory wired and tested and UL listed.
 - c. Components shall be labeled and include the following:
 - 1) Door mounted:
 - a) Power on light (white).
 - b) High and low pressure alarm lights (red).
 - c) High and low level alarm lights (red).
 - 2) Internally mounted:
 - a) Control relays.
 - b) Current switch.
 - c) Main circuit breaker.
 - d) Alternator.
 - e) Time delay relays.
 - f) Wire and terminal strip.
 - 3) Provide the following 120 VAC rated dry contacts:
 - a) Low Level.
 - b) High Level.
 - c) Low Pressure.
 - d) High Pressure.
 - e) PMP-311 Run.
 - 4) VCP shall accept the following 120VAC rated dry contacts:
 - a) PMP-311Running.
 2. The VCP shall start and stop the compressor indirectly via the add air solenoid valve and start/stop the pumps via dry contact closure.
 3. The control system shall include adjustable water level set point relays and adjustable pressure set point relays.
 - a. The levels shall be adjusted to 3 different set points within the tank.
 - b. Pressure set point relays shall be set to 2 pressures over the entire range of control.
 - c. Adjustments shall be made within plus or minus 0.5 percent of full range.
 4. The 2 pressure set points are specified as being open when the pressure is less than the pressure setting and closed when the pressure is equal to or greater than the pressure setting.
 - a. PS-1: High Pressure alarm: 110 psig.
 - b. PS-2: Energize vent air solenoid valve: 105 psig.
 - c. PS-3: Energize add air solenoid valve: 75 psig.
 - d. PS-4: Start duty pump: 75 psig.
 - e. PS-5: Low pressure alarm: 65 psig.
 5. The 4 level set points are specified as being open when the level is greater than the level setting and closed when the level is equal to or less than the level setting and corresponding pressures. The settings are as follows:
 - a. LHH: High-High Level (alarm): 105psig.
 - b. LLL: Low-Low Level (alarm): 75 psig.

- K. System control description:
1. The system shall be designed to maintain a discharged water pressure of 75 to 105 psig.
 - a. The pumps shall maintain pressure in the hydropneumatic tank via the level and pressure control relays.
 - b. Pressure set points energize pumps and level set points de-energize pumps.
 - c. As the water level falls (drops in pressure), the lead pump is energized at a pre-set pressure PS-4.
 - d. If the demand falls, pressure rises and the tank water level rises to the LH set point, the lead pump shall be shut down.
 2. Whenever the alternator senses that no pumps are running then the alternator shall automatically alternate the pumps.
 3. A low-pressure alarm (PS-5) and high-pressure alarm (PS-1) are provided to activate indicating lights and close dry contacts for remote signals at the VCP.
 4. Whenever the water level reaches the LH switch, all pumps are off.
 - a. If the pressure is below PS-3, then the add air solenoid valve will open until the pressure is increased to PS-3 reset point.
 - b. If the water level is at LH switch and the pressure is above PS-2 then the vent air solenoid valve will open until the pressure is decreased to PS-2 reset point.

2.03 AIR COMPRESSOR

- A. Manufacturers: One of the following or equal:
1. Ingersoll-Rand.
 2. Quincy Compressor.
 3. Gardner Denver.
- B. Type:
1. Supplier shall size the compressor and receiver tank.
 2. The horsepower shall be 5 horsepower.
 3. Supplier is responsible for a complete working system.
 4. Submit design catalog cut sheets, schematics, and sketches that include compressor size/type, horsepower, the displacement, receiver volumes, and motor speeds for the compressor.
- C. Compressor unit, including crankshaft, cylinders, flywheel, and motor shall be air cooled, and completely sealed against dirt.
1. Compressor shall be oil lubricated and suitable for raw water.
 2. A finned, multi-tube intercooler shall be provided between stages and shall include a safety valve to prevent over pressurization.
 - a. A dry-type 10-micron filter silencer shall be provided on the air inlet.
 3. An air-cooled aftercooler shall lower the discharge air temperature to within 25 degrees Fahrenheit of the ambient air temperature.
 4. Compressor shall be driven by an electric motor integral with the compressor.
- D. Receiver:
1. Air receiver shall be ASME, National Board coded, and tested to 1.3 times the design working pressure.

2. Receiver shall be provided with pressure gauge, safety valve, and automatic condensate drain trap.
 3. All taps shall be National Pipe Thread threaded, and receivers shall be provided with sturdy, steel mounting feet.
 4. Size compressor to meet hydropneumatic pressure system requirements.
 - a. Minimum capacity shall be 80 gallons.
- E. Motor:
1. Compressor motor: 460 volt, 3-phase, 60-hertz, TEFC, 1.15 service factor, severe duty, energy efficient, with self-lubricated ball bearings.
 2. Designed, manufactured, and tested in accordance with NEMA MG-1.
- F. Equipment identification plates:
1. A 16-gauge stainless steel identification plate shall be securely mounted on the compressor and receiver in a readily visible location.
 2. The plate shall bear the 1/4-inch die-stamped equipment number indicated in this Section.
- G. Piping:
1. General:
 - a. All interconnecting piping and tubing between components of the equipment package shall be shop installed, except as indicated on the Drawings.
 - b. Piping from the compressor discharges to the receiver shall be sized not less than the compressor discharge connection size and shall be as specified in 40_05_00.01 - Common Work Results for General Piping and as indicated on the Drawings.
 - 1) Close nipples will not be acceptable.
 2. Pneumatic control and instrument tubing:
 - a. Manufacturers: One of the following or equal:
 - 1) Parker-Hannifin.
 - 2) Ferulok.
 - 3) Crawford.
 - 4) Swagelock.
 - b. In accordance with ASTM A269, Type 316, stainless steel tubing, Type 316 stainless steel flareless double ferrule compression fittings.
 - c. Tubing shall not be less than 1/4-inch OD with a wall thickness of 0.028 inch.
 3. All piping and tubing shall be run in vertical and horizontal planes.
 - a. Piping shall be arranged to ensure that undue stresses, from thermal expansion, are not transmitted to equipment components.
 4. All control and instrument tubing shall be continuously supported.
- H. Control equipment:
1. All control equipment for the compressor shall be furnished as required for a complete installation, requiring only field connection of the electrical power supply and alarm output signals.
 2. Equipment shall include the following:
 - a. All control switches, pressure switches, timing relays, auxiliary relays, elapsed time meters, circuit breaker combination magnetic motor starters, and other accessories required for control of the compressor.

- b. Each starter shall include a thermal magnetic circuit breaker with external operating handle.
 - c. Starter overloads shall be matched to motor current and shall be provided with a reset pushbutton.
- 3. All control equipment for the compressor package shall be housed in a control panel mounted on the receiver.
- 4. All system wiring shall be shop installed to terminal blocks in the control panel. Wiring from the panel to system components shall be completely enclosed in liquid-tight flexible conduit.
- 5. All pneumatic tubing shall be shop installed to bulkhead fittings at the control panel.
 - a. All field connections shall be made to the fittings at the panel.
- 6. Control panel enclosure:
 - a. The control panel shall be NEMA Type 12 construction, fabricated from 14 USS gauge or heavier steel and shall be equipped with a full-size gasketed door with chromium-plated or stainless steel 3-point latch and hinges.
 - b. A screened vent shall be provided in the bottom of the control panel.
 - c. All control devices shall be rigidly mounted within the enclosure except for breaker handles, selector switches, pushbuttons, and indicating lights, which shall be mounted on the panel door.
- 7. Internal panel tubing shall be run in horizontal and vertical planes and shall be rigidly supported to withstand handling and shipping without damage.
 - a. Compression type bulkhead fittings shall be provided through the panel for all connections.
- 8. Panel wiring:
 - a. Internal panel wiring shall be neatly bundled and tied and identified with suitable wire markers.
 - b. Terminal blocks for external connections shall be furnished complete with marking strips, covers, and pressure connectors.
 - c. A terminal shall be provided for each conductor of external circuits.
 - d. All wiring shall be grouped or cabled and securely attached to the panel.
 - e. Clearance for field wiring shall be provided between the terminal strips and base.
- 9. Compressor control:
 - a. The control panel shall be provided with a power on light, Hand-Off-Automatic (HOA) switch, run light, motor thermal overload alarm light and low oil level alarm light.
 - 1) The panel shall contain combination magnetic motor starter and circuit breaker for the air compressor.
 - b. The air compressor shall start and stop based on pressure in the air receiver.
 - 1) Dry contacts shall be provided in the panel for remote indication of running conditions for the compressor.
 - 2) The compressor shall be shutdown by motor thermal overload, or low oil level.
 - 3) An alarm condition shall energize a local alarm light.

- c. The compressor shall start automatically, provided its HOA hand switch is in the AUTO position.
 - 1) The compressor shall run continuously if its HOA hand switch is in the HAND position and shall shut down if its HOA hand switch is in the OFF position.
- d. The hydropneumatic pressure control system supplier shall select the compressor volumetric capacity and discharge pressure.
 - 1) The capacity and discharge pressure selected shall be sufficient for operation.

I. Accessories:

- 1. The compressed air equipment package shall be provided with the following accessory equipment:
 - a. Safety valves:
 - 1) Manufacturers: One of the following, or equal:
 - a) Kunkle: Series 6000.
 - b) Conbraco: 19-Series.
 - 2) Safety valves with manual lifting levers shall be installed in the compressor discharge piping and on the receiver.
 - 3) Valves in the compressor discharge piping shall be capable of protecting the compressor from damage when operating against a closed discharge valve and shall be suitable for the maximum compressor discharge air temperature.
 - 4) The safety valve on the receiver shall be capable of protecting the receiver from excessive pressure.
 - 5) Relief pressure setting: 200 pounds per square inch.
 - b. Safety guard: Compressor cooling fan shall be provided with safety guards.
 - c. Intake filter muffler:
 - 1) Provide each compressor with a dry type intake filter muffler supported by the suction pipe and close coupled to the compressor intake connection.
 - 2) Intake filter muffler shall have an outer cover and replaceable filter element.
 - d. Discharge check valve:
 - 1) A line-mounted check valve shall be provided in the discharge piping leading from compressor.
 - 2) Check valve shall be sized in accordance with the manufacturer's recommendations and shall be suitable for service with reciprocating compressors at the maximum compressor discharge air temperature.
 - e. Shutoff valves:
 - 1) Type: All shutoff valves shall be ball valves.
 - 2) Valves in steel piping shall have carbon steel bodies, chrome-plated or stainless steel balls, and reinforced Teflon™ seals and seats.
 - 3) Valves in the compressor discharge piping shall be suitable for the maximum compressor discharge air temperature.
 - f. Receiver vent valve:
 - 1) Provide a globe type vent valve with bronze body and brass stem on receiver.
 - g. Air pressure regulating valve: As specified in Section 40_05_67.37 - Pressure Reducing and Pressure Relief Valves.

- h. Pressure gauge:
 - 1) Pressure gauge shall have a phenol case, adjustable pointer, stainless steel rotary geared movement, and shall be accurate to within 2 percent of full-scale.
 - 2) Gauge shall have a minimum dial size of 4-1/2 inches, and a range equal to approximately twice the normal operating pressure at the point of installation.
 - a) The units of measurement shall be indicated on the dial face.
- i. Gauge shall have a 1/4-inch NPT connection.
 - 1) All other gauges shall have 1/2-inch NPT connection.
 - 2) All gauges shall be provided with a shutoff valve.
- j. Pressure switch:
 - 1) Pressure switch shall have SPDT contacts rated 10 amperes at 120 volts AC and shall be complete with shutoff valve.
 - 2) Pressure switch shall have NEMA Type 1 housings.
- k. Thermometers:
 - 1) Remote reading or gas actuated dial type.
 - 2) Does not contain mercury.
 - 3) Minimum dial size of 4-1/2 inches, adjustable pointer, and shall be accurate within 1 percent of full-scale.
 - 4) Completely furnish with a uniformly graduated dial indicator, armored capillary tube, bulb or temperature sensor, and thermal well.
 - 5) Ranges shall be such that the normal operating reading will be near the midpoint of the range.
 - a) The units of measurement shall be indicated on the dial face.
 - b) Spare capillary length shall be neatly coiled and tied.
- l. Air piping shall be increased in size at the thermal well location so that the area between the well and pipe is not less than the cross-sectional area of the original size piping.
 - 1) The entire sensitive length of the temperature sensor shall be installed within the air flow stream.
- m. Temperature switches:
 - 1) Temperature switches shall be remote bulb type with SPDT contacts rated 10 amperes at 120 volts AC.
 - 2) Temperature switches shall have NEMA Type 1 housings, stainless steel thermal well assemblies, and armored capillaries.
 - a) Capillary length shall be sufficient for mounting the switch inside the control panel.
 - b) Spare capillary length shall be neatly coiled and tied.
- n. Finishes:
 - 1) Shop and field painting of piping and equipment shall be as specified in Section 09_96_01 - High-Performance Coatings.

2.04 SPARE PARTS AND SPECIAL TOOLS

- A. As specified in Section 01_60_00 - Product Requirements.
- B. Spare parts:
 - 1. Three air filters for the air compressor.

2.05 DELIVERY, STORAGE, AND HANDLING

- A. Package sight glass assembly, safety relief valves, pressure gauge and similar breakable components separately from tank for shipment.
 - 1. Suitably store these components at the project site and install after hydropneumatic tank has been anchored.
- B. Suitably seal tank openings to prevent entry of dust, dirt, and other contaminants until connections are made in the field.

PART 3 EXECUTION

3.01 GENERAL

- A. As specified in Section 46_05_10 - Common Work Results for Mechanical Equipment.

3.02 INSTALLATION

- A. Install piping in such a manner as to not place any strain on any part of the equipment.

3.03 COMMISSIONING

- A. As specified in Section 01_75_17 - Commissioning, 46_05_94 - Mechanical Equipment Testing, and this Section.
- B. Manufacturer services:
 - 1. Provide certificates:
 - a. Manufacturer's Certificate of Source Testing.
 - b. Manufacturer's Certificate of Installation and Functionality Compliance.
 - 2. Manufacturer's Representative onsite requirements:
 - a. Installation: 1 trip, 3-day minimum.
 - b. Functional Testing: 1 trip, 3-day minimum each.
 - 3. Training:
 - a. Maintenance: 2 hours per session, 1 session.
 - b. Operation: 2 hours per session, 1 session.
- C. Source testing:
 - 1. Prepare a Form U-1 "Manufacturers' Data Report for Unfired Pressure Vessels" certifying the hydropneumatic tank was fabricated in accordance with ASME BPVC Rules for the Construction of Unfired Pressure Vessels and inspected by a certified inspector.
 - 2. Test as specified in Section 46_05_94 - Mechanical Equipment Testing.
 - 3. Compressor:
 - a. Test witnessing: Not witnessed.
 - b. Conduct Level 1 General Equipment Performance Test.
 - 4. Conduct Level 1 Vibration Test.
 - a. Conduct Level 1 Noise Test.

5. Electrical Instrumentation and Controls:
 - a. Test witnessing: Not witnessed.
 - b. Conduct testing as specified in Section 40_80_01 - Commissioning for Instrumentation and Controls.
- D. Functional testing:
 1. Prior to testing the piping system shall be inspected for conformance with the Contract Documents, and ASME B31.1.
 2. Tank:
 - a. Test witnessing: Witnessed.
 3. Electrical Instrumentation and Controls:
 - a. Test witnessing: Witnessed.
 - b. Conduct testing as specified in Section 40_80_01 - Commissioning for Instrumentation and Controls.
 4. System:
 - a. Fully charge with air in accordance with the manufacturer's instructions prior to field-testing the system.
 - b. Test the level control system and a simulate power failure when pumps are running at maximum operating flow conditions.

END OF SECTION

SECTION 46_05_10

COMMON WORK RESULTS FOR MECHANICAL EQUIPMENT

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Mechanical equipment requirements for:
 - a. Basic design and performance criteria.
 - b. Prescriptive requirements for common components.
 - c. Installation requirements.

1.02 REFERENCES

- A. American Bearing Manufacturers Association (ABMA):
 - 1. 9 - Load Ratings and Fatigue Life for Ball Bearings.
 - 2. 11 - Load Ratings and Fatigue Life for Roller Bearings.
- B. American Gear Manufacturers Association (AGMA) Standards.
- C. American Petroleum Institute (API):
 - 1. 682 - Pumps—Shaft Sealing Systems for Centrifugal and Rotary Pumps.
- D. ASTM International (ASTM):
 - 1. A193 - Standard Specification for Alloy-Steel and Stainless Steel Bolting for High Temperature or High Pressure Service and Other Special Purpose Applications.
 - 2. A194 - Standard Specification for Carbon and Alloy Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both.
 - 3. A320 - Standard Specification for Alloy-Steel and Stainless Steel Bolting for Low-Temperature Service.
 - 4. F593 - Standard Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs.
 - 5. F594 - Standard Specification for Stainless Steel Nuts.
- E. Hydraulic Institute (HI):
 - 1. 9.6.8 - Guideline for Dynamics of Pumping Machinery.
- F. International Concrete Repair Institute (ICRI):
 - 1. Guideline No. 310.2R, Selecting and Specifying Concrete Surface Preparation for Sealers, Coatings, Polymer Overlays, and Concrete Repair.
- G. International Organization for Standardization (ISO):
 - 1. 21940 - Mechanical Vibration - Rotor Balancing - Part 1: Introduction.
- H. National Electrical Manufacturers Association (NEMA):
 - 1. MG-1 - Motors and Generators.

- I. Society for Protective Coatings (SSPC):
 - 1. SP 1 - Solvent Cleaning.

1.03 TERMINOLOGY

- A. The words and terms listed below are not defined terms that require initial capital letters, but, when used in this Section, have the indicated meaning.
 - 1. Definitions used in this specification and equipment Submittals for terms related to rotor-dynamic pumps shall be in accordance with HI 9.6.8, Appendix A, as clarified below.
 - 2. These definitions shall be applied to equipment other than pumps, unless otherwise specified in Technical Sections.
 - 3. Resonant frequency:
 - a. Frequency of a periodic excitation force that is close to the natural frequencies of an object. Also known as critical frequency, critical speed, or resonant speed.
 - b. An undamped resonant frequency within the separation margin is always considered harmful under Level 1 analysis.
 - c. A resonant frequency that occurs within a separation margin of 15 percent above or below the operating speed range and has a log decrement greater than +0.3 is considered harmful under Level 2 and Level 3 analysis.
 - 4. Rotordynamic analysis level:
 - a. Level of detail required for rotordynamic analysis is indicated in the Technical Sections schedules as None (no analysis required), Analysis Level 1, Analysis Level 2, or Analysis Level 3, which correlate to increasing levels of required detailed equipment design analysis. Analysis Levels 1, 2, and 3 are based on HI 9.6.8.
 - b. Where these specifications differ from HI the more stringent shall apply.
 - 5. Separation margin:
 - a. Span of operating speeds within which interference between excitation orders and resonant frequencies indicate the possibility of harmful vibrations.
 - b. Separation margin for a specific application extends 15 percent above and 15 percent below the span of operating speed required for the specified performance conditions.

1.04 ADMINISTRATIVE REQUIREMENTS

- A. Roof coordination.
 - 1. Show roof penetrations for mechanical equipment on roof drawing Submittal and include mechanical equipment information:
 - a. Type.
 - b. Size.
 - c. Location.
 - d. Configuration of penetration and the surround.
 - e. Weight.
 - f. Anchoring and support details.

1.05 SUBMITTALS

- A. Items in this Section are components of equipment or systems specified in other Sections.
 - 1. Include data for this Section's components with the equipment or system Submittal.

PART 2 PRODUCTS

2.01 DESIGN AND PERFORMANCE CRITERIA

- A. General:
 - 1. Equipment manufacturer's responsibility extends to selection and mounting of gear drive units, motors or other prime movers, accessories, and auxiliaries to provide a complete, operable unit.
 - 2. Manufacturer shall analyze rubber-bearing vertical-column pumps and equipment identified as non-reversing in the Technical Sections for reverse rotation and provide non reversing motor ratchets.
 - 3. Equipment that prevents reverse rotation shall be capable of both:
 - a. Handling 150 percent of the maximum torque at maximum operating speed.
 - b. 150 percent of torque that will be generated in reverse direction due to equipment shutoff head as calculated by the manufacturer.
 - 4. Motor shall be designed to run safely in the reverse direction at up to 140 percent times the reverse runaway speed under shutoff head conditions.
- B. Rotordynamic analysis and vibration testing:
 - 1. Submit information for the rotordynamic analysis level specified for each piece of equipment as shown in the Technical Sections prior to manufacture of the equipment.
 - 2. Rotordynamic analysis shall be performed on "like-new" and "as-worn" conditions, representing conditions when first installed and conditions when parts wear to the manufacturer's maximum allowable operating tolerances.
 - a. Conditions assumed for the "as-worn" condition shall be 2 times the "like-new" tolerances unless specified otherwise.
 - 3. Rotordynamic analysis criteria:
 - a. Torsional excitation forcing function magnitudes shall be no less than 1 percent of the maximum transmitted torque at given speed.
 - b. Motor mass elastic information in accordance with NEMA MG-1 shall be obtained from the original equipment manufacturer and included in the analysis. Motors shall be precision balanced to ISO 21940 Grade G2.5.
 - c. Bearings:
 - 1) At maximum bearing loads an L-10 life of 100,000 hours in accordance with ABMA 9-11 to be proven.
 - 4. Submit factory and field testing requirements as specified in the Technical Sections and specified in Section 46_05_94 - Mechanical Equipment Testing after manufacture and installation respectively.

5. Repair, replace, and modify equipment exhibiting vibration performance that does not meet criteria specified in this Section at no additional cost to the Owner.
 - a. Acceptable remedies include adjustments to equipment component geometry, materials, energy absorbing couplings, etc.
 - b. Locking out speed interval(s) within equipment specified operating range is unacceptable.
6. Vibration analysis expert:
 - a. Provide when specified in the equipment Technical Sections.
 - 1) Must be a third party, unaffiliated with the equipment vendor or Contractor.
 - b. Analysis shall be provided by one of the following or equal:
 - 1) Engineering Dynamics Inc. (EDI, Texas).
 - 2) Mechanical Solutions, Inc. (MSI, New Jersey).
 - c. Analysis shall be:
 - 1) Stamped by a registered professional mechanical engineer.
 - 2) Verified in-situ by the vibration analysis expert, including certification that installation conforms to field conditions assumed in the reports.
 - 3) Verified in-situ by the vibration analysis expert, including witness of at least 1 field vibration test, and certification that vibration measurements corroborate the rotordynamic analysis.
 - 4) Supplemented with additional field investigation and analysis should conditions during field vibration testing activity indicate non-compliance with these specifications; supplemental field investigation and analysis shall indicate remedies to comply with the specifications and shall be stamped by a registered professional mechanical engineer.
7. Rotordynamic Analysis Level 1:
 - a. Before the equipment is released for manufacture it shall be determined that the equipment/motor structures do not have any harmful resonant frequencies in the lateral and torsional modes. Representative analysis results for identical equipment may be submitted.
 - b. Calculate rotor lateral and torsional and equipment structural components' lateral frequencies with a spreadsheet calculation or finite element analysis software.
 - 1) Equipment structure lateral frequency shall include the motor.
 - 2) Speed changing drive systems (belt, gear) effects on rotational inertia and stiffness shall be incorporated.
 - c. Determine the equipment system components (rotor and structure) resonant frequencies.
 - d. An intersection of an equipment component resonant frequency with the 1x run speed excitation order that occurs within separation margin is unacceptable.
8. Rotordynamic Analysis Level 2:
 - a. Before the equipment and motor are released for manufacture it shall be determined that the equipment/motor structures do not have any harmful critical speeds in the lateral and torsional modes.
 - b. Calculate rotor lateral and torsional and structure lateral frequencies with finite element analysis software.
 - 1) Equipment structure lateral frequency shall include the motor.

- 2) Speed changing drive systems (belt, gear) effects on rotational inertia and stiffness shall be incorporated.
- 3) Rotational inertia of water within the impeller, in the wet well, and inside the equipment structure, e.g., the column of a vertical pump, shall be included in the calculation at both the high level and low level conditions.
- c. Potentially harmful critical speeds shall be investigated further with a forced, damped analysis to determine component stresses do not exceed material properties.
- d. Forced damped analysis:
 - 1) Forced lateral analysis shall include forcing function magnitudes at least 10 percent of rotor disc weight at each disc position and hydraulic imbalance at 5 operating conditions spaced equally over the equipment operating range. If synchronous motors are used ensure that the rotor analysis includes startup, shutdown, and motor control transients.
 - 2) Forced torsional analysis shall include not less than 1 percent of the maximum permitted torque at any given speed. Damping shall be 1 percent of critical at all shaft elements.
 - 3) Equipment rotor total stress (steady-state and alternating torque components plus lateral-bending stresses) shall not exceed:
 - a) Constant torque: Total stress limited to 30 percent of the material fatigue limit and to a maximum of 18 percent of ultimate tensile strength.
 - b) Variable torque (including variable speed equipment): Total stress limited to 50 percent of the material fatigue limit and to a maximum of 4 percent of the material ultimate tensile strength.
 - c) Submit documentation of material fatigue limit.
- e. Report Submittals:
 - 1) Confirmation of compliance with this Section, or detailed exceptions taken.
 - 2) Software used for analysis.
 - 3) Results with interpretation.
 - 4) Preparer's professional engineering stamp and seal.
 - 5) Input data, including component properties, materials and connectivity to other components.
 - 6) Schematic diagram of model mode shapes, nodes and elements.
 - 7) Bearing stiffness and damping properties, impeller/diffuser interaction coefficients, and seal dynamic properties.
 - 8) Campbell diagrams showing the system natural frequencies, excitation orders, and operating speed range for both lateral and torsional analysis.
 - a) Include equipment operating range; excitation lines at 1x, 2x run speed, and vane pass (or equivalent); and critical speeds associated with equipment system components, including the rotor, each major equipment structural component and the motor.
 - 9) Forced, damped analysis indicating acceptable material stress limits are maintained at interference points shown on the Campbell diagram.

9. Rotordynamic Analysis Level 3:
- a. Before the equipment and motor are released for manufacture it shall be determined that the equipment/motor structures do not have any harmful critical speeds in the lateral and torsional modes.
 - b. Calculate rotor lateral and torsional and structure lateral frequencies with finite element analysis software.
 - 1) Equipment structure lateral frequency shall include the motor.
 - 2) Speed changing drive systems (belt, gear) effects on rotational inertia and stiffness shall be incorporated.
 - 3) Rotational inertia of water within the impeller, in the wet well, and inside the equipment structure, e.g., the column of a vertical pump, shall be included in the calculation at both the high level and low level conditions.
 - c. Potentially harmful critical speeds shall be investigated further with a forced, damped analysis to determine component stresses do not exceed material properties.
 - d. Forced damped analysis:
 - 1) Forced lateral analysis shall include forcing function magnitudes at least 10 percent of rotor disc weight at each disc position and hydraulic imbalance at 5 operating conditions spaced equally over the equipment operating range. If synchronous motors are used ensure that the rotor analysis includes startup, shutdown, and motor control transients.
 - 2) Forced torsional analysis shall include 1 percent of the maximum permitted torque at any given speed. Damping shall be 1 percent of critical at all shaft elements.
 - 3) Equipment rotor total stress (steady-state and alternating torque components plus lateral-bending stresses) shall not exceed:
 - a) Constant torque: Total stress limited to 30 percent of the material fatigue limit and to a maximum of 18 percent of ultimate tensile strength.
 - b) Variable torque (including variable speed equipment): Total stress limited to 50 percent of the material fatigue limit and to a maximum of 4 percent of the material ultimate tensile strength.
 - c) Submit documentation of material fatigue limit.
 - e. Report Submittals:
 - 1) Report 1: Executive Summary, including:
 - a) Confirmation of compliance with this Section, or detailed exceptions taken.
 - b) Software used for analysis.
 - c) Results with interpretation.
 - d) Preparer's professional engineering stamp and seal.
 - e) Campbell diagrams showing the system natural frequencies, excitation orders, and operating speed range for both lateral and torsional analysis.
 - (1) Include equipment operating range; excitation lines at 1x, 2x run speed, vane pass (or equivalent), line- and twice-line frequency, motor-pole frequency, torsional harmonics from reciprocating drivers (including up to 6 times operating speed), control pulse frequencies induced by variable frequency drives (VFDs) (with certification from VFD

- f) Report 1 shall not include detailed analysis elements listed for Submittal under Report 2 below, Submittal of full analysis details in Report 1 is unacceptable.
- g) Following Submittal of Report 1, submit Report 2: Detailed Analysis, including responses to comments made on Report 1: Rotor-dynamic Executive Summary.

2) Report 2: Rotor-dynamic detailed analysis, including:

- a) Input data, including component properties, materials and connectivity to other components.
- b) Schematic diagram of model mode shapes, nodes and elements.
- c) Bearing stiffness and damping properties, impeller/diffuser interaction coefficients, and seal dynamic properties.
- d) Forced, damped analysis indicating acceptable material stress limits are maintained at interference points shown on the Campbell diagram.
- e) Synchronous motor information, including time-integration study results showing transient peak stresses at startup, shutdown and motor control transient events. Provide tomographic diagrams, including root and keyway stress concentration locations and the corresponding speeds that result in reported peak stresses.

A. V-belts, sheaves, shaft couplings, chains, sprockets, mechanical variable-speed drives, VFDs, gear reducers, open and enclosed gearing, clutches, brakes, intermediate shafting, intermediate bearings, and U-joints:

1. Rated for 24 hour-a-day continuous service, or for intermittent service with frequent stops-and-starts, whichever is most severe.
2. Sized with a service factor of 1.5 or greater:
 - a. Apply service factor to nameplate horsepower and torque of prime source of power and not to actual equipment loading.
 - b. Apply service factors in accordance with AGMA, or as specified in the Technical Sections.

- A. Oil or grease lubricated, ball or roller antifriction type, of standard manufacture.
 - 1. Design lubrication system based on the equipment location to operate in the temperatures as specified in Section 01_81_50 - Design Criteria.
 - a. To safely start after being shut off for 24 hours and operate safely:
 - 1) Suitable for the outdoor winter temperature as specified in Section 01_81_50 - Design Criteria.

- B. Oil-lubricated:
 - 1. Provide either pressure lubricating system or separate oil reservoir splash-type system as specified in the Technical Section.
 - 2. Design system to safely absorb heat energy generated in bearings when equipment is operating in the following conditions:
 - a. With the highest load and the temperature 15 degrees Fahrenheit above the outdoor summer temperature as specified in Section 01_81_50 - Design Criteria.
- C. Grease lubricated, except those specified to be factory sealed:
 - 1. Fit with easily accessible grease supply, flush, drain, and relief fittings.
 - 2. Lubrication lines and fittings:
 - a. Lines: Minimum 1/4-inch diameter stainless steel tubing.
 - b. Multiple fitting assemblies: Mount fittings together in easily accessible location.
 - c. Use standard hydraulic-type grease supply fittings:
 - 1) Manufacturers: One of the following or equal:
 - a) Alemite.
 - b) Zerk.
- D. Ratings: In accordance with ABMA 9 or ABMA 11 L10 life for bearings rating life of not less than 50,000 hours.

2.04 BELT DRIVES

- A. Sheaves:
 - 1. Separately mounted on bushings by means of at least 3 pull-up bolts or cap tightening screws.
 - 2. When 2 sheave sizes are specified, provide separate belts sized for each set of sheaves.
 - 3. Statically balanced for all; dynamically balanced for sheaves that operate at a peripheral speed of more than 5,500 feet per minute.
 - 4. Key bushings to drive shaft.
- B. Belts:
 - 1. Anti-static type when explosion-proof equipment or environment is specified.
 - 2. When spare belts are specified, furnish 1 spare belt for every different type and size of belt-driven unit:
 - a. Where 2 or more belts are involved, furnish matched sets.
 - b. Identify as to equipment, design, horsepower, speed, length, sheave size, and use.
 - c. Package in boxes labeled with identification of contents.
- C. Manufacturers: One of the following or equal:
 - 1. Dodge, Dyna-V belts with matching Dyna-V sheaves and Taper-Lock bushings.
 - 2. T.B. Woods, Ultra-V belts with matching Sure-Grip sheaves and Sure-Grip bushings.

2.05 FLANGED PIPING CONNECTIONS

- A. Unless specified otherwise in the Technical Sections or indicated on the Drawings, provide flat face flanges.

2.06 ASSEMBLY FASTENERS

- A. Stainless steel, Type 316:
 - 1. Bolts: In accordance with ASTM A193, Grade B8M, Class 2, heavy hex.
 - 2. Nuts: In accordance with ASTM A194, Grade B8M, heavy hex.
 - 3. Washers: Alloy group matching bolts and nuts.

2.07 GUARDS AT HIGH-TEMPERATURE SURFACES

- A. Exposed surfaces having an external surface temperature of 120 degrees Fahrenheit or higher and located within 7 feet, measured vertically from floor or working level, or within 15 inches measured horizontally from stairways, ramps, or fixed ladders.
- B. Cover with a thermal insulating material unless otherwise guarded against contact.
 - 1. Insulation thickness such that the insulation exterior temperature is below 120 degrees Fahrenheit.
 - 2. Insulation Type 3 and cover Type 5 as specified in Section 40_05_06.55 - Piping Insulation.

2.08 GUARDS AT MOVING COMPONENTS

- A. On rotating components that are within 7.5 vertical feet of an operating floor or platform.
- B. Allow visual inspection of moving parts without removal.
- C. Allow access to lubrication fittings.
- D. Easily removable for maintenance.
- E. Prevent entrance of rain or dripping water for outdoor locations.
- F. Size belt and sheave guards to allow for installation of sheaves 15 percent larger and addition of 1 belt.
- G. Materials:
 - 1. Sheet metal: Carbon steel, 12-gauge minimum thickness, hot-dip galvanized after fabrication.
 - 2. Fasteners: Type 316 stainless steel.

2.09 SHOP FINISHES

- A. Manufacturer's standard primer and finish coatings.
 - 1. Primer only if field coatings are to be applied.

2.10 GEAR MOTORS

- A. Parallel shaft drives: Helical gearing.
- B. Right-angle drives: Worm gearing.
- C. Manufacturers: One of the following or equal:
 - 1. Baldor Electric Company.
 - 2. Bodine Electric Company.

2.11 GEAR REDUCTION UNITS

- A. Design and performance criteria:
 - 1. Gear type:
 - a. Helical or herringbone.
 - 2. AGMA Class II service:
 - a. Use more severe service condition when such is recommended by unit's manufacturer.
 - 3. Cast-iron housing with gears running in oil.
 - 4. Anti-friction bearings.
 - 5. Thermal horsepower rating based on maximum horsepower rating of prime mover, not actual load.

2.12 MOUNTING AND LIFTING PROVISIONS FOR EQUIPMENT

- A. Equipment bases and base plates:
 - 1. Provide equipment bases with machined support pads, dowels for alignment for mating of adjacent items, openings for electrical conduits, and openings to facilitate grouting.
 - 2. Provide jacking screws in bases and supports for equipment and for equipment weighing 500 pounds or more.
 - 3. Materials:
 - a. Match equipment material or steel.
 - b. Coating: Match equipment.
- B. Steel support frames:
 - 1. Carbon steel:
 - a. At exterior locations and at interior wet or moist locations, provide continuous welds on both sides to close seams and edges between steel members.
 - b. Grind closure welds smooth.
- C. Lifting lugs or eyes:
 - 1. Equipment units weighing 50 pounds or more:
 - a. Provide with lifting lugs or eyes to allow removal with lifting device.

2.13 NAMEPLATES

- A. Fastened to equipment at factory in an accessible and visible location.
- B. Metal engraved or stamped with text, holes drilled or punched for fasteners.

- C. Material: Aluminum or stainless steel.
- D. Fasteners: Number 4 or larger oval head stainless steel screws or drive pins.
- E. Text:
 - 1. Manufacturer's name, equipment model number, equipment serial number, and identification tag number.
 - 2. Additional items indicated in the Technical Sections.
 - 3. Indicate the following additional information as applicable:
 - a. Maximum and normal rotating speed.
 - b. Service class in accordance with applicable standards.
 - 4. Include for pumps:
 - a. Rated total dynamic head in feet of fluid.
 - b. Rated flow in gallons per minute.
 - c. Impeller, gear, screw, diaphragm, or piston size.
 - 5. Include for motors:
 - a. Drive speed.
 - b. Motor horsepower with rated capacity.
 - 6. Include for gear reduction units:
 - a. AGMA class of service.
 - b. Service factor.
 - c. Input and output speeds.

2.14 PUMP SHAFT COUPLINGS

- A. General:
 - 1. Type and ratings: Non-lubricated designed for not less than 50,000 hours of operating life.
 - 2. Sizes: Provide as recommended by manufacturer for specific application, considering horsepower, speed of rotation, balance, and type of service.
 - 3. Suitable for an ambient temperature range between -40 degrees to +200 degrees Fahrenheit.
- B. Close-couplings for electric-motor-driven equipment:
 - 1. Manufacturers: One of the following or equal:
 - a. Lovejoy.
 - b. T.B. Woods.
 - 2. Provide flexible couplings designed to accommodate angular misalignment, parallel misalignment, and end float.
 - 3. Manufacture flexible component of coupling from synthetic rubber or urethane.
 - 4. Provide service factor of 2.5 for electric motor drives and 3.5 for engine drives.
 - 5. Do not allow metal-to-metal contact between driver and driven equipment.
- C. Flexible couplings for direct connected electric-motor-driven equipment:
 - 1. Manufacturers: One of the following or equal:
 - a. Rexnord.
 - b. T.B. Woods.
 - 2. Provide flexible couplings designed to accommodate shock loading, vibration, and shaft misalignment or offset.
 - 3. Provide flexible connecting element of rubber and reinforcement fibers.

4. Provide service factor of 2.0.
 5. Connect stub shafts through collars or round flanges, firmly keyed to their shafts with neoprene cylinders held to individual flanges by through pins.
- D. Spacer couplings:
1. Where cartridge-type mechanical seals or non-split seals are specified, provide a spacer-type coupling of sufficient length to remove the seal without disturbing the driver or driven equipment.

2.15 PUMP SEAL CHAMBER AND SEALS

- A. Seal chamber (stuffing box):
1. Large enough to retrofit with double mechanical seal.
- B. Seal types: Based on the following and as specified in the Technical Section:
1. Type 1: Packing:
 - a. Provide when specified in the Technical Section for wastewater, non-potable water, and sludge applications:
 - 1) Asbestos free.
 - 2) PTFE (Teflon™) free.
 - 3) Braided graphite.
 - 4) Manufacturers: One of the following or equal:
 - a) Chesterton, 1400.
 - b) John Crane.
 - b. Provide when specified for drinking water service:
 - 1) Asbestos free.
 - 2) Material: Braided PTFE (Teflon™).
 - 3) Manufacturers: One of the following or equal:
 - a) Chesterton, 1725.
 - b) John Crane.
 - c. Design:
 - 1) Packing gland to allow adjustment and repacking without dismantling pump, except to open up stuffing box.
 - 2) Seal chamber (stuffing box) large enough to retrofit with double mechanical seal.
 - 3) Manufacturers: One of the following or equal:
 - a) Chesterton, 1725.
 - b) John Crane.
 2. Type 2: Mechanical seal, flushing, cartridge, single O-ring.
 - a. Manufacturers: One of the following or equal:
 - 1) Chesterton, S10.
 - 2) John Crane, 5610 Series.
 3. Type 3: Mechanical seal, flushing, cartridge, double O-ring:
 - a. Manufacturers: One of the following or equal:
 - 1) Chesterton, S20.
 - 2) John Crane, 5620 Series.
 4. Type 4: Mechanical seal, flushing, cartridge, double split-ring:
 - a. Manufacturers: One of the following or equal:
 - 1) Chesterton, S20.
 - 2) John Crane, 5620 Series.

5. Type 5: Mechanical seal, flushing, cartridge, single split-ring:
 - a. Manufacturers: One of the following or equal:
 - 1) Chesterton, 442.
 - 2) John Crane, 5860.
 6. Type 6: Mechanical seal, flushless, cartridge, single split-ring:
 - a. Manufacturers: One of the following or equal:
 - 1) Chesterton, 156.
 - 2) John Crane, 3740 Series.
- C. Mechanical seals, Types 2 to 6:
1. Balanced hydraulically.
 2. Spring:
 - a. Stationary, out of pumping fluid.
 - b. Material as specified in the Technical Section. Hastelloy C; Type Elgiloy or 17-7 PH stainless steel for split seals.
 3. O-ring: Viton™ 747.
 4. Gland: Type 316L stainless steel.
 5. Set screws: Type 316L stainless steel.
 6. Faces: Reaction bonded, silicon carbide/carbon.
 7. Minimum differential pressures in either direction: 300 pounds per square inch gauge.
 - a. Manufacturers: One of the following or equal:
 - 1) Chesterton, 1400.
 - 2) John Crane, equivalent product.
 8. Drinking water service:
 - a. Asbestos free.
 - b. Material: Braided PTFE (Teflon™).
 - c. Manufacturers: One of the following or equal:
 - 1) Chesterton, 1725.
 - 2) John Crane, equivalent product.
- D. Flushing system:
1. Provide flushing connections:
 - a. 3/4-inch size.
 - b. Provide API 682 seal water plan arrangement as specified in the Technical Section:
 - 1) Plan 11 - Product stream seal water from discharge thru seal.
 - 2) Plan 13 - Product stream seal water through seal to suction.
 - 3) Plan 23 - Closed loop seal water with cooler and pumping ring.
 - 4) Plan 32 - Production seal water discharged to product stream.
 - 5) Plan 54 - Production seal water excluded from product stream.

2.16 SAFETY SIGNS

- A. Material, sign size, and text: As specified in Section 10_14_00 - Signage.

2.17 SHIPPING

- A. Prior to shipment of equipment:
 - 1. Bearings (and similar items):
 - a. Pack separately or provide other protection during transport.
 - b. Greased and lubricated.
 - 2. Gear boxes:
 - a. Oil filled or sprayed with rust preventive protective coating.
 - 3. Fasteners:
 - a. Inspect for proper torques and tightness.

PART 3 EXECUTION

3.01 PRE-INSTALLATION

- A. Field measurements:
 - 1. Prior to Shop Drawings preparation, take measurements and verify dimensions indicated on the Drawings.
 - 2. Ensure equipment and ancillary appurtenances fit within available space.
- B. Sequencing and scheduling:
 - 1. Coordinate details of equipment with other related parts of the Work, including verification that structures, piping, wiring, and equipment components are compatible.
 - 2. Equipment anchoring: Obtain anchoring material and setting drawings from equipment manufacturers in adequate time for templates to be constructed and anchors to be cast-in-place.

3.02 LUBRICATION LINES AND FITTINGS

- A. Support and protect lines from source to point of use.
- B. Fittings:
 - 1. Bring fittings to outside of equipment in manner such that they are readily accessible from outside without necessity of removing covers, plates, housings, or guards.
 - 2. Mount fittings together wherever possible using factory-mounted multiple fitting assemblies securely mounted, parallel with equipment lines, and protected from damage.
 - 3. For underwater bearings: Bring fittings above water surface and mount on edge of structure above.

3.03 ALIGNMENT OF DRIVERS AND EQUIPMENT

- A. Where drive motors or other drivers are connected to driven equipment by flexible coupling, disconnect coupling halves and align driver and equipment after driven equipment has been leveled on its foundation.

- B. Comply with procedures of appropriate HI, AGMA standards, alignment tolerances of equipment manufacturers and the following requirements to bring components into angular and parallel alignment:
 - 1. Maximum total coupling offset (not the per-plane offset): Not to exceed 0.5 mils per inch of coupling length for spacer couplings based on coupling length (not dial separation).
 - 2. Utilize jacking screws, wedges, or shims as recommended by the equipment manufacturer and as specified in the equipment sections.
- C. Use reverse-indicator arrangement dial-type or laser-type alignment indicators:
 - 1. Mount on the driver/coupling flange and equipment/coupling flange.
 - 2. Alignment instrumentation accuracy shall be sufficient to read angular and radial misalignment at 10 percent or less of the manufacturer's recommended acceptable misalignment.
- D. Alignment and calculations shall include measurement and allowance for thermal growth, spacer coupling length, indicator separation, and axial spacing tolerances of the coupling.
- E. When alignment satisfies most stringent tolerance of system components, grout between base and foundation.
 - 1. Allow minimum 48 hours for grout to harden.
 - 2. After grout hardens, remove jacking screws, tighten anchor bolts and other connections, and recheck alignment.
 - 3. Correct alignment as required.

3.04 EQUIPMENT SUPPORT AND ANCHORING TO STRUCTURES

- A. Anchor equipment to structures as indicated on the Drawings and as specified.
- B. Obtain final anchor bolt layouts for equipment prior to:
 - 1. Detailing reinforcement for equipment pads.
 - 2. Preparation of Shop Drawings for metal structures supporting equipment.
- C. Anchor bolt templates:
 - 1. Provide templates as specified in the Technical Sections.
 - 2. Use final anchor bolt layout to construct templates for setting anchor bolts.
 - 3. Make templates:
 - a. Rigid, and non-deformable during use.
 - b. With longitudinal axes of anchors parallel.
 - c. With longitudinal axes of anchors perpendicular to surface supporting the equipment.
 - 4. Templates may be reused for multiple locations of the same equipment only if:
 - a. Templates are in "like-new" condition prior to each reuse.
 - b. Anchor layout has not been deformed or damaged by previous installation, removal, or handling of templates.

- 5. Sequence:
 - a. Set and support templates prior construction of structures surrounding anchors.
 - b. Position anchors in templates to provide designated embedment in supporting structure, with required projection for installation of grout, base plates, and hardware for tightening.
 - c. Construct concrete or masonry around anchors using methods that preserve required anchor positions and alignment, and clearances to edges of supports or structures.
- D. Anchor adjustment sleeves:
 - 1. Use of adjustment sleeves around anchors:
 - a. Is at the option of the Contractor.
 - b. Does not relieve the Contractor of obligation to construct and use templates for setting of anchors.
 - c. May require increased anchor embedment length to develop the strength of the anchor in the embedded length below the adjustment sleeve.
 - 2. Submittal requirements for anchor adjustment sleeves:
 - a. Provide within sufficient time for Engineer approval and not less than 10 working days before setting those items.
 - b. Proposed locations of sleeves.
 - c. Details and dimensions of sleeves.
 - d. Sleeve materials of construction, and coatings.
 - e. Information on sleeve filler material and means of filler removal.
 - f. Type, details, and dimensions of anchor bolts or anchor rods to be used with sleeves.
 - g. Calculations showing development of anchor load capacity below the bottom of the sleeve.
 - h. Plan for removal of sleeve fillers, if any.
 - i. Plan for placement and consolidation of flowable grout inside sleeves and to a level equal to top of concrete slab or equipment pad surrounding the sleeve.

3.05 GROUTING UNDER EQUIPMENT BASES, BASE PLATES, SOLE PLATES, AND SKIDS

- A. General:
 - 1. In accordance with the equipment manufacturer's installation instructions, including:
 - a. Tolerances for level.
 - b. Tolerances for vertical and horizontal alignment.
 - c. Requirements or recommendations for grouting spaces and grout installation.
 - d. Recommendations for tightening of equipment anchors after grout has cured.
 - 2. Install equipment over grout as indicated on the Drawings or specified only after:
 - a. Equipment is leveled and in proper alignment.
 - b. Piping connections are complete and in alignment with no strain transmitted to equipment.

3. Install flowable grout, as specified in Section 03_60_00 - Grouting, placed with forms and head boxes.
 - a. Use flowable, non-shrink cement grout.
 - b. Use flowable, non-shrink epoxy grout, only where indicated on the Drawings, where specified in Technical Sections, or when approved in advance by the Engineer.
 - c. Grouting with dry-pack materials is not permitted.
- B. Prepare equipment bases, base plates, soleplates, and skids for grouting:
 1. Concrete equipment bases:
 - a. Roughen surface in accordance with ICRI, Guideline No. 310.2R, Surface Preparation Profiles CSP-3 and CSP-4.
 - b. Clean roughened concrete surfaces.
 2. Base plates, soleplates, and skids:
 - a. Clean surfaces in accordance with SSPC-SP 1-Solvent Cleaning, to remove dirt, dust, oil, grease, paint, and other material.
- C. Level equipment for grouting:
 1. Use removable jack screws, or removable steel wedges and shims to support and level equipment bases, base plates, sole plates, and skids.
 - a. Do not use leveling nuts placed on equipment anchors to support or level equipment bases, base plates, sole plates, and skids.
 2. Removable jack screws:
 - a. Provide number, size, and locations of jack screws required to support and level equipment in accordance with the manufacturer's recommendations.
 - b. Drill and tap equipment base plates, sole plates, and skids for jack screws.
 - c. Support jack screws on circular steel plates that have been epoxy bonded to the equipment foundation.
 - 1) Provide plates fabricated from Type 316 stainless steel where edges of support plates will have grout side cover of 3 inches or less in the finished Work.
 - d. Make provision for removal of jack screws after grouting:
 - 1) Prevent grout from bonding to jack screws by wrapping jack screw threads that will be in contact with grout with multiple layers of tape or other material acceptable to the Engineer.
 - e. Place and cure grout.
 - f. After grout is placed and cured:
 - 1) Remove jack screws and material used to prevent grout from bonding to jack screws.
 - 2) Provide jack screws to the Owner for future use.
 - 3) Fill jack screw holes with grout.
 - 4) Cure grout as specified.
 3. Removable steel wedges and shims:
 - a. Use for equipment bases, base plates, sole plates, and skids where it is not practical to use jack screws.
 - b. Provide number, size, and locations of wedges and shims required to support and level equipment in accordance with the manufacturer's recommendations.

- c. Make provision for removal of wedges and shims after grouting:
 - 1) Prevent grout from bonding to wedges and shims by wrapping wedges and shims that contact grout with multiple layers of tape or other material acceptable to the Engineer.
 - 2) Locate and orient wedges and shims to allow for removal after grouting, and to facilitate placement of grout in the remaining voids.
 - d. Place and cure grout.
 - e. After grout is placed and cured:
 - 1) Remove wedges and shims, and material used to prevent grout from bonding to them.
 - 2) Fill jack screw holes with grout.
 - 3) Cure grout as specified.
- D. Construct grout forms:
 - 1. Provide forms:
 - a. Rigid with adequate strength to withstand placement of grout.
 - b. With surfaces that will produce a smooth, uniform finish for grout edges exposed in the finished Work.
 - c. That allow grout to flow horizontally beyond the perimeter of the equipment base plate a distance not less than the thickness of the grout, and not less than 1 inch.
 - 2. Install forms:
 - a. Seal form cracks and joints with elastomeric sealant to make form watertight.
 - b. Line form surfaces in contact with grout with polyethylene film, or coat with 2 coats of heavy-duty paste wax.
 - 3. Construct grout "head box" over entire length of one side of form.
 - a. Make head box height sufficient to force grout to flow under full dimensions of equipment base and to the surrounding form faces.
- E. Pre-grouting procedures:
 - 1. Concrete surfaces receiving flowable, non-shrink cement grout:
 - a. Saturate concrete surface in contact with grout and concrete surfaces extending not less than at least 6 inches beyond limits of grout with clean water for a minimum of 24 hours prior to grouting.
 - b. Just prior to grout placement, remove standing water using clean rags or oil-free compressed air. Provide saturated surface dry (SSD) concrete for grout placement.
 - 2. Concrete surfaces receiving flowable, non-shrink epoxy grout:
 - a. Do not saturate concrete prior to grout placement.
- F. Grout placement and curing:
 - 1. Place and cure grout as specified in Section 03_60_00 - Grouting and in this Section.
 - 2. Grouting:
 - a. Keep level of grout in head box above bottom of equipment bases, base plates, sole plates, and skids always to drive flow under base.
 - b. Maintain continuous grout flow from head box to opposite sides of forms without trapping air or forming voids.
 - c. Vibrate, rod, or chain grout to facilitate grout flow, to consolidate grout, and to remove entrapped air.

3. After grout sets, remove forms and trim grout edges at 45-degree angle from bottom edge of equipment bases, base plates, sole plates, and skids.
 4. Cure grout as specified in Section 03_60_00 - Grouting.
- G. After grout is cured:
1. Remove jack screws or wedges and shims, and material used to prevent grout from bonding to leveling devices.
 2. Fill pockets from removed leveling devices with grout.
 3. Cure filled voids as specified in Section 03_60_00 - Grouting.
 4. Tighten equipment anchors in accordance with the equipment manufacturer's requirements.

3.06 FIELD FINISHES

- A. When touchup or repair is required, apply primer and coating systems as recommended by the equipment manufacturer.

END OF SECTION

SECTION 46_05_94

MECHANICAL EQUIPMENT TESTING

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Testing of mechanical equipment and systems.

1.02 REFERENCES

- A. American Gear Manufacturers Association:
 - 1. AGMA 6000-B96 - Specification for Measurement of Linear Vibration on Gear Units.
- B. American National Standards Institute (ANSI):
 - 1. S1.4 - Specification for Sound Level Meters.
- C. Hydraulic Institute (HI).
- D. National Institute of Standards and Technology (NIST).

1.03 SUBMITTALS

- A. Provide Source Test Plans as specified in Section 01_75_17 - Commissioning.
- B. Provide Installation and Functional Testing Plans as specified in Section 01_75_17 - Commissioning.
- C. Operation and maintenance manuals:
 - 1. As specified in Section 01_78_24 - Operation and Maintenance Manuals.
 - 2. Include motor rotor bar pass frequencies for motors larger than 500 horsepower.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 GENERAL

- A. Commissioning of equipment as specified in:
 - 1. This Section.
 - 2. Section 01_75_17 - Commissioning.
 - 3. Equipment sections:
 - a. If testing requirements are not specified, provide Level 1 tests.

- B. Test and prepare piping as specified in Section 40_05_00.09 - Piping Systems Testing prior to equipment testing.
- C. Provide necessary test instrumentation that has been calibrated within 1 year from date of test to recognized test standards traceable to the NIST or approved source.
 - 1. Properly calibrated field instrumentation permanently installed as a part of the Work may be utilized for tests.
 - 2. Prior to testing, provide signed and dated certificates of calibration for test instrumentation and equipment.
- D. Test measurement and result accuracy:
 - 1. Use test instruments with accuracies as recommended in the appropriate referenced standards. When no accuracy is recommended in the referenced standard, use 1 percent or better accuracy test instruments.
 - a. Improved (lower error tolerance) accuracies specified elsewhere prevail over this general requirement.
 - 2. Do not adjust results of tests for instrumentation accuracy.
 - a. Measured values and values directly calculated from measured values shall be the basis for comparing actual equipment performance to specified requirements.

3.02 VARIABLE SPEED EQUIPMENT TESTS

- A. Establish performance over the entire speed range and at the average operating condition.
- B. Establish performance curves for the following speeds:
 - 1. Speed corresponding to the rated maximum capacity.
 - 2. Speed corresponding to the minimum capacity.
 - 3. Speed corresponding to the average operating conditions.

3.03 PUMP TESTS - ALL LEVELS OF TESTING

- A. Test in accordance with the following:
 - 1. Applicable HI standards.
 - 2. This Section.
 - 3. Equipment sections.
- B. Test tolerances: In accordance with appropriate HI standards, except the following modified tolerances apply:
 - 1. From 0 to plus 5 percent of head at the rated design point flow.
 - 2. From 0 to plus 5 percent of flow at the rated design point head.
 - 3. No tolerance for head and flow when ranges are specified.
 - 4. No negative tolerance for the efficiency at the rated design point and other specified conditions.
 - 5. Use of specified test tolerances shall not result in motor overload while operating at any point on the supplied pump operating head-flow curve, including runout.
 - 6. No positive tolerance for vibration limits. Vibration limits and test methods in HI standards do not apply. Use limits and methods specified in this or other sections of the Specifications.

3.04 DRIVERS TESTS

- A. Test motors as specified in Section 26_05_09 - Low Voltage Motors up to 500 Horsepower.
- B. Test other drivers as specified in the equipment section.

3.05 NOISE REQUIREMENTS AND CONTROL

- A. Perform noise tests in conjunction with vibration test analysis.
- B. Make measurements in relation to reference pressure of 0.0002 microbar.
- C. Make measurements of emitted noise levels on sound level meter meeting or exceeding ANSI S1.4, Type II.
- D. Set sound level meter to slow response.
- E. Unless otherwise specified, maximum free field noise level not to exceed 85 dBA measured as sound pressure level at 3 feet from the equipment.

3.06 PRESSURE TESTING

- A. Hydrostatically pressure test pressure containing parts at the appropriate standard or code required level above the equipment component specified design pressure or operating pressure, whichever is higher.

3.07 INSPECTION AND BALANCING

- A. Statically and dynamically balance each of the individual rotating parts as required to achieve the required field vibration limits.
- B. Statically and dynamically balance the completed equipment rotating assembly and drive shaft components.
- C. Furnish copies of material and component inspection reports, including balancing reports for equipment system components and for the completed rotating assembly.
- D. Critical speed of rotating equipment:
 - 1. Satisfy the following:
 - a. The first lateral and torsional critical speed of all constant, variable, and 2-speed driven equipment that is considered rigid such as horizontal pumps, non-clog pumps, blowers, air compressors, and engines shall be at least 25 percent above the equipment's maximum operating speed.

- b. The first lateral and torsional critical speed of all constant, variable, and 2-speed driven equipment that is considered flexible or flexibly mounted such as vertical pumps (vertical in-line and vertical non-clog pumps excluded) and fans shall be at least 25 percent below the equipment's lowest operating speed.
 - c. The second lateral and torsional critical speed of all constant, variable, and 2-speed equipment that is considered flexible or flexibly mounted shall be at least 25 percent above the maximum operating speed.
- E. Vibration tests:
 - 1. Definitions:
 - a. Root mean square: For pumps operating at speeds greater than 600 revolutions per minute (rpm), the vibration measurement shall be measured as the overall velocity in inches per second root mean square (RMS).
 - b. Peak-to-peak displacement: The root means squared average of the peak-to-peak displacement multiplied by the square root of 2.
 - c. Peak velocity: The root mean squared average of the peak velocity multiplied by the square root of 2.
 - d. Peak acceleration: The root mean squared average of the peak acceleration multiplied by the square root of 2.
 - e. High-frequency enveloping: A process to extract very low amplitude time domain signals associated with impact or impulse events such as bearing or gear tooth defects and display them in a frequency spectrum of acceleration versus frequency.
 - 1) Manufacturers: One of the following or equal:
 - a) CSI, PeakVue.
 - b) Rockwell Automation, Entek Group, Spike Energy analysis.
 - f. Rotor bar pass frequency (RBF): For detecting loose rotor bars.
 - g. Low speed equipment: Equipment or components of equipment rotating at less than 600 rpm.
 - h. High speed equipment: Equipment and equipment components operating at or above 600 rpm.
 - i. Preferred operating range: Manufacturer's defined preferred operating range (POR) for the equipment.
 - j. Allowable operating range: Manufacturer's defined allowable operating range (AOR) for the equipment.
 - 2. Vibration instrumentation requirements:
 - a. Analyzers: Use digital type analyzers or data collectors with anti-aliasing filter, 12-bit A/D converter, fast Fourier transform circuitry, phase measurement capability, time wave form data storage, high-frequency enveloping capabilities, 35 frequency ranges from 21 to 1,500,000 cycles per minute, adjustable fast Fourier transform resolution from 400 to 6,400 lines, storage for up to one hundred 3,200 line frequency spectra, data output port, circuitry for integration of acceleration data to velocity or double integration to displacement.
 - 1) Manufacturers: One of the following or equal:
 - a) Computational Systems Inc., (CSI) Division of Emerson Process Management, Model 2120A, Data Collector/analyzer with applicable analysis software.
 - b) Pruftechnik, VIBXPERT II.

- b. Analyzer settings:
 - 1) Units: English, inches/second, mils, and gravitational forces.
 - 2) Fast Fourier transform lines: Most equipment 1,600 minimum; for motors, enough lines as required to distinguish motor current frequencies from rotational frequencies, use 3,200 lines for motors with a nominal speed of 3,600 rpm; 3,200 lines minimum for high-frequency enveloping; 1,600 lines minimum for low-speed equipment.
 - 3) Sample averages: 4 minimum.
 - 4) Maximum frequency (Fmax): 40 times rotational frequency for rolling element bearings, 10 times rotational frequency for sleeve bearings.
 - 5) Amplitude range: Auto select but full scale not more than twice the acceptance criteria or the highest peak, whichever is lower.
 - 6) Fast Fourier transform windowing: Hanning window.
 - 7) High pass filter: Minus 3 dB at 120 cycles per minute for high-speed equipment. Minus 3 dB at 21 cycles per minute for low-speed equipment.
- c. Accelerometers:
 - 1) For low-speed equipment: Low frequency, shear mode accelerometer, 500 millivolts per gravitational force sensitivity, 10 gravitational force range, plus/minus 5 percent frequency response from 0.5 hertz to 850 hertz, magnetic mount.
 - a) Manufacturers: One of the following or equal:
 - (1) PCB, Model 393C.
 - (2) Wilcoxon Research, Model 797L.
 - 2) For high-speed equipment: General purpose accelerometer, 100 millivolts per gravitational force sensitivity, 50 gravitational force range, plus/minus 3 dB frequency response range from 2 hertz to 12,000 hertz when stud mounted, with magnetic mount holder.
 - a) Manufacturers: One of the following or equal:
 - (1) Entek-IRD, Model 943.
 - (2) Wilcoxon Research, Model 793.
3. Accelerometer mounting:
 - a. Use magnetic mounting or stud mounting.
 - b. Mount on bearing housing in location with best available direct path to bearing and shaft vibration.
 - c. Remove paint and mount transducer on flat metal surface or epoxy mount for high-frequency enveloping measurements.
4. Vibration acceptance criteria:
 - a. Testing of rotating mechanical equipment: Tests are to be performed by an experienced, factory trained, and independent authorized vibration analysis expert.
 - b. Vibration displacement limits: Unless otherwise specified, equipment operating at speeds 600 rpm or less is not to exhibit unfiltered readings in excess of the following:

Operating Conditions and Application Data	Overall Peak-to-Peak Displacement	
	Field (mils)	Factory (mils)
Operation within the POR	3.0	4.0
Operation within the AOR	4.0	5.0

Operating Conditions and Application Data	Overall Peak-to-Peak Displacement	
	Field (mils)	Factory (mils)
Additive value when measurement location is greater than 5 feet above foundation.	2.0	2.0
Additive value for solids-handling pumps	2.0	N/A
Additive value for slurry pumps	2.0	N/A

- c. Vibration velocity limits: Unless otherwise specified, is not to exceed the following peak velocity limits:

HI Pump Type	Horsepower	Field Test	Factory Test
		Overall RMS	Overall RMS
Horizontal Solids Handling Centrifugal Pumps	Below 33 hp	0.25	0.28
	Between 33 and 100 hp	0.28	0.31
	100 hp and above	0.31	0.34
Vertical Solids Handling Centrifugal Pumps	Below 33 hp	0.30	0.33
	Between 33 and 100 hp	0.32	0.35
	100 hp and above	0.34	0.37
Submersible Pumps (Dry or Wet Pit Configuration)	Vibration velocity limits shall not exceed the peak velocity limits in HI 9.6.4		
Vertical Turbine, Mixed Flow, and Propeller Pumps (solids-handling type pumps)	Below 268 hp	0.20	0.26
	268 hp and above	0.26	0.32
Non-Solids Handling Centrifugal Pumps HI Types BB1, BB2, BB3, BB4, BB5, OH1, OH2, OH3, OH4, OH5, and OH7	Below 268 hp	0.15	0.19
	268 hp and above	0.19	0.22
Vertical Turbine, Mixed Flow, and Propeller Pumps HI Types VS1, VS2, VS3, VS4, VS5, VS6, VS7, and VS8	Below 268 hp	0.13	0.17
	268 hp and above	0.17	0.21
Slurry Pumps	All	0.25	0.30
Motors	All	See applicable motor Specification	See applicable motor Specification
Gear Reducers, Radial	All	Not to exceed AGMA 6000-B96 limits	Not to exceed AGMA 6000-B96 limits
Other Reducers, Axial	All	0.1	N/A

- d. Equipment operation: Measurements are to be obtained with equipment installed and operating within capacity ranges specified and without duplicate equipment running.

- e. Additional criteria:
 - 1) No narrow band spectral vibration amplitude components, whether sub-rotational, higher harmonic, or synchronous multiple of running speed, are to exceed 40 percent of synchronous vibration amplitude component without the manufacturer's detailed verification of origin and ultimate effect of such excitation.
 - 2) The presence of discernable vibration amplitude peaks in test Level 2 or 3 vibration spectra at bearing inner or outer race frequencies shall be cause for rejection of the equipment.
 - 3) For motors, the following shall be cause for rejection:
 - a) Stator eccentricity evidenced by a spectral peak at 2 times electrical line frequency that is more than 40 percent of the peak at rotational frequency.
 - b) Rotor eccentricity evidenced by a spectral peak at 2 times electrical line frequency with spectra side bands at the pole pass frequency around the 2 times line frequency peak.
 - c) Other rotor problems evidenced by pole pass frequency side bands around operating speed harmonic peaks or 2 times line frequency side bands around rotor bar pass frequency or around 2 times the rotor bar pass frequency.
 - d) Phasing problems evidenced by 1/3 line frequency side band spectral peaks around the 2 times electrical line frequency peak.
 - 4) The presence of peaks in a high-frequency enveloping spectra plot corresponding to bearing, gear or motor rotor bar frequencies or harmonics of these frequencies shall be cause for rejection of the equipment; since inadequate lubrication of some equipment may be a cause of these peaks, lubrication shall be checked, corrected as necessary and the high-frequency envelope analysis repeated.
- 5. Vibration testing results presentation:
 - a. Provide equipment drawing with location and orientation of measurement points indicated.
 - b. For each vibration measurement take and include appropriate data on equipment operating conditions at the time vibration data is taken; for pumps, compressors, and blowers record suction pressure, discharge pressure, and flow.
 - c. When vibration spectra data required:
 - 1) Plot peak vibration velocity versus frequency in cycles per minute.
 - 2) Label plots showing actual shaft or part rotation frequency, bearing inner and outer race ball pass frequencies, gear mesh frequencies and relevant equipment excitation frequencies on the plot; label probable cause of vibration peaks whether in excess of specification limits or not.
 - 3) Label plots with equipment identification and operating conditions such as tag number, capacity, pressure, driver horsepower, and point of vibration measurement.
 - 4) Plot motor spectra on a log amplitude scale versus frequency.
 - d. For low-speed equipment, plot peak vibration displacement versus frequency as well as velocity versus frequency.
 - e. Provide name of the manufacturer and model number of the vibration instrumentation used, including analyzer and accelerometer used together with mounting type.

3.08 TESTING LEVELS

A. Level 1 tests:

1. Level 1 Performance Test:

a. General:

- 1) For equipment, operate, rotate, or otherwise functionally test for 15 minutes minimum after components reach normal operating temperatures.
- 2) Operate at rated design load conditions.
- 3) Confirm that equipment is properly assembled.
- 4) Confirm the equipment moves or rotates in the proper direction.
- 5) Confirm shafting, drive elements, and bearings are installed and lubricated in accordance with proper tolerances.
- 6) Confirm that no unusual power consumption, lubrication temperatures, bearing temperatures, or other conditions are observed.

b. Pumps:

- 1) In accordance with general performance test requirements as specified in this Section.
- 2) Measure flow and head while operating at or near the rated condition; for factory testing, testing may be at reduced speeds with flow and head corresponding to the rated condition when adjusted for speed using the appropriate affinity laws.
 - a) Use of a test driver is permitted for factory tests when actual driver is given a separate test at its point of manufacture as specified in Section 26_05_09 - Low Voltage Motors up to 500 Horsepower, or the applicable equipment section.
 - b) Use actual driver for field tests.
- 3) Record measured flow, suction pressure, discharge pressure, and make observations on bearing temperatures and noise levels.

2. Level 1 Vibration Test:

a. Test requirement:

- 1) Measure filtered vibration spectra versus frequency in 3 perpendicular planes at each normally accessible bearing housing on the driven equipment, any gears and on the driver; 1 plane of measurement to be parallel to the axis of rotation of the component.
- 2) Vibration spectra versus frequency shall be in accordance with vibration acceptance criteria.

b. Equipment operating condition: Test at specified maximum speed.

3. Level 1 Noise Test:

- a. Measure unfiltered overall A-weighted sound pressure level in dBA at 3 feet horizontally from the surface of the equipment and at a mid-point of the equipment height.

B. Level 2 tests:

1. Level 2 Performance Test:

a. General:

- 1) For equipment, operate, rotate, or otherwise functionally test for at least 2 hours after components reach normal operating temperatures.
- 2) Operate at rated design load conditions.
- 3) Confirm that equipment is properly assembled.
- 4) Confirm the equipment moves or rotates in the proper direction.

- 5) Confirm shafting, drive elements, and bearings are installed and lubricated in accordance with proper tolerances.
- 6) Confirm that no unusual power consumption, lubrication temperatures, bearing temperatures, or other conditions are observed.
- b. Pumps:
 - 1) In accordance with general performance test requirements as specified in this Section.
 - 2) Test 2 hours minimum for flow and head at the rated condition; for factory testing, testing may be at a reduced speeds with flow and head corresponding to the rated condition when adjusted for speed using the appropriate affinity laws.
 - a) Use of a test driver is permitted for factory tests when actual driver is given a separate test at its point of manufacture as specified in Section 26_05_09 - Low Voltage Motors up to 500 Horsepower.
 - b) Use actual driver for field tests.
 - 3) Test for flow and head at 2 additional conditions; one at 25 percent below the rated flow and one at 10 percent above the rated flow.
 - 4) Record measured flow, suction pressure, discharge pressure, and observations on bearing temperatures and noise levels at each condition.
2. Level 2 Vibration Test:
 - a. Test requirement:
 - 1) Measure filtered vibration spectra versus frequency and measure vibration phase in 3 perpendicular planes at each normally accessible bearing housing on the driven equipment, any gears and on the driver; 1 plane of measurement to be parallel to the axis of rotation of the component; measure actual rotational speeds for each vibration spectra measured using photometric or other tachometer input connected directly to the vibration data collector.
 - 2) Vibration spectra versus frequency shall be in accordance with vibration acceptance criteria.
 - b. Equipment operating condition: Repeat test requirements at design specified maximum speed and at minimum speed for variable speed equipment.
 - c. Natural frequency test of field installed equipment:
 - 1) Excite the installed equipment and support system in 3 perpendicular planes, use same planes as operating vibration measurement planes, and determine the as-installed natural resonant frequency of the driven equipment, the driver, gears, and supports.
 - 2) Perform test at each bearing housing, at each support pedestal, and for pumps on the suction and discharge piping.
 - 3) Perform with equipment and attached piping full of intended service or process fluid.
3. Level 2 Noise Test:
 - a. Measure filtered A-weighted overall sound pressure level in dBA for each of 8 octave band mid-points beginning at 63 hertz, measured at 3 feet horizontally from the surface of the equipment at mid-point height of the noise source.

C. Level 3 tests:

1. Level 3 Performance Tests:

a. General:

- 1) For equipment, operate, rotate, or otherwise functionally test for at least 4 hours after components reach normal operating temperatures.
- 2) Operate at rated design load conditions for 1/2 the specified time; operate at each of any other specified conditions for a proportionate share of the remaining test time.
- 3) Confirm that equipment is properly assembled.
- 4) Confirm the equipment moves or rotates in the proper direction.
- 5) Confirm shafting, drive elements, and bearings are installed and lubricated in accordance with proper tolerances.
- 6) Confirm that no unusual power consumption, lubrication temperatures, bearing temperatures, or other conditions are observed.
- 7) Take appropriate capacity, power or fuel consumption, torque, revolutions per minute, pressure, and temperature readings using appropriate test instrumentation to confirm equipment meets specified performance requirements at the design rated condition.
- 8) Bearing temperatures: During maximum speed or capacity performance testing, measure and record the exterior surface temperature of each bearing versus time.

b. Pumps:

- 1) In accordance with general performance test requirements as specified in this Section.
- 2) Test 4 hours minimum for flow and head; begin tests at or near the rated condition; for factory and field-testing, test at full speed.
 - a) Use of a test driver is permitted for factory tests when actual driver is given a separate test at its point of manufacture as specified in Section 26_05_09 - Low Voltage Motors up to 500 Horsepower.
 - b) Use actual driver for field tests.
- 3) Test each specified flow and head condition at the rated speed and test at minimum as well as maximum specified speeds; operate at each test condition for a minimum of 15 minutes or longer as necessary to measure required performance, vibration, and noise data at each test condition.
- 4) Record measured shaft revolutions per minute, flow, suction pressure, discharge pressure; record measured bearing temperatures (bearing housing exterior surface temperatures may be recorded when bearing temperature devices are not required by the equipment section) and record observations on noise levels.
- 5) Perform efficiency and/or net positive suction head required (NPSHr) and/or priming time tests when specified in the equipment section in accordance with the appropriate HI standard and as follows:
 - a) Perform NPSHr testing at maximum rated design speed, head and flow with test fluids at ambient conditions; at maximum rated speed, test at 15 percent above rated design flow, and 25 percent below rated design flow.

- b) Perform efficiency testing with test fluids at maximum rated speed.
 - c) Perform priming time testing with test fluids at maximum rated speed.
 - 2. Level 3 Vibration Test:
 - a. Requirements: Same as Level 2 vibration test, except data taken at each operating condition tested and with additional requirements below.
 - b. Perform high-frequency enveloping analysis for gears and bearings.
 - 1) Measure bearing element vibration directly on each bearing cap in a location close as possible to the bearing load zone that provides a smooth surface and direct path to the bearing to detect bearing defects.
 - 2) Report results in units of acceleration versus frequency in cycles per minute.
 - c. Perform time wave form analysis for gears, low speed equipment and reciprocating equipment; plot true peak amplitude velocity and displacement versus time and label the period between peaks with the likely cause of the periodic peaks (relate the period to a cause).
 - d. Plot vibration spectra on 3 different plots; peak displacement versus frequency, peak acceleration versus frequency and peak velocity versus frequency.
 - 3. Level 3 Noise Test:
 - a. Measure filtered, un-weighted overall sound pressure level in dB at 3 feet horizontally from the surface of the equipment at mid-point height and at 4 locations approximately 90 degrees apart in plain view: report results for each of 8 octave band mid-points beginning at 63 hertz.
- D. Level 4 tests:
 - 1. Level 4 Performance Test:
 - a. General:
 - 1) For equipment, operate, rotate, or otherwise functionally test for at least 8 hours after components reach normal operating temperatures.
 - 2) Operate at rated design load conditions for 1/2 the specified time; operate at each of any other specified conditions for a proportionate share of the remaining test time.
 - 3) Confirm that equipment is properly assembled.
 - 4) Confirm the equipment moves or rotates in the proper direction.
 - 5) Confirm shafting, drive elements, and bearings are installed and lubricated in accordance with proper tolerances.
 - 6) Confirm that no unusual power consumption, lubrication temperatures, bearing temperatures, or other conditions are observed.
 - 7) Take appropriate capacity, power or fuel consumption, torque, revolutions per minute, pressure and temperature readings, using appropriate test instrumentation to confirm equipment meets specified performance requirements at the design rated condition.
 - 8) Bearing temperatures: During maximum speed or capacity testing, measure and record the exterior surface temperature of each bearing versus time.
 - b. Pumps:
 - 1) In accordance with general performance test requirements as specified in this Section.

- 2) Test 8 hours minimum for flow and head; begin tests at or near the rated condition; for factory and field-testing, test with furnished motor at full speed.
 - 3) Test each specified flow and head condition at the rated speed and test at minimum as well as maximum specified speeds; operate at each test condition for a minimum of 20 minutes or longer as necessary to measure required performance, vibration, and noise data at each test condition.
 - 4) Record measured shaft revolutions per minute, flow, suction pressure, discharge pressure; record measured bearing temperatures (bearing housing exterior surface temperatures may be recorded when bearing temperature devices not required by the equipment section) and record observations on noise levels.
 - 5) Bearing temperatures: During maximum speed or capacity testing, measure and record the exterior surface temperature of each bearing versus time.
 - 6) Perform efficiency and/or NPSHr and/or priming time tests when specified in the equipment section in accordance with the appropriate HI standard and as follows:
 - a) Perform NPSHr testing at maximum rated design speed, head and flow with test fluids at ambient conditions; at maximum rated speed, test at 15 percent above rated design flow, and 25 percent below rated design flow.
 - b) Perform efficiency testing with test fluids at maximum rated speed.
 - c) Perform priming time testing with test fluids at maximum rated speed.
2. Level 4 Vibration Test: Same as Level 3 Vibration Test.
 3. Level 4 Noise Test: Same as Level 3 Noise Test, except with data taken at each operating condition tested.

END OF SECTION