



City of Thornton
CIP 23-150
BMcD Project No. 162116

5MG Zone 1 Treated Water Storage Tank and Pipeline

Technical Specifications

ISSUED FOR BID

October 2024



TABLE OF CONTENTS
Technical Specifications
City of Thornton

Division 00	BID AND CONTRACT DOCUMENTS
00 01 07	Index and Certification Page
Division 01	GENERAL REQUIREMENTS
01 11 00	Summary of Work
01 29 00	Payment Procedures
01 31 00	Project Coordination and Meetings
01 32 33	Construction Photographs
01 43 33	Manufacturer's Field Services
01 51 00	Temporary Utilities and Facilities
01 52 00	Field Offices and Sheds
01 60 00	Product Requirements
Division 03	CONCRETE
03 10 00	Concrete Formwork
03 20 00	Concrete Reinforcing
03 30 00	Concrete
03 30 05	Void Forms
Division 05	METALS
05 05 19	Post-Installed Anchors
05 13 00	Stainless Steel Fabrications
05 45 00	Aluminum
Division 06	WOOD AND PLASTICS
06 82 00	Fiberglass Reinforced Plastic Products and Fabrications
Division 07	THERMAL AND MOISTURE PROTECTION
07 14 00	Sheet Waterproofing
Division 08	OPENINGS
08 31 13	Access Doors and Frames
Division 09	FINISHES
09 90 00	Protective Coatings
09 90 05	Steel Pipe Polyurethane Coating
Division 13	SPECIAL CONSTRUCTION
13 21 18	Ground-Level AWWA D115 Post-Tensioned Concrete Water Storage Tank
13 21 19	Ground-Level AWWA D110 Prestressed Concrete Water Storage Tank
13 21 20	Water Storage Reservoir Cleaning, Disinfection, and Testing
Division 26	ELECTRICAL
26 00 00	General Electrical Requirements

TABLE OF CONTENTS
Technical Specifications
City of Thornton

26 05 19	Low-Voltage Electrical Conductors and Cables
26 05 26	Grounding and Bonding for Electrical Systems
26 05 29	Hangers and Supports for Electrical Systems
26 05 33	Raceways, Boxes, Seals, and Fittings for Electrical Systems
26 05 43	Underground Duct Banks and Handholes
26 05 44	Sleeves and Sleeve Seals for Electrical Raceways and Cabling
26 05 53	Identification for Electrical Systems
26 24 16	Panelboards
26 27 26	Wiring Devices
26 42 13	Passive Cathodic Protection for Underground and Submerged Piping
26 50 00	Lighting
 Division 28	 ELECTRONIC SAFETY AND SECURITY
28 10 00	Electronic Access Control and Intrusion Detection
 Division 31	 EARTHWORK
31 20 00	Site Preparation and Earthwork
31 23 13	Subgrade Preparation
31 23 16	Excavation, Filling and Backfilling for Structures
31 23 13.26	Rock Removal
31 23 33.13	Trenching and Backfilling for Utilities
31 73 00	Contact Grouting
31 75 00	Construction Shafts
 Division 32	 EXTERIOR IMPROVEMENTS
32 11 23	Crushed Aggregate Base Course
 Division 33	 UTILITIES
33 05 07.23	Utility Boring and Jacking
33 05 16	Utility Structures
33 05 97	Utility Identification
33 11 20	Hydrodynamic Mixing System
33 12 16	Electrical Motor Actuators
33 14 11	Water Utility Transmission Piping
33 14 26	Waterline Accessories
 Division 40	 PROCESS INTEGRATION
40 27 02	Process Valves and Operators
40 66 00	Process Control Networks
40 67 00	Process Control Panels and Hardware
40 70 00	Instrumentation for Process Systems

CLIENT NAME: City of Thornton, Colorado
 PROJECT NAME: 5MG Zone 1 Treated Water Storage Tank and Pipeline
 CITY PROJECT NO.: 23-150
 BMcD PROJECT NO.: 162116

DOCUMENT 00 01 07 – INDEX AND CERTIFICATION PAGE

SPECIFICATION INDEX

DOCUMENT/ DIVISION	DESCRIPTION	NUMBER OF PAGES
00	Bid and Contract Documents	-
01	General Requirements	46
03	Concrete	30
05	Metals	14
06	Wood, Plastics, and Composites	4
07	Thermal and Moisture Protection	5
08	Openings	4
09	Finishes	21
13	Special Construction	36
26	Electrical	132
28	Electronic Safety and Security	9
31	Earthwork	41
32	Exterior Improvements	8
33	Utilities	84
40	Process Integration	44

CERTIFICATION(S)

INDEX-1

DIVISION 1 - GENERAL REQUIREMENTS

SECTION 01 11 00 - SUMMARY OF WORK

PART 1 - GENERAL

1.01 SUMMARY:

- A. This Section summarizes the Work covered in detail in the complete Contract Documents.
- B. For related items, see the General Conditions and Special Conditions in the Contract Documents.
- C. Owner: The City of Thornton, 9500 Civic Center Drive, Thornton Colorado, 80229.
 - 1. Contract Identification:
 - a. 23-150: 5 MG Zone 1 Treated Water Storage Tank and Pipeline
 - 2. Work Site Location:
 - a. The 5MG Tank is located 500 feet north of E 140th Ave and Dexter St in Thornton, Colorado on an existing parcel owned by the City of Thornton. The tank inlet and outlet waterline will tie into the existing Hilltop Tank inlet and suction waterlines located near Homestead Hills Park. The overflow waterline for the 5MG tank will tie into an existing storm manhole located at Dexter St and E 139th Ave.
- D. Engineer: The Contract Documents were prepared by Burns & McDonnell Engineering Company, Inc.

1.02 PROJECT DESCRIPTION:

- A. The Contract provides for the construction of one (1) fully buried five-million-gallon (5MG) concrete treated water storage tank and includes a tank mixing system, access hatches, ladders, and venting. Additional ancillary items which are part of the Work include, but are not limited to: erosion control, site grading, earthwork, inlet and outlet piping, bypass piping, overflow piping, drain piping, temporary and permanent access roads, fencing, miscellaneous yard piping, valves, vaults, and electrical equipment.
 - 1. The 5MG concrete tank shall be either AWWA D110-Type III prestressed concrete water storage tank or AWWA D115 post tensioned concrete water storage tank.
- B. All Work, whether indicated specifically or not, shall be for a fully functioning and complete treated water storage tank system and facility.

1.03 RELATED REQUIREMENTS:

- A. For measurement and payment: SECTION 01 29 00 and General Conditions, Section XIV.

1.04 CONTRACTOR'S USE OF PREMISES:

- A. Limited Use:
 - 1. Confine operations to areas within the Owner's property limits indicated.
 - 2. Coordinate with Owner to avoid interference of operations.
 - 3. Conduct operations so as to ensure the least inconvenience to Owner and surrounding neighboring property owners.

SECTION 01 11 00 - SUMMARY OF WORK: continued

4. Contractor shall coordinate construction with landowners and businesses and adhere to provisions described below during construction:
 - a. Tank work area has a single construction access and Contractor should access and construct only within Owner's parcel, right-of-way, temporary easement, and permanent easement boundaries as shown on the construction drawings.
 - b. Contractor shall be responsible for maintaining paved, gravel, and dirt access roads to the sites and on the sites, which are impacted by construction activities.
 - c. Landowners and Businesses shall be provided written notification a minimum of one (1) week before mobilization, land disturbance, or construction is to take place near the property. The notification shall include but not be limited to the following.
 - (1) Schedule of work
 - (2) Diagram of what properties will be impacted
 - (3) Sequence of work
 - (4) Detours and alternate routes
 5. Parking for project-related vehicles is not permitted outside of the Project limits at any time. Contractor to provide adequate parking space within the Project limits for project-related vehicles.
 6. Temporary Construction easements:
 - a. Are provided as indicated on the Contract Drawings for site access. Construction traffic shall be routed through the temporary construction access and easement.
- 1.05 WORK AREA LIMITS:
- A. The Contractor shall be limited to working in road right-of-way, utility easements, and City of Thornton property unless otherwise shown on the Contract Drawings.
 - B. The Contractor shall not allow work-related vehicles such as haul trucks, material deliveries, concrete trucks, etc. to park, stand, stage, or remain idle outside of Project limits outside of the hours listed below, Monday through Friday.
 1. This condition shall be inclusive of all slab pours when many concrete trucks are expected.
 2. The Contractor shall plan, route, stage, and coordinate his operations and the operations of his suppliers/vendors so that trucks are not stacked/staged/or standing outside of the Project Limits outside of the hours listed.
 - C. The Contractor shall confine all work including staging and lay down to within the Project limits owned by the City of Thornton.
 - D. The Contractor shall make arrangements with adjacent private landowners for the storage of equipment and materials if needed. Any such arrangements must be confirmed with a written statement from the landowner and a copy must be provided to the Owner for review and approval.
 - E. The Contractor shall maintain access to all roadways and private driveways at all times. No extra payment will be allowed for maintenance of access, any traffic control, or other required permits. All such items shall be accounted for in the Contractor's bid.

SECTION 01 11 00 - SUMMARY OF WORK: continued

- F. Any arrangement or requirements for additional storage/stockpiling/or staging area required by the Contractor shall be secured by the Contractor at no additional cost to the Owner.
- G. The Contractor shall protect all vegetation outside of the Project limits and shall be liable for replacement of any vegetation damaged by construction activities.
- H. All areas outside of the construction site shall be returned to their original conditions as determined by the Owner and prior to any final payment being made.

1.06 WORKDAYS AND HOLIDAYS

- A. Constructive efforts shall be limited to Monday through Friday. No work shall be installed or scheduled on Saturday without approval by the Owner.
 - 1. Work may be allowed on Saturday only at the written approval of the Owner.
- B. No work will be allowed on Sundays.
- C. The following holidays shall be observed by the Contractor. No work shall be schedule, planned, executed, or progressed on the following days:

New Year's Day	January 1 st
Martin Luther King, Jr. Day	3 rd Monday in January
Presidents' Day	3 rd Monday in February
Memorial Day	Last Monday in May
Juneteenth	June 19 th
Independence Day	July 4 th
Labor Day	1 st Monday in September
Veterans Day	November 11 th
Thanksgiving Day	4 th Thursday in November
Thanksgiving Friday	Friday following Thanksgiving Day
Christmas Day	December 25 th

1.07 WORK TIMES:

- A. The Contractor shall limit work hours to 8:00 AM to 5:00 PM Monday through Friday.
- B. After hour and weekend work shall be coordinated with the Owner, the Engineer, and Contractor will be subject to reimbursement to the Owner for observation time associated with such after-hour work and weekend work. All after-hour or weekend work must first be request and approved by the Owner.

1.08 SITE ACCESS:

- A. Access to the Project site shall be through the temporary access road.
 - 1. Access through or along other driveways (e.g. Homestead Hills Park) or other property is forbidden.
 - 2. Contractors bid shall include necessary costs to restore the site access to existing or better condition after construction. This shall include all work, labor, and equipment necessary to protect, restore, rehabilitate, or replace any damaged landscaping or hardscaping. Contractor's bid shall also include all necessary costs to maintain the roadways during construction as needed, and upon request by the Owner.

SECTION 01 11 00 - SUMMARY OF WORK: continued

1.09 OWNER'S USE OF PREMISES:

- A. Full Owner Occupancy: Cooperate with the Owner during construction operations to minimize conflicts and facilitate Owner usage. Perform the Work so as not to interfere with the Owner's operations.

1.10 WORK SEQUENCE:

- A. General: Construction sequence shall be determined by Contractor subject to Owner's need for continuous operation of existing facilities.
- B. Contractor shall Schedule the Work to conform to the following events and dates in addition to those specified in the General Conditions and Special Conditions:
 - 1. The Contractor is required to perform the tie ins to the existing Hilltop Tank pipelines when Hilltop Tank is offline during non-peak demand months (generally October to April) and have completed before the City of Thornton intends to bring Hilltop Tank online.
 - 2. The Contractor is required to perform the construction of the overflow line along Dexter St. as well as the connection to the existing storm manhole during the summer months when school is not in session.
 - a. Project is within Adams 12 Five Star Schools Boundary. Summer generally runs June 1 to August 14, but shall be confirmed during schedule development and scheduling for work activities.
- C. Continuous Service of Existing Facilities: Exercise caution and schedule operations to ensure that functioning of present facilities will not be disrupted. Shutdown of Owner's operating facilities to perform the Work shall be held to a minimum length of time and shall be coordinated with Owner who shall have control over the timing and schedules of such shutdowns.
 - 1. Contractor activities that result in the unplanned shutdown or disruption of the Owner's operating facilities which impedes the Owner's ability to maintain continuous service shall be subject to liquidated damages.
- D. In the event that the connections to the Hilltop Tank infrastructure exceed the allowed time, the Contractor shall be responsible for any additional costs incurred by the Owner as a result of that time period being exceeded. Such expenses may include, but are not limited to:
 - 1. Additional personnel costs incurred by the Owner as a result of that time period being exceeded.
 - 2. Additional costs incurred by the Owner to rent equipment necessary as a result of the Contractor's failure to complete the work within the allotted time.
 - 3. Penalties imposed on the Owner by any regulatory agency, which penalties were incurred by reason of a plant failure attributed in whole or part to the delay in completion of the connections.
 - 4. Owner may withhold from the Contractor's compensation the actual costs for any such expenses incurred.

1.11 MEASUREMENT AND PAYMENT:

- A. See Section 01 29 00 – "Measurement and Payment" in addition to the Special Conditions, Section VII.

SECTION 01 11 00 - SUMMARY OF WORK: continued

1.12 COPIES OF DOCUMENTS:

- A. **Furnished Copies:** After execution of Agreement, Contractor will be furnished a .zip file containing a pdf copy of the signed and sealed Construction Documents so the Contractor may make additional copies of the Contract Documents.

1.13 LIST OF DRAWINGS (AND SCHEDULES):

- A. **Contract Drawings:**
1. Individual sheet numbers and titles are as stated on index sheet under "Contract Drawings".
 2. Contract Documents are described in the Construction Contract, Section II, Paragraph D.

1.14 PERMITS AND LICENSES:

- A. The Contractor shall obtain all City, State, and County permits and licenses necessary for construction of the work in accordance with the General Conditions Section III.
- B. All costs associated with obtaining necessary permits shall be considered a subsidiary obligation of the Contractor and all costs in conjunction therewith shall be included in the prices bid for various items of work. This shall include all meetings, correspondence, document production, submittals, etc. required by outside agencies. Contractor shall comply with the requirements of all applicable permits for the project.
- C. The Contractor shall obtain and submit to the Owner a copy of all required permits before mobilization. The Contractor shall keep a full record of all inspections on-site for Owner review upon request. Copies of inspection records shall be submitted to the Owner with each pay application. The Contractor is responsible for closing/terminating all permits. The Owner will not assume responsibility for any permit requirements. The Contractor shall submit to the Owner copies of closed/terminated permits prior to the Construction Acceptance of the Project.
- D. The Contractor shall obtain and adhere to all required permits necessary to perform Work including, but not limited to:

Issuing Agency	Permit	Obtained By	Notes
City of Thornton	General Conditions, Section III	Contractor	
CDPHE	Construction Stormwater Discharge Permit	Contractor	
CDPHE	Construction Dewatering Permit	Contractor	If required
CDPHE	Permit for Discharges from Hydrostatic Testing of Pipelines, Tanks, and Similar Vessels	Contractor	

SECTION 01 11 00 - SUMMARY OF WORK: continued

Issuing Agency	Permit	Obtained By	Notes
CDPHE	Land Development Air Pollution Emission Notice (APEN) and Construction Permit	Contractor	If required
CDPHE	Drinking Water Design Submittal (Appendix B of Design Criteria for Potable Water Systems)	Consultant	By Owner
Any other permits not listed above required to complete project.		Contractor	

1.15 **UNDERGROUND UTILITIES:**

- A. Any known sewers, water mains, storm drains, gas mains, telephone conduits, electric cables, and other underground structures are shown on the Drawings only to the extent such information has been made available to or discovered by the Engineer. It is expected that there may be discrepancies and omissions in the location and quantities of utilities and structures shown. This information is shown for the convenience of the Contractor but is not guaranteed to be either correct or complete and all responsibility for the accuracy and completeness thereof is expressly disclaimed by Owner and Engineer. The Contractor shall make such investigation as he thinks necessary to verify its correctness and completeness. The Contractor shall, ahead of excavation, locate all underground utilities and structures so that they will not be accidentally damaged by his construction operation.
- B. Contractor shall be responsible for contacting all utilities concerning location of all above and below ground facilities before proceeding with the Work.
- C. Contractor is responsible for, at no additional cost to the Owner, potholing all existing utilities to be crossed or that may otherwise affect their means & methods for constructing the project no later than 48 hours prior to making crossing.
- D. Contractor shall support and protect all existing utilities as required to prevent any damage that may occur during construction.
 - 1. Contractor shall factor all costs associated with this requirement in their bid.
 - a. No additional cost will be paid for this item and Contractor will be responsible for repairing any damage to existing utilities at Contractor's expense.

1.16 **CONSTRUCTION SURVEYING:**

- A. Contractor shall furnish and set all control points and construction stakes establishing all lines, grades, and measurements necessary for the completion of the Work contracted under these Specifications. Construction stakes shall also clearly define limits of construction and site access as defined on the Drawings and shall be considered incidental to the construction or installation of water pipelines. Additional surveying required for construction of the Project shall also

SECTION 01 11 00 - SUMMARY OF WORK: continued

- be provided by the Contractor. As such, no additional compensation will be allowed for surveying. The surveyor shall be registered in the State of Colorado.
- B. The Contractor shall be responsible for all construction staking for the Project including surveying of reference points and setting lines and grades required for the completion of the Work specified in the Specifications, on the Plan or in any Supplementary Conditions. Such surveys shall also be required before establishing pay limits and determining quantities for progress pay estimates. Contractor shall furnish Owner with one copy of all field notes of such surveys.
- 1.17 SOILS INFORMATION:
- A. Soils/geotechnical borings, investigations, and reports have been developed for this project by Kumar and Associates, Inc., and entitled:
Geotechnical Engineering Study and Pavement Thickness Design
Proposed North Water Treatment Plant 5 MG Water Tank
Northwest Corner of Dahlia Way and East 140th Avenue
- B. A copy of this information can be provided with the Bid Documents for additional reference but is not to be considered part of the Contract Documents.
- C. The information available pertains only to the time of year the borings were performed. As such there is no guaranteed accuracy to the information shown and it should be considered for information only. Before submitting a Bid each Bidder will, at Bidder's expense, make or obtain any additional examinations, investigations, explorations, test and studies, and obtain any additional information and data which pertain to the physical conditions, surface or subsurface, at or contiguous to the Site or otherwise which may affect costs, progress, performance, or furnishing of the Work and which Bidder deems necessary to determine its Bid for performing and garnishing the Work in accordance with the time, price, and other terms and conditions of the Contract Documents.
- 1.18 DEWATERING:
- A. During construction activities, groundwater may be encountered during excavation which may need to be discharged to groundwater or surface water. Contractor shall obtain permit for discharge as required by the Authority having Jurisdiction.
- 1.19 NOISE AND VIBRATIONS
- A. The Contractor shall comply with noise and vibration requirements as described in the City of Thornton Municipal Code, Chapter 38 Section 38-441.
- B. All equipment alarms shall not exceed 55 decibels (dBA), the Contractor is required to modify equipment at no additional cost to the Owner to meet listed noise and vibration requirements specified.
- 1.20 CONCRETE REMOVAL AND REPLACEMENT:
- A. Concrete removal and replacement is required whenever concrete must be removed, cut, or is damaged by constructive efforts. The impacts and limits of such removal and replacement will be based upon the means and methods of the Contractor.

SECTION 01 11 00 - SUMMARY OF WORK: continued

- B. When concrete flatwork is to be replaced, the entire monolithic slab from joint to joint will need to be replaced. This includes curb and gutter, sidewalks, concrete pans, etc.
- 1.21 CONCRETE BATCHING:
 - A. Concrete shall be batched at an approved batching plant with a history of successful service.
- 1.22 CONSTRUCTION SITE SUPPORT:
 - A. Contractor shall support the project by providing a responsible project superintendent on site at all times (during working hours).
 - B. This person shall be available to:
 - 1. Support the general contractors work
 - 2. Support all subcontractor work
 - 3. Answer questions from the Owner and Engineer
 - 4. Respond to public question, comments, and issues
 - 5. Be responsible for site safety and site security
- 1.23 INTERPRETATION OF CONFLICTS:
 - A. Should conflicts occur in Contract Documents, request interpretation before proceeding with Work by submitting a Request for Information (RFI). Such requests shall first be preceded by a diligent investigation into Contract Documents and field conditions. Provide evidence of such investigation in requests for interpretation, including but not limited to drawing detail and specification references, sketches of existing conditions, and proposed recommendations.
 - B. Unless otherwise approved by the Owner, work shall not continue at locations where a conflict has been encountered.
 - C. Specifications included in these contract documents establish the performance, quality requirements, location, and general arrangement of materials and equipment, and establish the minimum standards for quality of workmanship and appearance.
 - D. Specification sections have not been divided into groups for work by individual Subcontractor or various trades. Should there be questions concerning the applicability or interpretation of a particular section or part of a section of the Drawings, direct questions should be submitted to the Owner.
 - E. A part of the work that is necessary or required to make each installation satisfactory and operable for its intended purpose, even though it is not specifically included in the specifications or on the Drawings, shall be performed as incidental work as if it were described in the specification and shown on the Drawings.
- 1.24 ALTERNATES
 - A. The Owner will consider alternates as indicated in the Bid Form, Agreement, and Section 33 05 07.23.
 - B. Alternates will be reviewed and accepted or rejected at the Owner's sole option.
 - C. Alternates shall result in no change in Contract Time.

SECTION 01 11 00 - SUMMARY OF WORK: continued

PART 2 - PRODUCTS - Not Applicable.

PART 3 - EXECUTION – Not Applicable.

END OF SECTION 01 11 00

SECTION 01 29 00 – PAYMENT PROCEDURES

PART 1 - GENERAL

1.01 SUMMARY:

- A. This Section covers methods of measurement and payment for items of Work under this Contract.
- B. The Contract Price shall cover all Work required by Contract Documents. All costs in connection with the proper and successful completion of the Work, including furnishing all materials, equipment, supplies, and appurtenances; providing all construction plant, equipment, and tools; and performing all necessary labor and supervision to fully complete the work, shall be included in the unit and lump sum prices. All work not specifically set forth as a pay item in the Bid Schedule shall be considered a subsidiary obligation of the Contractor, and all costs in connection therewith shall be included in the schedule prices.
- C. Compliance with all permits required for the Project including but not limited to those listed in SECTION 01 11 00 – “Summary of Work” and General Conditions, Section III Paragraph N, shall be considered incidental to the work, and no additional payment will be made to the Contractor. This includes all work necessary to comply with such permits and any fees associated with obtaining permits.
- D. Contractor shall submit a schedule of values for each lump sum item so that verification of work value completed can be calculated.
- E. See Special Conditions, Section XIV for related requirements.

1.02 ESTIMATED QUANTITIES:

- A. All estimated quantities stipulated in the Contract Documents for this portion of Work are approximate and are to be used as a basis for estimating the probable cost of the Work and for the purpose of comparing bids submitted for the Work. The actual amounts of Work done and materials furnished under unit price items may differ from the estimated quantities. The basis of payment for work and materials will be the actual amount of work done and materials furnished. Lump sum bid items will include all the quantities of work as indicated in the specification and drawings. See the BID PROPOSAL Contract Document for related information.

1.03 EARTHWORK, EXCAVATION, AND TRENCHING:

- A. Except where otherwise specified, the unit or lump sum price bid for each item of work that involves earthwork, excavation, and trenching shall include all costs for such work. No direct payment shall be made for excavation and trenching. All excavation and trenching shall be unclassified as to materials which may be encountered, and trenches shall be unclassified as to depth. Any rock encountered shall be removed and disposed of at no additional cost to the Owner. Contractor shall comply with all OSHA Safety Standards including all work necessary for the Contractor to comply with trench and excavation safety systems according to OSHA Part 1926 – Subpart P. All labor, materials, equipment, etc. required to meet these Standards shall be incidental to the Work and therefore no additional payment will be made under any circumstances.

SECTION 01 29 00 – PAYMENT PROCEDURES: continued

1.04 SITE SAFETY:

- A. Site safety measures as required in the General Conditions are required on this Project. No direct payment shall be made for site safety.

1.05 DEWATERING:

- A. Except where otherwise specified, the unit or lump sum price bid for each item of work that involves dewatering shall include all costs for such work. No direct payment shall be made for dewatering. Dewatering shall include construction dewatering, un-watering, or water control as used to describe the removal, draining, or control of groundwater or surface water from a riverbed, reservoir, pond, lowland, or wetland from the excavation area. All dewatering shall be at no additional cost to the Owner. Contractor shall comply with all Federal, State, and Local permit requirements including all precautions required for the Contractor to comply with the storm water management plan (SWMP) if applicable. All engineering, design, labor, materials, equipment, etc. required to construct the project under wet conditions are incidental to the Work and therefore no additional payment will be made under any circumstances.

1.06 MOBILIZATION AND DEMOBILIZATION (BID ITEM #1)

- A. See Thornton Special Conditions Section XIV.

1.07 CONTRACT BONDS AND INSURANCE (BID ITEM #2)

- A. See Thornton Special Conditions Section XIV.

1.08 TRAFFIC CONTROL: (BID ITEM #3):

- A. The measurement and payment for this item will be based on the completion of the work. No quantity measurement will be made of any of the work and materials required to complete this item of the construction project.
- B. Payment will be based on a percentage equal to the percentage of the original Contract Price earned (PCE) excluding the amount paid for Materials Stored on Site.
- C. The unit price bid for this item shall include all of the Contractor's costs of whatsoever nature. The unit price bid shall include, but not be limited to: crushed rock surfacing, furnishing, installing, moving, maintaining and removing all temporary traffic signs including; variable messaging boards, barricades, channelizing devices, warning lights, delineator, and any other equipment or personnel as required by the latest revision of the "Manual on Uniform Traffic Control Devices for Streets and Highways" and the requirements of the Colorado Department of Transportation; all signs, emergency replacements, warning lights, traffic cones, barricades, traffic maintenance plans that may be required by any entity, concrete barriers, line markings, flagging, notification of property owners; traffic control management; and all other related and necessary materials, work and equipment required to complete this item in accordance with the Drawings and Specifications.
- D. Measurement and payment for this item shall also include all of the Contractor's cost whatsoever for establishing and maintaining the traffic control for the temporary access road.

SECTION 01 29 00 – PAYMENT PROCEDURES: continued

- E. Measurement and payment for this item shall also include all of the Contractor's cost whatsoever for establishing and maintaining the traffic control for all temporary devices according to the requirements set forth the latest edition of the Quality Guidelines for Temporary Traffic Control Devices and Features published by the ATSSA.

1.09 GRADING, EROSION, AND SEDIMENT CONTROL PLANS AND PERMIT: (BID ITEM #4)

- A. The measurement and payment for conformance with the grading, erosion, and sediment control drawings, NPDES Permit, and/or County permits and will be based on a lump sum.
- B. The lump sum amount bid for this item shall include all labor, materials, costs, and fees associated with planning, designing, developing, applying, and achieving a stormwater discharge permit from the Colorado Department Public Health and Environment (CDPHE). The lump sum bid shall also cover all costs in planning, designing, engineering, and developing a Storm Water Pollution Prevention Plan (SWPPP).
- C. The lump sum bid for this item shall include all of the Contractor's costs of whatsoever nature. The lump sum bid for development, implementation, conformance, inspection, reporting, and compliance with state and/or county 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. The lump sum bid shall include but not be limited to permitting, 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.
- D. The lump sum bid for this item shall include all maintenance of seeding, sodding, and landscaped areas in conformance with the GESC permit and revegetation requirements therein.
- E. The lump sum bid for this item shall also include all labor, equipment, and materials required to perform regular and special GESC inspections and reporting by a certified, trained, and competent specialist.
- F. The GESC drawings show areas relating to proposed gravel roads. These "hardscaped" areas are measured and paid for under different bid items.
- G. Payment will be based on a percentage equal to the percentage of the original Contract Price earned (PCE) excluding the amount paid for Materials Stored on Site.

1.10 TREE REMOVAL AND REPLACEMENT (BID ITEM #5):

- A. The measurement and payment for this item will be each tree that is removed and replaced with a new tree. Tree type and diameter to be determined based on coordination with Parks Department and Resident Engineer.

SECTION 01 29 00 – PAYMENT PROCEDURES: continued

- B. The unit price bid for this item shall include, all work, materials, coordination, and labor required to perform the work. This shall include, but not be limited to: coordination with the property owner, tree cutting, chipping, shredding, complete tree removal, tree disposal, excavation and removal of the stump, furnish and install new tree, soil preparation, fertilizer, staking and wiring, maintenance, watering, and all other necessary material, work, and equipment required to complete this item in accordance with the Plans and Specifications.
 - C. Bid item shall also include the Contractor's cost of whatsoever nature to maintain newly planted tree(s) for at least two (2) years or until the time of acceptance (whichever is longer) and shall include but not be limited to: watering, trimming, replacement of tree(s) and all other maintenance to ensure adequate establishment of the tree(s) as outlined in the specifications.
- 1.11 5MG TANK AND FOUNDATION INSTALLATION (BID ITEMS: #6)
- A. The measurement and payment for the fully buried concrete tank and foundation will be lump sum.
 - B. The lump sum bid for this item shall include all of the Contractor's costs of whatsoever nature for the concrete tank, completed tank foundation and structure including all tank piping and tank appurtenances, tank under drain, and tank mixing system. The piping included in this item shall be all piping below or within the inside of tank wall. The lump sum item shall include all labor, materials, work, and all costs of whatsoever nature to install the tank.
 - C. Payment will be based on a percent complete of each item in the schedule of values excluding the amount paid for Materials Stored on Site.
- 1.12 ROCK EXCAVATION FOR TANK AND OTHER STRUCTURES: (BID ITEM #7)
- A. The measurement and payment of this item will be the actual cubic yards of excavated rock material. Contractor shall provide certified survey of the rock elevation limits prior to the start of excavation into the rock. Horizontal limits shall be as indicated below. Rock Excavation shall be verified as Rock with the Engineer and the Owner before excavation of the rock and any measurement and payment will be made.
 - B. All rock excavation to be paid for under this item shall be measured in cut and will be paid for only once whether the material is placed directly in its final position or re-handled. Excavation above the elevation of the top of the rock will be paid for as earth excavation in the lump sum amounts. Payment will be made only for rock excavation within the lines and grades given and within the following defined limits.
 - 1. STRUCTURES: Rock excavation for structures, unless otherwise specified or shown on the drawings, shall be measured between vertical planes four (4) feet farther apart than the outside dimensions of the foundations of the structures and from the surface of the rock to the neat lines of the bottom of the structures.

SECTION 01 29 00 – PAYMENT PROCEDURES: continued

- C. Under the Rock Excavation bid item, excavate hard, solid rock in ledges, bedded deposits, and unstratified masses, and conglomerate deposits or any other material so firmly cemented they present the characteristics of solid rock, and the engineer determines it is impracticable to excavate this material without blasting or using rippers with the use of a crawler mounted hydraulic excavator of not less than 40,000 pounds gross operating weight equipped with a general purpose excavator bucket of not less than 1 cu yd (0.76 m³) capacity, in satisfactory running condition and operated in accordance with the manufacturers recommended operating instructions. Rock excavation also includes removing rock boulders having a volume of one cubic yard or more. Rock is classified as material having a SPT blow count of more than 50 blow counts in 3 inches and is indicated in the boring logs as weathered sandstone and shale.
- D. The unit price bid for rock excavation and removal shall include all of the Contractor's costs of whatsoever nature. The unit price for this item shall include but not be limited to: excavation, protection and support of existing utilities, pre- and post- rock excavation studies and surveys, rock saws, rippers, scrapers, pneumatic equipment, and all necessary drilling and blasting as deemed by the Contractor and approved by the Engineer, removal of necessary rock and boulders from excavation, crushing of the rock at the discretion of the Contractor, hauling, disposal of excess and deleterious material, and all other necessary material, work and equipment required to complete this item in accordance with the Drawings and Specifications.
- E. Rock encountered and removed through excavation may be crushed or otherwise processed to the standards for backfill and/or bedding and used as backfill and/or bedding at no additional cost to the Owner.
- F. Payment for over-breakage will be made only if the excavation outside the specified lines and grades is directed by the Engineer or the Owner to remove unsuitable material and if the unsuitable condition is not a result of the Contractor's improper operations as determined by the Engineer.

1.13 ROCK EXCAVATION FOR PIPE INSTALLATION: (BID ITEM #8)

- A. The measurement and payment of this item will be the actual number of linear feet of rock excavation needed to successfully install the pipeline regardless of the depth of rock excavation encountered. Measurement shall be in linear feet along the centerline of the proposed pipeline where rock (as specifically defined) is encountered and special rock removal technique is required.
- B. Rock Excavation shall be verified as Rock with the Resident Engineer and the Owner before measurement and payment will be made.
- C. The unit price will be full compensation for material, equipment, and work required for excavation, rock saw work, rock trencher work, loading, hauling, and disposal of rock material; forming embankments; and shaping and trimming slopes and surfaces.
- D. The unit price bid for rock excavation and removal shall include all of the Contractor's costs of whatsoever nature. The unit price for this item shall include but not be limited to: excavation, protection and support of existing utilities, pre- and post- rock excavation studies and surveys, rock saws, rippers, scrapers, pneumatic equipment, and all necessary equipment as deemed by the Contractor and approved by the Engineer, removal of necessary rock and

SECTION 01 29 00 – PAYMENT PROCEDURES: continued

- boulders from trench, crushing of the rock at the discretion of the Contractor, hauling, disposal of excess and deleterious material, and all other necessary material, work and equipment required to complete this item in accordance with the Drawings and Specifications.
- E. Rock encountered and removed through excavation may be crushed or otherwise processed to the standards for backfill and/or bedding and used as backfill and/or bedding at no additional cost to the Owner.
 - F. Payment for over-breakage will be made only if the excavation outside the specified lines and grades is directed by the Resident Field Representative or Town to remove unsuitable material and if the unsuitable condition is not a result of the Contractor's improper operations as determined by the Engineer.
- 1.14 PIPELINES AND APPURTENANCES: (BID ITEMS #9, #10, #11, &12)
- A. The measurement and payment for this item will be the actual number of linear feet of waterline piping installed for each size pipe, with restraint, including all fittings. Waterline shall be measured for payment on a horizontal plane after installation of the pipe. Where lines are laid to conform to stationed profiles, payment shall be made on linear quantities based on the pipeline stationing as determined by the surveys made after installation.
 - B. The unit price bid for waterline and appurtenances shall include all of the Contractor's costs of whatsoever nature. The unit price for this item shall include but not be limited to: locating existing utilities, potholing existing utilities, clearing, grubbing, stockpiling, excavation, dewatering, protection and support of existing utilities, saw-cutting, asphalt grinding, temporary pavement, concrete sidewalk replacement and associated materials and equipment required, concrete curb and gutter replacement and associated materials and equipment required, asphalt surface restoration and associated materials and equipment required, furnishing and installation of the pipe, furnishing and installation of all fittings and appurtenances, furnishing and installation of all valves, furnishing and installing access manways, furnishing and the installation of all pipe coatings and pipe linings, pipe restraint, differential settlement couplings, pipe welding, weld quality inspections, thermal weld control fittings and procedures, joint wrap, coating replacement and repair, cement mortar lining repair, tracer wire, warning tape, utility locate markers, marker posts and test stations, removal and replacement of unsuitable backfill material, furnish and install imported granular pipe embedment material, Controlled Low Strength Material (CLSM) as required embedment zone, CLSM as required backfill, compacted backfill, processing backfill to appropriate moisture content (as required), removal of excess soil and spoil materials, all extra compaction for backfill beneath surfacing, trench stabilization material, flushing, relocation and protection of utility guy wires and/or poles, removal and replacement or irrigation lines, furnish and install bolted sleeve couplings, and all other necessary materials, work and equipment required to complete this item in accordance with the Drawings and Specifications.
 - C. The unit price submitted for waterline and appurtenances shall also include any other items necessary for a completely functioning system and to bring the site to original conditions which are not specifically called for in other bid items. Any such items shall be at no additional cost to Owner.

SECTION 01 29 00 – PAYMENT PROCEDURES: continued

- D. The measurement of the length of each line or run of pipe of each size will begin and end at:
 - 1. The end of the pipe were connected to an existing pipe, fitting, valve, or structure.
 - 2. The length of pipe along the existing Hilltop Tank pipelines removed as necessary for connections. The end of the pipe shall be measured from the bell and or spigot ring of the existing pipeline.
 - 3. The length of pipe included in this item shall be that pipe connected to the tank and shall be measured at the inside face of the tank wall.
- E. The measurement of each type of pipe of each size, which is to be paid for on a unit price basis, will be continuous through and shall include the full laying lengths of all fittings and valves installed between the ends of each line.

1.15 CAST-IN-PLACE VAULTS (BID ITEM #13)

- A. The measurement and payment of this item will be the actual number of cast-in-place vaults installed.
- B. The unit price bid for the valve vaults shall include all of the Contractor's costs of whatsoever nature. The unit price bid shall include but not be limited to: excavation, furnishing and installing cast-in-place concrete vault, vault foundation, valves, valve actuator, operators, extensions, extension stem guide, pipe supports, eye bolts, grating, ventilation fan, vent piping, routing of vent piping, sump pit, sump pumps, water sampling tap and all associated fittings , dismantling joints, furnishing and installation of all fittings, ladders, hatches and all other items called for in the details, compaction, backfill around the valve vault, and all other necessary material, work and equipment required to complete this item in accordance with the Drawings and Specifications.
- C. Rock excavation for vaults if encountered shall be paid under 1.11 Rock Excavation for Structures (BID ITEM #7).

1.16 OVERFLOW MANHOLES (BID ITEM #14)

- A. The measurement and payment of this item will be the actual number of overflow manholes installed.
- B. The lump sum price for the overflow manholes shall include the furnishing and installation of everything shown on the drawings and associated as required to provide a fully functioning system as well as any associated site civil work. The work will include but may not be limited to: furnishing and installing pre-cast concrete manhole, manhole ring and cover, ladder, manhole steps, pipe support, grouting, field painting, excavation, dewatering, backfill around manhole structure, manhole repair, bench build up, invert build up, pipe embedment, backfill, compaction, field verification of piping configuration and dimensions, and all other necessary material, work, testing, and equipment required to complete this item in accordance with the Plans and Specifications.

1.17 CONNECTION TO EXISTING WATERLINES: (BID ITEM #15 AND #16):

- A. The measurement and payment for connections to existing waterlines shall be per each connection to existing Hilltop Tank waterlines.
- B. The unit price for connections to the existing waterline shall include the furnishing and installation of everything shown on the drawings and associated as required

SECTION 01 29 00 – PAYMENT PROCEDURES: continued

to provide a fully functioning system as well as any associated site civil work. The work will include but may not be limited to: excavation, dewatering, shutdown, cutting and removal of existing piping, end caps, plugs, tees, butt straps, or crosses, draining exist pipe, removal and replacement of any existing cathodic protection systems, repairs to the pipes cement mortar lining, furnish and install adapters, furnish and install reducers, furnish and install pipe, fittings, couplings, restraint, welding, pipe embedment, backfill, compaction, field verification of existing piping configuration and dimensions, and all other necessary material, work, testing, and equipment required to complete this item in accordance with the Plans and Specifications.

1.18 CONNECTION TO EXISTING STORM MANHOLE: (BID ITEM #17):

- A. The measurement and payment for connections to existing storm manhole shall be per each connection to the existing storm manhole.
- B. The unit price for the connection to the existing storm manhole shall include the furnishing and installation of everything shown on the drawings and associated as required to provide a fully functioning system as well as any associated site civil work. The work will include but may not be limited to: excavation, dewatering, shutdown, cutting and removal of existing piping, manhole repair, bench build up and repair, invert build up and repair, end caps, plugs, tees, or crosses, draining exist pipe, furnish and install adapters, furnish and install reducers, furnish and install pipe, fittings, couplings, restraint, pipe embedment, backfill, compaction, field verification of existing piping configuration and dimensions, and all other necessary material, work, testing, and equipment required to complete this item in accordance with the Plans and Specifications.

1.19 HILLTOP TANK DRAIN LINE CONNECTION (BID ITEM #18):

- A. The measurement and payment for the Hilltop Tank drain line connection shall be lump sum.
- B. The lump sum price for the Hilltop Tank drain line connection shall include the furnishing and installation of everything shown on the drawings and associated as required to provide a fully functioning system as well as any associated site civil work. The work will include but may not be limited to: excavation, dewatering, shutdown, cutting and removal of existing piping, manhole repair, bench build up and repair, invert build up and repair, end caps, plugs, tees, or crosses, draining exist pipe, pipe embedment, backfill, compaction, field verification of existing piping configuration and dimensions, and all other necessary material, work, testing, and equipment required to complete this item in accordance with the Plans and Specifications.

1.20 CATHODIC PROTECTION SYSTEM: (BASE BID ITEM #19):

- A. The measurement and payment for this item will be on a lump sum basis.
- B. The lump sum price for cathodic protection system shall include all of the Contractor's costs of whatsoever nature. The lump sum price shall include but not be limited to: furnishing and installing anodes, anode wiring, welded wire connections, test stations, joint bonding, wire connection protection, test station boxes, terminal boards, shunts, wire labels, holiday testing, coating testing, record keeping, system testing, and all other necessary material, work and

SECTION 01 29 00 – PAYMENT PROCEDURES: continued

equipment required to complete this item in accordance with the Drawings and Specifications.

- C. The lump sum price shall also include purchasing and providing the necessary and specified equipment used to test coatings for imperfections. This shall include holiday test equipment. Contractor shall provide new, calibrated equipment for all testing. Contractor shall provide new, calibrated equipment to the Owner for additional testing.
- D. All test stations shall be located outside of the roadways. Contractor's unit price bid shall include all additional costs associated with locating all test stations outside of the roadways and into the shoulder, median, or edge of road, as directed in the field by the Engineer or Owner.
 - 1. This shall include additional cost for excavation, bedding, backfill, street cutting, asphalt removal and replacement, curb and gutter removal and replacement, additional seeding and sod, and all other costs required to complete this item in accordance with the specifications.
- E. Payment will be based on a percentage equal to the percentage of the percent completion of the waterline as determined by the Owner's Project Representative.

1.21 WATERLINE FILLING, DISINFECTION, HYDROSTATIC TESTING, BACTERIOLOGICAL TESTING, AND DEWATERING: (BID ITEM #20):

- A. The measurement and payment for this item will be on a lump sum basis.
- B. The lump sum price for this item shall include all of the Contractor's costs of whatsoever nature to fill the waterline and all test segments with water, successfully hydrostatic test the waterline and test segments, then dewater the waterline and test sections after completion. The lump sum price shall include but not be limited to: developing a testing plan, securing water, paying all costs for water including hydrant fees, completely filling the waterline with clean water, chlorination, admitting air from the line, pumps and testing equipment, providing hydrostatic testing equipment, coordinating and running the hydrostatic test, coordinating bacteriological and turbidity testing, coordinating chlorine residual testing, retesting as required for successful completion, flushing, high chlorine slug flushing, dewatering the waterline, pumped removal of waterline bellies, chemical treatment of the discharge water, chemical treatment equipment, coordination with discharge requirements, testing, record keeping, coordination with Engineer, Owner and other applicable Owner representatives, and all other necessary material, work and equipment required to complete this item in accordance with the Drawings and Specifications.

1.22 ELECTRICAL AND INSTRUMENTATION (BID ITEM #21)

- A. The measurement and payment of this item will be based on a lump sum.
- B. The lump sum bid price for the electrical and instrumentation shall include all of the Contractor's costs of whatsoever nature. The lump sum price shall include but not be limited to: trenching and backfill, conduit, conductors, terminations, electrical equipment, instrumentation, instrumentation equipment, electrical vaults, copper sensing lines, electrical equipment for the vaults and tank hatches, and all other items called for in the Drawings and Specifications.

SECTION 01 29 00 – PAYMENT PROCEDURES: continued

1.23 SEEDING AND RESTORATION: (BID ITEM #22)

- A. The measurement and payment for this item will be lump sum.
- B. The lump sum bid for this item shall include all of the Contractor's costs of whatsoever nature. The unit price bid shall include but not be limited to: rut removal, soil preparation, furnishing and installing seed, furnishing and installing hydroseeding, maintenance, watering, and all other necessary material, work, and equipment required to complete this item in accordance with the Plans and Specifications.
- C. Lump sum bid shall also include the Contractor's cost of whatsoever nature to maintain newly seeded areas until the time of acceptance and shall include but not be limited to: watering, fertilization, re-seeding thin areas, weed control, mowing, and all other maintenance to ensure adequate growth coverage as outlined in the specifications.

1.24 TEMPORARY ACCESS ROAD: (BID ITEM #23)

- A. The measurement and payment for this item will be lump sum.
- B. The lump sum bid for this item shall include all of the Contractor's costs of whatsoever nature. The unit price bid shall include but not be limited to the installation and materials required to build the temporary access road, equipment needed to protect existing utilities and infrastructure, maintenance of the access road, signage, dust control, aggregate, compaction, and materials and equipment required to remove the temporary access road, seeding, sodding, and materials and equipment required to return the site to the pre-existing conditions or conditions as required by the property Owner.

1.25 TUNNEL – SHAFTS: (ADD ALTERNATE ITEM #24 AND #25)

- A. The measurement and payment for tunnel shafts which includes both launch shafts and receiving shafts and includes both traditional shafts and watertight shafts and will be measured for each shaft constructed as required to complete the work.
- B. The unit price bid for tunnel shafts shall include all of the Contractor's costs of whatsoever nature. The unit price for this item shall include but not be limited to: engineering/design, shoring, sheeting, dewatering, excavation, permeation grouting, concrete and rebar, concrete drop shaft foundations, shaft backfilling, compaction, finish grading, subgrade preparation, and all other related and necessary materials, work, and equipment required to complete this item in accordance with the Drawings and Specifications.
- C. The unit price bid for each tunnel shaft shall include all of the Contractor's costs for removal and replacement of existing storm sewer culverts and storm drain lines as required to install the shafts. Storm sewers in the way of construction related activities shall be removed and replaced as required to perform the work at no additional cost to the Owner. This includes furnishing new culvert materials if required to make the installations.
- D. Payment for each shaft will be based on a percentage equal to the percentage of the percent completion of each shaft (complete) as determined by the Owner's Project Representative.

SECTION 01 29 00 – PAYMENT PROCEDURES: continued

1.26 TUNNEL – EXCAVATION, CASING PIPE, AND INSTALLATION: (ADD ALTERNATE ITEM #26)

- A. The measurement and payment for tunnel excavation, casing pipe/tunnel liner, and instrumentation will be per linear foot as measured for payment, after installation, based on the tunnel stationing as determined by tunnel installation surveys. The measurement of the length of each installation shall begin and end at the erected support or casing pipe which shall conform to the stationed location as shown on the Drawings.
- B. The unit price bid for this item shall include all costs associated with construction of the tunnel. The price shall include, but not be limited to: engineering/design, providing pre-installation surveys including building foundation surveys, providing equipment and performing tunneling operations, utility monitoring points and instrumentation, furnishing and installing steel casing pipe or erected support, welding, muck removal, existing utility investigation and protection measures, controlling line and grade and meeting tolerances, contact grouting, and all equipment, materials, and labor as require to construct the work as specified in the Contract Documents.
- C. The unit price bid for this item shall include all work as required for geotechnical instrumentation and monitoring for each tunnel. This shall include all costs associated with survey points, monitoring points, extensometers, and all other associated work as shown and specified in the Contract Documents.

1.27 TUNNEL – CARRIER PIPE INSTALLATION AND BACKFILL: (ADD ALTERNATE ITEM #27)

- A. The measurement and payment for tunneled carrier pipe installation and backfill shall be per linear foot as measured for payment, after installation, on the basis of the tunnel stationing as determined by tunnel installation surveys. The measurement of the length of each installation shall begin and end at the end of the erected support or casing pipe which shall conform to the stationed locations shown on the drawings.
- B. The price shall include, but not be limited to: furnishing and installing of the carrier pipe (fully welded steel pipe) in the casing, furnishing and installing casing insulators, furnishing and installing end seals, furnishing and installing end wraps, installation of the 3x 2" HDPE conduits in the tunnel, backfill grouting, successful testing, and all necessary materials, work, testing, and equipment required to complete this item in accordance with the Drawings and Specifications.

PART 2 - PRODUCTS (Not used)

PART 3 - EXECUTION (Not used)

END OF SECTION 01 29 00

SECTION 01 31 00 - PROJECT COORDINATION AND MEETINGS

PART 1 - GENERAL

1.01 SUMMARY:

- A. This Section includes administrative provisions for coordinating construction operations on Project including, but not limited to, the following:
 - 1. Coordination drawings.
 - 2. Project meetings.
 - 3. Requests for information (RFIs).
- B. Each contractor shall participate in coordination requirements.

1.02 DEFINITIONS:

- A. RFI: Request for information prepared by Contractor and submitted to Engineer seeking interpretation or clarification of the Contract Documents.

1.03 COORDINATION:

- A. Coordination: Coordinate construction operations included in different Sections of the Specifications to ensure efficient and orderly installation of each part of the Work. Coordinate construction operations, included in different Sections that depend on each other for proper installation, connection, and operation.
 - 1. Schedule construction operations in sequence required to obtain the best results where installation of one part of the Work depends on installation of other components, before or after its own installation.
 - 2. Coordinate installation of different components with other contractors to allow optimum accessibility for required maintenance, service, and repair.
 - 3. Make adequate provisions to accommodate items scheduled for later installation.
 - 4. Where availability of space is limited, coordinate installation of different components to allow optimum performance and accessibility for required maintenance, service, and repair of all components, including mechanical and electrical.
- B. Prepare memoranda for distribution to each party involved, outlining special procedures required for coordination. Include such items as required notices, reports, and list of attendees at meetings.
 - 1. Prepare similar memoranda for Owner and separate contractors if coordination of their Work is required.
- C. Administrative Procedures: Coordinate scheduling and timing of required administrative procedures with other construction activities and activities of others to avoid conflicts and to ensure orderly progress of the Work. Such administrative activities include, but are not limited to, the following:
 - 1. Preparation of construction progress schedule.
 - 2. Preparation of the schedule of values.
 - 3. Installation and removal of temporary facilities and controls.
 - 4. Delivery and processing of Submittals.
 - 5. Progress meetings.
 - 6. Preinstallation conferences.

SECTION 01 31 00 - PROJECT COORDINATION AND MEETINGS: continued

7. Project closeout activities.
 8. Startup and adjustment of systems.
 9. Project closeout activities.
- 1.04 SUBMITTALS:
- A. See General and Special Conditions for supplementary provisions.
 - B. Coordination Drawings: Prepare Coordination Drawings if limited space availability necessitates maximum utilization of space for efficient installation of different components or if coordination is required for installation of products and materials fabricated by separate entities.
 1. Content: Project-specific information, drawn accurately to scale. Do not base Coordination Drawings on reproductions of the Contract Documents or standard printed data. Include the following information, as applicable:
 - a. Indicate functional and spatial relationships of components of structural, civil, mechanical, process, and electrical systems.
 - b. Indicate required installation sequences.
 - c. Indicate dimensions shown on the Contract Drawings and make specific note of dimensions that appear to be in conflict with submitted Equipment and minimum clearance requirements. Provide alternate sketches to Engineer for resolution of such conflicts. Minor dimension changes and difficult installations will not be considered changes to the Contract.
 2. Submit one electronic copy to Engineer. Engineer will return comments electronically.
 3. Refer to individual Sections for coordination drawing requirements for Work in those Sections.
- 1.05 PROJECT MEETINGS:
- A. See General and Special Conditions for supplementary provisions.
 - B. Preconstruction Conference:
 1. Engineer will conduct a meeting within 7 days after the Effective Date of the Agreement, to review items stated in the following agenda and to establish a working understanding between the parties as to their relationships during performance of the Work.
 2. Preconstruction conference shall be attended by:
 - a. Representative(s) of Contractor including Contractor's superintendent.
 - b. Engineer
 - c. Representative(s) of Owner.
 - d. At Owner's option, representatives of principal Subcontractors and Suppliers.
 3. Meeting Agenda:
 - a. Construction schedules.
 - b. Phasing.
 - c. Critical Work sequencing and long-lead items.
 - d. Designation of key personnel and their duties; lines of communication.
 - e. Project coordination.

SECTION 01 31 00 - PROJECT COORDINATION AND MEETINGS: continued

- f. Procedures and Processing of:
 - (1) RFIs.
 - (2) Field decisions.
 - (3) Substitutions.
 - (4) Submittals.
 - (5) Change Orders.
 - (6) Applications for Payment.
 - g. Procedures for testing.
 - h. Procedures for preparing and maintaining record documents.
 - i. Use of Premises:
 - (1) Office, work, storage, laydown, and parking areas.
 - (2) Owner's requirements.
 - (3) Work restrictions and hours.
 - j. Construction facilities, controls, and construction aids.
 - k. Temporary utilities.
 - l. Safety and first-aid.
 - m. Security.
 - n. Deliveries of Equipment and Materials.
 - o. Within three working days after the meeting, Engineer will prepare and distribute minutes of the meeting to Owner and Contractor.
 - p. Contractor shall provide copies to Subcontractors and major Suppliers.
- C. Scheduling Workshop
- 1. Contractor will conduct a meeting within 30 days after the Notice to Proceed to review items stated in the following agenda and to establish a working understanding between the parties as to their relationships during performance of the Work.
 - a. Agenda will be provided 72 hours prior to meeting date upon notification of meeting date.
- D. Preinstallation Conferences:
- 1. Contractor shall conduct a preinstallation conference at the Project Site before each construction activity that requires coordination with other construction and where required in DIVISIONS 2 through 48.
 - 2. Installer and representatives of manufacturers and fabricators, of products furnished by this Contract or by others, involved in or affected by the installation Work and its coordination or integration with other materials and installations, shall attend the meeting. Advise Engineer of scheduled meeting dates.
 - 3. Review the progress of other construction activities and preparations for the particular activity under consideration at each preinstallation conference, including installation procedures and requirements for the following:
 - a. Contract Documents.
 - b. Options.
 - c. Related Change Orders.
 - d. Purchases.
 - e. Deliveries.
 - f. Shop Drawings, product data, and quality control Samples.

SECTION 01 31 00 - PROJECT COORDINATION AND MEETINGS: continued

- g. Review of mockups.
 - h. Possible conflicts.
 - i. Compatibility problems.
 - j. Time schedules.
 - k. Weather limitations.
 - l. Manufacturer's recommendations.
 - m. Warranty requirements.
 - n. Acceptability of substrates.
 - o. Temporary facilities and controls.
 - p. Space and access limitations.
 - q. Governing regulations.
 - r. Safety.
 - s. Inspecting and testing requirements.
 - t. Required performance results.
 - u. Recording requirements.
 - v. Protection of construction, personnel, and adjacent work.
 - 4. Record significant discussions and agreements and disagreements of each conference. Distribute the minutes of the meeting within 3 working days after the meeting to everyone concerned, including Owner and Engineer.
 - 5. Do not proceed with the installation if disagreements arise during the conference which cannot be successfully resolved at the time. Contractor shall take actions necessary to resolve impediments to performance of Work and reconvene the conference at the earliest feasible date.
- 1.06 REQUESTS FOR INFORMATION (RFIs):
- A. Procedure: Promptly on discovery of the need for interpretation of the Contract Documents, and if not possible to request interpretation at Project meeting, prepare and submit an RFI with the content specified.
 - 1. RFIs shall originate with Contractor. RFIs submitted by entities other than Contractor will be returned with no response.
 - 2. Coordinate and submit RFIs in a prompt manner so as to avoid delays in Contractor's Work or work of Subcontractors.
 - B. Content of the RFI: Include a detailed, legible description of item needing interpretation and the following:
 - 1. Project name.
 - 2. Date.
 - 3. Name of Contractor.
 - 4. Contract number and title.
 - 5. Name of Engineer.
 - 6. RFI number, numbered sequentially.
 - 7. Specification Section number and title and related paragraphs, as appropriate.
 - 8. Drawing number and detail references, as appropriate.
 - 9. Field dimensions and conditions, as appropriate.
 - 10. Contractor's suggested solution(s). If Contractor's solution(s) impact the Contract Times or the Contract Price, Contractor shall state impact in the RFI.

SECTION 01 31 00 - PROJECT COORDINATION AND MEETINGS: continued

11. Contractor's signature.
12. Attachments: Include drawings, descriptions, measurements, photos, product data, Shop Drawings, and other information necessary to fully describe items needing interpretation.
- C. Software-Generated RFIs:
 1. RFI to be initiated and discussed in Microsoft Excel spreadsheet
 - a. Engineer will provide Contractor with preformatted Excel spreadsheet after the Pre-Construction meeting.
 - b. Attachments shall be electronic files in Adobe Acrobat PDF format.
- D. Engineer's Action: Engineer will review each RFI, determine action required, and return it. Allow seven working days for Engineer's response for each RFI. RFIs received after 1:00 p.m. local time will be considered as received the following working day.
 1. The following RFIs will be returned without action:
 - a. Requests for approval of Submittals.
 - b. Requests for approval of substitutions.
 - c. Requests for coordination information already indicated in the Contract Documents.
 - d. Requests for adjustments in the Contract Times or the Contract Price.
 - e. Requests for interpretation of Engineer's actions on Submittals.
 - f. Incomplete RFIs or RFIs with numerous errors.
 2. Multiple RFIs addressing similar or identical issues may be addressed by Engineer with a single broad response.
 3. Engineer's action may include a request for additional information, in which case Engineer's time for response will start again upon Contractor's response and resubmittal.
 4. If Contractor believes the RFI response warrants change in the Contract Times or the Contract Price, notify Engineer in writing within three days of receipt of the RFI response.
- E. On receipt of Engineer's action, Contractor shall update the RFI log and promptly distribute the RFI response to affected parties. Review response and notify Engineer within three days if Contractor disagrees with response.
- F. RFI Log: Prepare, maintain, and submit a tabular log of RFIs organized by the RFI number. Submit log weekly. Electronic log with not less than the following:
 1. Project name.
 2. Name and address of Contractor.
 3. Contractor representative name and telephone number.
 4. Name and address of Engineer.
 5. RFI number including RFIs that were dropped and not submitted.
 6. RFI description.
 7. Date the RFI was submitted.
 8. Date Engineer's response was received.
 9. Identification of related Field Order, Work Change Directive, and Proposal Request, as appropriate.

SECTION 01 31 00 - PROJECT COORDINATION AND MEETINGS: continued

PART 2 - PRODUCTS - Not Applicable.

PART 3 - EXECUTION - Not Applicable.

END OF SECTION 01 31 00

SECTION 01 32 33 – CONSTRUCTION PHOTOGRAPHS

PART 1 - GENERAL

1.01 SUMMARY:

- A. This Section specifies administrative and procedural requirements for construction photographs.

1.02 SUBMITTALS:

- A. Submit prints as specified in the General and Special Conditions and in PART 3 - this Section.
- B. Contractor shall submit sample electronic photos of the type and quality required during construction, for review and acceptance by Owner and Engineer.

1.03 QUALITY CONTROL:

- A. All photographs shall be taken by a photographer experienced in construction photography.
- B. All videography shall be taken and processed by an electrographer experienced in the production of color audio/video tape documentation for the construction industry.

PART 2 - PRODUCTS

- 2.01 PHOTOGRAPHIC REQUIREMENTS: Specified in PART 3, this Section.

PART 3 - EXECUTION

3.01 PROGRESS SITE PHOTOGRAPHS:

- A. Contractor shall be responsible for photographs of the Site to show the existing and general progress of the Work. Engineer will advise as to which views are of interest. Photographs shall be taken of the following areas and at the following times.
 - 1. Existing Site conditions before Site work is started. Number of views shall be adequate to cover the Site.
 - 2. Progress of the Work from excavation throughout construction. There shall be a minimum of 80 different views taken throughout the progress of the project.
 - 3. Finished Project after completion of Work. Number of views shall be adequate to show the finished Work.
 - 4. If Project is not completed during the Contract Time or authorized extensions, photographs shall continue to be taken at no increase in Contract Price.
 - 5. Submit a complete set of digital image electronic files:
 - a. Provide images in JPEG format, with minimum sensor size of 12.0 megapixels.
 - b. Submit images that have same aspect ratio as the sensor, uncropped.
- B. Identification:
 - 1. Identify each digital image with a digital information tag which contains the Contract name and Contract number, date of exposure, site location, and

SECTION 01 32 33 – PHOTOGRAPHIC DOCUMENTATION: continued

description of view. Photographs can be sorted into electronic folders to also indicate the required label.

2. Identify electronic media with date digital photographs were taken.
- C. Deliver electronic media files to Engineer.

3.02 EXISTING SITE PHOTOGRAPHS:

- A. Contractor shall be responsible for providing photographs within the entire construction site showing the condition of the terrain previous to any alterations by Contractor and before construction is started. These same views shall be rephotographed after completion of all construction. Three days' notice shall be given to Engineer and Owner prior to this Work to allow them to accompany photographer.
- B. Photographs shall be taken at intervals of not more than 10 feet and at other intervals deemed necessary to record detailed conditions, possible field conflicts, and as may be designated by Engineer.
- C. Each photograph shall be identified in the view stating the Contract name and Contract number, or other suitable identification, date, site location, and sequential view number.
- D. Contractor shall keep a log of all photographs noting detailed information or comments pertinent to each photograph.
- E. Submit a complete set of digital image electronic files with each submittal of photographic prints and as a Project record document.
 - a. Provide images in JPEG format, with minimum sensor size of 12.0 megapixels.
 - b. Submit images that have same aspect ratio as the sensor, uncropped.
- F. Identification:
 1. Identify each digital image with a data tag which identifies the Contract name and number, date of exposure, description of view, site location, and comments or detailed information from the log sheet. Photographs can be sorted into electronic folders to also indicate the required label.
 2. Identify electronic media with date digital photographs were taken.
- G. Deliver electronic media files to Engineer.

3.03 AUDIO/VIDEO TAPE RECORDINGS:

- A. As required in the General Conditions and as indicated herein.
- B. Audio/video recordings shall be made of the entire Site showing the condition of the Site or terrain previous to any alterations by Contractor and before disturbing of the Site is started. A second audio/video recording shall be produced after completion of all construction operations, showing the same view or views as close as possible, to illustrate "before" and "after" conditions. This is the responsibility of Contractor. Three days' notice shall be given to Engineer and Owner prior to this Work to allow them to accompany electrographer.
- C. All required equipment, accessories, materials, and labor for the timely production of this documentation shall be arranged/furnished through Contractor.
 1. The audio/video system camera-recorder used by the electrographer shall have the following capabilities and features:

SECTION 01 32 33 – PHOTOGRAPHIC DOCUMENTATION: continued

- a. Digital media format in mpeg, MP4, or other format viewable on a standard personal computer.
2. The audio/video system shall be capable of producing bright, sharp, clear visual images which render accurate colors free from imperfections and distortions that might obscure recorded information during playback. The simultaneous audio record shall be made directly onto the original tapes, and shall record narration of the electrographer clearly and audibly, with adequate volume, free from unnecessary interruptions and distortions that might eliminate recorded information during playback.
- D. Zone of Influence: Unless otherwise indicated by Engineer or Owner, the "Zone of Influence" which might be affected by the construction operations and, therefore, shall be documented in these tape recordings, shall be whichever of the following includes the greatest area.
 1. All areas within the temporary construction right-of-ways and land disturbance limits, as indicated on the Contract Drawings or expected by the Contractor.
 2. The permanent easement for the completed improvements, as indicated on the Contract Drawings.
 3. All areas within 35 feet of the proposed improvements.
 4. All areas within the Project Site.
- E. Ownership and Authenticity of Original Tapes:
 1. All original audio/video tape recordings shall become the property of Owner, plus one duplicate of each shall be provided to Engineer. Each tape shall be provided in a protective sleeve or case, identified as to Contract name and number, production date of original recording, name of Contractor, and electrographer's name or trademark; a legible copy of the log shall be included.

3.04 ADDITIONAL PHOTOGRAPHS:

- A. From time to time Engineer may issue requests for additional photographs, in addition to periodic photographs specified. Additional photographs will be paid for by Change Order, and are not included in the Contract Price or an Allowance.
 1. Engineer will give the photographer three days' notice, where feasible.
 2. In emergency situations, the photographer shall take additional photographs within 24 hours of Engineer's request.
 3. Circumstances that could require additional photographs include, but are not limited to:
 - a. Substantial Completion of a major phase or component of Work.
 - b. Owner's request for special publicity photographs.
 - c. Special events planned at Project Site.
 - d. Immediate follow-up when on-site events result in construction damage or losses.
 - e. Photographs to be taken at fabrication locations away from Project Site.
 - f. Extra record photographs at time of final acceptance.

END OF SECTION 01 32 33

SECTION 01 43 33 – MANUFACTURER’S FIELD SERVICES

PART 1 - GENERAL

- 1.01 SUMMARY: This Section includes requirements of manufacturers for services to be performed at the Project Site in regards to erection, start-up, and testing equipment and tanks.
- 1.02 SERVICES REQUIRED:
- A. Services with Equipment and Materials Furnished Under this Contract:
1. Furnish the services of qualified field personnel from the Suppliers or manufacturers of Equipment furnished and installed under this Contract, as required to perform all manufacturer's Field Services called for in the Specifications. Field personnel shall be certified by the Supplier or manufacturer of the specific product or system as having the necessary knowledge and experience to perform the required functions.
 2. Where such service is specified, Contractor shall not perform any Work related to the installation or operation of Equipment furnished and installed under this Contract without direct observation and guidance of the Supplier's or manufacturer's field personnel unless Engineer concurs otherwise.
 3. Contractor shall arrange for the Supplier's or manufacturer's field personnel to perform the following:
 - a. Observe the erection, installation, start-up, and testing of Equipment.
 - b. Instruct and guide Contractor in proper procedures.
 - c. Supervise the initial start-up, operational check, and any required adjustments of Equipment.
 - d. Instruct Owner's designated personnel in proper operation and maintenance of all Equipment.
 - e. Furnish a written report to Engineer covering all Work done at least once each week and when Work on each item of Equipment or system is completed.
 4. Advise Engineer of arrival at the Site of all Supplier's and manufacturer's field personnel.

PART 2 - PRODUCTS: Specified in applicable Sections.

PART 3 - EXECUTION

- 3.01 OPERATION AND TESTING:
- A. Placing Equipment and Tanks in Operation:
1. Place all Equipment and Tanks installed under this Contract into successful operation according to instructions of the Supplier, manufacturer, or field representative, including making all required adjustments, tests, operation checks, and the following:
 - a. Cleaning, sounding, blowing-out, and flushing of lubricating oil and water systems, and other pipelines.
 - b. Lubrication (lubricants supplied by Contractor unless specified to be furnished by Owner or others).
 - c. Tests of lubrication system safety interlocks and system performance.

SECTION 01 43 00 – MANUFACTURER’S FIELD SERVICES: continued

- d. Final alignment checks and measurements made under observation of Engineer and Owner. Alignment checks shall include opening connections, if required, to ensure there are no abnormal stresses on Equipment from pipes or other attachments. Alignment shall be within tolerances specified by the manufacturer, and measurements shall be recorded and furnished to Engineer.
 - e. Inspection of sleeve bearings for adequate contact.
 - f. Checking of anchor-bolt tensions, grout, and shims. Tighten anchor bolts with calibrated torque wrenches using care not to over stress bolts.
- 2. After "run-in" and acceptance of alignment, affix major Equipment in place using standard tapered dowels with jack-out nuts at head end to facilitate removal.
- 3. Record all above operations on forms furnished by Engineer.
- 4. Furnish all necessary attendants and personnel as part of the Work to accomplish the above operations until such time as individual items, systems, Equipment, or sections of the plant are acceptable for operation by Owner.
- 5. Provide attendants on a continuous basis as required to complete events without interruption once they have been started.
- 6. Contractor shall provide fuel, electricity, water, and lubricants for placing Equipment in operation. Owner's operating personnel may assist.
- B. Performance Tests:
 - 1. Equipment Furnished Under this Contract:
 - a. Owner may conduct acceptance tests after installation to determine if the Equipment installed as part of the Work perform in accordance with Contract Documents and as guaranteed. Final acceptance of Equipment and Substantial Completion will be based on acceptable results of such tests.
 - b. No tests will be conducted on Equipment for which Supplier's or manufacturer's Field Service is specified unless Supplier's or manufacturer's field representative is present and declares in writing that the Equipment is ready for such test.
 - c. Contractor will be notified by Owner so that Contractor can have a representative or manufacturer's representative present during any tests of Equipment for which Supplier's or manufacturer's Field Service is not specified.
 - d. The tests will be made as set forth in the Contract Documents unless the interested parties mutually agree upon some other manner of testing.
- C. Operations and Maintenance Instructions:
 - 1. Manufacturer's field representative shall instruct Owner's staff in the proper operation and maintenance of equipment where specified in the individual Specification Sections.
 - 2. The length of time for training shall be sufficient to cover all operating and maintenance instructions, but not less than the minimum length of time specified in the individual equipment Specification Sections.
 - 3. Manufacturer's field representative shall use manufacturer's operation and maintenance manual for basis of instructions. Therefore, no operation and

SECTION 01 43 33 - MANUFACTURER'S FIELD SERVICES: continued

maintenance instructions shall be performed until approved distribution copies of operation and maintenance manuals are in the Owner's possession.

4. All manufacturer's field operation and maintenance instructions shall be videotaped as specified in SECTION 01 32 33.

END OF SECTION 01 43 33

SECTION 01 51 00 - TEMPORARY UTILITIES AND FACILITIES

PART 1 - GENERAL

1.01 SUMMARY:

- A. This Section includes requirements of a temporary nature not normally incorporated into final Work. It includes the following:
 - 1. Utility services.
 - 2. Construction and support facilities.
 - 3. Construction aids.
 - 4. Safety and health.
 - 5. Fire protection.
- B. Related Work Specified Elsewhere:
 - 1. Field Offices and Sheds: SECTION 01 52 13.

1.02 REFERENCES:

- A. American National Standards Association (ANSI):
 - 1. A10 Series - Safety Requirements for Construction and Demolition.
- B. National Electrical Contractors Association (NECA):
 - 1. Electrical Design Library - Temporary Electrical Facilities.
- C. National Fire Protection Association (NFPA):
 - 1. 10 - Portable Fire Extinguishers.
 - 2. 70 - National Electrical Code.
 - 3. 241 - Safeguarding Construction, Alterations, and Demolition Operations.
- D. National Electrical Manufacturers Association (NEMA).
- E. Underwriters Laboratories (UL).

1.03 SUBMITTALS:

- A. Temporary Utilities: Submit reports of tests, inspections, meter readings, and similar procedures performed on temporary utilities.
- B. Implementation and Termination Schedule: Submit a schedule indicating implementation and termination of each temporary utility within 15 days of the date established for commencement of the Work.

1.04 QUALITY CONTROL:

- A. Regulations: Comply with industry standards and applicable laws and regulations of authorities having jurisdiction, including but not limited to:
 - 1. Building Code requirements.
 - 2. Health and safety regulations.
 - 3. Utility company regulations.
 - 4. Police, Fire Department, and rescue squad rules.
 - 5. Environmental protection regulations.
 - 6. Storm drainage requirements.
- B. Standards:
 - 1. Comply with NFPA 10 and 241, and ANSI A10 Series standards "Temporary Electrical Facilities."
 - 2. Comply with NEMA, NECA, and UL standards and regulations for temporary electric service. Install service in compliance with NFPA 70.

SECTION 01 51 00 - TEMPORARY UTILITIES AND FACILITIES: continued

- C. Inspections: Arrange for authorities having jurisdiction to inspect and test each temporary utility before use. Obtain required certifications and permits.

1.05 PROJECT CONDITIONS:

- A. Temporary Utilities: Prepare a schedule indicating dates for implementation and termination of each temporary utility. At the earliest feasible time, when acceptable to Owner, change over from use of temporary service to use of the permanent service.
- B. Conditions of Use: Keep temporary services and facilities clean and neat in appearance. Operate in a safe and efficient manner. Take necessary fire prevention measures. Do not overload facilities, or permit them to interfere with progress. Do not allow hazardous, dangerous, unsanitary conditions, or public nuisances to develop or persist on the Site.

PART 2 - PRODUCTS

2.01 MATERIALS AND EQUIPMENT:

- A. Provide new materials and equipment. If acceptable to Engineer, undamaged previously used materials and equipment in serviceable condition may be used. Provide materials and equipment suitable for the use intended, of capacity for required usage, and meeting applicable codes and standards. Comply with requirements of DIVISIONS 3 through 33.
- B. Water: Provide potable water approved by local health authorities.
- C. Water Hoses: Provide 3/4-inch, heavy-duty, abrasion-resistant, flexible rubber hoses 100 feet long, with pressure rating greater than the maximum pressure of the water distribution system. Provide adjustable shutoff nozzles at hose discharge.
- D. Electrical Outlets: Provide properly configured, NEMA-polarized outlets to prevent insertion of 110- to 120V plugs into higher voltage outlets. Provide receptacle outlets equipped with ground-fault circuit interrupters, reset button, and pilot light for connection of power tools and equipment.
- E. Electrical Power Cords: Provide grounded extension cords. Use hard-service cords where exposed to abrasion and traffic. Provide waterproof connectors to connect separate lengths of electric cords if single lengths will not reach areas where construction activities are in progress. Do not exceed safe length-voltage ratio.
- F. Lamps and Light Fixtures: Provide general service incandescent lamps of wattage required for adequate illumination. Provide guard cages or tempered-glass enclosures where exposed to breakage. Provide exterior fixtures where exposed to moisture.
- G. Heating Units: Provide temporary heating units that have been tested and labeled by UL, FM, or another recognized trade association related to the type of fuel being consumed.
- H. Fire Extinguishers: Provide hand-carried, portable, UL-rated, Class A fire extinguishers for temporary offices and similar spaces. In other locations, provide hand-carried, portable, UL-rated, Class ABC, dry-chemical extinguishers or a

SECTION 01 51 00 - TEMPORARY UTILITIES AND FACILITIES: continued

combination of extinguishers of NFPA-recommended classes for the exposures. Comply with NFPA 10 and NFPA 241 for classification, extinguishing agent, and size required by location and class of fire exposure.

PART 3 - EXECUTION

3.01 TEMPORARY UTILITIES:

A. General:

1. Engage the appropriate local utility company to install temporary service or connect to existing service. Where utility company provides only part of the service, provide the remainder with matching, compatible materials and equipment. Comply with utility company recommendations.
2. Provide adequate utility capacity at each stage of construction.
3. Obtain and pay for temporary easements required to bring temporary utilities to the Project Site, where City of Thornton owned property cannot be used for that purpose.
4. Furnish, install, and maintain temporary utilities required for adequate construction, safety, and security. Modify, relocate, and extend systems as Work progresses. Repair damage caused by installation or use of temporary facilities. Grade the areas of Site affected by temporary installations to required elevations and grades, and clean the area. Remove on completion of Work or until service or facilities are no longer needed.
5. The types of temporary construction utilities and facilities required include, but not by way of limitation, water distribution, drainage, dewatering equipment, enclosure of Work, heat, ventilation, electrical power distribution, lighting, hoisting facilities, stairs, and ladders.
6. Inspect and test each service before placing temporary utilities in use. Arrange for required inspections and tests by governing authorities, and obtain required certifications and permits for use.
7. Materials used for temporary service shall not be used in the permanent system unless so specified or acceptable to Engineer.

3.02 TEMPORARY WATER

- ##### A. See General Conditions Section XXIV.

3.03 TEMPORARY TELEPHONE SERVICE:

A. General:

1. Arrange with local cellular/mobile telephone service company and provide mobile telephone service for use by Contractor and so Contractor can be reached at construction site during normal working hours.

3.04 TEMPORARY SANITARY FACILITIES:

A. Contractor-Furnished Facilities:

1. Furnish, install, and maintain temporary sanitary facilities for use through construction period. Remove on completion of Work.
2. Provide for all construction workers under this Contract and representatives at the Site.

SECTION 01 51 00 - TEMPORARY UTILITIES AND FACILITIES: continued

3. Toilet facilities shall be of the chemical type, properly vented, and fully enclosed with a glass- fiber-reinforced polyester shell or similar nonabsorbent material.
 4. Wash Facilities: Install potable water-supplied wash facilities at locations convenient to construction personnel involved in the handling of compounds and materials where wash-up is necessary to maintain a safe, healthy and sanitary condition. Where recommended or required by governing authorities and regulations or recognized standards provide emergency safety showers, emergency eye-wash fountains, showers, and similar facilities. Dispose of drainage properly. Supply soap and other cleaning compounds appropriate for each condition.
 5. Drinking Water Fixtures: Provide containerized tap-dispenser type drinking water units.
 6. Supply and maintain toilet tissue, paper towels, paper cups and similar disposable materials as appropriate for each facility. Provide appropriate covered waste containers for used material.
- 3.05 SEWERS AND DRAINAGE:
- A. General: sewers or drainage facilities are not available for discharge of effluent, provide containers to remove and dispose of effluent off the Site in a lawful manner.
 - B. Maintain temporary sewers and drainage facilities in a clean, sanitary condition. Following heavy usage, restore to normal conditions promptly. Provide and maintain temporary earthen embankments and similar barriers in and around construction excavations and subgrade construction, sufficient to prevent flooding by runoff of storm water from heavy rain storms.
- 3.06 TEMPORARY CONSTRUCTION AIDS:
- A. General:
 1. Provide construction aids and equipment required by personnel and to facilitate the execution of the Work; scaffolds, staging, ladders, stairs, ramps, runways, platforms, railings, hoists, cranes, chutes, and other such facilities and equipment.
 2. Materials may be new or used, must be suitable for the intended purpose, and meet the requirements of applicable codes, regulations, and standards.
- 3.07 TEMPORARY SAFETY AND HEALTH:
- A. General: Contractor shall be solely responsible for initiating, maintaining, and supervising all safety and health precautions and programs in connection with the Work. Contractor shall take all necessary precautions for the safety of, and shall provide necessary protections to prevent injury or loss to, all employees on the Work and other persons and organizations who may be affected thereby.

SECTION 01 51 00 - TEMPORARY UTILITIES AND FACILITIES: continued

3.08 TEMPORARY FIRE PROTECTION:

A. General:

1. Contractor shall be responsible for development of a fire prevention and protection program for all Work under this Contract.
2. The program shall comply with the applicable provisions for safety and protection specified in the Contract Documents and with applicable parts of the NFPA 10 and 241.
3. Locate fire extinguishers where convenient and effective for their intended purpose.
4. Store combustible materials in containers in fire-safe locations.
5. Maintain unobstructed access to fire extinguishers, fire hydrants, temporary fire protection facilities, and other access routes for fighting fires. Prohibit smoking in hazardous fire exposure areas.
6. Provide supervision of welding operations and similar sources of fire ignition.
7. Post warning and instructions at each extinguisher location, and instruct construction personnel on proper use of extinguishers and other available facilities at Project Site. Post local fire department telephone number on or near each telephone instrument at Project Site.

3.09 INSTALLATION AND REMOVAL:

- A. Relocation: Relocate construction aids as required by progress of construction, storage limitations, or Work requirements and to accommodate requirements of Trust and other contractors at the Site.
- B. Removal: Remove temporary materials, equipment, and services when construction needs can be met and allowed by use of permanent construction, or at completion of the Project.
- C. Repair: Clean and repair damage caused by installation or by use of temporary facilities.
 1. Remove foundations and underground installations for construction aids.
 2. Grade the areas of the Site affected by temporary installations to required elevations and clean the area.

END OF SECTION 01 51 00

SECTION 01 52 00 – FIELD OFFICES AND SHEDS

PART 1 - GENERAL

1.01 SUMMARY:

- A. This Section includes requirements for temporary field offices and other structures required for office and storage space required by Contractor and Engineer.
- B. Field Offices for Contractor and Owner Project Representative shall be provided at the Thornton 5MG Tank and Pipeline project site.

1.02 RELATED REQUIREMENTS:

- A. Product Requirements: SECTION 01 60 00.
- B. Temporary Utilities and Facilities: SECTION 01 51 00.
- C. Use of Existing Facilities:
 - 1. Existing facilities at the Site shall not be used for field offices.
- D. Use of Permanent Facilities:
 - 1. Permanent facilities when substantially completed shall not be used for field offices or for storage.

PART 2 - PRODUCTS

2.01 FIELD OFFICES:

- A. General:
 - 1. Provide trailers, mobile buildings, or buildings constructed with floors raised aboveground, with steps, landings, and railings at entrance doors.
 - 2. Buildings shall be structurally sound, secure, and weathertight.
 - 3. Provide appropriate type fire extinguishers at each office and storage area.
 - 4. Maintain offices during progress of the Work.
 - 5. Install office spaces ready for occupancy 15 days after date stated in Notice to Proceed.
 - 6. Provide adequate space, tables and chairs for progress meetings in one of the field offices.
- B. Contractor's Office:
 - 1. Provide a field office for Contractor's superintendent on the Site.
 - 2. It shall be of size required for general use, with lights, heat, furnishings, internet service, and other necessary facilities and utilities required by Contractor's operations.
- C. Owners Project Representative's Office:
 - 1. Provide a field office for Owner's Project Representative on the Site. Owners Project Representative's office may be located within Contractor's trailer (but suitably separated by wall and doorway), mobile building, or building constructed with floors raised aboveground with steps and landings at entrance doors as long as requirements as stated in Paragraph 2.01 C. 2, this Section, are met.
 - 2. Provide the following minimum requirements:
 - a. The office shall be suitable height and of ample size to accommodate the furniture and equipment listed below, without crowding (at least 200 sq. ft. of floor area). The office shall be subdivided and contain one private office of approximately 200 sq. ft. for use by the Owners Project

SECTION 01 52 00 – FIELD OFFICES AND SHEDS: continued

Representative. The office shall be weather-tight; the walls and roof shall be insulated with at least 1 1/2-inch insulating board and suitably ventilated; and the floor shall be tight and of double-thick construction. The office door shall have a cylinder lock with two keys. If trailer is furnished, provide weather skirt around trailer base. Storm doors are required at all entrances.

- b. The Contractor shall furnish the following furniture, equipment, supplies, and services:
- (1) One plan table or sloping plan shelf, about 3 feet by 5 feet, with a reasonably smooth top, and one suitable swivel stool.
 - (2) One conference table, approximately 30 inches by 72 inches and two additional folding chairs.
 - (3) Shelves, counters, and tack board as directed.
 - (4) Electric lights and outlets as directed. Contractor shall pay all charges for the energy used.
 - (5) Two desks for general office use, each about 3 feet by 5 feet, each with a desk chair of the armchair swivel type.
 - (6) Two four-drawer, legal size, metal filing cabinets, each with lock and two keys.
 - (7) Two portable ABC type fire extinguishers of at least 4-lb capacity.
 - (8) Supply of drinking water with a suitable electric water cooler.
 - (9) Janitor service weekly.
 - (10) Thermostatically controlled heating units or system of adequate capacity to maintain a minimum temperature of not less than 70°F under all cold weather conditions. Contractor shall provide all fuel or power used and service necessary.
 - (11) Thermostatically controlled, refrigerant type, air conditioners of adequate capacity to maintain a maximum temperature of not more than 72°F under all hot weather conditions. Contractor shall provide all service necessary and provide all power used.
 - (12) One (1) new 48" min. 1080p "Smart" LED high-definition television (HDTV) with min. 1 HDMI connection, 1 USB connection, min. 1 VGA PC connection, built-in Wi-Fi and Ethernet connection (Sony Model #KDL48R510C/US or approved equal), including one (1) 50' min. HDMI cable, and one full-motion swiveling wall mount located in conference room.
 - (13) Printer that can copy, print and scan up to and including 11 inch by 17 inch sized paper. Copy capability shall be at the approximate rate of 40 copies per minute with the first copy produced in approximately 10 seconds. The machine shall accommodate ordinary, un-sensitized stock paper in variable weight, colors, and sizes. The machine shall use standard 115-volt, 60-hertz electrical power. Contractor shall maintain, at all times, an adequate supply of white paper in both letter and legal sizes. Contractor shall also provide maintenance for the machine.

SECTION 01 52 00 – FIELD OFFICES AND SHEDS: continued

c. Services:

- (1) Lighting: 50 foot candles at desktop height. Exterior lighting at entrance door.
- (2) Heating and air conditioning.
- (3) Electrical Service: Minimum of two circuits, 110V, 60-hertz. Minimum of four 110V duplex convenience outlets.
- (4) Toilet facilities - may be separate portable toilet.
- (5) Private line telephone with one telephone (with speaker phone). The Contractor shall pay all charges for local calls.
- (6) Hi speed internet connection with high speed router capable of uploading and downloading large files such as pictures.

2.02 STORAGE SHEDS AND TRAILERS:

A. On Site:

1. Provide temporary buildings or trailers needed for storage of Equipment and Materials installed under this Contract.
2. Provide ventilation and heating as required by Equipment and Material stored.

B. Off Site:

1. Advise Engineer of any arrangements made for storage of Equipment and Materials in a place other than Owner's Site. Furnish evidence of insurance coverage with Application for Payment as specified by the Contract Documents.

PART 3 - EXECUTION

3.01 LOCATION, INSTALLATION AND MAINTENANCE:

A. General:

1. Place temporary buildings, trailers, and stored materials in locations acceptable to Owner or Engineer.
2. Install field offices and sheds to resist winds and elements of the locality where installed.
3. Remove when no longer needed at the Site or when Work is completed.
4. Keep approach walks free of leaves, mud, water, ice, or snow.
5. At completion of Work, remove temporary buildings and trailers, foundations (if any), utility services, and debris.
6. Prepare ground or paved areas as specified in applicable Sections.

END OF SECTION 01 52 00

SECTION 01 60 00 – PRODUCT REQUIREMENTS

PART 1 - GENERAL

1.01 SUMMARY:

- A. This Section includes administrative and procedural requirements governing Contractor's selection of products for use in the Project.
- B. This section shall not supersede any requirements of the general or special provisions nor any requirements of the SRF funding general requirements.
- C. Related Sections: The following Sections contain requirements that relate to this Section:
 - 1. For the applicability of industry standards to products specified: DIVISIONS 3 through 40.
 - 2. For submittal of Contractor's construction progress schedule and the Submittal schedule: General and Special Conditions

1.02 DEFINITIONS:

- A. Definitions used in this Article are not intended to change the meaning of other terms used in these Contract Documents, such as "specialties," "systems," "structures," "finishes," "accessories," and similar terms. Such terms are self-explanatory and have well-recognized meanings in the construction industry.
 - 1. "Products" are items purchased for incorporation in the Work, whether purchased for the Project or taken from previously purchased stock. The term "product" includes the terms "Material," "Equipment," "system," and terms of similar intent.
 - a. "Named Products" are items identified by the manufacturer's product name, including make or model number or other designation, shown or listed in the manufacturer's published product literature that is current as of the date of the Contract Documents.
 - b. "Foreign Products," as defined else where in the specifications.
 - 2. "Materials" are products substantially shaped, cut, worked, mixed, finished, refined or otherwise fabricated, processed, or installed to form a part of the Work.
 - 3. "Equipment" is a product with operational or nonoperational parts, whether motorized, or manually operated, that may require service connections, such as wiring or piping.

1.03 SUBMITTALS:

- A. Submittal of preliminary procurement schedule is specified in the General and Special Conditions.
- B. Submittals for products are specified in the General and Special Conditions and in applicable Sections of DIVISIONS 3 through 40.

1.04 QUALITY CONTROL:

- A. Source Limitations: To the fullest extent possible, provide products of the same kind from a single source.
 - 1. When specified products are available only from sources that do not, or cannot, produce a quantity adequate to complete Project requirements in a

SECTION 01 60 00 – PRODUCT REQUIREMENTS: continued

timely manner, consult with Engineer to determine the most important product qualities before proceeding. Qualities may include attributes, such as visual appearance, strength, durability, or compatibility. When a determination has been made, select products from sources producing products that possess these qualities, to the fullest extent possible.

- B. Compatibility of Options: When the Contractor is given the option of selecting between 2 or more products for use on the Project, the product selected shall be compatible with products previously selected, even if previously selected products were also options.
 - 1. Each prime contractor is responsible for providing products and construction methods that are compatible with products and construction methods of other prime or separate contractors.
 - 2. If a dispute arises between prime contractors over concurrently selectable, but incompatible products, Engineer will determine which products shall be retained and which are incompatible and must be replaced.
- C. Foreign Product Limitations: Contractor shall comply with the American Iron and Steel requirements indicated elsewhere in the specification. Except under one or more of the following conditions, provide domestic products, not foreign products, for inclusion in the Work:
 - 1. No available domestic product complies with the Contract Documents.
 - 2. Domestic products that comply with the Contract Documents are available only at prices or terms substantially higher than foreign products that comply with the Contract Documents.
- D. Nameplates: Except for required labels and operating data, do not attach or imprint manufacturer's or producer's nameplates or trademarks on exposed surfaces of products that will be exposed to view in occupied spaces or on the exterior.
 - 1. Labels: Locate required product labels and stamps on concealed surfaces or, where required for observation after installation, on accessible surfaces that are not conspicuous.
 - 2. Equipment Nameplates: Provide a permanent nameplate on each item of service-connected or power-operated Equipment. Locate on an easily accessible surface that is inconspicuous in occupied spaces. The nameplate shall contain the following information and other essential operating data:
 - a. Name of product and manufacturer including address (and telephone number).
 - b. Model and serial number.
 - c. Capacity.
 - d. Speed.
 - e. Ratings.
- E. Electronic Equipment Compliance:
 - 1. Contractor warrants that all equipment, devices, items, systems, software, hardware, or firmware provided shall properly, appropriately, and consistently function and accurately process date and time data (including without limitation: calculating, comparing, and sequencing). This warranty supercedes anything in the Specifications or other Contract Documents which

SECTION 01 60 00 – PRODUCT REQUIREMENTS: continued

might be construed inconsistently. This warranty is applicable whether the equipment, device, item, system, software, hardware, or firmware is specified with or without reference to a manufacturer's name, make, or model number.

1.05 TRANSPORTATION AND SHIPMENT:

A. Shipment Preparation:

1. Contractor shall require manufacturers and Suppliers to prepare products for shipment in a manner to facilitate unloading and handling, and to protect against damage, deterioration, or unnecessary exposure to the elements in transit and storage. Provisions for protection shall include the following:
 - a. Crates or other suitable packaging materials.
 - b. Covers and other means to prevent corrosion, moisture damage, mechanical injury, and accumulation of dirt in motors, electrical equipment, and machinery.
 - c. Suitable rust-preventive compound on exposed machined surfaces and unpainted iron and steel.
 - d. Grease packing or oil lubrication in all bearings and similar items.

- #### B. Marking:
- Each product item shall be tagged or marked as identified in the delivery schedule or on Submittals. Complete packing lists and bills of material shall be included with each shipment. Each piece of every item need not be marked separately, provided that all pieces of each item are packed or bundled together and the packages or bundles are properly tagged or marked.

1.06 PRODUCT DELIVERY, STORAGE, AND HANDLING:

A. Deliver, store, and handle products according to the manufacturer's recommendations, using means and methods that will prevent damage, deterioration, and loss, including theft.

1. Schedule delivery to minimize long-term storage at the Site and to prevent overcrowding of construction spaces. Allow ample time to avoid delay of the Work.
2. Coordinate delivery with installation time to assure minimum holding time for items that are flammable, hazardous, easily damaged, or sensitive to deterioration, theft, and other losses.
3. Deliver products to the Site in an undamaged condition in the manufacturer's original sealed container or other packaging system, complete with labels and instructions for handling, storing, unpacking, protecting, and installing.
4. Inspect products upon delivery to ensure compliance with the Contract Documents and to ensure that products are undamaged and properly protected. Inspect shipment to assure:
 - a. Product complies with requirements of Contract Documents and reviewed Submittals.
 - b. Quantities are correct.
 - c. Containers and packages are intact and labels are legible.
 - d. Products are properly protected and undamaged.
5. Store products at the Site in a manner that will facilitate inspection and measurement of quantity or counting of units. Mark deliveries of component

SECTION 01 60 00 – PRODUCT REQUIREMENTS: continued

parts of Equipment to identify the Equipment, to permit easy accumulation of parts, and to facilitate inspection and measurement of quantity or counting of units.

6. Store heavy Materials away from the Project structure in a manner that will not endanger the supporting construction.
 7. Store products subject to damage by the elements above ground, under cover in a weathertight enclosure, and with ventilation adequate to prevent condensation. Maintain temperature and humidity within range required by manufacturer's instructions.
 8. Protect motors, electrical Equipment, plumbing fixtures, and machinery of all kinds against corrosion, moisture deteriorations, mechanical injury, and accumulation of dirt or other foreign matter.
 9. Protect exposed machined surfaces and unpainted iron and steel as necessary with suitable rust-preventive compounds.
 10. Protect bearings and similar items with grease packing or oil lubrication.
 11. Handle and store steel plate, sheet metal, and similar items in a manner to prevent deformation.
 12. For storage of pipe and other products on easements and rights-of-way in residential and commercial areas, do not exceed the minimum required by scheduled laying operations, and conform to all requirements of public authorities. Store or place pipe along roads, set back from shoulder or curb, and at an angle tending to deflect vehicles if struck. Place or block pipe to preclude its accidental movement.
- B. Handling:
1. Provide equipment and personnel necessary to unload and handle products, by methods to prevent damage or soiling to products, or packaging.
 2. Handle by methods to prevent bending or overstressing. Where lifting points are designated, lift components only at those points.
 3. Provide additional protection to surrounding surfaces as necessary to prevent damage.
- C. Maintenance of Storage:
1. Inspect stored products on a scheduled basis.
 2. Verify that storage facilities comply with manufacturer's product storage requirements, including environmental conditions continually maintained.
 3. Verify that surfaces of products exposed to elements are not adversely affected; that any weathering of finishes is acceptable under requirements of Contract Documents.
 4. For mechanical and electrical Equipment in long-term storage, provide manufacturer's service instructions to accompany each item, with notice of enclosed instructions on exterior of package. Service Equipment on a regularly scheduled basis.
- D. Protection After Installation: Provide substantial coverings as necessary to protect installed products from damage from subsequent construction operations. Remove coverings when no longer needed or as specified.

SECTION 01 60 00 – PRODUCT REQUIREMENTS: continued

PART 2 - PRODUCTS

2.01 PRODUCT SELECTION:

- A. General Product Requirements: Provide products that comply with the Contract Documents, that are undamaged and, unless otherwise specified or indicated, new at the time of installation.
 - 1. Provide products complete with accessories, trim, finish, safety guards, and other devices and details needed for a complete installation and the intended use and effect.
 - 2. Where available, provide standard products of types that have been produced and used successfully in similar situations on other projects.
 - 3. Continued Availability: Where, because of the nature of its application, Owner is likely to need replacement parts or additional amounts of a product at a later date, either for maintenance and repair or replacement, provide standard products for which the manufacturer has published assurances that the products and its parts are likely to be available to Owner at a later date.
 - 4. Conform to applicable Specifications, codes, standards, and regulatory agencies.
 - 5. Comply with size, make, type, and quality specified, or as specifically approved in writing by Engineer.
 - 6. Manufactured and Fabricated Products:
 - a. Design, fabricate, and assemble in accordance with the best engineering and shop practices.
 - b. Manufacture like parts of duplicate units to standard sizes and gages, to be interchangeable.
 - c. Equipment and Materials shall be suitable for service conditions intended.
 - d. Equipment capacities, sizes, and dimensions indicated or specified shall be adhered to unless variations are specifically approved in writing by Engineer.
 - e. Provide labels and nameplates where required by regulatory agencies or to state identification and essential operating data.
 - 7. Do not use products for any purpose other than that for which designed.
 - 8. To the fullest extent possible, provide products of the same kind from a single source.

PART 3 - EXECUTION

3.01 INSTALLATION OF PRODUCTS:

- A. Comply with manufacturer's instructions and recommendations for installation of products in the applications indicated. Anchor each product securely in place except as required for proper movement and performance, and accurately located and aligned with other Work.
 - 1. Obtain and distribute copies of manufacturer's printed instructions and recommendations if not a part of Submittals, containers, or packaging to parties involved in the installation, including a copy to Engineer and Owner.

SECTION 01 60 00 – PRODUCT REQUIREMENTS: continued

2. Maintain one complete set of instructions at the Site during installation and until completion.
 3. Handle, install, connect, clean, condition, and adjust products in accordance with such instructions and in conformance with specified requirements.
Should job conditions or specified requirements conflict with manufacturer's instructions, consult with Engineer for further instructions.
- B. Clean exposed surfaces and protect as necessary to ensure freedom from damage and deterioration at time of Substantial Completion.

END OF SECTION 01 60 00

DIVISION 03 – CONCRETE

SECTION 03 10 00 – CONCRETE FORMWORK

PART 1 - GENERAL

1.01 RELATED DOCUMENTS:

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and DIVISION 01 Specification Sections, apply to this Section.

1.02 SUMMARY:

- A. This Section includes formwork for cast-in-place concrete.
- B. Related Work Specified Elsewhere:
 - 1. Concrete Reinforcing: SECTION 03 20 00
 - 2. Concrete: SECTION 03 30 00

1.03 REFERENCE STANDARDS:

- A. Applicable Standards:
 - 1. American Concrete Institute (ACI):
 - a. ACI 117 - Specifications for Tolerances for Concrete Construction and Materials.
 - b. ACI 301 - Specifications for Structural Concrete.
 - c. ACI 318 - Building Code Requirements for Reinforced Concrete.
 - d. ACI 347R - Guide to Formwork for Concrete.
 - e. ACI 350 - Code Requirements for Environmental Engineering Concrete Structures.
 - f. ACI 350.5 - Specifications for Environmental Concrete Structures.
 - 2. ASTM International (ASTM):
 - a. ASTM C31/C31M REV A – Standard Practice for Making and Curing Concrete Test Specimens in the Field.
 - b. ASTM C39/C39M - Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens.
 - c. ASTM C1077 - Standard Practice for Laboratories Testing Concrete and Concrete Aggregates for Use in Construction and Criteria for Laboratory Evaluation.

PART 2 - PRODUCTS

2.01 MATERIALS FOR FACING:

- A. Where concrete will be exposed to view after construction:
 - 1. Use exterior grade plywood at least 5/8-inch-thick or steel forms capable of producing a smooth, uniform appearance.
 - 2. Do not use form-facing materials with raised grain, torn surfaces, worn edges, dents, or other defects that will impair the texture of concrete surfaces.
- B. Where concrete will not be exposed to view after construction:
 - 1. Exterior grade plywood at least 5/8 inch thick.

SECTION 03 10 00 – CONCRETE FORMWORK: continued

- 2. Steel.
 - 3. Wood fiberboard.
 - 4. Dressed lumber free of loose knots.
 - C. Treat forms with commercially available form releasing agents that will not bond with, stain, or adversely affect concrete surfaces. Agents shall not impair subsequent treatment of concrete surfaces depending upon bond or adhesion, nor shall it impede the wetting of surfaces to be cured with water or curing compounds. Form releasing agents shall be VOC compliant with a maximum VOC content of 3.8 lbs./gal. (450 g/L), or less where area restrictions are more stringent.
 - D. Clean forms of sawdust, dust, dirt, and other foreign materials.
- 2.02 FORM TIES:
- A. Break back, coil, or screw type, except where otherwise specified.
 - B. Use water-seal coil type in walls below grade and in walls of water bearing structures.
 - C. Coil type shall leave conical depression in concrete.
 - D. Space as required against pressure of fresh concrete.
 - E. The portion of the form tie remaining in place shall provide for a clearance of two times the minimum dimension of the tie, but not less than 3/4 inch, from the formed surface.
- 2.03 CHAMFER STRIPS:
- A. Chamfer: 3/4 inch except where otherwise indicated.
 - B. Place in all forms to provide chamfer where concrete will have exposed projecting corners.

PART 3 - EXECUTION

- 3.01 FORM CONSTRUCTION:
- A. Conform to ACI 301, 318, and 347R, except Shop Drawings for formwork, shoring, and reshoring shall not be submitted for approval.
 - B. Adequately brace, stiffen, and support forms to prevent perceptible deflection or settlement, and to hold plumb, level, and true to line.
 - C. Construct and maintain forms to the tolerances given in ACI 117.
 - D. Construct sufficiently tight to prevent mortar leakage.
 - E. Avoid offsets between adjacent forms and construct so that shores, braces, and stiffening members are in line with those below.
 - F. Space studs and stringers as required to support facing against concrete pressure, but not more than 12 inches for 5/8-inch plywood or 16 inches for 3/4-inch plywood. Maximum deflection of facing materials reflected on concrete surfaces exposed to view shall be 1/240 of the span between structural members of the formwork.
 - G. Use wales, strongbacks, shores, and bracing as required.
 - H. Form all necessary openings or chases for piping, ductwork, and similar items where indicated or as required for the Work.
 - I. Construct forms to be removable in sections without marring concrete surface.

SECTION 03 10 00 – CONCRETE FORMWORK: continued

- J. Surface of forms shall provide a smooth, dense, plane surface to finished concrete where exposed to view.
- K. Contractor shall be responsible for structural adequacy, design, engineering, and construction of the formwork.
- L. Stay-in-place metal forms shall not be used.

3.02 TIME-IN-PLACE FOR FORMS:

- A. It is the responsibility of Contractor to consider all applicable factors and leave the formwork in place until it is safe to remove them.
- B. All removal shall be performed in a manner which will prevent damage to the concrete and ensure the complete safety of the structure.
- C. Where forms support more than one element, the forms shall not be removed until the form removal criteria are met by all supported elements.
- D. Evidence that concrete has gained sufficient strength to permit removal of forms shall be determined by tests on control cylinders. All control cylinders shall be stored in the structure or as near the structure as possible, so they receive the same curing conditions and protection methods as given those portions of the structure they represent. Control cylinders shall be removed from the molds at an age of no more than 24 hours. All control cylinders shall be prepared and tested in accordance with ASTM C31/C31M REV A and ASTM C39/C39M at the expense of Contractor by an independent laboratory that complies with ASTM C1077. Control cylinders shall be tested within 4 hours after removal from the Site.
- E. Forms shall not be removed unless the minimum time or minimum compressive strength requirements below are met.
 - 1. Formwork Not Supporting Weight of Concrete:
 - a. Formwork for walls, columns, sides of beams, gravity structures, slabs-on-ground and other vertical type formwork not supporting the weight of concrete shall remain in place 24-hours minimum after concrete placement is completed.
 - 2. Formwork Supporting Weight of Concrete:
 - a. Formwork supporting weight of concrete and shoring shall not be removed until structural members have acquired sufficient strength to safely support their own weight and any construction or other superimposed loads to which the supported concrete may be subjected. As a minimum, no forms or shoring shall be loosened or removed until control concrete test cylinders indicate the concrete has attained the following compressive strengths for the respective structural members:

<u>Structural Member</u>	<u>Percent of Design Compressive Strength</u>
Unshored slab and beam forms or forms which can be removed without disturbing shores	70
Slab or beam shoring	85

SECTION 03 10 00 – CONCRETE FORMWORK: continued

END OF SECTION 03 10 00

SECTION 03 20 00 - CONCRETE REINFORCING

PART 1 - GENERAL

1.01 SUMMARY:

- A. This Section includes steel reinforcement bars, ties, bolsters, chair supports, and accessories.
- B. Related Work Specified Elsewhere:
 - 1. Concrete Formwork: SECTION 03 10 00.
 - 2. Concrete: SECTION 03 30 00.

1.02 REFERENCES:

- A. Applicable Standards:
 - 1. American Society for Testing and Materials (ASTM):
 - a. A615/A615M - Deformed and Plain Billet-Steel Bars for Concrete Reinforcement.
 - 2. American Concrete Institute (ACI):
 - a. 350 – Code Requirements for Environmental Engineering Concrete Structures
 - b. 301 - Specifications for Structural Concrete for Buildings.
 - c. SP-66 - Detailing Manual.
 - d. 318 - Building Code Requirements for Reinforced Concrete.
 - e. 117 - Specifications for Tolerances for Concrete Construction and Materials.
 - 3. American Welding Society (AWS):
 - a. A5.5 - Low Alloy Steel Covered Arc Welding Electrodes.
 - b. B2.1 - Standard for Welding Procedure and Performance Qualification.
 - c. D1.4 - Structural Welding Code - Reinforcing Steel.
 - 4. Concrete Reinforcing Steel Institute (CRSI):
 - a. Manual of Standard Practice.

1.03 SUBMITTALS:

- A. Submit as specified in the General and Special Conditions.
- B. Include, but not limited to, the following:
 - 1. Complete bar schedule, bar details, and erection drawings to conform to ACI SP-66.
 - 2. Drawing with each type of bent bar marked with identification mark. Straight bars shall have mark number or be identified by size and length.
 - 3. Erection drawings shall be clear, easily legible, and to a minimum scale of:
 - a. 1/4 inch = 1 foot (1:50).
 - b. 1/8 inch = 1 foot (1:100) if bars in each face are shown in separate views.
 - 4. Size and location of all openings with required additional reinforcement around openings.
 - 5. Concrete protective cover.
 - 6. Grade of steel.
 - 7. Lap splice lengths.
 - 8. Mechanical splice product specification and data (if allowed and approved by Engineer)

SECTION 03 20 00 - CONCRETE REINFORCING: continued

1.04 DELIVERY, STORAGE, AND HANDLING:

- A. Store steel reinforcement blocked-up off the ground and in orderly stacks.
- B. Store only bars with the same identifying label in the same stack.

1.05 TESTING:

- A. Perform at the mill for each heat.
- B. Submit certified test results to Engineer upon request.

PART 2 – PRODUCTS

2.01 REINFORCEMENT BARS, TIES, AND STIRRUPS:

- A. Materials:
 - 1. Conform to ASTM A615, Grade 60.
- B. Fabrication of Bars:
 - 1. Fabricate with cold bends conforming to the recommended dimensions shown in ACI 318.
 - 2. Fabricate bars according to the tolerances given in ACI 301, Chapter 5.
 - 3. Field fabrication will be allowed only if Contractor has equipment to properly fabricate steel.
 - 4. Attach metal or plastic tags with identifying mark or length corresponding to mark number or length on Drawing. Straight bars shall have mark number or size and length. Bent bars shall have mark number.
 - 5. Contractor may, at his option, continue steel reinforcement through openings in walls and slabs, then field-cut the opening so that there will be the required concrete cover between ends of bars and edge of opening.

2.02 WELDED WIRE REINFORCEMENT:

- A. Conform to ASTM 1064.
- B. Wire sizes W1.4 and smaller shall be galvanized.
- C. Provide mats only. Rolled fabric is not acceptable.

2.02 BOLSTERS, CHAIRS, AND ACCESSORIES:

- A. Conform to ACI SP-66 and the CRSI Manual of Standard Practice.
- B. Provide all spacers, bolsters, chairs, ties, and other devices necessary to properly space, place, support, and fasten steel reinforcement in place during the concrete placement.
- C. Metal accessories shall be galvanized or plastic-coated where legs will be exposed in finished concrete surfaces.
- D. Do not use rocks, broken bricks, wood blocks, or concrete fragments for support of steel reinforcement.

2.03 PRECAST CONCRETE BLOCK BAR SUPPORTS:

- A. May be used only for bar supports in slabs on ground.
- B. Blocks shall be made with a minimum of nine sacks of cement per cubic yard and have a minimum compressive strength of 6,000 psi in 28 days.

SECTION 03 20 00 - CONCRETE REINFORCING: continued

- C. Each block shall have a minimum of 9 square inches of bearing area. Space as required by the particular condition of weight, bearing surface, and rigidity of the steel reinforcement.

PART 3 - EXECUTION

3.01 PLACEMENT OF STEEL REINFORCEMENT:

- A. Place all steel reinforcement before concrete is cast in accordance with approved erection drawings, ACI 117, ACI 318, and the CRSI Manual of Standard Practice.
- B. Remove oil, mill scale, pitting, mud, loose rust, ice, and other materials that would reduce bond from bars before placing.
- C. Tie securely with 16 gage (1.6 mm) or larger annealed iron wire.
- D. Place to maintain concrete cover to conform to ACI 117 and ACI 318, unless otherwise indicated.
- E. Splice steel where indicated. Splices shall be in full contact and shall conform to ACI 318.
 - 1. Unless otherwise indicated, lap splices shall be Class B as defined by ACI 318.
 - 2. Splice steel using Cadweld Series T-splices where indicated or approved.
 - a. Provide a manufacturer's representative to give on site instructions to all welders who will perform the splices in the field.
 - b. Contractor shall have the manufacturer's representative instruct, observe, and approve in writing those persons doing the welding.
 - c. Contractor shall arrange for the manufacturer's representative to return at the request of the Engineer.
 - 3. Splices in members indicated as "tension tie members" shall be made with Cadweld Series T-splices or Lenton mechanical splices in accordance with ACI 318.
 - 4. Any additional Subcontractor-proposed splice shall be submitted for acceptance of location and splice length.
- F. Lap welded wire reinforcement in accordance with of ACI 318, but not less than the length of one mesh plus 2 inches (50 mm).
- G. Connection of reinforcement bars to steel shapes or plate shall be with a Cadweld Series B-splice.
- H. Do not bend bars embedded in hardened or partially hardened concrete without approval from Engineer. If bending is permitted, conform to procedures of ACI 301 unless otherwise prescribed by the governing building code.
- I. Do not weld reinforcing bars unless specifically indicated. Where welding is indicated, provide bars conforming to ASTM A706/A706M and comply with AWS D1.4.

END OF SECTION 03 20 00

SECTION 03 30 00 – CONCRETE

PART 1 - GENERAL

1.01 RELATED DOCUMENTS:

- A. Drawings and general provision of the Contract, including General and Special Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY:

- A. This Section includes concrete and related items.
- B. Related Work Specified Elsewhere:
 - 1. Concrete Formwork: SECTION 03 10 00.
 - 2. Concrete Reinforcement: SECTION 03 20 00.
 - 3. Post Installed Concrete Anchors: SECTION 05 05 19.
 - 4. Protective Coatings: SECTION 09 90 00.

1.03 REFERENCE STANDARDS:

- A. Comply with the provisions of the following codes, specifications, and standards, except as otherwise indicated.
- B. Publication Dates: Comply with standards in effect as of date of the Contract Documents unless otherwise indicated.
 - 1. American Concrete Institute (ACI):
 - a. 211.1 - Standard Practice for Selecting Proportions for Normal, Heavyweight, and Mass Concrete.
 - b. 301 - Specifications for Structural Concrete.
 - c. 302.1R - Guide for Concrete Floor and Slab Construction.
 - d. 304R - Guide for Measuring, Mixing, Transporting, and Placing Concrete.
 - e. 305.1 - Specification for Hot Weather Concreting
 - f. 306R - Committee Report on Cold Weather Concreting.
 - g. 306.1 - Standard Specification for Cold Weather Concreting
 - h. 308.1 - Standard Specification for Curing Concrete.
 - i. 309R - Guide for Consolidation of Concrete.
 - j. 318 - Building Code Requirements for Structural Concrete.
 - k. 350 - Environmental Engineering Structures.
 - l. 350.1 – Tightness Testing of Environmental Concrete Structures.
 - 2. ASTM International (ASTM):
 - a. B370 - Copper Sheet and Strip for Building Construction.
 - b. C31/C31M - Practice for Making and Curing Concrete Test Specimens in the Field.
 - c. C33 - Concrete Aggregates.
 - d. C39 - Test Method for Compressive Strength of Cylindrical Concrete Specimens.
 - e. C40 - Test Method for Organic Impurities in Fine Aggregates for Concrete.
 - f. C42 - Test Method for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete.

SECTION 03 30 00 – CONCRETE: continued

- g. C88 - Test Method for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate.
- h. C114 - Test Methods for Chemical Analysis of Hydraulic Cement.
- i. C117 - Test Method for Material Finer than 75 μ (No. 200) Sieve in Mineral Aggregates by Washing.
- j. C136 - Test Method for Sieve Analysis of Fine and Coarse Aggregates.
- k. C142 - Test Method for Clay Lumps and Friable Particles in Aggregates.
- l. C143 - Test Method for Slump of Hydraulic Cement Concrete.
- m. C150 - Portland Cement.
- n. C172 - Practice for Sampling Freshly Mixed Concrete.
- o. C192/C192M - Practice for Making and Curing Concrete Test Specimens in the Laboratory.
- p. C231 - Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method.
- q. C233 - Test Methods for Air-Entraining Admixtures for Concrete.
- r. C260 - Air-Entraining Admixtures for Concrete.
- s. C289 - Test Method for Potential Alkali-Silica Reactivity of Aggregates (Chemical Method).
- t. C309 - Liquid Membrane-Forming Compounds for Curing Concrete.
- u. C430 - Test Method for Fineness of Hydraulic Cement by the 45 μ (No. 325) Sieve.
- v. C494 - Chemical Admixtures for Concrete.
- w. C566 - Test Method for Total Evaporable Moisture Content of Aggregate by Drying.
- x. C595/C595M - Blended Hydraulic Cements.
- y. C618 - Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete.
- z. C881 - Epoxy-Resin-Base Bonding Systems for Concrete.
- aa. C1107 - Packaged Dry, Hydraulic Cement Grout (Nonshrink).
- bb. C1193 - Guide for Use of Joint Sealants.
- cc. C1218 - Standard Test Method for Water-Soluble Chloride in Mortar and Concrete.
- dd. C1260 - Standard Test Method for Potential Alkali Reactivity of Aggregates (Mortar-Bar Method)
- ee. C1293 - Standard Test Method for Determination of Length Change of Concrete Due to Alkali-Silica Reaction
- ff. C1315 - Liquid Membrane-Forming Compounds Having Special Properties for Curing and Sealing Concrete.
- gg. C1567 - Standard Test Method for Determining the Potential Alkali-Silica Reactivity of Combinations of Cementitious Materials and Aggregate (Accelerated Mortar-Bar Method)
- hh. C1602 – Standard Specification for Mixing Water Used in the Production of Hydraulic Cement Concrete.
- ii. C1778 - Standard Guide for Reducing the Risk of Deleterious Alkali-Aggregate Reaction in Concrete

SECTION 03 30 00 – CONCRETE: continued

- jj. D1751 - Preformed Expansion Joint Filler for Concrete Paving and Structural Construction. (Nonextruding and Resilient Bituminous Types).
- kk. D1752 - Preformed Sponge Rubber, Cork and Recycled PVC Expansion Joint Fillers for Concrete Paving and Structural Construction.
- ll. D1752 - Preformed Sponge Rubber, Cork and Recycled PVC Expansion Joint Fillers for Concrete Paving and Structural Construction.
- 3. Concrete Plant Manufacturers Bureau (CPMB):
 - a. 100 - Concrete Plant Standards.
 - b. 102 - Recommended Guide Specifications for Batching Equipment and Control Systems in Concrete Batch Plants.
- 4. Plant Mixer Manufacturers Division (PMMD):
 - a. 100 - Concrete Plant Mixer Standards.
- 5. Federal Specification (FS):
 - a. SS-S-200 - Sealants, Joint: Two-Component, Jet-Blast-Resistant, Cold-Applied, for Portland Cement Concrete Pavement.
 - b. TT-S-227 - Sealing Compound: Elastomeric Type, Multi-Component (for Calking, Sealing, and Glazing in Buildings and Other Structures).
- 6. National Bureau of Standards (NBS) Specifications for Scales.
- 7. Truck Mixer Manufacturers Bureau (TMMB):
 - a. Truck Mixer, Agitator and Front Discharge Concrete Carrier Standards.

1.04 SUBMITTALS:

- A. Submit as specified in the General and Special Provisions.
- B. Include, but not limited to, product data and Shop Drawings of the following:
 - 1. Nonshrink grouts.
 - 2. Admixtures.
 - 3. Bonding agents.
 - 4. Curing agents.
 - 5. Floor hardeners, sealers, and coloring compounds.
 - 6. Expansion joint materials.
 - 7. Formwork spray agents.
 - 8. Joint sealants.
 - 9. Waterstops.
- C. Mill Certificates:
 - 1. Submit to Engineer, a minimum of one copy for each cement shipment.
- D. Concrete Mix Design:
 - 1. Submit the following test data for each mix design for approval prior to placing concrete. Resubmit for any change in each mix design.
 - a. Concrete:
 - (1) Fine and coarse aggregate, water and cement sources.
 - (2) Mix proportions, slump and air content.
 - (3) Data on 30 consecutive satisfactory compressive strength tests and standard deviation calculations, laboratory trial batch strength curves.
 - (4) Dry shrinkage test results
 - b. Cement:
 - (1) Mill certificate.

SECTION 03 30 00 – CONCRETE: continued

- (2) ASTM C430.
- c. Fine Aggregate:
 - (1) ASTM C33.
 - (2) ASTM C40.
 - (3) ASTM C88.
 - (4) ASTM C117.
 - (5) ASTM C136.
 - (6) ASTM C142.
 - (7) Fineness modulus.
 - (8) ASTM C1260, ASTM C1567, or approved service records.
- d. Coarse Aggregate:
 - (1) ASTM C33.
 - (2) ASTM C88.
 - (3) ASTM C136.
 - (4) ASTM C142.
 - (5) ASTM C1260, ASTM C1567, or approved service records.
- E. Construction Joint layout
 - 1. Dimensioned drawings showing location of all wall and slab construction joints.

1.05 QUALITY CONTROL:

- A. Field Testing: Shall be performed by an ACI Concrete Field Testing Technician Grade 1.
 - 1. Reference Section 3.08 for concrete testing requirements.

PART 2 - PRODUCTS

2.01 CONCRETE:

- A. Materials:
 - 1. Cementitious Materials:
 - a. Provide one of the following:
 - (1) ASTM C150, Type II:
 - (a) 15 to 25% Fly ash shall be used as the pozzolan. Fly ash shall conform to ASTM C618, Class F or C. Class C fly ash shall have a Dunstan ratio no greater than 3.0. The Dunstan Ratio (R shall be defined as $(CaO-5)/Fe_2O_3$) expressed as a percent.
 - (2) ASTM 595, Any Type with MS designation. ASTM C595 cements that include ASTM C1157 cements are not permitted.
 - b. The maximum amount retained on the No. 325 sieve shall be 10% as determined in accordance with ASTM C430.
 - c. The maximum amount of alkalis ($Na_2O + 0.658 K_2O$) shall be 0.80% determined in accordance with ASTM C114.
 - d. Use one brand of cement throughout the Project unless otherwise approved by Engineer.
 - 2. Fine Aggregate:
 - a. Conform to ASTM C33.
 - b. Fineness modulus shall be between 2.3 and 3.1.

SECTION 03 30 00 – CONCRETE: continued

- c. Approved service record of 3 years with a history indicating that the fine aggregate is not chemically reactive.
 - d. Fine aggregate considered deleterious or potentially deleterious shall not be used without approval.
 - (1) If aggregates are not considered innocuous per ASTM C1260, provide tests results per ASTM C1567.
 - e. Maintain fine aggregate free of ice and frozen lumps.
- 3. Coarse Aggregate:
 - a. Conform to ASTM C33.
 - (1) Limits for deleterious substances and physical property requirements shall conform to Table 3 and applicable class designation 5S, 5M, or 1N.
 - b. Approved service record of 3 years with a history indicating that the coarse aggregate is not chemically reactive.
 - c. For a new coarse-aggregate source, when 3 years' approved service records are not available, or when the service records are unacceptable; the aggregate shall be evaluated for potential reactivity. The aggregate shall be evaluated for potential reactivity. Aggregate must be considered innocuous in accordance by ASTM C1260.
 - (1) Alternatively, provide reactivity results as tested in accordance with ASTM C1567.
 - d. Blast furnace slag will not be permitted.
 - e. Maintain coarse aggregate free of ice and frozen lumps.
 - f. Grading Requirements:
 - (1) Size No. 57, from 1-inch to No. 4 sieve for all concrete unless otherwise specified.
- 4. Mixing Water:
 - a. Only potable water will be acceptable.
- 5. Admixtures:
 - a. Water-Reducing Type:
 - (1) Conform to ASTM C494, Type A.
 - (2) Conform to manufacturer's recommendations for use.
 - (3) Technical assistance of the manufacturer's field representative shall be furnished upon request.
 - b. Air-Entraining Type:
 - (1) Conform to ASTM C260.
 - (2) Conform to manufacturer's recommendations for use.
 - (3) Technical assistance of the manufacturer's field representative shall be furnished upon request.
 - (4) Testing of air-entraining admixtures shall conform to ASTM C233.
 - c. Other Admixtures: Use only with Engineer's written concurrence.
 - (1) Water-Reducing, Retarding Type: Conform to ASTM C494, Type D.
 - (2) Color: For electrical duct banks only, use a red dye additive mixed into the concrete.
 - d. Admixtures shall not contain any chloride ions.

SECTION 03 30 00 – CONCRETE: continued

- e. Storage: Admixtures shall be stored in such a manner as to avoid contamination, evaporation, freezing, temperature changes, settling, or any damage which would adversely affect their characteristics.
- B. Laboratory Testing of Materials for Use in Concrete:
 - 1. An approved independent testing laboratory shall be selected and paid by Contractor to perform all required laboratory tests of materials proposed for use in the production of concrete and to determine mix proportions when laboratory trial batches are required.
- C. Concrete Qualities Required:
 - 1. Minimum 28-day compressive strength:
 - a. Structural concrete and all concrete unless otherwise indicated: 4,500 psi.
 - b. Drilled Shafts: Refer to Section 32 63 29.
 - c. Electrical Duct Banks: 4,000 psi
 - d. Pavements, Curbs, Gutters, Sidewalks, and drainage pavements: 4,000 psi.
 - e. Compressive strength determinations shall be made from concrete cylinders tested in accordance with ASTM C39 and per PART 3 this Section.
 - 2. Concrete Slump:
 - a. Structural concrete and all concrete unless otherwise indicated: 4 to 6 inches.
 - b. Drilled Shafts: Refer to Section 32 63 29.
 - c. Slump of concrete shall be tested in accordance with ASTM C143. If the contractor wishes to use a mix with a slump outside the range listed above, the written approval from the engineer of record is required prior to mix design submittal.
 - 3. Air Content:
 - a. Structural concrete and all concrete unless otherwise indicated: 6% $\pm$ 1.5%.
 - b. Interior concrete slabs receiving vehicular or pedestrian traffic: 3% maximum.
 - c. Drilled Shafts: 6% $\pm$ 1.5%.
 - d. Pavements, Curbs, Gutters, Sidewalks, and drainage pavements: 6% $\pm$ 1.5%.
 - e. Testing shall be in accordance with ASTM C231.
 - 4. Water-Cement Ratio:
 - a. In addition to the aforementioned requirements, water-cement ratios shall be limited as follows:
 - (1) Structural Concrete: 0.42
 - (2) All other elements: 0.45
 - 5. Dry shrinkage shall not exceed 0.040 percent when tested in accordance with ASTM C157 for concrete used in liquid retaining structures.
 - 6. Chloride Ion Content:
 - a. Maximum water-soluble chloride ion content, in percent by weight of cement:

SECTION 03 30 00 – CONCRETE: continued

- (1) 0.10 for all concrete unless otherwise specified.
 - b. Testing shall be in accordance with ASTM C1218.
- D. Mix Proportions:
 - 1. Concrete shall be homogeneous, readily placeable, uniformly workable, and finishable; proportioned to conform to ACI 211.1.
 - a. Mix proportions for all concrete, unless otherwise specified, shall be selected preferably on the basis of field experience; but in the case where sufficient or suitable strength test data is not available, concrete shall be proportioned on the basis of laboratory trial mix design.
 - b. Field experience using test results within the preceding year, with the materials and plant to be employed may be the basis of mix proportioning, provided that not less than 30 consecutive satisfactory compressive strength tests on concrete using the proposed materials with a similar mix are available. A compressive strength test is defined as the average 28-day compressive strength of two companion cylinders made conforming to ASTM C172 and ASTM C31 and tested conforming to ASTM C39
 - (1) The standard deviation of compressive strength tests shall be computed as a basis for design of the mix. The design average compressive strength shall exceed the specified strength by at least:
 - (a) 400 psi if standard deviation is less than 300 psi
 - (b) 550 psi if standard deviation is 300 to 400 psi.
 - (c) 700 psi if standard deviation is 400 to 500 psi.
 - (d) 900 psi if standard deviation is 500 to 600 psi.
 - (e) 1,200 psi if standard deviation is greater than 600 psi.
 - c. Laboratory Trial Batch: When laboratory trial batches are used as a basis for determining mix proportions, all such Work shall be performed by the laboratory as specified in PART 2, Paragraph 2.01.B. - Laboratory Testing of Materials for Use in Concrete, this Section.
 - (1) Laboratory trial batches shall be used to establish a water-cement ratio, compression-strength curve with at least three points, each representing the strength of a separate trial batch. At least one point shall be above and one below the strength required. Each point on the curve shall represent the average of at least three cylinders tested at 28 days or an earlier age when approved by Engineer. The slump and air content shall be at the maximum limits specified in PART 2, Paragraph 2.01.C. - Concrete Qualities Required, this Section.
 - (2) A point on the water-cement ratio, compressive strength curve shall be selected that will provide an average compressive strength at least 1,200 psi greater than the specified minimum strength.
 - (3) Laboratory trial batches shall be used to determine the drying shrinkage of concrete trial mixes. A drying shrinkage test shall be conducted for every mix design proposed for the project. Drying shrinkage tests shall be conducted including all admixtures required

SECTION 03 30 00 – CONCRETE: continued

in proposed mix designs. Three test specimens shall be prepared for each drying shrinkage test. Test specimens (4 inch by 4 inch by 11 inch prisms) shall be molded, cured, dried, and measured in accordance with ASTM C157 except with modifications listed below.

- (a) After 7 days in the lime saturated water the specimen shall be removed and measured to determine the base length for drying shrinkage calculations. This point shall be considered day zero for time measurement. Specimens shall be immediately placed in a humidity controlled room maintained at 73° F, $\pm 3^\circ\text{F}$ and 50 percent, ± 4 percent relative humidity for the remainder of the test (21 days after day zero measurement). Final length measurement shall be conducted at 28 days after the addition of water to the cement during the mixing operations.

E. Mixing and Delivery:

- 1. Conform to ACI 304R.
 - a. Ready-mixed concrete shall be produced and delivered conforming to ASTM C1602 as applicable.
- 2. Cement temperature, when added to mix, shall not exceed 170°F (77°C).
- 3. Adjust the amount of mix water to compensate for the moisture content of the aggregates.
- 4. Concrete Plant:
 - a. Conform to "Concrete Plant Mixer Standards" of the Plant Mixer Manufacturers Division, Concrete Plant Manufacturers Bureau, and "Concrete Plant Standards" of the Concrete Plant Manufacturers Bureau.
 - b. Before test sampling and placing concrete, water may be added at Project Site, subject to limitations of ACI 301. Water added to concrete having a slump below the specified minimum shall be at Contractor's risk. If the water added produces a slump greater than the specified maximum, the concrete will be rejected. If water is added, the concrete shall be remixed for a minimum of 25 revolutions. Water shall not be added after the truck mixer has begun to discharge concrete.
 - c. Contractor shall furnish Owner with a concrete delivery ticket for each load of concrete. The ticket shall have the following information recorded:
 - (1) Serial number of ticket.
 - (2) Time batched.
 - (3) Time arrived on jobsite.
 - (4) Specified compressive strength of concrete at 28 days.
 - (5) Amount of concrete (by volume).
 - (6) Batch weights of all cementitious materials, aggregates, admixtures and water.
 - (7) Mix number.
 - (8) Amount of water with-held (by volume).

SECTION 03 30 00 – CONCRETE: continued

- (9) Amount of all water added at jobsite by Contractor.
- (10) Name of ready-mix batch plant.
- (11) Date.
- (12) Truck number.
- (13) Name of purchaser.
- 5. Plant and truck mixer uniformity shall be tested according to ASTM C1602. Frequency of tests shall be as specified in PART 3, this Section.

2.02 GROUT:

- A. Grout for Dry Packing:
 - 1. Volume: 1 part Portland cement to 2 parts sand.
 - 2. Keep water to a minimum as required for placing by the dry packing method.
 - 3. Place after the mixed grout has been allowed to stand for 2 hours.
 - 4. The sand and cement shall be as specified for concrete.
- B. Flowable Non-shrinking Grout:
 - 1. Required for setting handrail posts, for setting equipment recommended by the manufacturer to be set with non-shrinking grout, and in other places indicated.
 - 2. Grout shall be nonmetallic and conform to ASTM C1107.
 - 3. Prepare and place conforming to manufacturer's printed instructions.
 - 4. For equipment bases, the concrete surfaces shall be grit blasted or roughened with a chipping hammer prior to grouting. The foundation plates shall be cleaned of any grease, oil, paint, primers, or epoxy coatings.
- C. Grout for tie-hole patching:
 - 1. Where tie hole is in contact with finished drinking water, product shall be ANSI/NSF 61 certified.
 - a. Master Builder Solutions, MasterSeal 590.
 - b. Engineer approved equal.
 - 2. For all other locations:
 - a. Dayton Superior 1107 Advantage Grout.
 - b. Euclid Chemical, Speed Plug.
 - c. W.R Meadows, Meadow-Plug.
 - d. Engineer approved equal.
- D. Grout for Bonding:
 - 1. Proportion (by weight): 1 part cement to 1-1/2 parts sand.
 - 2. Keep water to a minimum.

2.03 BONDING AGENT:

- A. Provide moisture-insensitive, epoxy-resin bonding agent conforming to ASTM C881, Type V.

2.04 CONCRETE ACCESSORIES:

- A. PVC Waterstops:
 - 1. Serrated virgin polyvinyl chloride equal to one of the following:
 - a. Water tank cover base seal: PVC waterstop per tank builder standard.
 - b. CJ-3 or CJ-5: 9" Base Seal Waterstop
 - (1) Sika Greenstreak Style 771

SECTION 03 30 00 – CONCRETE: continued

- (2) Vinylex Style BS9532
 - (3) Engineer approved equal.
 - c. CJ-1 or CJ-8: 4" ribbed with center bulb
 - (1) Sika Greenstreak Style 702
 - (2) Vinylex Style RB4316
 - (3) Engineer approved equal.
 - d. CJ-10: 6" ribbed with center bulb
 - (1) Sika Greenstreak Style 705
 - (2) Vinylex Style RB6316A
 - (3) Engineer approved equal.
 - e. CJ-12: 6" Ribbed Split-Flange Waterstop
 - (1) Sika Greenstreak Style 724
 - (2) Vinylex Style RSB638
 - (3) Engineer approved equal.
 - f. All other locations unless otherwise indicated or specified
 - (1) Sika Greenstreak Style 703
 - (2) Vinylex Style RB6316
 - (3) Engineer approved equal for
 - 2. Provide factory fabricated waterstop corner transitions and intersections leaving only straight butt joint splices for the field.
 - 3. Use for all locations unless otherwise specified.
 - B. Plastic Waterstops:
 - 1. Swellable, Chloroprene Rubber Waterstop:
 - a. Greenstreak, Inc. - Hydrotite Product N. CJ-1020-2K-ADH.
 - b. Adeka - Ultra Seal MC-2010MN.
 - 2. Swellable, Bentonite Waterstop:
 - a. Greenstreak, Inc. - Swellstop Profile 594 (3/4 inch by 1 inch).
 - b. CETCO Building Materials - Volclay RX 101 (3/4 inch by 1 inch).
 - 3. Non-swelling, Mastic/Asphaltic Waterstop:
 - a. Greenstreak, Inc. - Lockstop.
 - b. Henry Company - Synko-Flex (SF302).
 - C. Provide all accessories as recommended by the manufacturer including, but not limited to, primers, adhesives, and sealants to ensure watertight construction. Install per manufacturer's written instructions and recommendations
- Expansion Joints:
- 1. Expansion Joint Filler: Premolded cork of thickness indicated and conforming to ASTM D1752, Type III, self-expanding cork. Unless indicated to be asphalt-impregnated fiber.
 - 2. Expansion Joint Filler: Preformed asphalt-impregnated fiber of thickness indicated and conforming to ASTM D1751. Use where indicated.
 - 3. Bond Breaker: Polyethylene tape or other plastic tape as recommended by sealant manufacturer.
 - 4. Sealant Backer Rod: Provide closed cell backer rod or other backing material as recommended by sealant manufacturer.
 - 5. Joint Sealants:
 - a. Multi-component sealant as follows:

SECTION 03 30 00 – CONCRETE: continued

- (1) Joint Sealant - General Use:
 - (a) BASF Building Systems: Sonneborn Sonolastic NP 2 (vertical use) and Sonolastic SL 2 (horizontal use).
 - (b) Epoxy Systems Products Company: Product #11.
 - (c) Euclid Chemical Company: Eucolastic II.
 - (d) Pecora Corporation: NR-200, Dynatred.
- (2) Joint Sealant - Industrial Floors (Shore A hardness >80):
 - (a) BASF Building Systems: Sonneborn TF-100.
 - (b) Euclid Chemical Company: EUCO 800.
- (3) Joint Sealant - Traffic Grade (conforming to FS TT-S-227):
 - (a) BASF Building Systems: Sonneborn Sonolastic SL 2.
 - (b) Epoxy Systems Products Company: Product #913.
 - (c) Pecora Corporation: Dynatrol II SG.
 - (d) Sika Corporation: Sikaflex-2c NS TG.
- (4) Joint Sealant - Potable Water Treatment and Storage Facilities:
 - (a) Sika Corporation: Sikaflex-2c NS.
- (5) Joint Sealant - Wastewater Treatment and Storage Facilities:
 - (a) BASF Building Systems: Sonneborn Polysulfide Sealant.
 - (b) Pecora Corporation: Synthacalc GC2+.
 - (c) Sika Corporation: Sikaflex-2c NS.
- (6) Joint Sealant - Jet-Fuel Resistant (conforming to FS SS-S-200):
 - (a) Epoxy Systems Products Company: Product #917.
 - (b) Pacific Polymers: Elasto-Seal 200.
 - (c) Pecora Corporation: Urexpan NR-300.
- D. Preformed Contraction Joints: Zip Joint T-shaped plastic strip as manufactured by BoMetals, Inc., Powder Springs, Georgia. Depth of preformed construction joint shall exceed 1/4 of the slab thickness.

2.05 CURING AGENT:

- A. Apply to all concrete surfaces unless otherwise indicated or specified.
- B. Curing agent shall conform as follows:
 - 1. ASTM C309, Type 1: Use for conditions where hot concreting does not apply.
 - 2. ASTM C309, Type 2: Use as specified in PART 3, Article 3.05 - Hot Weather Concreting, this Section.
- C. Curing compound used on floors to be sealed, painted, tiled, topped, dampproofed, waterproofed, or covered with resilient floor covering shall be guaranteed not to interfere with application of sealer, paint, tile mortar, or tile adhesive after a 28-day curing period.
- D. Curing compound shall be VOC compliant with a maximum VOC content of 2.9 lbs./gal (350 g/L), or less where Project location regulations are more stringent.

SECTION 03 30 00 – CONCRETE: continued

PART 3 - EXECUTION

3.01 PREPARATION FOR CONCRETE PLACEMENT:

- A. Openings Through Concrete: Provide openings through concrete as indicated and for the proper installation of all equipment, piping, wiring, ductwork and similar items, installed under this Contract.
- B. Installation of Embedded Items:
 - 1. Provide for accurate installation of embedded items installed under this Contract.
 - 2. Securely fix floor drains in place to prevent flotation while placing concrete. Uniformly and accurately slope finish floor slab toward the drains.
 - 3. Embedded items shall be as indicated or specified, or as selected by Contractor and approved by Engineer.
 - 4. During cold weather, protect pipe sleeves, shear pockets, and blockouts from moisture which may freeze, expand, and crack the sleeve, pocket or blockout and concrete structure.
 - 5. Grease or tape anchor bolt threads to protect from concrete splatter.
- C. Installation of Joints:
 - 1. Construction Joints:
 - a. Location:
 - (1) Locate joints, which are not indicated or specified, in conformance with ACI 318.
 - (2) Flatwork or slabs may be placed in sections with a maximum area of 3000 square ft and a maximum aspect ratio of 1:1.5 (width:length).
 - (3) Obtain Engineer's approval of joints located by Contractor prior to preparation of reinforcing steel drawings.
 - b. Preparation and Installation:
 - (1) Clean and break laitance or other foreign material from bonding surface.
 - (2) Tighten forms remaining in place (where applicable) to prevent seepage between forms and hardened concrete.
 - (3) Provide waterstops as indicated or specified and as required in any new construction joint requested by Contractor.
 - c. Waterstops:
 - (1) Install in all construction joints where indicated.
 - (2) Install conforming to manufacturer's printed instructions. All joints and splices of PVC waterstop shall be 100% fused. Use thermostatically controlled splicing iron as recommended by manufacturer.
 - 2. Expansion Joints:
 - a. Install filler, backer rod and sealant in strict conformance with manufacturer's written instructions.
 - b. Reinforcing steel shall not extend through expansion joints unless indicated otherwise.
 - c. Attach rigid joint filler to the face of the joint prior to placing adjacent concrete. The filler shall occupy the entire width of the joint.

SECTION 03 30 00 – CONCRETE: continued

- d. Install sealant backer rod for sealant except where indicated to be omitted. Install bond breaker where indicated.
 - e. Clean joint surfaces immediately before application of sealant.
 - f. Install joint sealants to conform to ASTM C1193. Tool sealants to provide smooth, uniform bead with a slightly concave surface, eliminate air pockets, and insure sealant contact and adhesion with sides of joint.
 - g. Protect joints from moisture and ice during freezing.
 - 3. Contraction Joints: As specified in this PART 3, Article 3.03 - Finishing, this Section.
- D. Cutting and Bonding to Existing Concrete:
 - 1. Cutting Existing Concrete:
 - a. Use methods and equipment that will avoid damage to adjacent parts of the structure from heavy blows or vibration.
 - b. Cut existing concrete with power concrete saw where possible to prevent spalling and chipping and to form neat, straight edge.
 - c. Remove all loose or cracked concrete resulting from cutting existing concrete, leaving only sound, undamaged concrete adjacent to new Work.
 - d. Leave access opening edges with a neat, true grout surface to the opening size indicated.
 - e. Cut reinforcing steel with sufficient length remaining (approximately 38 bar diameters) for bending and lapping into new construction.
 - 2. Bonding to Existing Concrete:
 - a. Roughen concrete to 1/4-inch (6-mm) amplitude by use of a pneumatic chipping hammer or other approved means.
 - b. Thoroughly clean the concrete surface and apply the bonding agent in accordance with manufacturer's written instructions.

3.02 PLACING OF CONCRETE:

- A. Conventional Placing:
 - 1. General Requirements:
 - a. Conform to ACI 304R.
 - b. Bonding surfaces, including reinforcement, shall be clean, free of laitance and foreign materials.
 - c. Place concrete on properly prepared and unfrozen subgrade and only in dewatered excavation and forms.
 - d. Use forms for all concrete except where otherwise indicated or specified. Footings entirely below grade may be earth formed.
 - e. Do not place concrete that has partially hardened or has been contaminated by foreign materials.
 - f. Prevent mud or foreign materials from entering the concrete or forms during placement operations.
 - 2. Conveying:
 - a. Convey concrete from the mixer and deposit in place by methods which will prevent the segregation or loss of materials.

SECTION 03 30 00 – CONCRETE: continued

- b. Equipment for chuting, pumping, and pneumatically conveying concrete shall be of such size and design as to provide a practically continuous flow of concrete at the delivery end.
 - c. Aluminum conveying equipment shall not be used.
 - 3. Depositing:
 - a. Place concrete in continuous horizontal lifts not to exceed 2 feet, and place concrete against bulkheads and keyways at vertical joints.
 - b. Maximum free drop of concrete and grout for bonding shall be 5 feet, in walls 10 inches or less in thickness, with 1-foot additional drop allowed for each inch of wall thickness over 10 inches, with a maximum drop of 10 feet.
 - c. When vapor barrier is used, keep lapped joints closed and take precautions to avoid puncturing the barrier.
 - 4. Consolidation of Concrete:
 - a. Consolidate concrete in conformance with ACI 309R. Characteristics and application of concrete vibrators shall be as set forth in Table 5.1.5.
 - b. Provide an adequate number of vibrators of sufficient capacity to keep up with the maximum rate of concrete placement. Keep on hand adequate standby equipment in good operating condition.
 - c. Vibrate concrete only until the concrete is thoroughly consolidated and the voids filled, as evidenced by the leveled appearance of the concrete at the exposed surface and the embedment of the surface aggregate.
 - d. Insert internal vibrators vertically to the full depth of the layer being placed and into the previous layer. Do not drag vibrators through the concrete. Insert and withdraw vibrator slowly with the vibrator running continuously so that no hole will be left in the concrete. Do not flow concrete from one location to another by use of a vibrator.
 - e. Consolidate concrete layer to full depth when using a surface vibrator. Use thinner layers or a more powerful vibrator if necessary to achieve complete consolidation.
 - f. Use form vibrators only where sections are too thin or where sections are inaccessible for internal vibrators.
 - 5. Time Requirements:
 - a. Place concrete at a sufficient rate to assure that lifts below have not taken initial set before fresh concrete is deposited.
 - b. Place concrete within 45 minutes after mixing. This period may be extended to 1 hour and 30 minutes provided that the combined air temperature, relative humidity, and wind velocity are such that the plasticity of the fresh concrete is satisfactory for placement and consolidation, and that the specified mixing water is not exceeded. Concrete which has partially set shall not be retempered but shall be discarded.
- B. Placing Concrete at Joints:
 - 1. Take precautions to ensure tight, well-bonded construction joints with no air pockets or voids.

SECTION 03 30 00 – CONCRETE: continued

2. Take special precautions to avoid bending or displacing waterstop while placing concrete around it.
3. Delay construction at a joint a minimum of 16 hours where placement is continued past joint, except where otherwise indicated.

3.03 FINISHING:

A. Unformed Surfaces:

1. Screed Finish:
 - a. Use as first stage for all concrete finishes.
 - b. Use as final finish on surfaces that will be covered by additional concrete, grout placement, or mortar setting bed except as otherwise specified.
 - c. Place, consolidate, strike off, and level concrete, eliminating high and low spots.
 - d. Immediately after screeding, use a wood float, darby, or bullfloat to eliminate high and low spots and to embed large aggregate.
2. Scratch Finish:
 - a. Use as second and final stage after screed finish for surfaces intended to receive bonded cementitious mixtures, including concrete toppings.
 - b. Roughen the surface with stiff brushes or rakes before final setting.
3. Floated Finish:
 - a. Use as second stage of all finishes except for scratch finishes.
 - b. After screeding, do not work concrete further until it is ready for floating. Begin floating with a hand float, a bladed power float equipped with float shoes, or a powered disk float when the bleed water sheen has disappeared and the surface has stiffened sufficiently to permit operation of the specific float apparatus.
 - c. Use as final finish at floors of below-grade vaults, on interior steps and ramps, and for surfaces intended to receive waterproofing, roofing, and insulation.
4. Trowel finish:
 - a. Float-finish and trowel the surface with multiple passes. Hand-trowel the surface smooth and free of trowel marks.
 - b. Addition of water to surface during finishing is prohibited.
 - c. Use where indicated.
5. Broomed or belt Finish:
 - a. Immediately after concrete has received a floated finish, give the concrete surface a coarse transverse scored texture of uniform corrugations not more than 1/16" inch deep by drawing a broom or burlap belt across the surface perpendicular to the direction of traffic.
 - b. Use as final finish on all outdoor slabs including pavements, sidewalks, loading docks, and the top slab of the lift station..
6. Floor Flatness and Levelness:
 - a. Finish to a true uniform surface so that surface irregularities do not exceed 3/8 inch in 10 feet, except at floor drains.

SECTION 03 30 00 – CONCRETE: continued

- B. Formed Surfaces:
 - 1. Repair surface defects as specified in PART 3, Paragraph 3.03.C. - Repair of Defective Surfaces, this Section.
- C. Repair of Defective Surfaces:
 - 1. Defined as any concrete surface showing misalignment, rock pockets, poor joints, holes from ties, voids, honeycomb, or any other defective area.
 - 2. Repairing:
 - a. Repair as soon as forms have been removed.
 - b. Chip surface back to minimum depth of 1/2 inch, chip edges perpendicular to surface, prewet depression and brush with neat cement immediately before patching.
 - c. Patch surfaces using stiff mortar with same sand-cement ratio as original concrete and with minimum water for placing. Blend with white cement to match concrete color.
 - d. Compact mortar into depressions so that after curing, hole is filled and mortar is flush with surface. Use hammer and ramming rod for compacting the holes.
 - e. Moist-cure for 3 days or use curing compound.
 - f. Engineer shall be notified of areas containing defects or where reinforcing steel is exposed, prior to determination of repair method.

3.04 CURING:

- A. Cure concrete by one of the following methods in accordance with ACI 308.1:
 - 1. Leaving in forms for a minimum of 7 days when the temperature is at least 50°F. When temperatures are below, follow requirements of cold weather concreting.
 - 2. When absorbent wood forms are used, keep formwork wet until removed.
 - 3. Use of saturated bays, soaker hoses, or sprinkler for a minimum of 7 days. Keep concrete continuously wet.
 - 4. Using polyethylene sheets applied in full contact with surfaces.
 - 5. Using one coat of a liquid membrane forming compound as specified. Apply immediately after removal of forms (which have been continuously wet); or in case of a slab, after the concrete has been finished and is hardened sufficiently to walk on.
 - 6. Curing of concrete during hot or cold weather shall conform to PART 3 - Hot Weather Concreting and Cold Weather Concreting, this Section.

3.05 HOT WEATHER CONCRETING:

- A. Conform to all requirements of ACI Specification 305.1, "Specification for Hot Weather Concreting," published by the American Concrete Institute, Farmington Hills, MI, except as modified by these contract documents.
- B. Follow the requirements of ACI 305.1 if any of the following conditions occur:
 - 1. When the temperature is 90°F or above.
 - 2. When the temperature is likely to rise above 90°F within the 24-hour period after concrete placement.
 - 3. When there is any combination of high air temperature, low relative humidity, and wind velocity which would impair either concrete strength or quality.

SECTION 03 30 00 – CONCRETE: continued

- C. Concrete shall have a maximum temperature of 95°F at time of discharge.
- D. Dampen subgrade and forms with cool water immediately prior to placement of concrete.
- E. Protect freshly placed concrete immediately after placement so that the rate of evaporation as determined by ACI 305.1 Equation 3.1.3 does not exceed 0.2 pound per square foot per hour.
- F. Protect concrete with suitable insulation if rapidly decreasing nighttime temperatures occur, which would cause thermal shock to concrete placed during warm daytime temperatures.
- G. Protect the concrete with temporary wet covering during any appreciable delay between placement and finishing.
- H. Begin curing unformed surfaces immediately after finishing and continue for 24 hours. Curing shall consist of application and maintenance of water-saturated material to all exposed surfaces; horizontal, vertical, and otherwise. After the 24-hour interval, continue curing using one of the following methods:
 - 1. Moist curing for 6 days.
 - 2. Application of one coat of curing compound as specified.
 - 3. Application and maintenance of curing paper or heat-reflecting plastic sheets for 6 more days.
- I. Begin curing formed concrete immediately after placing. Curing shall consist of keeping forms continuously wet for 24 hours. Thereafter, continue curing using one of the following methods:
 - 1. Loosen forms and position soaker hose so that water runs down along concrete surfaces. Continue for 6 days.
 - 2. Strip forms and apply curing compound as specified. Do not allow concrete surfaces to dry prior to application of curing compound.

3.06 COLD WEATHER CONCRETING:

- A. Work shall conform to all requirements of ACI 306.1, Standard Specification for Cold Weather Concreting, except as modified by the requirements of these Contract Documents.
 - 1. Modification to Section 3.2.2: Temperature shall be measured twice per day until protection may be terminated
 - 2. Modification to Section 3.4.5: Refer to Section 03 10 00 to determine when forms may be removed.
- B. Follow the requirements of ACI 306.1 if any of the following conditions apply:
 - 1. When the temperature is 40°F or is likely to fall below 40°F during the 24-hour period after concrete placement.
- C. Minimum temperature for concrete as mixed shall be as indicated in Table 3.2.1 of ACI 306.1. Maximum temperature for concrete as mixed shall be 20°F greater than the corresponding minimum temperature, unless a higher temperature is required by an accepted curing method.
- D. Place and maintain concrete so that its temperature is never less than the temperature indicated on line 1 of Table 5.1 of ACI 306R. Maintain the required temperature for the time duration indicated on Tables 5.1 and 7.1 of ACI 306R.
- E. Monitor temperature of concrete in place at corners or edges of formwork as applicable.

SECTION 03 30 00 – CONCRETE: continued

- F. Air Heaters:
 - 1. Do not expose concrete to carbon monoxide or carbon dioxide fumes from heaters or engines.
 - 2. Salamanders will not be permitted.
 - 3. Heaters shall be indirect fired heaters which use a heat exchanger to avoid direct contact with combustion air or portable hydronic heaters.
 - 4. Personnel shall be present at all times to maintain safe, continuous operation of heating system.
- G. Control temperature and humidity of protected concrete so that excessive drying of concrete surfaces does not occur.
- H. Calcium chloride will not be permitted as a concrete accelerator or to thaw frozen subgrade prior to concrete placement.
- I. The maximum allowable temperature drop during the first 24-hour period after protection is discontinued shall be as indicated on line 1 of Table 5.1 of ACI 306R.
- J. Cure the concrete in accordance with Chapter 10 of ACI 306R.

3.07 LOW-STRENGTH CONCRETE:

- A. Low-Strength Concrete:
 - 1. Defined as either:
 - a. Concrete whose average, of any sets of three consecutive 28-day compressive strength tests, is below the required 28-day strength.
 - b. Concrete whose individual 28-day strength test (average of two cylinders) is more than 500 psi below the required 28-day strength.
 - 2. Should concrete meet either definition of low-strength concrete as a minimum, the Contractor shall take the following steps:
 - a. Increase the cement content. The increase shall be based on a statistical evaluation of the strength data, the design water-cement ratio, compressive strength curve, and acceptable mix-design literature as follows:
 - (1) If sufficient concrete has been furnished to accumulate 30 tests, these should be used to establish a new target average strength in accordance with ACI 318, Section 5.3.
 - (2) If less than 30 tests have been made, the new target average strength should be at least as great as the average strength used in the initial selection of the mix proportions. Increase the target average strength based on a statistical evaluation of the available strength data, the design water-cement ratio, compressive strength curve, and acceptable mix-design literature. If the statistical average equals or exceeds the initial mix-design level, a further increase in the average level is required.
 - b. Remove and replace with acceptable concrete when the quality and location of the low-strength concrete is such that Engineer considers the strength or durability of the structure is impaired and so orders.
 - 3. Low-strength concrete shall be considered defective Work as defined in General Conditions.

SECTION 03 30 00 – CONCRETE: continued

- B. Potentially Low-Strength Concrete: Defined as concrete whose 7-day test (average of two cylinders) is less than 70% of the specified minimum 28-day compressive strength.
- C. Construction delays caused by low-strength or potentially low-strength concrete shall not relieve Contractor from responsibility for late completion even though extensions of time may be granted.

3.08 TESTING:

- A. Field Testing of Concrete Plant and Mixing Trucks:
 - 1. The concrete plant shall be inspected and tested to ensure conformance with ACI 304R and the "Concrete Plant Standards of the Concrete Plant Manufacturers Bureau." The scales shall be calibrated at the initial setup and at 3-month intervals thereafter.
 - 2. Mixing trucks shall be inspected and tested to ensure conformance with ACI 304R and "Truck Mixer and Agitator Standards of the Truck Mixer Manufacturers Bureau" of the National Ready-Mix Concrete Association. Tests shall be done at initial setup and every 3 months thereafter.
 - 3. Submit test reports when requested.
- B. Construction Testing Service
 - 1. Owner shall select and pay for an independent material testing service for field testing from their on-call testing agencies. The material testing service shall furnish test equipment, test cylinder molds, and certified personnel to perform all required field tests, make the required concrete test cylinders, and deliver test cylinders to the testing laboratory. The prescribed tests shall be made in the presence of or with the concurrence of the Owner.
 - 2. Contractor shall schedule and coordinate with the independent testing service.
 - 3. Field testing shall be paid for by the Owner.
 - 4. If additional compressive strength tests are desired by the contractor to obtain additional data points for scheduling purposes the contractor shall pay for the additional tests.
- C. Field Testing of Concrete and Making of Concrete Test Cylinders:
 - 1. Field testing personnel shall be on Site throughout placement of concrete.
 - 2. Concrete sampling for tests and cylinder making shall be done conforming to ASTM C172. Samples shall be taken at random and at the point of truck discharge.
 - 3. Perform the following tests:
 - a. Prepare test cylinders conforming to ASTM C31, with not less than one set of cylinders (four or five cylinders) from each day's placement for each 100 cubic yards or fraction thereof.
 - (1) A set of cylinders is defined as the following for different cylinder sizes:
 - (a) 6-inch by 12-inch: 4 cylinders
 - (b) 4-inch by 8-inch: 5 cylinders
 - b. Slump test conforming to ASTM C143. Perform tests on the first batch produced each day, for every 50 cubic yards or fraction thereafter, and

SECTION 03 30 00 – CONCRETE: continued

with every set of test cylinders. Additional tests shall be run when directed by Engineer or Owner.

- c. Air content test conforming to ASTM C231. Perform for first batch of day and with each set of test cylinders.
 - d. The batch of concrete being tested for slump or air content shall not be placed until acceptable results are obtained.
 - e. Discard concrete used for slump and air tests.
 - f. Perform concrete and air temperature tests for first batch of day and with each set of test cylinders. Additional readings shall be taken when directed by Engineer.
 - g. Any batch of concrete with slump or air content not in conformance with Specifications shall be rejected.
 - h. Furnish slump, air content, and temperature test results to the testing laboratory for inclusion in the cylinder test reports.
- D. Laboratory Testing of Aggregates and Concrete During Construction:
- 1. Laboratory will cure and test concrete cylinders conforming to ASTM C192 and C39, testing 1 cylinders at 7 days of age, three at 28 days of age and one hold.
 - 2. Contractor shall have the right to observe all phases of concrete cylinder curing and testing. Should Contractor observe any deviations from the prescribed testing procedures that he considers detrimental to concrete strength test results, he shall immediately notify Owner in writing.
 - 3. Contractor shall make arrangements with the testing laboratory to receive copies of test reports. The cost of providing a maximum of two copies of each report to the Contractor will be paid by Owner.
 - 4. Should the test results indicate low strength concrete as defined in PART 3, Article 3.07 - Low-Strength Concrete, this Section, Contractor shall take immediate corrective action.
 - 5. Should the statistical data indicate an excessive margin of safety, the concrete mix may be modified subject to Engineer's approval.
 - 6. Should the material tests taken during construction indicate nonconformance with the Specifications, Contractor shall take immediate corrective action.

3.09 REPAIR, REPLACEMENT, AND FIELD MODIFICATIONS:

- A. Embedded items and concrete that are misplaced or damaged during construction shall not be repaired, replaced, or field-modified without approval of Engineer.

END OF SECTION 03 30 00

SECTION 03 30 05 – VOID FORMS

PART 1 - GENERAL

1.01 SUMMARY:

- A. Work under this Section consists of furnishing all labor, equipment, and materials necessary to install void forms and backfill retainers as indicated to create a temporary support for placement of structural concrete over expansive soils.
- B. Unless otherwise shown or specified, design, place, and maintain void forms or carton forms for cast-in-place concrete work in compliance with the American Concrete Institute Standard ACI 347 – Guide to Formwork for Concrete.
- C. Void forms are to be placed under grade beams, walls, and first floor slabs as detailed on the Contract Drawings, and are expected to be left in place after concrete placement.

1.02 RELATED REQUIREMENTS:

- A. SECTION 03 30 00 – Concrete.
- B. SECTION 31 20 00 – Site Preparation and Earthwork.

1.03 REFERENCE STANDARDS:

- A. General:
 - 1. Standards listed by reference, including revisions by issuing authority, form a part of this Section to extent indicated. Standards listed are identified by issuing authority, authority abbreviation, designation number, title or other designation established by issuing authority. Standards subsequently referenced herein are referred to by issuing authority abbreviation and standard designation.
 - 2. Where specifications and reference documents conflict, the Engineer shall make the final determination of applicable document.
 - 3. Unless otherwise noted, the latest revision of the following reference standards shall apply to this Section.
- B. Applicable Standards:
 - 1. American Concrete Institute (ACI):
 - a. 347 – Guide to Formwork for Concrete

1.04 SUBMITTALS:

- A. Submit as specified in the General and Special Conditions.
- B. Bid Submittals:
 - 1. The void form and soil retainer manufacturer shall submit product data sheets on the void form system and soil retainers to Engineer verifying compliance with this Section.
- C. Design and Pre-Construction Submittals:
 - 1. Two weeks prior to mobilization, submit Shop Drawings and details of the proposed vendor, product type(s) and name(s), hardboard cover sheet, vapor barrier, backfill retainer, load carrying capacity, rate of deterioration, storage requirements, manufacturer's product selection guide, manufacturer's installation guidelines, and a contingency plan for a void form collapse.

SECTION 03 30 05 – VOID FORMS: continued

- D. Construction and Closeout Submittals:
 - 1. Within 7 days after installation, Subcontractor shall provide letter certifying that no capillary breaks exist between the void forms and the supporting soil.

1.05 DELIVERY, STORAGE AND HANDLING:

- A. Comply with requirements of DIVISION 01.
- B. Materials shall be stored in accordance with manufacturer's recommendations and shall be protected from moisture and other means of damage prior to installation. Do not install or use void form that has received damage due to water, improper use/handling, storage or improper installation.
- C. Backfill retainers composed of materials that are adversely affected by moisture shall not be used.

PART 2 - PRODUCTS

2.01 VOID FORMS:

- A. Materials for void forms shall be the product of a reputable manufacturer regularly engaged in the commercial production of void forms.
- B. Acceptable manufactures include the following:
 - 1. Surevoid
 - 2. Void Forms International
 - 3. Approved equal.
- C. The void form components shall be constructed of double-faced, partially wax-impregnated corrugated fiberboard that is laminated with moisture-resistant adhesive. Fully wax-impregnated corrugated fiberboard is not acceptable due to resistance to deterioration. The interior construction shall be of a uniform, cellular configuration.
- D. Soil retainers shall be composed of materials that are not adversely affected by moisture.
- E. Grade beams and wall void forms shall be of rectangular construction, used in conjunction with soil retainers. Trapezoidal void forms shall not be used. Earth forming of footings and grade beams shall not be permitted.
- F. Design and maintain void forms to support all temporary vertical and lateral loads that might be applied until such loads can be supported by the concrete structure. This includes, but is not limited to, live load, dead load, weight of moving equipment, height of concrete drop, vibrator frequency, ambient temperature, soil pressures, and lateral stability.
- G. Void forms must have a minimum strength to sustain an average working construction load of 100psf, or as otherwise determined necessary by Subcontractor's manufacturer representative for the concrete loads as determined from Drawings and based on manufacturer's recommendations.
- H. Void form material shall be designed to lose its strength upon prolonged contact with the moisture which normally accumulates beneath slabs and beams on grade. Sufficient deterioration to cushion uplift forces in soil shall take place within a maximum time of eight weeks after placement of concrete.

SECTION 03 30 05 – VOID FORMS: continued

PART 3 - EXECUTION

3.01 ASSEMBLY AND INSTALLATION:

- A. Prepare the subgrade in accordance with SECTION 31 20 00 – Site Preparation and Earthwork prior to placement of void forms to provide a relatively flat and stable working surface.
- B. Forms shall be protected from moisture prior to installation. If void forms become wet, contact the manufacturer to determine if the forms are still capable of performing as required. Any forms that are damaged due to exposure to moisture shall be replaced before concrete is placed at no additional cost to Owner or Engineer.
- C. Forms shall be assembled and placed in accordance with the manufacturer's directions, and in a manner to provide tight joints that will prevent loss of paste during concrete placement. Provide seam pads at joints per manufacturer's directions.
- D. End closures shall be provided on all grade beam and wall voids.
- E. The upper 2 feet of each drilled shaft, when used, must be properly formed and contained to the designated diameter, and must be correctly voided at the intersection with the grade beams or structural slabs by using a pre-manufactured, non-field cut, sealed form with curved, radial, vertical edge adjacent to the drilled shaft.
- F. Protective hardboard cover sheets must be placed over void forms at slabs and grade beams wider than 12 inches to distribute working loads, bridge small gaps, and protect void material from puncture and other damage during concrete placement. The minimum thickness of the cover sheets shall be 0.125 inch.
- G. Forms must be properly placed and anchored as required to prevent displacement or flotation during placement of concrete.
- H. Vapor barrier shall not be placed between the void forms and the supporting soil. It is acceptable to place vapor barrier over the top of the void forms, but the forms should not be wrapped with the vapor barrier.
- I. If void forms collapse during concrete placement, concrete and reinforcing steel shall be removed from the affected area, the collapsed void forms replaced and concrete placement resumed at no additional cost to the Owner or Engineer. If normal concrete placement cannot resume, contact Engineer.
- J. The manufacturer's representative shall be on-site during initial installation of the void forms to confirm compliance with the manufacturer's product selection and installation requirements.

END OF SECTION 03 30 05

DIVISION 05 – METALS

SECTION 05 05 19 – POST-INSTALLED ANCHORS

PART 1 - GENERAL

RELATED DOCUMENTS:

- A. Drawings and general provisions of the Contract, including General and Special Conditions and Division 01 Specification Sections, apply to this Section.

1.01 SUMMARY:

- A. This section includes post installed adhesive anchors, mechanical anchors and epoxy anchorage of rebar in hardened concrete.

1.02

RELATED WORK SPECIFIED ELSEWHERE:

- 1. Section 03 20 00 - Concrete Reinforcement
- 1.03 2. Section 03 30 00 - Concrete
- 3. Section 05 13 00 – Stainless Steel Fabrications
- 4. Division 26 Hangers and Supports Section.

REFERENCE STANDARDS:

- 1.04 A. Publication Dates: Comply with standards in effect as of date of the Contract Documents unless otherwise indicated.
 - 1. International Building Code (IBC).
 - 2. American Concrete Institute (ACI):
 - a. 318 – Building Code Requirements for Reinforced Concrete.
 - b. 355.2 – Qualification of Post-Installed Mechanical Anchors in Concrete.
 - c. 355.4 – Qualification of Post-Installed Adhesive Anchors in Concrete
 - 3. International Code Council Evaluation Service (ICC-ES)
 - a. AC01 – Acceptance Criteria for Expansion Anchors in Masonry Elements
 - b. AC58 – Acceptance Criteria for Adhesive Anchors in Masonry Elements
 - c. AC60 - Acceptance Criteria for Anchors in Unreinforced Masonry Elements
 - d. AC193 – Acceptance Criteria for Mechanical Anchors in Concrete Elements
 - 1.05 e. AC308 – Acceptance Criteria for Post-Installed Adhesive Anchors in Concrete Elements
 - 4. International Association of Plumbing and Mechanical Officials (IAPMO)

SUBMITTALS:

- A. Submit as specified in the General and Special Conditions.
- B. Include but not limited to, the following:
 - 1. Product specification data with recommended design values and physical characteristics for epoxy dowels, expansion and undercut anchors.
 - 2. Quality Control Submittals:
 - a. Test Reports: Certified test reports showing compliance with specified performance characteristics and physical properties.

SECTION 05 05 19 – POST-INSTALLED ANCHORS: continued

- b. Certificates:
 - (1) ICC ES Evaluation Reports.
- 3. Manufacturer's installation instructions.
- 4. Installer Qualifications & Procedures: Submit installer qualifications as stated in Section 1.06.B. Submit a letter of procedure stating method of drilling, the product proposed for use, the complete installation procedure, manufacturer training date, and a list of the personnel to be trained on anchor installation.
- C. Closeout Submittals: Submit the following:
 - 1. Record Documents: Project record documents for installed materials in accordance with Division 1 Closeout Submittals Section.

QUALITY CONTROL

- A. Installer Qualifications:
 - 1. Drilled-in anchors for life safety applications shall be installed by a Subcontractor with at least three years of experience performing similar installations.
 - 2. All personnel installing adhesive anchors shall be ACI adhesive anchor certified.
- B. Installer Training: Conduct a thorough training with the manufacturer or the manufacturer's representative for the Subcontractor on the project. Training to consist of a review of the complete installation process for drilled-in anchors, to include but not limited to:
 - 1. hole drilling procedure
 - 2. hole preparation & cleaning technique
 - 3. adhesive injection technique & dispenser training / maintenance
 - 4. rebar dowel preparation and installation
 - 5. proof loading/torquing
- C. Certifications: Unless otherwise authorized by the Engineer, anchors shall have one of the following certifications:
 - 1. ICC ES Evaluation Report indicating conformance with current applicable ICC ES Acceptance Criteria.
 - 2. IAPMO UES Evaluation Report indicating conformance with current applicable acceptance criteria.

DELIVERY, STORAGE, AND HANDLING

- A. Deliver products to job site in manufacturer's clearly labeled unopened packaging, complete with installation instructions.
- B. Protect and handle materials in accordance with manufactures recommendations to prevent damage or deterioration.

PART 2 - PRODUCTS:

MATERIALS

- A. Fasteners and Anchors:
 - 1. Bolts and Studs: ASTM A307; ASTM A449 where "high strength" is indicated on the Drawings.
 - 2. Carbon and Alloy Steel Nuts: ASTM A563.

SECTION 05 05 19 – POST-INSTALLED ANCHORS: continued

3. Carbon Steel Washers: ASTM F436.
4. Carbon Steel Threaded Rod: ASTM A36; or ASTM A193 Grade B7; or ISO 898 Class 5.8.
5. Wedge Anchors: ASTM A510; or ASTM A108.
6. Stainless Steel Bolts, Hex Cap Screws, and Studs: ASTM F593.
7. Stainless Steel Nuts: ASTM F594.
8. Zinc Plating: ASTM B633.
9. Hot-Dip Galvanizing: ASTM A153.
10. Metric Anchor Bolts, Screws, and Studs: ISO 898 Part 1.
11. Metric Anchor Nuts: EN 24033.
12. Metric Anchor Stainless Steel Bolts, Screws, and Studs: ISO 3506 Part 1.
13. Metric Anchor Stainless Steel Nuts: ISO 3506 Part 2.
14. Reinforcing Dowels: ASTM A615

MECHANICAL ANCHORS

- 2.02
- A. Mechanical anchors shall meet the qualification criteria of ACI 355.2, ICC-ES AC01 (masonry) or AC193 (concrete).
 - B. Use of mechanical anchors in permanently submerged conditions shall not be permitted.
 - C. Interior Use: Unless otherwise indicated on the Drawings, provide carbon steel anchors with zinc plating in accordance with ASTM B633, Type III Fe/Zn 5 (SC1).
 - D. Exterior Use: Unless otherwise indicated on the Drawings, provide stainless steel anchors. Stainless steel anchors shall be AISI Type 304 or Type 316 stainless steel provided with stainless steel nuts and washers of matching alloy group and minimum proof stress equal to or greater than the specified minimum full-size tensile strength of the externally threaded fastener. Stainless steel nuts shall conform to ASTM F594 unless otherwise specified. Avoid installing stainless steel anchors in contact with galvanically dissimilar metals.
 - E. The type of anchors shall be as follows:
 1. Wedge type, torque-controlled, with impact section to prevent thread damage complete with required nuts and washers.
 - a. Life safety applications (Including but not limited to handrail and direct tension hangers)
 - (1) Simpson Strong Tie – Strong Bolt 2
 - (2) Hilti Kwik Bolt TZ2
 - (3) DeWalt – Power-Stud SD
 - b. Low risk to life safety (small pipe stands, Unistrut, etc.)
 - (1) Simpson Strong Tie – Wedge All
 - (2) Hilti Kwik Bolt 3
 - (3) DeWalt – Power-Stud SD
 2. Screw Anchors: screw type. Pre-drilling of the hole requires a standard ANSI drill bit with the same diameter as the anchor and installing the anchor will be done with an impact wrench. Provide anchors with a diameter and anchor length marking on the head. Type and size as indicated on Drawings.
 - a. Hilti Kwik-HUS-EZ
 - b. Simpson Titen HD

SECTION 05 05 19 – POST-INSTALLED ANCHORS: continued

3. Heavy Duty Undercut Anchors: Bearing type. Installed anchor shall have a minimum tension bearing area in the concrete, measured as the horizontal projection of the bearing surface, not less than two times the net tensile area of the anchor bolt. The installed anchor shall exhibit a form fit between the bearing elements and the undercut in the concrete. Type and size as indicated on Drawings.
 - a. Simpson Strong Tie – TCA
 - b. Hilti HDA Undercut Anchor
 - c. DeWalt – Atomic+ Undercut
 - d. Use only where specifically called for on drawings

ADHESIVE ANCHORS

- 2.03 A. Adhesive anchors shall meet the qualification criteria of ACI 355.4, ICC-ES A58 (masonry) or A308 (concrete).
- B. Adhesive anchors shall not be installed in concrete less than 21 days of age.
- C. Interior Use: Unless otherwise indicated on the Drawings, provide carbon steel threaded rods conforming to ASTM A36, ASTM A 193 Type B7 or ISO 898 Class 5.8 with zinc plating in accordance with ASTM B633, Type III Fe/Zn 5 (SC1).
- D. Exterior Use: Unless otherwise indicated on the Drawings, provide stainless steel anchors. Stainless steel anchors shall be AISI Type 304 or Type 316 stainless steel provided with stainless steel nuts and washers of matching alloy group and minimum proof stress equal to or greater than the specified minimum full-size tensile strength of the externally threaded fastener. All nuts shall conform to ASTM F594 unless otherwise specified. Avoid installing stainless steel anchors in contact with galvanically dissimilar metals.
- E. Reinforcing dowels shall be A615 Grade 60.
- F. The type of anchors shall be as follows:
 1. Epoxy Anchors – Life safety applications.
 - a. Simpson Strong Tie – SET 3G
 - b. Hilti – HIT-RE500 V3
 - c. Hilti – HIT-HY200 V3
 - d. DeWalt– PE1000+
 - e. Adhesives Technology – Ultrabond HS-1CC
 2. Adhesive Anchors: (Used for non-vibrating equipment anchorage and other non-life safety attachments)
 - a. Simpson Strong Tie – AT-XP
 - b. Hilti – HIT-HY200 V3
 - c. DeWalt– AC200+
 - d. Adhesives Technology – Ultrabond EXP-3CC
 3. Epoxy Rebar Dowels:
 - a. Simpson Strong Tie – SET 3G
 - b. Hilti HIT-RE500 V3
 - c. Adhesives Technology – Ultrabond HS-1CC
 4. Anchorage to Masonry, ICC-ES AC58 & AC60:
 - a. Hilti HIT-HY270
 - (1) Provide Hilti HIT-SC mesh sleeve when anchoring to hollow masonry.

SECTION 05 05 19 – POST-INSTALLED ANCHORS: continued

PART 3 - EXECUTION

INSTALLATION

A. Drilled-In Anchors:

- 3.01
1. Drill holes with rotary impact hammer drills. Drill bits shall be of diameters as specified by the anchor manufacturer. Unless otherwise shown on the Drawings, all holes shall be drilled perpendicular to the concrete surface.
 - a. Cored Holes: Where anchors are permitted to be installed in cored holes, use core bits with matched tolerances as specified by the manufacturer. Properly clean cored hole per manufacturer's instructions.
 - b. Embedded Items: Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Exercise care in coring or drilling to avoid damaging existing reinforcing or embedded items. Take precautions as necessary to avoid damaging prestressing tendons, electrical and telecommunications conduit, and gas lines.
 - (1) Notify the Engineer prior to abandoning and relocating anchor holes if reinforcing steel or other embedded items are encountered during drilling and the specified embedment depth has not been met.
 - c. Base Material Strength: Unless otherwise specified, do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
 2. Perform anchor installation in accordance with manufacturer instructions.
 3. Wedge Anchors, Heavy-Duty Sleeve Anchors, and Undercut Anchors: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in part to be fastened. Set anchors to manufacturer's recommended torque, using a torque wrench. Following attainment of 10% of the specified torque, 100% of the specified torque shall be reached within 7 or fewer complete turns of the nut. If the specified torque is not achieved within the required number of turns, the anchor shall be removed and replaced unless otherwise directed by the Engineer.
 4. Cartridge Injection Adhesive Anchors: Clean all holes per manufacturer instructions to remove loose material and drilling dust prior to installation of adhesive. Inject adhesive into holes proceeding from the bottom of the hole and progressing toward the surface in such a manner as to avoid introduction of air pockets in the adhesive. Follow manufacturer recommendations to ensure proper mixing of adhesive components. Sufficient adhesive shall be injected in the hole to ensure that the annular gap is filled to the surface. Remove excess adhesive from the surface. Shim anchors with suitable device to center the anchor in the hole. Do not disturb or load anchors before manufacturer specified cure time has elapsed.
 5. Capsule Anchors: Perform drilling and setting operations in accordance with manufacturer instructions. Clean all holes to remove loose material and drilling dust prior to installation of adhesive. Remove water from drilled holes in such a manner as to achieve a surface dry condition. Capsule anchors shall be installed with equipment conforming to manufacturer

SECTION 05 05 19 – POST-INSTALLED ANCHORS: continued

recommendations. Do not disturb or load anchors before manufacturer specified cure time has elapsed.

6. Observe manufacturer recommendations with respect to installation temperatures for cartridge injection adhesive anchors and capsule anchors.

REPAIR OF DEFECTIVE WORK

- 3.02 A. Remove and replace misplaced or malfunctioning anchors. Fill empty anchor holes and patch failed anchor locations with high-strength non-shrink, nonmetallic grout. Anchors that fail to meet proof load or installation torque requirements shall be regarded as malfunctioning.

FIELD QUALITY CONTROL

- 3.03 A. Mechanical anchor installation shall have periodic special inspection per IBC.
- B. Adhesive anchors installed in horizontally or upwardly inclined orientations to resist sustained tensions loads shall have continuous special inspection per IBC.
 1. All other adhesive anchors not described above shall have periodic special inspection per IBC.
- C. Minimum anchor embedment's, proof loads and torques shall be as shown on the Drawings.

END OF SECTION 05 05 19

SECTION 05 13 00 – STAINLESS-STEEL FABRICATIONS

PART 1 - GENERAL

1.01 SUMMARY:

- A. This Section includes fabrication and installation of Stainless-steel fabrications.
- B. Although such Work may not be specifically indicated, furnish and install all supplementary or miscellaneous items, appurtenances, and devices incidental to or necessary for a complete installation and suitable for its intended use.

1.02 REFERENCES:

- A. Applicable Standards:
 - 1. American Society for Testing and Materials (ASTM):
 - a. A276 - Stainless Steel Bars and Shapes.
 - b. A 380 - Standard Practice for Cleaning, Descaling, and Passivation of Stainless Steel Parts, Equipment and Systems.
 - c. A666 - Specification for Annealed or Cold-Worked Austenitic Stainless Steel Sheet, Strip, Plate, and Flat Bar.
 - d. A 967 - Chemical Passivation Treatments for Stainless Steel Parts.
 - 2. American Welding Society (AWS).
 - 3. Federal Specifications (FS):
 - a. QQ-P-35C, Passivation Treatments for Corrosion Resistant Steels.
 - 4. National Association of Architectural Metal Manufacturers (NAAMM).
 - 5. Society for Protective Coatings (SSPC) Surface Preparation Specifications:
 - a. SP1 - Solvent Cleaning.
 - b. SP2 - Hand Tool Cleaning.
 - c. SP3 - Power Tool Cleaning.
 - d. SP7 - Brush Off Blast Cleaning.
 - e. Pickling, SSPC-SP 8 November 1, 1982 Editorial Changes September 1, 2000, Surface Preparation Specification No. 8

1.03 SUBMITTALS:

- A. Submit as specified in the General and Special Conditions.
- B. Includes, but not limited to, the following:
 - 1. Fabrication and erection drawings for all Work including anchor bolts and welds.
 - 2. Shop Drawings for all components fabricated from stainless steel.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS:

- A. As specified for each item.

2.02 BASIC MATERIALS:

- A. Stainless Steel Strip, Plate, Flat Bars, Grating, and sheets: ASTM A479, Type 316L, unless indicated otherwise.

SECTION 05 13 00 – STAINLESS STEEL FABRICATIONS: continued

2.03 STAINLESS STEEL FABRICATIONS:

A. General:

1. Provide all items and related accessories as required to complete construction and installation.
2. Provide anchorage accessories as required to securely anchor items to substrate.

B. Stainless Steel Fabrications:

1. Form to profiles indicated, in maximum lengths to minimize joints. Produce flat, flush surfaces without cracking or grain separation at bends.
2. Hem exposed edges.
3. Preassemble fabrications in shop to greatest extent possible to minimize field splicing and assembly. Disassemble units only as necessary for shipping, handling, and installation limitations. Clearly mark units for reassembly and coordinated installation.
4. Build in straps, plates, and brackets as needed to support and anchor fabricated items to adjoining construction.
5. Provide support framing, mounting and attachment clips, splice sleeves, fasteners, and accessories needed to install fabrications.
6. Weld joints and seams continuously. Grind, fill, and dress to produce smooth, flush exposed surfaces in which joints are not visible after finishing is completed.
 - a. Use welding procedures that will blend with and not cause discoloration of adjoining surfaces.
7. Thickness: As indicated.
8. Finish: Dull Satin Finish, No. 6.
 - a. Remove tool and die marks and stretch lines or blend into finish.
 - b. Grind and polish surfaces to produce uniform, directionally textured, polished finish indicated, free of cross scratches. Run grain with long dimension of each piece.
 - c. When polishing is completed, pickle, passivate, and rinse surfaces. Remove embedded foreign matter and leave surfaces chemically clean.

2.04 PICKLING AND PASSIVATING:

- #### A. Pickling shall be performed per ASTM A 380-99 to remove tightly adherent oxide films resulting from hot-forming, heat treating, welding and other high temperature operations (scale).
1. Where applicable, alternative mechanical methods such as blasting, shot peening, tumbling, and wheel abrading may also be performed.
 2. Abrasives containing iron should not be used.
 3. If required, pickling of stainless steels shall be performed in two steps, one for softening the scale and one for final scale removal.
 4. Over-pickling, under-pickling and pitting shall not be permitted.
 5. Prior to pickling, the heavy surface soils such as oil, grease, buffing compounds, drawing compounds, some scale, heavy rust, dye and paint markings, tape, adhesive residue and other foreign substances must be removed. This step may be accomplished by the use of alkaline cleaners, solvent cleaning, vapor degreasing, ultrasonic cleaning, steam cleaning, water-jetting, or other

SECTION 05 13 00 – STAINLESS-STEEL FABRICATIONS: continued

mechanical cleaning. Pre-cleaning is not required if oxide or scale is the only soil on the surface.

6. Stainless steel fabrications to be pickled and passivated: All stainless steel fabrications.
- B. Stainless steel fabrications shall be passivated according to ASTM A 967, Chemical Passivation Treatments for Stainless Steel Parts.
 1. Passivation shall be performed on cleaned and pickled stainless steel.
 2. Passivation shall remove all of exogenous iron or iron compounds from the surface of stainless steel by means of a chemical dissolution with an acid solution that will remove the surface contamination but will not affect the stainless steel itself.
 - a. A mild oxidant such as nitric acid solution shall be used.

PART 3 - EXECUTION

3.01 PREPARATION:

- A. Verify suitability of substrate to accept installation.
- B. Coordinate installation of embedded anchors with other trades.

3.02 FABRICATION:

- A. Form to shapes indicated with straight lines, sharp angles, smooth curves.
- B. Drill or punch holes for temporary field connections and attachment of Work by other trades. Smooth edges of holes for proper securement of fasteners.
- C. Make permanent shop connections with continuous fillet-type welds. Grind exposed welds smooth.
- D. Conceal fastenings where practicable.
- E. Shop-fabricate in as large assemblies as practicable.
- F. Qualify welding processes and welding operators in accordance with AWS.

3.03 INSTALLATION:

- A. Set Work level, true to line, and plumb.
- B. Shim and grout as necessary.
- C. Weld field connections and grind smooth.
- D. Where practicable, conceal fastenings.
- E. Secure metal to concrete or concrete masonry units with embedded expansion anchors, setting compounds, caulking and sleeves, or setting grout.
- F. Do not field-splice fabricated items unless size requires splicing.
- G. Weld all splices.
- H. After installation, pickle and passivate all surfaces that may have been exposed to metal cutting or grinding tools and or field welded. Use approved field applied pickling paste.

END OF SECTION 05 13 00

SECTION 05 45 00 - ALUMINUM

PART 1 - GENERAL

1.01 RELATED DOCUMENTS:

- A. Drawings and general provisions of the Contract, including General and Special Conditions and DIVISION 01 Specification Sections, apply to this Section.

1.02 SUMMARY:

- A. This Section includes the following aluminum-fabricated items:
 - 1. Structural shapes and plate.
 - 2. Grating and treads.
 - 3. Nuts and bolts.

1.03 REFERENCE STANDARDS:

- A. Applicable Standards:
 - 1. Aluminum Association (AA):
 - a. Aluminum Design Manual.
 - 2. American National Standards Institute (ANSI):
 - a. A14.3 - Fixed Ladders - Safety Requirements.
 - 3. ASTM International (ASTM):
 - a. A167 - Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip.
 - b. B209 - Aluminum and Aluminum Alloy Sheet and Plate.
 - c. B221(B211) - Aluminum and Aluminum Alloy Extruded Bars, Rods, Wire, Shapes and Tubes.
 - d. B308 - Aluminum Alloy 6061 T6 Standard Structural Profiles.
 - e. B429 - Aluminum-Alloy Extruded Structural Pipe and Tube.
 - f. B632 - Aluminum-Alloy Rolled Tread Plate.
 - g. F436 - Hardened Steel Washers.
 - h. F467 - Nonferrous Nuts for General Use.
 - i. F468 - Nonferrous Bolts, Hex Cap Screws, and Studs for General Use.
 - j. F593 - Stainless-Steel Bolts, Hex Cap Screws, and Studs.
 - k. F594 - Stainless-Steel Nuts.
 - 4. American Welding Society (AWS):
 - a. D1.2 - Structural Welding Code - Aluminum.

1.04 DEFINITIONS:

- A. Handrails: A single pipe supported on a guardrail or brackets from a wall, as on a stairway or ramp, to furnish persons with a handhold in case of tripping.
- B. Guardrails and railings: A vertical barrier erected along exposed edges of a floor opening, wall opening, ramp, platform, runway, or stairway to prevent falls of persons. The top member of a guardrail serves as a handrail. The terms handrails, guardrails, and railings may be used interchangeably.
- C. Toeboards: A vertical barrier at floor level erected along exposed edges of a floor opening, wall opening, platform, runway, or ramp to prevent falls of materials.

1.05 SUBMITTALS:

- A. Submit as specified in the General and Special Conditions.

SECTION 05 45 00 – ALUMINUM: continued

- B. Include, but not limited to, the following:
 - 1. Specifications.
 - 2. Fabrication and erection drawings including sizes, connections, anchorage, size and type of fasteners, and accessories.
 - 3. Catalog cuts.
 - 4. Structural computations and metal properties.
 - 5. Material samples.
 - 6. Manufacturer's assembly and installation instructions.
 - 7. Manufacturer's maintenance manual.

1.06 QUALITY CONTROL:

- A. Guardrails and handrails shall be the product of a company normally engaged in the manufacture of pipe railings.
- B. Inspection: Material and workmanship will be subject to inspection in the shop and field.
- C. Welder Qualifications:
 - 1. Welders shall be previously qualified by passing the tests prescribed in the AWS D1.2 Qualification Section and the AA Qualification Standard for Structural Welding of Aluminum, or by passing such other tests as Engineer may accept.
 - 2. Welders shall have been tested within the past 12 months, and their qualification will be considered as remaining in effect unless the welder has not engaged in a given process of welding for a period exceeding 6 months.
 - 3. Submit two certified copies of the qualification records as evidence of qualification to the above mentioned codes.

1.07 DELIVERY, STORAGE, AND HANDLING:

- A. Protect aluminum Work from abuse, staining, or damage during shipment, storage, erection, and installation.
- B. Store in a manner to prevent warping of materials.
- C. Materials shall be properly packaged to prevent scratching and denting during shipment, storage, and erection. Maintain protective wrapping until Project is completed.

1.08 DESIGN REQUIREMENTS:

- A. Guardrails, handrails, and ladders shall be designed and fabricated in strict compliance with the requirements of the 2021 International Building Code.

PART 2 - PRODUCTS

2.01 GENERAL REQUIREMENTS:

- A. Fabricate all aluminum to conform to AA specifications, codes, and standards.
- B. Standard tolerances of all aluminum members shall conform to AA Aluminum Design Manual.
- C. Fabricate all materials free of blemishes, tool marks, burrs, and other defects.
- D. Shop-fabricate insofar as possible.
- E. Welding:

SECTION 05 45 00 – ALUMINUM: continued

1. Conform to AA Aluminum Design Manual, and AWS D1.2.
2. All welding shall be performed using inert gas, shielded arc, or resistance welding processes. Welding processes that require welding flux shall not be used.
3. All welding shall be accomplished using filler Alloy 4043.
4. Contractor shall perform fabrication inspection of welds in accordance with AWS D1.2 to determine the acceptability of welds. Inspection shall be performed by an AWS Certified Welding Inspector qualified in accordance with AWS Standard for Qualification and Certification of Welding Inspectors.
5. Joints found to be defective shall be repaired by rewelding.

2.02 STRUCTURAL SHAPES AND PLATE:

- A. Conform to ASTM B209 and ASTM B308.
- B. Conform to AA Aluminum Standards and Data.
- C. Shall be aluminum Alloy 6061 T6 unless otherwise specified.

2.03 NUTS AND BOLTS:

- A. Bolts, nuts, and washers shall be AISI Type 304 or Type 316 stainless steel.
- B. Bolts shall conform to ASTM F593.
- C. Nuts shall conform to ASTM F594.
- D. Washers shall conform to ASTM A167 with dimensional tolerances of ASTM F436.

2.04 GRATINGS AND TREADS:

- A. Grating:
 1. Conform to ASTM B221, aluminum Alloy 6061 or Alloy 6063, mill finish.
 2. Main Bars: 3/16 inch thick (unless otherwise noted) and spaced not more than 1-3/16 inches o.c. Depth as indicated, dovetail slotted to receive cross bars.
 3. Cross Bars: Of depth as required by main bars, spaced not more than 4 inches o.c. Top surface shall be flush with top of main bars.
 4. Configuration of top surface of main bars unless otherwise indicated.
 - a. Exterior - Exposed to Weather: Striated.
 - b. Interior - Not Exposed to Weather: Striated.
 5. Provide with aluminum "saddle clip"-type fasteners and stainless steel bolts.
- B. Treads:
 1. Manufacturer's standard rectangular, with corrugated nosing, aluminum Alloy 6061 T6 or 6063-T6.
 2. Main Bars: As indicated on Drawings.
 3. Crossbars: Spaced not more than 4 inches o.c.
 4. Top Surface of Grating Tread: Striated.
 5. Provide with stainless-steel hardware.
- C. Fabrication:
 1. Main bars shall be vertical within a tolerance of 0.10-inch per inch of depth.
 2. Longitudinal bow (before fastening to supports) shall be less than 1/200 of the length.

SECTION 05 45 00 – ALUMINUM: continued

3. Transverse bow before fastening to supports shall be less than 3/8 inch in 3 feet.
 4. Crossbars shall not deviate from a straight line perpendicular to the main bars by more than 3/16-inch in 3 feet.
 5. Crossbars shall match crossbars of adjacent sections to form a continuous pattern of straight lines.
 6. Panel width and length tolerances shall be +1/4 inch.
 7. Provide all openings in grating indicated and as required for installation of all piping, wiring, and equipment installed under this Contract.
 8. Band all openings 4 inches and larger with a bar same size as main bearing bar. Weld to each bearing bar with a 3/16-inch fillet weld, 3/4 inch long. Tack weld to all crossbars.
 9. Trim band all locations as follows:
 - a. Open end of grating at head of a ladder.
 - b. Grating edges that are not perpendicular or parallel to the main bars.
 - c. Grating panels with four crossbars or less.
 - d. Other locations as indicated.
- D. Openings in Grating:
1. Furnish for other contracts as follows:
 - a. Include an allowance in Lump Sum Contract Price for (2) field-fabricated banded openings of 12 inches or less in diameter or rectangular openings of equivalent area.
 - b. Include an allowance in Lump Sum Contract Price for (10) shop-fabricated banded openings greater than 12 inches and less than 30 inches in diameter or rectangular openings of equivalent area.
 - c. Increase or decrease of quantity of openings required will be adjusted at the Unit Price set forth in the Agreement.
 - d. Exact size, location, and final quantities of openings required will be furnished to Contractor during the construction period.
- E. Manufacturer:
1. Gratings and treads shall be as manufactured by one of the following:
 - a. Alabama Meals Industries Corporation, Birmingham, AL.
 - b. BarnettBates Corporation, Joliet, IL.
 - c. Ohio Grating, Canton, OH.
 - d. Grating Pacific, Los Alamitos, CA
 - e. IKG Industries, Aberdeen, NJ.
 - f. Engineer-approved equal.

PART 3 - EXECUTION

3.01 GENERAL:

- A. Conform to applicable standards of AA.
- B. Protect aluminum at contact with other metals, grout, and concrete by a heavy brush coat of alkali-resistant bituminous coating, or a nonporous tape or gasket. Coating is not required for aluminum in contact with stainless-steel bolts. Apply

SECTION 05 45 00 – ALUMINUM: continued

bituminous coating at 15-mil minimum dry film thickness and which shall be one of the following:

1. Carboline - Bitumastic No. 50.
2. Tnemec - H.B. Tnemecol 46-465.

3.02 INSTALLATION:

A. Aluminum Handrail and Guardrail:

1. Space posts a maximum of 6 ft.-0 inches o.c. except where otherwise indicated.
2. Install posts as indicated on fabrication drawings.
3. Install toeboards (kick plates) and anchor to each post with clamps and bolts. Allow ¼-inch space between bottom of toeboard and top of floor surface.
4. Install handrail to walls with brackets spaced not greater than 6 ft.-0 inches o.c., except where otherwise indicated.
 - a. Use anchors as indicated on fabrication drawings.
5. Protect aluminum after cleaning with a clear methacrylate lacquer coating.

B. Grating and Treads:

1. Space fasteners as required to overcome irregularities and maintain grating contact with supports. Minimum anchorage of each panel will be two fasteners at each end and one fastener at each intermediate support.
2. Unless indicated as fixed, fasten grating with clips using stainless-steel bolts.
3. Bolt stair treads to stringers with a minimum of two 3/8-inch stainless-steel bolts at each end of tread.
4. All grating shall be removable unless otherwise indicated.

C. Ladders: Install as indicated. Ladder shall be securely fastened to wall or substrate.

D. Tread Plates: Install as indicated and as specified in PART 2, this Section.

3.03 CLEANING:

- #### A.
- Clean all aluminum surfaces after installation free of smudges, stains, or other deleterious substances.

END OF SECTION 05 45 00

DIVISION 6 – WOOD AND PLASTICS

SECTION 06 82 00 - FIBERGLASS REINFORCED PLASTIC PRODUCTS AND FABRICATIONS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS:

- A. Drawings and general provisions of the Contract, including General and Special Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY:

- A. This Section includes fiberglass reinforced grating, structural shapes, and related accessories.

1.03 RELATED WORK SPECIFIED ELSEWHERE:

- 1. Section 05 13 00 – Stainless Steel Fabrication.
- 2. Section 05 45 00 – Aluminum.

1.04 REFERENCES:

- A. American Society for Testing and Materials (ASTM):
 - 1. D2584 - Test Method for Ignition Loss of Coved Reinforced Resins.
 - 2. E84 - Test Method for Surface Burning Characteristics of Building Materials.

1.05 SUBMITTALS:

- A. Submit as specified in the General and Special Conditions.
- B. Product Data: Catalog data and specifications, including structural design data, structural properties data, load deflection tables, corrosion tables, and materials of construction.
- C. Shop Drawings: Plans, elevations, and details showing grating and structural component layout, fasteners, member sizes, dimensions, fabrication, and assembly details.
- D. Color chart for selection of color(s) from manufacturer standard selection.
- E. Small Sample of each specified grating and component. Sample pieces shall be manufactured by the method to be used in the Work.

1.06 QUALITY CONTROL:

- A. All grating and related components for the Project shall be manufactured and supplied by the same manufacturer.
- B. Manufacturer shall be experienced in fiberglass reinforced plastic fabrications of type and quantity as required for this Project and shall have a record of at least 5 previous similar installations.

1.07 DELIVERY, STORAGE, AND HANDLING:

- A. All systems, subsystems and structures shall be shop fabricated and assembled into the largest practical size suitable for transporting.
- B. All materials and equipment necessary for the fabrication and installation of the grating, plate, handrails, stair treads, and structural shapes shall be stored before, during, and after shipment in a manner to prevent cracking, twisting, bending,

SECTION 06 82 00 - FIBERGLASS REINFORCED PLASTIC PRODUCTS AND FABRICATIONS:
continued

- breaking, chipping or damage of any kind to the materials or equipment, including damage due to over exposure to the sun. Adhesives, resins and their catalysts and hardeners shall be crated or boxed separately to facilitate dry indoor storage.
- C. Grating shall be shipped from the manufacturer, palletized, and banded with exposed edges protected with cardboard.
 - D. All materials, items, and fabrications shall be identified and match-marked for installation and field assembly.

PART 2 - PRODUCTS

2.01 MANUFACTURERS:

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Creative Pultrusions.
 - 2. Fibergrate Composite Structures, Inc.
 - 3. IKG Industries, a Harsco Co.
 - 4. International Grating, Inc.
 - 5. Strongwell.

2.02 RESIN SYSTEM:

- A. Premium grade isophthalic polyester resin, with good chemical resistance and flame spread rating of 25 or less per ASTM E84.
- B. Premium grade vinylester with excellent corrosion resistance in caustic and acid environments, and with flame spread rating of 25 or less per ASTM E84.

2.03 MOLDED GRATING:

- A. Fiberglass reinforced composite molded with smooth mold surfaces.
- B. Glass content of grating shall be a minimum of 25% and a maximum of 35% as determined by ASTM D2584, for maximum UV and chemical resistance.
- C. Bearing and cross bars shall be molded at same time into a one-piece construction. Top surfaces shall have a nonporous concave surface to provide a skid resistant walking surface.
- D. Grating shall be square pattern with spacing of bearing and cross bars standard of the manufacturer to safely support a uniform load of 100psf with maximum deflection of 3/8-inch. Grating thickness shall be as indicated on Drawings.
- E. Color shall be standard of the manufacturer.

2.04 GRATING FASTENERS:

- A. Fasteners shall be one of the following:
 - 1. Saddle Clips: Stainless steel clamps with hex-head bolt and nut, designed to clamp two bars to supporting structure.
 - 2. Z Clips: Stainless steel clamps with hex-head bolt and nut, designed to clamp one bar to supporting structure.
 - 3. Interlocking Clips: Stainless steel clamps with self-tapping screw to tie two adjacent grating panels together.

SECTION 06 82 00 - FIBERGLASS REINFORCED PLASTIC PRODUCTS AND FABRICATIONS:
continued

- 4. Beam Clip: Fiberglass clamps used in conjunction with saddle clips to secure grating from underside of supporting structure flange.
- 2.05 STRUCTURAL SHAPES:
 - A. Fiberglass reinforced pultruded structural shapes.
 - B. Provide in the shapes and sizes indicated on the drawings. Use stock structural shapes to greatest extent possible.
 - C. Color shall be standard of the manufacturer.
- 2.06 FABRICATION:
 - A. Grating supplied shall meet the dimensional requirements and tolerances as indicated or specified. Contractor shall provide and/or verify measurements in field for work fabricated to fit field conditions as required by grating manufacturer to complete the Work. When field dimensions are not required, Contractor shall determine correct size and locations of required holes or cutouts from field dimensions before grating fabrication.
 - B. Shop fabricate grating and other components in sections to facilitate shipping, handling, installation, and future removal. Each grating section shall be readily removable except where indicated or not feasible.
 - C. Grating openings which fit around protrusions (pipes, cables, machinery, and similar items) shall be discontinuous at approximately the centerline of opening so each section of grating is readily removable. Shop cut penetrations to greatest extent possible. Field cutting will be permitted when penetration locations are not known at time of fabrication or differ from locations indicated. Clearances shall be as indicated, or if not indicated shall not exceed governing codes and regulations at Project locations.
 - D. All cut edges of grating and structural plates shall be smooth and sealed with catalyzed resin of equal or superior corrosion resistance to the grating.
 - E. Grating shall be fabricated free from warps, twists, or other defects which affect appearance and serviceability. The grating shall be as free, as commercially possible, from visual defects such as foreign inclusions, delamination, blisters, resin burns, air bubbles, and pits.
 - F. Fabricate structural shapes to lengths required.

PART 3 - EXECUTION

- 3.01 PREPARATION:
 - A. Fabricator shall coordinate and furnish anchorages, setting drawings, diagrams, templates, instructions, and directions for installation of anchorages, including concrete inserts, sleeves, anchor bolts, and miscellaneous items having integral anchors that are to be embedded in concrete or masonry construction. Coordinate delivery of such items to Project Site. Contractor may provide concrete and masonry anchorages, coordinating with fabricator.
 - B. Set sleeves in concrete with tops flush with finish surface elevations; protect sleeves from water and concrete entry.

SECTION 06 82 00 - FIBERGLASS REINFORCED PLASTIC PRODUCTS AND FABRICATIONS:
continued

3.02 INSTALLATION:

- A. Fastening to in-place construction: Provide anchorage devices and fasteners as required for securing fiberglass fabrications; include threaded fasteners for concrete and masonry inserts, toggle bolts, through-bolts, lag bolts, and other connectors as required. Secure grating panels in place with hold down fasteners specified.
- B. Cutting, fitting, and placement: Perform cutting, drilling, and fitting required for installation of miscellaneous fiberglass fabrications. Set fiberglass fabrication accurately in location, alignment, and elevation; with edges and surfaces level, plumb, true, and free of rack; and measured from established lines and levels.
- C. Provide temporary bracing or anchors in formwork for items that are to be built into concrete masonry or similar construction.
- D. Seal all field cut and drilled edges, holes, and abrasions with a catalyzed resin compatible with the original resin as recommended by the manufacturer. The sealing of the edges shall prevent premature fraying at the field cut edges.
- E. Install items specified as indicated and in accordance with manufacturer's instructions.

END OF SECTION 06 82 00

DIVISION 07 – THERMAL AND MOISTURE PROTECTION

SECTION 07 14 00 – SHEET WATERPROOFING

PART 1 - GENERAL

1.01 SUMMARY

- A. This Section includes the following:
 - 1. Below-grade waterproofing for the concrete roof slab of the storage tank.
- B. Related Work Specified Elsewhere:
 - 1. For concrete placement, curing, and finishing: DIVISION 3.

1.02 REFERENCES:

- A. American Society for Testing and Materials (ASTM):
 - 1. D1004 - Test Method for Initial Test Resistance of Plastic Film and Sheeting.
 - 2. D1505 - Standard Test Method for Density of Plastics by the Density-Gradient Technique.
 - 3. D4833 - Standard Test Method for Index Puncture Resistance of Geomembranes and Related Products.
 - 4. D5199 - Standard Test Method for Measuring the Nominal Thickness of Geosynthetics.
 - 5. D6693 - Standard Test Method for Determining Tensile Properties of Nonreinforced Polyethylene and Nonreinforced Flexible Polypropylene Geomembrane.

1.03 PERFORMANCE REQUIREMENTS:

- A. General: Provide waterproofing that prevents the passage of liquid water under hydrostatic pressure and complies with requirements as demonstrated by testing performed by an independent testing agency of manufacturer's current sheet membrane.

1.04 SUBMITTALS:

- A. General: Submit in accordance with the General and Special Conditions.
- B. Product Data for waterproofing specified, including manufacturer's written instructions for evaluating, preparing, and treating substrate, technical data, and tested physical and performance properties.
- C. Shop Drawings showing locations and extent of waterproofing, including details for substrate joints and cracks, sheet flashings, penetrations, tie-ins with adjoining construction, and other termination conditions.
- D. Samples, 3-by-6-inch (75-by-150-mm) minimum size, of each waterproofing material required for Project.
- E. Installer certificates signed by manufacturer certifying that installers comply with requirements under the "Quality Control" Article.
- F. Product test reports from a qualified independent testing agency evidencing compliance of waterproofing with requirements and other physical properties reported by manufacturer based on comprehensive testing of products according to current standard test methods within previous 5 years.

SECTION 07 14 00 - SHEET WATERPROOFING: continued

1.05 QUALITY CONTROL:

- A. Installer Qualifications: Engage an experienced installer who is licensed or approved by waterproofing manufacturer as qualified to install manufacturer's waterproofing.
- B. Installer Qualifications: Engage an installer who has completed waterproofing similar to that indicated for this Project and who is acceptable to waterproofing manufacturer.
- C. Single-Source Responsibility: Obtain waterproofing materials from a single manufacturer regularly engaged in manufacturing waterproofing
- D. Preinstallation Conference: Conduct conference at Project Site to comply with requirements of DIVISION 1.
 - 1. Before installing waterproofing, meet with Owner, Engineer/Architect, consultants, independent testing agency, waterproofing manufacturer, and other concerned entities.
 - 2. Review requirements for waterproofing, including surface preparation specified under other Sections, substrate condition and pretreatment, minimum curing period, forecasted weather conditions, special details and sheet flashings, installation procedures, inspection and testing procedures, and protection and repairs.
 - 3. Notify participants at least 7 days before conference.

1.06 DELIVERY, STORAGE, AND HANDLING:

- A. Deliver materials to Project Site in original packages with seals unbroken, labeled with manufacturer's name, product, date of manufacture, and directions for storage.
- B. Store materials in their original undamaged packages in a clean, dry, protected location and within temperature range required by waterproofing manufacturer. Protect stored materials from direct sunlight.

1.07 PROJECT CONDITIONS:

- A. Environmental Conditions: Apply waterproofing within range of ambient and substrate temperatures recommended by waterproofing manufacturer. Do not apply waterproofing to a damp or wet substrate. Do not apply waterproofing in snow, rain, fog, or mist.
- B. Maintain adequate ventilation during preparation and application of waterproofing materials.

1.08 WARRANTY:

- A. Special Warranty: The HDPE waterproofing material manufacturer shall warrant, on a pro- rata basis, the HDPE materials against manufacturing defects and material degradation during the specified warranty period. The manufacturer shall replace any material which fails due to manufacturing defects or material degradation within the warranty period.
 - 1. Warranty Period: 20 years after date of Substantial Completion.

SECTION 07 14 00 - SHEET WATERPROOFING: continued

PART 2 - PRODUCTS

2.01 SHEET WATERPROOFING:

A. Synthetic Butyl Rubber Sheet:

1. Sheet Type: 60-mil- (1.5-mm-) thick flexible sheet formed from HDPE material with the following properties as determined per ASTM test method indicated.
2. Service Conditions: The HDPE material and all solvents, adhesives, and filler shall be certified by the manufacturer to be safe for use in potable water storage. Solvents, fillers, adhesives, and other material containing trichloroethylene, perchloroethylene, or any other regulated or toxic substance as identified by Federal or other governing agencies shall not be used.
3. Physical Properties:
 - a. Density: 0.94 g/CM³; ASTM D1505.
 - b. Overall Thickness, mils: 60; ASTM D5199.
 - c. Tensile Property:
 - (1) Yield Strength: 126 lbs/in-width; ASTM D6693, Type IV.
 - (2) Break Strength: 90 lbs/in; ASTM D6693, Type IV.
 - d. Tear Resistance: 45 lbs (200 N); ASTM D1004.
 - e. Puncture Resistance: 90 lbs (400 N); ASTM D 4833.

2.02 AUXILIARY MATERIALS:

- ##### A. General: Furnish auxiliary materials recommended by waterproofing manufacturer for intended use and compatible with polymeric sheet waterproofing.
1. Furnish liquid-type auxiliary materials that meet volatile organic compound (VOC) limits of authorities having jurisdiction.
- ##### B. Bonding Adhesives: Adhesive for bonding sheets and sheet flashings to substrates and projections as recommended by HDPE material manufacturer.
- ##### C. Splice Adhesive and Cleaner: Single-component butyl splicing cement and solvent-based splice cleaner.
- ##### D. In-Seam and Lap Sealant: Single-component sealant.
- ##### E. Water Cutoff Mastic: Butyl mastic sealant.
- ##### F. Butyl Gum Tape: 30-mil- (0.76-mm-) thick-by-6-1/4-inch- (160-mm-) wide uncured butyl with polyethylene release film.
- ##### G. Waterproofing and Sheet Flashing Accessories: Provide sealants, pourable sealers, cone and vent flashings, inside and outside corner flashings, termination reglets, discs, and other accessories recommended by waterproofing manufacturer for intended use.
- ##### H. Metal Termination Bars: Manufacturer's standard stainless-steel bars, approximately 1/4 inch thick x 2 inch wide.
- ##### I. Expansion Anchors: Type 316 stainless steel; Ramset "Trubolt" or Hilti "Kwik bolts".
- ##### J. Thickol Sealant: Fed Spec TT-S-00277; poly-sulfide rubber, two components; Pecora "GC-5", PRC "Rubber Calk 350", Sonneborn "Sololastic", or Woodmont "Chem-Calk 200".

SECTION 07 14 00 - SHEET WATERPROOFING: continued

- K. Joint Filler: Pacific Polymers "Elasto-Deck No. 5001", suitable for submerged service.
- L. Bolts: IFI-104, Grade 316 or 304.

PART 3 – EXECUTION

3.01 EXAMINATION:

- A. Examine substrates, areas, and conditions under which waterproofing systems will be applied, with Installer present, for compliance with requirements. Do not proceed with installation until unsatisfactory conditions have been corrected.
 - 1. Do not proceed with installation until after minimum concrete curing period recommended by waterproofing manufacturer.
 - 2. Verify substrate is visibly dry and free of moisture. Test for capillary moisture by plastic sheet method according to ASTM D4263.
 - 3. Notify Engineer/Architect in writing of anticipated problems using waterproofing over substrate.

3.02 SURFACE PREPARATION:

- A. Clean, prepare, and treat substrate according to manufacturer's written instructions. Provide clean, dust-free, and dry substrate for waterproofing application.
- B. Remove grease, oil, bitumen, form release agents, paints, and other penetrating contaminants from concrete.
- C. Remove fins, ridges, mortar, and other projections and fill honeycomb, aggregate pockets, holes, and other voids.
- D. Prepare, fill, prime, and treat joints and cracks in substrate. Remove dust and dirt from joints and cracks according to ASTM D4258.
- E. Prepare, treat, and seal vertical and horizontal surfaces at terminations and penetrations through waterproofing and at drains and protrusions.

3.03 LOOSELY LAID SHEET INSTALLATION:

- A. Install loosely laid sheet over entire area to receive waterproofing according to manufacturer's written instructions.
- B. Accurately align sheets and maintain uniform side and end laps of minimum dimensions required. Stagger end laps.
- C. Secure terminations and perimeter of deck sheet waterproofing with metal termination bars anchored 12 inches (300 mm) o.c.
- D. Secure top termination of waterproofing with termination bar as indicated on the Drawings.
- E. Repair tears, voids, and lapped seams in waterproofing not meeting requirements. Patch with sheet waterproofing extending beyond repaired areas in all directions.

3.04 SEAM INSTALLATION:

- A. Clean splice areas, apply splicing cement and in-seam sealant, and firmly roll side and end laps of overlapping sheets according to manufacturer's written instructions to ensure a watertight seam installation. Apply lap sealant and seal

SECTION 07 14 00 - SHEET WATERPROOFING: continued

exposed edges of sheet terminations.

3.05 FIELD QUALITY CONTROL:

- A. All seams shall be vacuum tested by the installation contractor. Any weak or unbonded seams shall be repaired with a minimum 6 inch patch overlay. All membrane repair shall be made with patches having rounded corners. The installation contractor shall be responsible for all membrane repairs.
- B. Correct deficiencies in or remove waterproofing that does not comply with requirements, repair substrates, and reapply waterproofing.

3.06 PROTECTING AND CLEANING:

- A. Protect waterproofing from damage and wear during application and remainder of construction period according to manufacturer's written instructions.
- B. Protect installed insulation from damage due to ultraviolet light exposure, physical abuse, and other causes.
- C. Clean spillage and soiling from adjacent construction using cleaning agents and procedures recommended by manufacturer of affected construction.

END OF SECTION 07 14 00

DIVISION 8 – OPENINGS

SECTION 08 31 13 - ACCESS DOORS AND FRAMES

PART 1 - GENERAL

1.01 SUMMARY:

- A. This Section includes metal access doors for the following areas:
 - 1. Aluminum floor hatches (floor doors).
 - 2. Aluminum roof hatches.
 - 3. Access hatches shall be provided complete with all accessories, spare parts, and other appurtenances as specified and as may be required for a complete and operating installation.

1.02 SUBMITTALS:

- A. Submit as specified in the General and Special Conditions.
- B. Includes, but not limited to, the following:
 - 1. Product Data: Manufacturer's technical data and installation instructions for each type of access-door assembly, including setting drawings, templates, instructions, and directions for installation of anchorage devices.
 - 2. Include complete schedule, including types, general locations, sizes, wall and ceiling construction details, finishes, latching or locking provisions, and other data pertinent to installation.
 - 3. Shop Drawings: Submit for fabrication and installation of customized access doors and frames, including details of each frame type, elevations of door-design types, anchorage and accessory items.
 - 4. ASME Code Section VIII Division 1 Pressure Calculations

1.03 QUALITY CONTROL:

- A. The manufacturer of the watertight doors shall present evidence attesting to at least 5 years of successful experience in the design and fabrication of doors of the type specified.
- B. Provide each access door or hatch as a complete unit. Furnish all metal access doors of each type by one manufacturer.
- C. Furnish inserts and anchoring devices which must be built into other Work for installation of access doors. Coordinate delivery with other Work to avoid delay.

1.04 DELIVERY, STORAGE, AND HANDLING:

- A. Handle and store units to prevent racking, warping, or other damage.

1.05 GUARANTEE:

- A. Floor doors and roof hatches shall be guaranteed by the manufacturer for proper operation and against defects in material and workmanship for 5 years.

SECTION 08 31 00 - ACCESS DOORS AND FRAMES: continued

PART 2 - PRODUCTS

2.01 TANK ROOF HATCH

- A. Furnish and install Type D and Type J Roof Equipment Hatch by the Bilco Company or approved equal where indicated on drawings.
 - 1. The Type D roof hatch shall be single leaf and pre-assembled from the manufacturer. See Drawings for dimensions.
 - 2. The Type J roof hatch shall be double leaf and pre-assembled from the manufacturer. See Drawings for dimensions.
- B. Performance characteristics:
 - 1. Covers shall be reinforced to support a minimum live load of 40 psf (195kg/m²) with a maximum deflection of 1/150th of the span or 20 psf (97 kg/m²) wind uplift.
 - 2. Operation of the covers shall be smooth and easy with controlled operation throughout the entire arc of opening and closing.
 - 3. Operation of the covers shall not be affected by temperature.
 - 4. Entire hatch shall be weather tight with fully welded corner joints on covers and curb.
- C. Covers: Shall be 11 gauge (2.3mm) aluminum with a 3" (76mm) beaded flange with formed reinforcing members. Covers shall have a heavy extruded EPDM rubber gasket that is bonded to the cover interior to assure a continuous seal when compressed to the top surface of the curb.
- D. Cover insulation: Shall be fiberglass of 1" (25mm) thickness, fully covered and protected by a metal liner 18 gauge (1mm) aluminum.
- E. Curb: Shall be 12" (305mm) in height and 11 gauge (2.3mm) aluminum. The curb shall be formed with a 3-1/2" (89mm) flange with 7/16" (11mm) holes provided for securing to the roof deck. The curb shall be equipped with an integral metal capflashing of the same gauge and material as the curb, fully welded at the corners, that features the Bil-Clip® flashing system, including stamped tabs, 6" (153mm) on center, to be bent inward to hold single ply roofing membrane securely in place.
- F. Lifting mechanisms: Manufacturer shall provide compression spring operators enclosed in telescopic tubes to provide, smooth, easy, and controlled cover operation throughout the entire arc of opening and closing. The upper tube shall be the outer tube to prevent accumulation of moisture, grit, and debris inside the lower tube assembly. The lower tube shall interlock with a flanged support shoe welded to the curb assembly.
- G. Hardware:
 - 1. Heavy pintle hinges shall be provided.
 - 2. Covers shall be equipped with Yale 112 deadbolt locks with keyed outside and turn knob on interior. Exterior key access shall be provided with weathertight cover. Type D hatch shall have the Yale lock mechanism on each end of upper door panel.
 - 3. Roof hatch shall be equipped with interior and exterior padlock hasps.
 - 4. The latch strike shall be a stamped component bolted to the curb assembly.

SECTION 08 31 00 - ACCESS DOORS AND FRAMES: continued

- 5. Covers shall automatically lock in the open position with a rigid hold open arm equipped with a 1" (25mm) diameter red vinyl grip handle to permit easy release for closing.
- 6. Hardware: All hardware shall be Type 316 stainless steel.
- 7. Cover hardware shall be bolted into heavy gauge channel reinforcing welded to the underside of the cover and concealed within the insulation space.
- H. Finish: Anodized aluminum. Color to be selected by Architect from manufacturer's full range and Approved by Owner.

2.02 FLOOR DOORS (VALVE VAULT AND TANK INTERIOR ACCESS HATCHES):

- A. Acceptable manufacturers:
 - 1. Babcock-Davis Hatchways, Inc.
 - 2. The Bilco Company.
 - 3. Halliday.
- B. Performance Characteristics:
 - 1. Cover: Shall be reinforced to support a minimum live load of 300 psf. Minimum thickness of 1/4" with diamond pattern.
 - 2. Operation of cover be smooth with controlled operation throughout the entire arc of opening and closing.
 - 3. Entire door, including all hardware components, shall be highly corrosion resistant.
- C. Frame: Channel frame shall be extruded aluminum with bend down anchor tabs around perimeter.
- D. Hinges: Shall be specifically design for horizontal installation and shall be through bolted to covers with tamperproof Type 316 stainless steel lock bolts and shall be through bolted to the frame with Type 316 stainless steel bolts and locknuts.
- E. Drain Coupling: Provide a 1 1/2" drain coupling in the corner of the channel frame. Contractor to coordinate location of coupling and submit to engineer for approval.
- F. Lifting Mechanisms: Manufacturer shall provide the required number and size of compression spring operators enclosed in telescopic tubes to provide, smooth, easy, and controlled cover operation throughout the entire arc of opening and to act as a check in retarding downward motion of the covers when closing. The upper tube shall be the outer tube to prevent accumulation of moisture, grit, and debris inside the lower tube assembly. The lower tube shall interlock with a flanged support shoe fastened to a formed 1/4" (6mm) gusset support plate.
- G.
- H. Latch mechanism shall be steel slam lock with fixed interior handle and removable exterior turn/lift handle. The latch release shall be protected by a flush, gasketed, removable screw plug.
- I. Hardware:
 - 1. Hinges: Heavy forged Type 316 stainless steel hinges, each having a minimum 1/4" (6mm) diameter Type 316 stainless steel pin, shall be provided and shall pivot so the covers do not protrude into the channel frame.
 - 2. Cover shall be equipped with a hold open arm which automatically locks each cover in the open position.

SECTION 08 31 00 - ACCESS DOORS AND FRAMES: continued

- 3. Cover shall be fitted with the required number and size of compression spring operators. Springs and spring tubes shall be Type 316 stainless steel.
- 4. A Type 316 stainless steel snap lock with fixed handle shall be mounted on the underside of one cover.
- 5. Hardware: Shall be Type 316 stainless steel throughout.
- J. Finishes: Factory finish shall be mill finish aluminum with bituminous coating applied to the exterior of the frame.

PART 3 - EXECUTION

3.01 INSTALLATION:

- A. Install metal access doors/hatches in locations indicated.
- B. Install to conform to manufacturer's requirements and coordinate installation with Work of other trades. Set frames accurately in position and securely attach to supports with face panels plumb or level in relation to adjacent finish surfaces.
- C. Anchor as required by manufacturer.

3.02 ADJUSTMENT AND CLEANING:

- A. Adjust access doors as required for proper operation.
- B. Remove and replace panels or frames which are warped or bowed. Repair damaged surfaces and gaskets.
- C. Clean all surfaces using methods and products which will not cause damage to the surface or finish.

END OF SECTION 08 31 13

DIVISION 9 – FINISHES

SECTION 09 90 00 – PROTECTIVE COATING

PART 1 - GENERAL

1.01 SUMMARY:

- A. This Section includes coating of exterior and interior surfaces throughout the Project and which are listed in PART 2, with systems specified on "coating system" sheets at the end of this Section.
- B. Coating systems include surface preparation, prime coat (first coat), finish coats (second and third coats), inspection, cleaning, and touch-up of surfaces and equipment. Shop preparation, prime coat, and finish coats to be shop-applied, may be specified elsewhere or referenced to this Section so that a complete system is specified and coordinated.
 - 1. Where surface preparation and first (prime) coat are specified in other Sections to be shop-applied, such as for structural steel, hollow metal doors or equipment, only the touch-up and finish coats are a part of field painting. Surface preparation is the required degree of preparation prior to application of first (prime) coat regardless if done in shop or field.
 - 2. If materials are provided without shop primer such as miscellaneous steel or sheet metal, then surface preparation, first, second, and third coats are a part of field painting.
 - 3. Concealed surfaces are generally not required to have finish-coats unless otherwise specified, but prime coat should be applied and touched up prior to concealment.
 - 4. Where Equipment and Materials are provided with shop-applied finished coating system, only touch-up is a part of field painting.
 - 5. Refer to applicable Sections to determine whether surface preparation and first coat, or complete coating system, is to be shop-applied.
- C. Related Work Specified Elsewhere:
 - 1. Steel Pipe Polyurethane Coating: SECTION 09 90 05.
 - 2. Shop Painting and Coatings: All applicable Divisions.
 - 3. Factory Prefinished Items: All applicable Divisions.
- D. Colors:
 - 1. Color of finish coatings shall match accepted color Samples.
 - 2. When second and finish coats of a system are of same type, tint or use an alternate color on second coat to enable visual coverage inspection of the third coat. When first and second coats only are specified and are of same or different types, tint or use an alternate color on first coat to enable visual coverage inspection of the second coat.

1.02 REFERENCES:

- A. Applicable Standards:
 - 1. American National Standards Institute (ANSI):
 - a. A13.1 - Scheme for the Identification of Piping Systems.
 - b. Z53.1 - Safety Color Code for Marking Physical Hazards.

SECTION 09 90 00 – PROTECTIVE COATINGS: continued

2. American Society for Testing and Materials (ASTM):
 - a. D2092 – Guide for Treatment of Zinc-Coated (Galvanized) Steel Surfaces for Painting.
 - b. D4258 - Surface Cleaning Concrete for Coating.
 - c. D4259 - Abrading Concrete.
 - d. D4261 - Surface Cleaning Concrete Unit Masonry for Coating.
 3. Society for Protective Coatings (SSPC) Surface Preparation Specifications:
 - a. SP1 - Solvent Cleaning: Removes oil, grease, soil, drawing and cutting compounds, and other soluble contaminants.
 - b. SP2 - Hand Tool Cleaning: Remove loose material. Not intended to remove adherent mill scale, rust, and paint.
 - c. SP3 - Power Tool Cleaning: Removes loose material. Not intended to remove all scale or rust.
 - d. SP7 - Brush-Off Blast Cleaning: Removes only loose material, remaining surface tight and abraded to give anchor pattern.
 - e. SP10 - Near-White Blast Cleaning: At least 95% of every nine square inches shall be free of all visible residues.
 - f. SP12 – Surface Preparation and Cleaning of Steel and Other Hard Materials by High and Ultrahigh Pressure Water Jetting Prior to Recoating.
 - g. SP13 – Surface Preparation of Concrete.
 4. National Sanitation Foundation (NSF):
 - a. 61 - Drinking Water Treatment Chemicals - Health Effects.
- 1.03 SUBMITTALS:
- A. Submit as specified in the General and Special Conditions.
 - B. Includes, but not limited to, the following:
 1. Schedule of products and paint systems to be used. Schedule shall include the following information:
 - a. Surfaces for system to be applied.
 - b. Surface preparation method and degree of cleanliness.
 - c. Product manufacturer, name, and number.
 - d. Method of application.
 - e. Dry film mil thickness per coat of coating to be applied.
 2. Color charts for selection and acceptance.
 3. Technical and material safety data sheets.
 4. Certification(s) by coating manufacturer(s) that all coatings are suitable for service intended as stated on each coating system sheet. If manufacturer has an equivalent product as that specified, and it is suitable for the intended purpose, Contractor shall submit the recommended product for approval at no increase in cost, and state reasons for substitution.
 5. Contractor shall certify in writing to the Engineer/Architect that applicators have previously applied all the systems in this Specification and have the

SECTION 09 90 00 – PROTECTIVE COATINGS: continued

ability and equipment to prepare the surfaces and apply the coatings correctly.

- C. Submittals for industrial maintenance coatings shall be prepared by, or have assistance in preparation of, a corrosion engineer or industrial coatings technical representative of the coating manufacturer.

1.04 QUALITY CONTROL:

- A. Certification: Coating work shall be performed by an SSPC certified contractor having a minimum of Category QP 1 certification for work without hazardous paint removal, and Category QP 2 certification for work involving hazardous paint removal.
- B. Include on label of container:
 - 1. Manufacturer's name, product name, and number.
 - 2. Type of paint and generic name.
 - 3. Color name and number.
 - 4. Storage and temperature limits.
 - 5. Mixing and application instructions, including requirements for precautions which must be taken.
 - 6. Drying, recoat, or curing time.
- C. Sampling of Materials:
 - 1. All materials to be used will be subject to testing for compliance with Specifications.
 - 2. Contractor shall provide testing at no additional cost to the Owner.
- D. In the event a problem occurs with coating system, surface preparation, or application, Contractor shall require coating applicator and coating manufacturer's technical representative to promptly investigate the problem and submit results to Engineer/Architect.
- E. Specified VOC shall mean unthinned maximum VOC certified by manufacturer. VOC content as a result of thinning shall not exceed that allowed by federal or local environmental regulations.

1.05 DELIVERY, STORAGE, AND HANDLING:

- A. Delivery of Materials:
 - 1. Deliver in sealed containers with labels and information legible and intact. Containers shall also have correct labels with required information.
 - 2. Allow sufficient time for testing if required.
- B. Storage of Materials:
 - 1. Store only acceptable materials on Project Site.
 - 2. Provide separate area and suitable containers for storage of coatings and related coating equipment.
 - 3. Dispose of used or leftover containers, thinners, rags, brushes, and rollers in accordance with applicable regulations.

1.06 REGULATORY REQUIREMENTS:

- A. In addition to requirements specified elsewhere for environmental protection, provide coating materials that conform to the restrictions of the U.S. EPA and the

SECTION 09 90 00 – PROTECTIVE COATINGS: continued

local and regional jurisdictions. Notify Engineer/Architect of any coating specified herein that fails to conform to the requirements for the location of the Project or location of application.

- B. Lead Content: Use only coatings that are totally lead free.
- C. Chromate Content: Do not use coatings containing zinc-chromate or strontium chromate.
- D. Asbestos Content: Materials shall not contain asbestos.
- E. Mercury Content: Materials shall not contain mercury or mercury compounds.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS:

- A. Proprietary names and product numbers are specified in most systems for material identification from these manufacturers:
 - 1. Ameron Protective Coatings Systems Group, Ameron Corp.
 - 2. Carboline Company, Inc.
 - 3. Ceilcote USA, Inc
 - 4. Devoe Coating Company, Division of ICI.
 - 5. ITW Devcon Futura Coatings, Inc.
 - 6. International Protective Coatings.
 - 7. Keeler & Long, Inc., Division of PPG Industries, Inc.
 - 8. Pittsburgh Paints, PPG Industries Inc.
 - 9. Sherwin-Williams.
 - 10. Tnemec Company, Inc.
 - 11. Euclid Chemicals
 - 12. Equivalent coatings (on approval by Engineer) are acceptable from the following alternate companies:
 - a. E.I. DuPont de Nemours & Co., Inc
 - b. Benjamin Moore Company.
 - c. Coronado Paint Company.
 - d. Rust-Oleum.
 - e. Sigma Coatings USA B.V.
 - f. U.S. Coatings, Inc.
 - g. Kwal-Howells, Inc.

2.02 GENERAL:

- A. Materials furnished for each coating system must be compatible to the substrate.
- B. When unprimed surfaces are to be coated, entire coating system shall be by the same coating manufacturer to assure compatibility of coatings.
- C. When shop-painted surfaces are to be coated, ascertain whether finish materials will be compatible with shop coating. Inform Engineer/Architect of any unsuitable substrate or coating conditions.

2.03 COATING SYSTEMS:

- A. Specified on the "Protective Coating System" sheets at the end of this Section.

SECTION 09 90 00 – PROTECTIVE COATINGS: continued

2.04 SURFACES TO BE COATED:

- A. System D-1:
 - 1. Interior and Exterior Surfaces of Submerged Service Valves.
- B. System E-1:
 - 1. Exterior of all steel and iron piping exposed in vaults.
 - 2. Exterior surface of Valves exposed in vaults.
- C. System F-6:
 - 1. Concrete Tank Exterior Coating.

2.05 PAINT COLOR SCHEDULE:

- A. All new interior and exterior exposed piping and exposed piping in vaults and pump station
 - 1. Blue (Potable Water).
- B. All new steel piping supports, except stainless steel
 - 1. Color selection by Owner.
- C. New gates/fence posts
 - 1. Match existing except aluminum, galvanized, or stainless steel.

PART 3 - EXECUTION

3.01 SURFACE PREPARATION:

- A. Prepare surfaces for each coating system conforming to SSPC or ASTM surface preparation specifications listed.
 - 1. If grease or oils are present, SSPC-SP1 shall precede any other method specified for metal substrates.
 - 2. Remove surface irregularities such as weld spatter, burrs, or sharp edges prior to specified surface preparation.
- B. Depth of profile will be as specified or as recommended by the manufacturer for each system, but in no instance shall it exceed one-third of the total dry film thickness of complete system.
- C. Prepare only those areas which will receive the first coat of the system on the same day.
 - 1. On steel substrates, apply coating before rust bloom forms.
- D. Concrete and masonry surfaces shall be adequately cured prior to coating application.
 - 1. Use surface cleaning methods, followed by mechanical or chemical surface preparation as specified in SSPC SP13.
 - a. Acid etching shall only be used where:
 - (1) Procedures are in place for removal of acid residues and the handling, containment, and disposal of hazardous materials.
 - (2) Measures for protection of worker health and safety are provided.

3.02 APPLICATION:

- A. Apply coatings in accordance with coating manufacturer's recommendations.
- B. Use properly designed brushes, rollers, and spray equipment for all applications.
- C. On unprimed surfaces apply first coat of the system the same day as surface preparation.

SECTION 09 90 00 – PROTECTIVE COATINGS: continued

- D. Dry film thickness of each system shall meet the minimum specified. Maximum dry film thickness shall not exceed the minimum more than 20% or coating manufacturer's requirements if less. Where a dry film thickness range is specified, the range shall not be less than or exceeded.
- E. Shop and field painting shall remain 3 inches away from unprepared surface of any substrate such as areas to be welded or bolted.
- F. Environmental Conditions:
 - 1. Atmospheric temperature must be 50°F or higher during application, unless otherwise approved by coating manufacturer. Do not apply coatings when inclement weather or freezing temperature may occur within coating recoat cure times.
 - 2. Wind velocities for exterior applications shall be at a minimum to prevent overspray or fallout and not greater than coating manufacturer's limits.
 - 3. Relative humidity must be less than 85%. The ambient temperature and the temperature of the surface to be painted must be at least 5°F above the dew point.
 - 4. Provide adequate ventilation in all areas of application to ensure that at no time does the content of air exceed the Threshold Limit Value given on the manufacturer's Material Safety Data Sheets for the specific coatings being applied.
- G. Recoat Time: In the event a coating, such as an epoxy, has exceeded its recoat time limit, prepare the applied coating in accordance with manufacturer's recommendations.
- H. Protection:
 - 1. Cover or otherwise protect surfaces not to be painted. Remove protective materials when appropriate.
 - 2. Mask, remove, or otherwise protect finish hardware, machined surfaces, grilles, lighting fixtures, and prefinished units as necessary.
 - 3. Provide cover or shields to prevent surface preparation media and coatings from entering orifices in electrical or mechanical Equipment. Where ventilation systems must be kept in operation at time of surface preparation, take precautions to shield intakes and exhausts to prevent the materials from entering the system or being dispersed.
 - 4. Provide signs to indicate fresh paint areas.
 - 5. Provide daily cleanup of both storage and working areas and removal of all paint refuse, trash, rags, and thinners. Dispose of leftover containers, thinners, rags, brushes, and rollers which cannot be reused in accordance with applicable regulations.
 - 6. Do not remove or paint over Equipment data plates, code stamps on piping, or UL fire-rating labels.

3.03 INSPECTION:

- A. Contractor shall provide and use a wet film gauges to check each application approximately every 15 minutes in order to immediately correct film thickness under or over that specified.

SECTION 09 90 00 – PROTECTIVE COATINGS: continued

- B. Contractor shall provide and use a dry film gauge to check each coat mm thickness when dry, and the total system mm thickness when completed.
- C. Use holiday or pinhole detector on systems over metal substrates to detect and correct voids when indicated on system sheet.
- D. Furnish a sling psychrometer and perform periodic checks on both relative humidity and temperature limits.
- E. Check air temperature and temperature of the substrate at regular intervals to be certain surface is 5°F or more above the dew point.

3.04 CLEANING AND REPAIRS:

- A. Remove spilled, dripped, or splattered paint from surfaces.
- B. Touch up and restore damaged finishes to original condition. This includes surface preparation and application of coatings specified.

SECTION 09 90 00 – PROTECTIVE COATINGS: continued

Burns & McDonnell Engineering Company Engineers – Architects – Consultants Kansas City, Missouri		PROTECTIVE COATING SYSTEM	
		System: D-1	
<u>SERVICE:</u>		Steel & Iron – Potable Water Immersion, Normal Service Interior of Tank or Basin. Exterior of steel, Piping, or Equipment in Tank or Basin.	
Surface Preparation:		Shop or Field First Coat: SSPC-SP10 and profile depth of 1.5 to 2.5 mils. Field Touch-Up: Same as for first coat.	
First Coat:		High solids amine, polyamide, or polyamidoamine epoxy coating with minimum 62% solids by volume and be for use with potable water meeting NSF Standard 61. Apply at 5.0 mils dry film thickness.	
Second Coat:		Same as first coat.	
System Total:		Minimum 10.0 mils dry film thickness. Check for voids with holiday or pinhole detector.	
Volatile Organic Content:		Maximum 2.8 lb/gal.	
COATING MANUFACTURER		PRODUCT DESIGNATION	
	FIRST COAT	TOUCH UP	SECOND COAT
Ameron	Amercoat 370	Same as first coat	Same as first coat
Carboline	Carboguard 891	Same as first coat	Same as first coat
ICI Devoe	Bar-Rust 233H	Same as first coat	Same as first coat
Keeler & Long	Kolor-Poxy Primer No. 3200	Same as first coat	Same as first coat
Pittsburgh Paints	Aquapon 95-132 Series	Same as first coat	Same as first coat
Tnemec	Pota-Pox Plus, Series N140	Same as first coat	Same as first coat
Alternate System			
International	Interline 850	Same as first coat	Same as first coat

SECTION 09 90 00 – PROTECTIVE COATINGS: continued

Burns & McDonnell Engineering Company Engineers – Architects – Consultants Kansas City, Missouri		PROTECTIVE COATING SYSTEM	
		System:	E-1
<u>SERVICE:</u>	Steel & Iron – Nonpotable Liquid Immersion, Normal to Severe Exposure. Interior of Tank or Basin. Exterior of Steel, Piping, or Equipment in Tank or Basin.		
Surface Preparation:	Shop or Field First Coat: SSPC-SP5 and profile depth of 1.5 to 2.5 mils. Field Touch-Up: Same as for First Coat.		
First Coat:	High solids amine or polyamidoamine epoxy coating with minimum 67% solids by volume. Apply at 5.0 mils dry film thickness.		
Second Coat:	Same as first coat.		
System Total:	Minimum 10.0 mils (0.254 mm) dry film thickness. Check for voids with holiday or pinhole detector.		
Volatile Organic Content:	Maximum 2.8 lb/gal (340 g/L).		
COATING MANUFACTURER	PRODUCT DESIGNATION		
	FIRST COAT	TOUCH UP	SECOND COAT
Ameron	Amerlock 2 or 400	Same as first coat	Same as first coat
Carboline	Carboguard 890	Same as first coat	Same as first coat
ICI Devoe	Bar-Rust 235	Same as first coat	Same as first coat
International	Interseal 670 HS	Same as first coat	Same as first coat
Keeler & Long	KL 3500 Kolor-Poxy Self-Prime Enamel	Same as first coat	Same as first coat
Pittsburgh Paints	Pitt-Guard DTR 97-145 Series	Same as first coat	Same as first coat
Sherwin-Williams	Macropoxy 646 B58-600/B58V600	Same as first coat	Same as first coat
Tnemec	Epoxoline II Series N69	Same as first coat	Same as first coat

SECTION 09 90 00 – PROTECTIVE COATINGS: continued

Burns & McDonnell Engineering Company Engineers – Architects – Consultants Kansas City, Missouri	PROTECTIVE COATING SYSTEM	
	System:	F-6
SERVICE: Concrete Tank Exterior Coating High pressure water blast or abrasive blasting to bare concrete. Cement based waterproofing finish Water based, acrylic coating applied in combination with bonding agent Same as second recommended by manufacturer for horizontal and vertical surfaces. Tammscoat shall be applied at a rate of 2 gallons per 80 square feet.		
COATING MANUFACTURER	PRODUCT DESIGNATION	
Euclid Chemicals	FIRST COAT	SECOND COAT
	Tamoseal (with AKKRO-7T or Flex-Con)	Tammscoat

END OF SECTION 09 90 00

SECTION 09 90 05 – STEEL PIPE POLYURETHANE COATING

PART 1 - GENERAL

1.01 SCOPE OF WORK:

- A. The coating system for steel pipe, steel pipe fittings, steel pipe specials, steel pipe accessories, and steel pipe field joints shall be in accordance with AWWA C222.
- B. The Contractor shall furnish all labor, tools, equipment and materials to prepare surfaces, apply, and test a polyurethane pipeline coating system for steel pipe and fittings.
- C. Materials shall comply with the requirements of the Safe Drinking Water Act and other federal regulations for potable water, wastewater, and reclaimed water systems as applicable.

1.02 REFERENCE STANDARDS:

- A. General: The latest revision of the following minimum standards shall apply to the coating materials, testing, and installation except where standards that are more stringent are applicable.
- B. ASTM International (ASTM):
 - 1. ASTM D16 - Standard Terminology for Paint, Related Coatings, Materials, and Applications.
- C. American Water Works Association (AWWA):
 - 1. AWWA C222 - Polyurethane Coatings for Interior and Exterior of Steel Water Pipe and Fittings.
- D. National Association of Corrosion Engineers (NACE):
 - 1. Recommended Practice RP 274 - High Voltage Electrical Inspection of Pipeline Coatings Prior to Installation.
- E. Society for Protective Coatings (SSPC):
 - 1. SSPC-SP-1 - Solvent Cleaning Surface Preparation.
 - 2. SSPC-SP-2 - Hand Tool Cleaning Surface Preparation.
 - 3. SSPC-SP-3 - Power Tool Cleaning Surface Preparation.
 - 4. SSPC-SP-6 - Commercial Abrasive Blast Surface Preparation.
 - 5. SSPC-SP-10 - Near White Metal Abrasive Blast Surface Preparation.

1.03 DEFINITIONS:

- A. Manufacturer: The party that manufactures the coating material described in this Section.
- B. Manufacturer's Representative: Employee of manufacturer who is factory trained and knowledgeable in technical aspects of their products and systems.

1.04 ABBREVIATIONS:

- A. ANSI: American National Standards Institute.
- B. AWWA: American Water Works Association.
- C. MDFT: Minimum Dry Film Thickness.
- D. Mil: Thousandths of an Inch.
- E. OSHA: Occupational Safety and Health Act.

SECTION 09 90 05 – STEEL PIPE POLYURETHANE COATING: continued

F. SSPC: Society for Protective Coatings.

1.05 SUBMITTALS:

A. General

1. Submittals shall be made in accordance with the General and Special Conditions
2. Catalog cuts and other manufacturer's information shall be submitted for all materials provided on a system-by-system basis.
3. Provide copies of polyurethane coating system submittals to the coating applicator.
4. Indiscriminate submittal of manufacturer's literature only is not acceptable.

B. Coating Systems Data Sheets

1. For each coating system, furnish a Material Safety Data Sheet (MSDS), the manufacturer's technical data sheets, and colors available (where applicable) for each product used in coating system.
2. Technical and performance information that demonstrate compliance with Specification.

1.06 QUALITY CONTROL:

- A. Coating Applicator's Experience and Certification: Coating applicator shall be certified by the coating manufacturer as an approved applicator.
- B. The coating manufacturer's technical representative shall provide a qualified technical representative, employed by the coating manufacturer, in the shop or field (as applicable) for 1 day, minimum, at the start of coating application. During this visit, the manufacturer's representative shall conduct inspections as required to ensure that coating application is in conformance with their recommended methods and conditions.
- C. Additional visits by the manufacturer's representative shall be made at sufficient intervals during surface preparation and coating application as may be required for product application quality control, and to determine compliance with manufacturer's instructions, and as may be necessary to resolve problems attributable to, or associated with, manufacturer's products furnished for this Project.

1.07 OBSERVATION OF WORK:

- A. Provisions shall be made to allow the Owner, Engineer, and/or Owner Advisor full access to the Work and appropriate documentation regarding coating application.
- B. Materials shall be subject to observation for suitability, prior to or during incorporation into the Work, including compliance with proper storage of materials and with material expiration dates.

SECTION 09 90 05 – STEEL PIPE POLYURETHANE COATING: continued

1.08 FACTORY AND FIELD INSPECTION AND TESTING:

- A. The Owner, Engineer, and/or Owner Advisor shall reserve the right to perform observation of materials provided and work performed by the manufacturer at the manufacturer's plant. The manufacturer shall give the Owner and Engineer 21-day notice prior to date of start of any shop coating work to allow for travel and scheduling.
- B. The Contractor shall provide the Owner and Engineer a minimum of 21 days advance notice of the start of any shop coating work and a minimum of 7 days advance notice for field work.
- C. Unless the Engineer has granted prior approval, all field coating work shall be performed in the presence of the Owner, Engineer, and/or Owner Advisor.
- D. Inspection Devices: The Contractor shall furnish inspection devices that are calibrated and in good working condition for the detection of holidays and measurement of coating thicknesses.
- E. Inspection: The Contractor shall retain the services of trained technicians to test the coating system in the shop and field, and prepare reports, at no additional cost to the Owner. As a minimum, the tests shall include holiday detection and coating thickness.
- F. Manufacturer Representative: The Contractor shall require the polyurethane manufacturer to furnish a qualified factory technical representative to visit the pipe coating shop for technical support at the beginning of the coating operation and as may be necessary to resolve shop or field problems.
- G. Immediately before the coated pipe is lowered into the trench, the Contractor shall provide a visual and holiday inspection of the coating on the underside of the pipe.
- H. Immediately before placing pipe embedment around the coated pipe, the Contractor shall provide a visual and holiday inspection of the remainder of the coating or as directed by the Engineer, Owner, or Owner's Advisor.

1.09 DELIVERY, STORAGE, AND HANDLING:

- A. Pipe shall be handled in accordance with AWWA C222 and in such a manner as to protect the pipe and coating from damage.
- B. Coated pipe shall not be installed until the coating has developed full adhesion and cure.
- C. During coating application, storage, loading, transportation, unloading, laying and installation, every precaution shall be taken to protect and prevent damage to pipe and coating. Lift pipe using slings placed at quarter points along the pipe. Lift pipe with web slings of a type that will not damage the coating. Metal chains, cable, tongs, forklifts or other equipment likely to damage the coating will not be permitted. Dragging or skidding of pipe on grade or in the trench will not be permitted.
- D. Provide transportation vehicles with padded bolsters between each layer of pipe and heavy padding under load ties. All pipe contact locations shall be heavily padded with carpet during shipment to the Project Site and from the storage yard to the point of installation.
- E. Pipe shall not be stored on rocks, gravel, or other hard materials that might damage the coating. Provide padded 12-inch-wide skids and chucks, sand

SECTION 09 90 05 – STEEL PIPE POLYURETHANE COATING: continued

- bags, select loamy or sand berms, or suspended from cutback ends, where possible, to minimize coating damage. Pipe shall not be laid on asphalt without suitable padding at all contact points.
- F. Pipe shall be inspected by the Contractor at the Project Site for damage. Any damage to the pipe or coating shall be repaired as directed if, in the opinion of the Engineer or Owner, a satisfactory repair can be made; otherwise, the damaged section shall be replaced at the sole expense of the Contractor.
 - G. No metal tools or heavy objects shall be permitted to come into contact unnecessarily with the finished coating. Workmen shall not be permitted to walk on the coating except when absolutely necessary and approved by the Engineer, Owner, or Owner's Advisor. When permitted, shoes with rubber or composition soles and heels or other suitable footwear that will not damage coating shall be used.

PART 2 - PRODUCTS:

2.01 GENERAL:

- A. Coatings shall be stored, handled, and applied per the manufacturer's written directions. Exterior pipe surfaces shall be cleaned and coated in accordance with referenced AWWA Standards, written directions of the coating manufacturer, and these Specifications, whichever is more stringent. Other surfaces to be coated shall be prepared as required for steel pipe, as applicable.
- B. Polyurethane coating shall be the product of a single manufacturer. Substitutions will not be permitted.

2.02 EXTERIOR SHOP APPLIED COATINGS:

- A. Plural Component Polyurethane
 - 1. Polyurethane coating system shall consist of an ASTM D16 Type V thermoset, aromatic polyurethane plastic polymer that is the reaction product of diphenylmethane diisocyanate (MDI) resin and polyol resin or polyamine resin or a mixture of polyol and polyamine resins (referred to hereafter as polyurethane system). The polyurethane system shall meet the performance requirements as specified in AWWA C222.4.2 and shall be applied in accordance with AWWA C222, except as modified herein.
 - 2. Coating: Self-priming, plural component, 100 percent solids, polyurethane, suitable for burial or immersion.
 - 3. Approved manufacturers:
 - a. Carboline Company (Polyclad 777), St. Louis, Missouri;
 - b. Lifelast (Durashield), Pflugerville, Texas;
 - c. Valspar (CorroPipe 3000);
 - d. Chemline (Chemthane 2265);
 - e. Engineer approved equal.
 - 4. Coating Thickness:
 - a. The minimum applied dry film thickness of the exterior polyurethane

SECTION 09 90 05 – STEEL PIPE POLYURETHANE COATING: continued

system shall be 30 mil or the minimum dry film thickness required by the manufacturer to meet the requirements of AWWA C222, whichever is greater. At the crossing of existing cathodically protected facilities, the minimum dry film thickness shall be 60 mil for a minimum distance of 20-feet each side of crossing.

- b. The polyurethane system may be applied to any maximum dry film thickness as recommended by the manufacturer. When applied at the maximum dry film thickness, the coating system shall pass all performance requirements as specified in AWWA C222.4.2.
- c. The dry film thickness of the coating shall be measured in accordance with SSPC-PA 2. The averages listed in SSPC-PA 2 shall be deleted, and no single gauge reading shall be less than the specified minimum thickness.

2.03 FIELD EXTERIOR JOINT COATING:

- A. Pipe joints shall be field coated with heat shrink sleeves after pipe assembly as specified.
- B. Provide heat-shrink sleeves for field joints as follows:
 - 1. Design:
 - a. Meet or exceed the requirements of AWWA C216-15.
 - b. Minimum Total Thickness: 90 mils.
 - 2. Acceptable Manufacturers:
 - a. Heat Shrink Sleeve (Normal application):
 - (1) Canusa Aqua-Shield AQW-HS.
 - (2) Covalence Waterwrap.
 - b. Heat Shrink Sleeve (Weld-after-backfill):
 - (1) Canusa Aqua-Shield AQW-WAB.
 - (2) Covalence Waterwrap-WAB (system).

2.04 FIELD REPAIR OF COATINGS:

- A. General: Field coating shall be compatible with the shop applied coating system or shall be provided by the same manufacturer.
- B. Polyurethane Coating
 - 1. Polyurethane coating system repair shall be in accordance with the coating manufacturer's recommended procedures.
 - 2. Coating material for repairs greater than 6 inches diameter shall be the same as the existing coating, or for repairs less than 6 inches diameter, repair coating as recommended by the polyurethane coating manufacturer, subject to Engineer approval. Repair coating shall have adhesion and performance characteristics equal to the existing coating.
 - 3. Melt Stick or Patch Repair Materials
 - a. Skotchkote, 3M 206P
 - b. Canusa, CRP Patch
 - c. Seal For Life, Melt Stick
 - d. Seal For Life, PERP

SECTION 09 90 05 – STEEL PIPE POLYURETHANE COATING: continued

PART 3 - EXECUTION:

3.01 GENERAL:

- A. Inspect and provide substrate surfaces prepared in accordance with these Specifications and the printed directions and recommendations of coating manufacturer whose product is to be applied.

3.02 ENVIRONMENTAL CONTROLS:

A. General

1. Provide heating, cooling, or dehumidification equipment as required to meet the surface preparation and coating application environmental requirements as specified and recommended by the coating manufacturer.
2. Products shall comply with federal, state, and local requirements limiting the emission of volatile organic compounds and worker exposure.
3. Comply with applicable federal, state, and local, air pollution and environmental control regulations for surface preparation, blast cleaning, disposition of spent aggregate and debris, and coating application.
4. Do not perform abrasive blast cleaning whenever the relative humidity exceeds 85 percent or whenever the steel pipe surface temperature is less than 5 degrees F above the dew point of the ambient air.
5. Do not apply coatings when:
 - a. Surface and ambient temperatures exceeds the maximum or minimum temperatures recommended by the coating manufacturer or these Specifications.
 - b. In dust or smoke laden atmosphere, blowing dust or debris, damp or humid weather, or under conditions that could cause icing on the metal surface.
6. Where weather conditions or Project requirements dictate, provide and operate heaters and/or dehumidification equipment to allow pipe surfaces to be abrasive blasted and coated as specified and in accordance with the manufacturer's coating application recommendations.

B. Temperature Control

1. When temperatures are above or below the coating manufacturer's recommended application temperatures, provide temperature controls to permit Work to proceed within the temperature limitations of the Project.
2. Heating shall be with indirect fired heaters that do not increase humidity levels within the Work area. Heaters shall be sized for the area to be heated.
3. The steel surface may be heated to a temperature within the manufacturer's recommended limits without contaminating the surface preparation in any way.
4. Preheated coating material components, in-line heaters, heated hoses, or other methods may be used to facilitate the application of the coating. Heating shall conform to the recommendations of the coating

SECTION 09 90 05 – STEEL PIPE POLYURETHANE COATING: continued

manufacturer.

5. Provide tenting, baffles, or bulkheads as required to zone and control the heating or cooling effectiveness.

3.03 SHOP APPLIED COATING SYSTEM:

A. General

1. Applicator Qualifications:
 - a. Equipment will be certified by the coating manufacturer to meet the requirements for material mixing, temperature control, application rate, and ratio control for multi part coatings.
 - b. Equipment not meeting the written requirements of the coating manufacturer shall be rejected for coating application until repairs or replacement of the equipment is made to the satisfaction of the Engineer or Owner.
 - c. All personnel applying the coating system shall provide certification of attendance at the coating manufacturer's training class within the last 3 years.
2. Coating manufacturer shall provide to the Engineer or Owner a copy of the manufacturer's coating application quality assurance manual prior to beginning coating application. Strict conformance to the requirements of the manual will be required. Deviation from the requirements of the manual will be grounds for the Engineer or Owner to reject the applied coating. Rejected coating shall be removed to bare metal and reapplied using proper application methods in accordance with the quality assurance manual and the requirements of these Specifications.
3. Coating applied under improper environmental conditions will be rejected and shall be removed to bare metal and reapplied under proper environmental conditions.
4. Pipes and other items that exceed the maximum number of major coating defects shall be stripped of coating, re-blasted, and recoated.
 - a. Defect Size
 - (1) Minor: Repairs that are less than 6 inches in the greatest dimension.
 - (2) Major: Repairs that exceed 6 inches in the greatest dimension
 - b. Maximum Quantity of Defects Allowed:
 - (1) Minor coating or lining repairs on any joint of pipe shall not exceed 1.5 square feet and/or two (2) locations per 100 square feet of surface area.
 - (a) Two or more minor repairs within a 6-inch diameter area will be considered a single repair.
 - (b) Repairs for adhesion testing will not be included in the total number of repairs.
 - (2) Major repairs shall not exceed two per pipe joint and the combined area shall not be greater than 20% of the pipe.

B. Weld Surface Preparation

SECTION 09 90 05 – STEEL PIPE POLYURETHANE COATING: continued

1. Welds shall be ground to a tolerance of plus 1/32 inch to plus 1/16 inch above the pipe surface to be coated or as recommended in writing by the coating manufacturer.
- C. Surface Preparation:
1. Visible oil, grease, dirt, and contamination shall be removed in accordance with SSPC-SP1, solvent cleaning.
 2. Surface imperfections such as metal slivers, burrs, weld splatter, gouges, or delamination's in the metal shall be removed by filing or grinding prior to abrasive surface preparation.
 3. In cold weather or when moisture collects on the pipe and the temperature of the pipe is less than 45 degrees F, preheat pipe to a temperature above 50 degrees F and 5 degrees F above dew point.
 4. Pipe shall be cleaned by abrasive blasting with a mixture of steel grit and shot to produce the surface preparation cleanliness as specified. Recycled abrasive shall be cleaned of debris and spent abrasive.
 5. Protect prepared pipe from humidity, moisture, and rain. Keep pipe clean, dry, and free of flash rust. All flash rust, imperfections, or contamination on cleaned pipe surface shall be removed by reblasting prior to primer application.
 6. Coating of pipe shall be completed the same day as surface preparation.
 7. Surface Preparation: SSPC-SP10, Near White Metal blast, 3.0 mil profile, minimum, or as required by the manufacturer, whichever is greater.
- D. Polyurethane Coating Application:
1. Pipe temperature shall be between 75- and 100-degrees F and 5 degrees F above dew point during coating application or as recommended in writing by the coating manufacturer. Coating application shall be performed in an environmentally controlled area that meets or exceeds the written environmental application requirements of the coating manufacturer.
 2. Thickness: One coat, 30 mils total dry film thickness, minimum. Additional thickness may be required to pass the holiday and coating defects limitations as specified in this section.
 3. Coating adhesion tests and holiday testing shall be performed as specified in this section.
 4. Complete coating repairs as specified in this section.
- E. Holdbacks and Cutbacks:
1. 6 inches, minimum.
 2. Coating cutbacks or holdbacks shall be made straight and cut through the full thickness of the coating. Cutbacks shall be completed in a manner that permits field coating of joints in accordance with the manufacturer's recommendations and as specified herein.
- F. Coating Special Pipe Connections and Appurtenances:
1. Prior to shipping, threaded connections and appurtenances that must be assembled and operated in the field shall be left uncoated and shipped with rust-preventing compounds or strippable protective coatings applied

SECTION 09 90 05 – STEEL PIPE POLYURETHANE COATING: continued

to the threads only. After final field assembly, the compound shall be completely removed. The exposed threads shall be coated per AWWA C222.4.7. Flange faces and other mating surfaces of other mechanical connections shall be coated as specified by the supplier.

3.04 FIELD COATING OF JOINTS:

- A. Coat joints with heat shrinkable sleeves as specified in this section.

3.05 FIELD REPAIR OF COATING:

A. General

1. All areas where holidays are detected or coating is visually damaged, such as blisters, tears, rips, bubbles, wrinkles, cuts, or other defects shall be repaired in accordance with the Coating Manufacturer's recommendations. Areas where no holidays are detected but are visually damaged shall also be repaired in accordance with the Coating Manufacturer's recommendations.
2. Clean area to be repaired for a minimum distance of 6 inches in all directions from the damaged area by solvent wiping.

B. Polyurethane Coating Repairs

1. Shop and field coating repairs shall be completed in accordance with the manufacturer's written instructions and these Specifications, whichever is stricter.
2. Minor repairs less than 6-inches in the greatest dimension shall be repaired with Manufacturer-approved material.
 - a. Clean and feather the defect into the existing coating. Feather edges for a minimum of 2-inches around the defect. Apply repair material to the thickness recommended by the manufacturer.
3. Coating repairs on any joint of pipe shall not exceed two (2) minor defects per 100 square feet of surface area per joint of pipe or an individual defect that exceeds 6 inches in the greatest dimension. Holidays within a 4-inch radius of a holiday shall be counted as a single holiday.
4. Pipes exceeding the maximum number or size of coating defects shall be blasted to bare metal and recoated.
5. Pipe arriving in the field with defects or repairs exceeding the maximum number or size of coating defects will be returned to the shop for recoating at the Contractor's expense.
6. Surface defects that do not expose the metal substrate shall be repaired by power tool sanding with coarse sandpaper to roughen the coating surface and feathering the edges of the defect for a minimum of 3 inches around the defect. Apply a single coat of the specified patch coating material to a properly prepared surface at the specified coating thickness.
7. Deep defects, defined as defects which penetrate to the metal substrate or expose the metal substrate, shall be prepared to the metal substrate by power tool sanding to expose the metal and feather the coating edges a minimum of 6 inches. The metal surface and surrounding coating shall be reblasted to equal cleanliness and profile as the original surface

SECTION 09 90 05 – STEEL PIPE POLYURETHANE COATING: continued

preparation. Existing coating shall be roughened to the equivalent of coarse sandpaper by abrasive blasting. One coat of the specified coating material shall be applied over the repaired surface at the specified thickness.

3.06 INSPECTION AND TESTING:

A. General

1. Applicator shall conduct quality control inspection and testing of the applied coatings in accordance with AWWA C222 specifications and these Specifications. The frequency of testing and inspections shall be determined by the applicator.
2. Manufacturer and applicator shall conduct quality control inspection and testing as defined herein and as required by AWWA C222 for final acceptance of the pipeline coating. Manufacturer's certified test reports and applicator quality control testing will be the basis for product acceptance. The Engineer or Owner reserves the right to perform additional quality control testing in the determination of product acceptance. Coating repairs for quality control testing shall be repaired by the applicator as specified herein.

B. Adhesion Testing

1. General:
 - a. Adhesion testing shall be conducted on two (2) sufficiently cured, coated sections of pipe from each shift selected at random with one from the beginning of each shift and one from halfway through the shift. If the adhesion is not satisfactory, two additional tests shall be made at two different locations on the same pipe segment. If either additional test fails, the pipe shall be rejected, cleaned to bare metal in its entirety, and re-coated. If a pipe segment is rejected, a systematic inspection of all pipe made on that shift shall be performed, and all pipe not meeting this adhesion requirement shall be rejected, cleaned to bare metal in their entirety, and re-coated.
 - b. The pipe coating applicator shall repair all coating damage from adhesion testing.
 - c. Adhesion tests will be performed not less than 24 hours after coating application.
 - d. Pipe segments will be randomly selected for adhesion testing. As noted above, if any one of the pipe segments tested fails the adhesion test, each pipe segment coated on that shift will then be individually tested for adhesion and rejected on a segment-by-segment basis.
2. Polyurethane Adhesion Testing:
 - a. Polyurethane coatings shall have an adhesion to steel of 1,500 pounds per square inch, minimum.
 - b. Polyurethane coating adhesion to steel substrates shall be tested using pneumatic pull off equipment, such as HATE equipment or equal, in accordance with ASTM D4541 and AWWA C222, except as modified in this section.

SECTION 09 90 05 – STEEL PIPE POLYURETHANE COATING: continued

- c. Dollies for adhesion testing shall be glued to the coating surface and permitted to cure for a minimum of 12 hours. Coating shall be scored around the dolly prior to conducting the adhesion test. Flat dollies in the size range of 10mm to 14mm shall be utilized for adhesion testing on any pipe less than 30 inches in diameter.
 - d. Failure shall be by adhesive failure only. Adhesive failure is defined as separation of the coating from the steel substrate. Glue failures in excess of the minimum required tensile adhesion would be accepted as meeting the specified adhesion requirements.
 - e. Repair patches on the polyurethane coating shall be randomly selected for adhesion testing in a manner as described herein and at the discretion of the person conducting the adhesion tests. Inter coat adhesion of repairs shall be not less than 50 percent of the specified polyurethane coating adhesion requirements to steel.
- 3. Holiday Testing:
 - a. Polyurethane Coatings:
 - (1) Holiday tests will be conducted on the completed coating after a minimum of 1-hour cure or any time after the polyurethane has reached a “cure to handle” state as recommended by the polyurethane manufacturer using a high voltage spark test in accordance with NACE Standard RP 274 and these Specifications.
 - (2) Holiday testing shall be performed at the greater of the manufacturer’s recommendation or 100 V/mil of the minimum specified (not the average) coating thickness.
 - (3) Coating thickness will be determined by dry film thickness testing and the average coating thickness used for holiday testing.
- 4. Dry Film Thickness Testing: Coatings shall be tested for dry film thickness in accordance with SSPC PA 2 using a properly calibrated magnetic pull off or eddy current equipment.

END OF SECTION 09 90 05

DIVISION 13 – SPECIAL CONSTRUCTION

SECTION 13 21 18 – GROUND-LEVEL AWWA D115 POST-TENSIONED CONCRETE WATER STORAGE TANKS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Special Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY:

- A. This specification section includes requirements related to the tank contractor's responsibilities for design and construction of an AWWA D115 type internal tendon prestressed concrete tank
- B. The work performed under these specifications includes furnishing all engineering design, supervision, labor, materials, equipment, tools, inspection and testing necessary for the construction.
- C. The tank shall have a bi-axially prestressed concrete floor and roof each cast in single placements, and a cast-in-place bi-axially prestressed wall cast in full-height sections.
- D. Furnish all labor, materials, equipment, and incidentals required to complete the work to the limits shown on the drawings and as specified herein.
- E. Furnish and install appurtenances including inlet and outlet piping, overflow piping, wash down piping, piping supports, roof vents, access ladders, railings, hatches, and all other internal and external features required for full operation.

1.03 RELATED REQUIREMENTS

- A. Related project specification sections include but are not necessarily limited to:
 - 1. DIVISION 03: Concrete and Reinforcing.
 - 2. DIVISION 05: Metal guardrails, supports, and miscellaneous framing.
 - 3. DIVISION 06: FRP Assemblies and Framing.
 - 4. DIVISION 08: Access Doors and Frames.
 - 5. DIVISION 09: Protective Coatings.
 - 6. DIVISION 13: Disinfection and Testing.
 - 7. DIVISION 31: Site preparation, excavation, fill, backfill, grading.

1.04 REFERENCE STANDARDS:

- A. The materials, design, fabrication, erection and inspection of the tank and foundation, shall conform to the latest editions of the following Standards, Codes, and Guides:
 - 1. American Concrete Institute (ACI):
 - a. 117 – Standard Tolerances for Concrete Construction and Materials
 - b. 228.1R – In-Place Methods to Estimate Concrete Strength
 - c. 301 - Specification for Structural Concrete.
 - d. 305 – Hot Weather Concreting.
 - e. 306 – Cold Weather Concreting.
 - f. 309R – Guide for Consolidation of Concrete.

SECTION 13 21 18 – GROUND-LEVEL AWWA D115 POST TENSIONED CONCRETE
WATER STORAGE TANKS: continued

- g. 318 - Building Code Requirements for Structural Concrete and Commentary.
- h. 350 – Code Requirements for Environmental Engineering Concrete Structures and Commentary.
- i. 350.1 - Tightness Testing of Environmental Concrete Structures
- j. 350.3 - Seismic Design of Liquid Containing Concrete Structures and Commentary.
- k. 506.2 – Specification for Shotcrete
- l. 506R – Guide to Shotcrete.
- 2. American Society for Testing and Materials (ASTM)
 - a. A185 - Specification for Steel Welded Wire, Fabric, Plain for Concrete.
 - b. A416 - Standard Specification for Steel Strand, Uncoated Seven- Wire for Prestressed Concrete.
 - c. A475 - Standard Specification for Zinc-Coated Steel Wire Strand.
 - d. A615 or A615M - Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement.
 - e. A821 - Specification for Steel Wire, Hard Drawn for Prestressing Concrete Tanks.
 - f. A1008/A1008M - Specification for Steel, Sheet, Cold-Rolled, Carbon, Structural, High-Strength Low-Alloy and High-Strength Low-Alloy with Improved Formability.
 - g. C31 - Standard Practice for Making and Curing Concrete Test Specimens in the Field.
 - h. C33 - Standard Specification for Concrete Aggregates.
 - i. C39 - Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens.
 - j. A123/A123M - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
 - k. A421/A421M - Standard Specification for Uncoated Stress-Relieved Steel Wire for Prestressed Concrete
 - l. A615/A615M - Standard Specification for Deformed and Plain Carbon Steel Bars for Concrete Reinforcement.
 - m. A653/A653M - Standard Specification for Steel Sheet, Zinc-coated (Galvanized) or Zinc-iron Alloy-coated (Galvanealed) by Hot Dip Process
 - n. A706/A706M - Standard Specification for Low-alloy Steel Deformed and Plain Bars for Concrete Reinforcement.
 - o. C231 - Test Method for Air Content of Freshly Mixed Concrete by Pressure Method
 - p. D698 - Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 Ft. – lbf/ft³) (600 KN-M/M³)
 - q. C618 – Type F Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete.
 - r. C920 – Specification for Elastomeric Joint Sealants.
 - s. D1056 – Standard Specification for Flexible Cellular Materials – Sponge or Expanded Rubber.

SECTION 13 21 18 – GROUND-LEVEL AWWA D115 POST TENSIONED CONCRETE WATER STORAGE TANKS: continued

- t. D1556 - Standard Test Method for Density and Unit Weight of Soil in Place by the Sand-Cone Method.
 - u. D1557 – Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 Ft. – lbf/ft³) (2700 KN-M/M³).
 - v. D2000 - Classification System for Rubber Products in Automotive Applications.
- 3. American Society of Civil Engineers (ASCE)
 - a. ASCE7 – Minimum Design Loads for Buildings and Other Structures
- 4. American Society of Mechanical Engineers (ASME)
 - a. B31.1- Code for Pressure Piping - Power Piping.
- 5. American Water Works Association (AWWA):
 - a. C219 – Bolted, Sleeve-type Couplings for Plain-End Pipe
 - b. C652 – Disinfection of Water Storage Facilities
 - c. D115 – Tendon Prestressed Concrete Water Tanks
- 6. International Code Council (ICC):
 - a. International Building Code 2021 Edition with local amendments.
- 7. National Fire Protection Association (NFPA)
 - a. NFPA 22 – Standard for Water Tanks for Private Fire Protection.
- 8. Post-Tensioning Institute (PTI):
 - a. Post-Tensioning Manual.
 - b. Manual for Certification of Plants Producing Unbonded Single Strand Tendons.
 - c. Post-Tensioned Commercial and Industrial Floors.
 - d. Design of Post-Tensioned Slabs Using Unbonded Tendons.
 - e. Field Procedures Manual for Unbonded Single Strand Tendons.
 - f. Specification for Unbonded Single Strand Tendons.
 - g. Specification for Grouting of Post-Tensioned Structures.
 - h. Guide Specification for Grouted Post-Tensioning.
 - i. Manual for Certification of Plants Producing Unbonded Single Strand Tendons.

1.05 QUALITY CONTROL

- A. Tank Contractor Qualifications:
 - 1. Shall have the skill, reliability, and financial resources and stability to construct and warranty the tank in accordance with the contract documents. The tank contractor shall be responsible for the design, construction, and warranty of the internal tendon prestressed concrete tank.
 - 2. Shall provide a full-time, on-site superintendent that has been responsible for the construction of at least two concrete tanks in the last five (5) years that are giving satisfactory service. Qualifications for the superintendent shall be submitted to the owner for approval; the owner reserves the right to have the individual replaced if experience requirements are inadequate.
- B. Tank Design Engineering Firm:
 - 1. Shall have ten (10) years minimum experience in design and field construction of internal tendon prestressed concrete tanks and shall have

SECTION 13 21 18 – GROUND-LEVEL AWWA D115 POST TENSIONED CONCRETE WATER STORAGE TANKS: continued

- been responsible for the design of at least five internal tendon prestressed concrete tanks in the last five (5) years.
- 2. Shall be in responsible charge of engineering work to be done for the tank design, construction, and testing.
- 3. Shall provide sealed calculations and drawings by licensed professional engineer in the project state.
- C. Post-Tensioning Subcontractor:
 - 1. Post-tensioning systems shall be produced by a Post-Tensioning Institute (PTI) Certified Plant owned and operated by the post-tensioning subcontractor.
 - 2. The subcontractor that supplies the post-tensioning system shall provide a superintendent and be responsible for placement of both the post-tensioning and mild reinforcing steel.
 - 3. The superintendent shall be a full-time employee of the post-tensioning supplier/installer and be on the project full-time during all placing, stressing and grouting operations, and shall have superintended the construction of at least three prestressed concrete tendon tanks in the last five years. The superintendent shall be a holder of a current Certified Grouting Technician certificate from the American Segmental Bridge Institute or be PTI level 2 certified in Multistrand/Grouted Prestressing. The superintendent's qualifications shall be submitted to the owner for approval; the owner reserves the right to have the individual replaced if experience requirements are inadequate.
 - 4. The post-tensioning subcontractor shall employ a full-time professional engineer with a minimum of ten (10) years' experience in the construction of internal tendon prestressed concrete tanks available to assist in technical issues as required for the success of the project. The engineers' qualifications shall be submitted to the owner for approval; the owner reserves the right to have the individual replaced if experience requirements are inadequate.
- D. It is the express intent of this specification to create a singular responsibility for the design and construction of the AWWA D115 tank. The design construction of all aspects of the foundation, floor slab, wall, post-tensioning, roof and appurtenances of the tank shall be performed by the general contractor and the post-tensioning manufacturer.
- E. Welding: Qualify procedures and personnel according to the following:
 - 1. AWS D1.1/D1.1M, "Structural Welding Code - Steel."
 - 2. AWS D1.4, "Structural Welding Code - Reinforcing Steel."
- F. Pipe Welding: Qualify procedures and personnel according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."
- G. 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.
- H. Comply with NFPA 22, "Water Tanks for Private Fire Protection," for surface water-storage tanks for fire-suppression water supply.

SECTION 13 21 18 – GROUND-LEVEL AWWA D115 POST TENSIONED CONCRETE
WATER STORAGE TANKS: continued

1.06 SUBMITTALS

- A. Submit as specified in the General and Special Conditions.
- B. Submit the following with the bid.
 - 1. The following information shall be included in the tank contractor's bid submittal. Failure to meet the requirements of Section 1.05 shall result in the bid being considered non-responsive and cause for rejection.
 - a. Resumé of the proposed on-site superintendent responsible for the construction with list of qualifying projects.
 - b. Resumé of the proposed engineer in responsible charge of the project with list of qualifying projects.
 - c. Resumé of the proposed post-tensioning subcontractor's superintendent with list of qualifying projects.
 - d. Resumé of the proposed post-tensioning subcontractor's professional engineer in responsible charge.
- C. Construction submittals shall include, but are not limited to the followings:
 - 1. Structural design calculations and detailed construction drawings, seals by the professional engineer in responsible charge.
 - 2. Technical data including product manufacturer's information, specifications, and installation instructions.
 - 3. Shop drawings for mild steel reinforcement, formwork, post-tensioning systems, piping, appurtenances, etc.
 - 4. Design calculations with clear indications of loads used in design. Calculations shall be sealed by a professional engineer licensed in the State of Colorado.
 - 5. Reinforcing shop drawings showing fabrication and placement and including mill certificates for mild reinforcing, prestressing steel, and any other steel components.
 - 6. Concrete design mixes, including all admixtures, and placement procedures.
 - 7. Weld certificates.
 - 8. Bacteriological test results.
 - 9. Operation and maintenance manuals.
 - 10. Tank surface finishes and coating materials.
 - 11. Field quality control and test results.
 - 12. Warranty documents.
 - 13. Safety program.
- D. Approval by the Engineer of the drawings and calculations submitted by the Contractor will not in any way relieve the Contractor of full responsibility for the accuracy and completeness of the drawings and calculations.
- E. Operation and Maintenance Data: For the following to include in emergency, operation, and maintenance manuals:
 - 1. Obstruction lighting.
 - 2. Lightning protection.
 - 3. Cathodic protection.
 - 4. Tank heaters.
- F. Submit as-constructed drawings at completion in accordance with Division 1 and as follows:

SECTION 13 21 18 – GROUND-LEVEL AWWA D115 POST TENSIONED CONCRETE WATER STORAGE TANKS: continued

1. Submit one (1) 22"x34" computer source copy of as-constructed drawings in PDF format.
- 1.07 PREINSTALLATION MEETINGS:
- A. Preinstallation Conference: Contractor to conduct conference at Project Site or remotely at Contractor's option. Contractor shall prepare agenda and provide to project team a minimum of 24 hours in advance of scheduled meeting.
- 1.08 PERFORMANCE REQUIREMENTS:
- A. The prestressed, post-tensioned concrete tank shall be designed and constructed in accordance with the provisions of AWWA D115, Tendon Prestressed Concrete Water Tanks, and ACI 350.
 - B. Tendons shall be continuous. Discontinuous tendons or strands will not be allowed.
 - C. Required dimensions and capacities:
 1. Tank Capacity:
 - a. Treated Water Storage Tank: 5.0 million gallons (active storage).
 2. Tank Dimensions: As indicated on Drawings.
 3. Vent Capacity Requirements:
 - (1) Maximum Fill Rate: 1430 gpm.
 - (2) Maximum Draw Down Rate: 3400 gpm.
 4. Overflow Design Capacity: Designed to accommodate maximum fill rate as indicated.
 - D. Structural Performance: Surface water-storage tank, including structural reinforcement and foundation, shall be capable of withstanding the effects of the following loads:
 1. Dead Loads: Estimated of all permanent imposed loads.
 2. Live Loads: Weight of all the liquid when the reservoir is filled to overflowing. Unit weight of liquid 62.4 pounds per cubic foot.
 3. Roof Live Loads: 100 psf plus the weight of soil on roof.
 4. Roof Snow Loads: 46 psf.
 5. Wind Loads: As required by ASCE 7
 - a. Ultimate Design Wind Speed: 113 mph.
 6. Backfill Soil Pressure: 70 pcf.
 7. Geotechnical Requirements: As indicated on Drawings.
 - a. A geotechnical investigation has been carried out at the site. Pertinent geotechnical information has been included on the drawings. The report will be provided "for reference only" and is not considered or made part of the contract documents. The allowable capacity of deep foundation elements has been defined in this report. The Contractor shall be responsible for securing any further geotechnical information required beyond the provided in this report.
 8. Seismic Performance: Surface water-storage tank, including structural reinforcement and foundation, shall be capable of withstanding the effects of earthquake motions determined according to authorities having jurisdiction.
 - a. Risk Category: III

SECTION 13 21 18 – GROUND-LEVEL AWWA D115 POST TENSIONED CONCRETE
WATER STORAGE TANKS: continued

- b. Mapped Spectral Accelerations for Short Periods, S_s : 0.193
- c. Mapped Spectral Accelerations for 1-Second Period; S_1 : 0.056
- d. Site Class: C
- e. Long-period Transition Period, T_L : 4 sec.
- f. Sloshing Height: The sloshing height shall be calculated using AWWA D115, but need not exceed the fluid displacement calculation when determined using ACI 350.3, TID 7024 or ASCE 7. The effects of the “sloshing wave” shall be accounted for by increasing the freeboard between the normal operating surface and the underside of the roof, or a roof capable of resisting the uplift of such a wave designed. A minimum freeboard height of 11 inches above the design liquid level shall be utilized. Any confined portion of the convective (sloshing) mass shall be calculated and applied as an additional impulsive mass.
- g. Dynamic Effects of Backfill: Seismic design shall consider the additive effects of the dynamic backfill loading.
- 9. Construction Loads: In addition to the design loads listed above, the following load cases shall be considered for the Treated Water Storage Tank:
 - (1) Case 1: Fully buried, empty tank
 - (2) Case 2: Leak test, No backfill, full tank
- E. Thermal Movements: Surface water-storage tank, including structural reinforcement and foundation, shall allow for thermal movements resulting from the following maximum change (range) in ambient and surface temperatures by preventing buckling, opening of joints, overstressing of components, failure of connections, and other detrimental effects. Base engineering calculations on surface temperatures of materials due to both solar heat gain and nighttime-sky heat loss.
 - 1. Temperature Change (Range): 120°F (67°C), ambient; 180°F (100°C), material surfaces.
- F. The Tank Contractor shall design the concrete wall and joints in combination with vertical mild steel reinforcement based on the following design criteria and requirements:
 - 1. The prestressed tank wall shall be considered as a cylindrical shell with partial edge restraint.
 - 2. The prestressed tank wall shall be reinforced vertically by deformed steel reinforcing bars as required.
 - 3. No reduction in ring compression or tension in the wall will be taken due to restraint at the bottom.
 - 4. The long-term prestressing losses caused by shrinkage, creep, and relaxation in the prestressed reinforcement of the tank walls shall not be assumed less than 25,000 psi.
 - 5. Lateral soil pressures shall not be considered in resisting seismically generated shear forces between the wall footing and the wall.
- G. Floor Slab
 - 1. The floor slab shall be designed per the guidelines of ACI 350 for floor slabs. Construction joints will only be allowed as shown on the shop drawings and as

SECTION 13 21 18 – GROUND-LEVEL AWWA D115 POST TENSIONED CONCRETE
WATER STORAGE TANKS: continued

- approved by the Engineer. Construction joints shall incorporate a horizontal 6-inch PVC waterstop.
 - 2. If required, the floor shall have thickened regions to facilitate transitions from under slab concrete pipe encasements into the floor, appurtenance loadings and temporary bracing requirements. Minimum slab thickness is 12 inches.
 - 3. Minimum cross sectional area ratio of floor reinforcement to concrete shall be in accordance with ACI 350.
 - 4. Polypropylene or cellulose fibers may be used at the Tank Contractor's discretion.
 - H. Roof Slab:
 - 1. The roof shall be connected to the tank wall and supported by interior columns as required.
 - 2. The roof shall be of post-tensioned construction with a minimum thickness of 12".
 - 3. Minimum cross sectional area ratio of roof reinforcement to concrete shall be in accordance with ACI 350.
 - 4. Polypropylene or cellulose fibers may be used at the Tank Contractor's discretion.
- 1.09 WARRANTY:
- A. The tank contractor shall warranty the tank structure against any defective materials or workmanship for a period of two years from the date of tank acceptance. If any materials or workmanship, including piping and appurtenances, prove to be defective within the two-year period, they shall be repaired or replaced by the tank contractor at no additional cost to the owner.

PART 2 - PRODUCTS

- 2.01 MATERIALS:
- A. General Requirements:
 - 1. All materials shall comply with AWWA D115, ACI, and PTI.
 - B. Concrete
 - 1. Concrete shall conform to ACI 301.
 - 2. Cement shall be Portland cement conforming to ASTM C150 Type II or ASTM C595 any type with MS designation.
 - 3. Admixtures, other than air-entraining, superplasticizers, shrinkage reducing and water reducing admixtures will not be permitted unless approved by the Engineer.
 - 4. Concrete for tank wall, and roof construction shall have a minimum compressive strength of 4,500 psi at twenty-eight days and be air-entrained.
 - 5. Concrete for the tank floor, footings, pipe encasement, and all other work shall have a minimum compressive strength of 4,500 psi at twenty-eight days, shall not be air-entrained, unless exposed to freeze thaw conditions.
 - 6. Concrete indicated to be air-entrained with an air content of 5% +/- 1.5% per ASTM C173.

SECTION 13 21 18 – GROUND-LEVEL AWWA D115 POST TENSIONED CONCRETE
WATER STORAGE TANKS: continued

7. The coarse and fine aggregate shall meet the requirements of ASTM C33 with a maximum coarse aggregate size of 1".
8. If fibers are used, they shall be virgin poly-propylene or cellulose fibers, Microfiber by Grace, Fibermesh 150 by Propex, UltraFiber 500 by Buckeye, or equal. Fiber lengths shall be a maximum of ¾ inches. The amount of fibers added to the concrete mix shall conform to the Manufacturer's recommendations.
9. Proportioning for concrete shall be in accordance with ACI 301.
 - a. The allowable w/(c+p) range shall be .36-.42.
 - b. Concrete slump at maximum w/(c+p) shall be 5" -7" maximum per ASTM C143.
 - c. The water shall be potable, clean, and free from injurious amounts of oils, acids, alkalis, salts, organic materials, or other substances that may be deleterious to concrete, reinforcing steel, or other embedded items.
10. All concrete shall have a maximum water soluble chloride ion concentration of 0.08% by weight of cementitious material.
11. All concrete mix designs shall be submitted to the engineer for approval. Alternate mixes cold weather conditions, or self-consolidating concrete shall be considered.
12. Dry shrinkage shall not exceed 0.040 percent when tested in accordance to ASTM C157 for concrete used in liquid and chemical retaining structures.
- C. Reinforcing Steel:
 1. Mild reinforcing steel shall be new billet steel conforming to ASTM A615, Grade 60.
 2. Reinforcing steel shall be accurately positioned on supports, spacers, hangers, or other reinforcing and shall be secured in place with wire ties or suitable clips. Rebar chair supports may be either steel with plastic tips, turned up legs, or plastic.
 3. Continuous reinforcing is required through floor and roof cast-in-place construction joints.
- D. Post-Tensioning Systems:
 1. All post-tensioning components and systems shall be furnished by a PTI certified plant.
 2. Strand shall be low relaxation, seven wire strand, having a guaranteed minimum ultimate tensile strength of 270,000 psi, per ASTM Designation A416, low relaxation.
 3. Bonded Tendons:
 - a. Anchorages must develop at least 95 percent of the guaranteed ultimate tensile strength (GUTS) of the prestressing steel, tested in an unbonded state, without exceeding anticipated wedge seating. Anchorages shall include details that completely encapsulate the post-tensioning steel with mechanical connections; friction-type connections will not be allowed. Anchorages shall be VSL type ECI, type VSLAB, and type SO, or approved equals.

SECTION 13 21 18 – GROUND-LEVEL AWWA D115 POST TENSIONED CONCRETE
WATER STORAGE TANKS: continued

- b. Duct for bonded tendons shall be manufactured from polypropylene materials that completely encapsulate the post-tensioning steel and include mechanical type couplers. Duct shall be VSL type PT-Plus or approved equal.
 - c. Grout for injection grouting of bonded tendons shall be Prepackaged Class C per PTI Specifications.
- E. Strand for Seismic Cables:
 - 1. ASTM A416, grade 270 low-relaxation before galvanizing. Galvanize in accordance with ASTM A 475. Only hot-dipped galvanizing shall be permitted; cold galvanizing shall not be permitted.
- F. Elastomeric Materials:
 - 1. Bearing pads shall be furnished with the dimensions, material properties, and elastomer grade as required by the drawings per ASTM D2240 or D2000, Type A Shore, 30 to 60 Durometer. Prepare concrete surfaces and adhere pads to concrete per manufacturer's recommendations.
 - 2. Neoprene Sponge filler conforming to ASTM D1056, Type 2, Class A, and Grade 1 or 3.. Compression deflection limited to 25% at 2 to 5 psi. Prepare concrete surfaces and adhere sheet to concrete per manufacturer's recommendations.
- G. Water stops:
 - 1. PVC, hydrophilic rubber, and chemical grout waterstops shall be furnished and installed with the dimensions, material, and type as required by the drawings and per the manufacturer's recommendations.
 - 2. PVC waterstops shall be 9-inch minimum meeting the requirements of Corps of Engineers Specification CRD-C572. Splices shall be made in accordance with the Manufacturer's recommendations subject to the approval of the Engineer. Waterstop shall be manufactured by Greenstreak Plastic Products Company, Inc., or equal.
- H. Appurtenances:
 - 1. The Tank Contractor shall provide and install all appurtenances as shown on the drawings. Appurtenances shall include the following:
 - a. Inlet-Outlet Piping with mixing system.
 - b. Overflow Piping and Weir.
 - c. Roof Hatches:
 - (1) Two 5-foot square Bilco Type F aluminum hatch with lockable, hinged cover and curb frame. The hatch shall have a lift handle, padlock tab, padlock and a cover hold open mechanism. All hardware shall be 316 stainless steel. Locate hatches as shown on drawings.
 - (2) Two 8-foot by 9-foot Bilco Type D aluminum hatches with lockable, hinged cover and curb frame. Latch operation shall be interior to the hatch requiring special tools to open similar to the Hilltop Tank. Contractor shall coordinate with owner and hatch manufacturer. The hatch shall have a lift handle, padlock tab, and a cover to hold open the mechanism. All hardware shall be 316 stainless steel. Locate hatches as shown on drawings.

SECTION 13 21 18 – GROUND-LEVEL AWWA D115 POST TENSIONED CONCRETE
WATER STORAGE TANKS: continued

- (3) Two 3-foot by 6-foot Bilco Type J-AL hatches inside Type D hatch roof curbs. All hardware shall be 316 stainless steel.
- d. Roof Vent: Two 316 stainless steel gooseneck vents with insect screen. Tank manufacturer to determine size of vents. Locate as shown on the drawings.
- e. Interior Ladders: The ladders shall extend from the tank floor to the hatch. The ladder shall be 316 stainless steel and have an OSHA-approved Stainless Steel fall prevention device consisting of a sliding, locking mechanism and safety belt. Location as shown on the drawings.
- f. Floor Sump with Drain Pipe: Location and size of sump as shown on the drawings.

PART 3 – EXECUTION

3.01 EXCAVATION AND BACKFILL:

- A. Refer to DIVISION 31 – Earthwork.

3.02 FLOOR:

- A. All aspects of tank construction shall comply with AWWA D115 and ACI 350.
- B. Prior to placement of the floor reinforcing, a polyethylene moisture barrier shall be placed over the void form or over the subgrade. Joints in the polyethylene shall be overlapped a minimum of 6 inches and be taped.
- C. Prior to placement of the floor concrete, all piping that penetrates the floor, shall be set and encased in concrete.
- D. The vertical waterstop shall be placed and secured in position so that the bottom of the center bulb is at the elevation of the top of the footing. The waterstop shall be secured without puncturing any portion of the waterstop unless it is manufactured with holes for tying. The waterstop shall be spliced using a thermostatically controlled sealing iron and each splice shall be successfully spark tested prior to encasement in concrete.
- E. The floor may be poured monolithically or divided into roughly equal segments with appropriate water stop detail at each joint.
- F. The floor shall be cured by flooding with water and shall remain saturated for a minimum of 7 days.
- G. For crack control in the floor, the minimum reinforcement in each direction in the horizontal plane shall be as recommended by ACI 350.

3.03 ROOF:

- A. All aspects of tank construction shall comply with AWWA D115.
- B. The roof shall be poured monolithically unless approved by owner and engineer.
- C. Construction joints, if approved, shall include appropriate water stop detail at each joint. Joint locations are subject to the approval of the engineer.
- D. The roof shall be cured by flooding with water and shall remain saturated for a minimum of 7 days.
- E. For crack control in the roof, the minimum reinforcement in each direction in the horizontal plan shall be as recommended by ACI 350.

SECTION 13 21 18 – GROUND-LEVEL AWWA D115 POST TENSIONED CONCRETE
WATER STORAGE TANKS: continued

- F. Prior to placement of concrete, all piping and appurtenances that penetrate wall or roof shall be set and securely tied in place.

3.04 WALL CONSTRUCTION AND ERECTION:

- A. All aspects of tank construction shall comply with AWWA D115 and ACI 350.
- B. Construction joints, if required, shall include appropriate water stop detail at each joint. Joint locations are subject to approval of engineer.
- C. Prior to placement of concrete, all piping and appurtenances that penetrate wall or roof shall be set and securely tied in place.
- D. No holes for form ties, nails, or other punctures will be permitted in the wall.
- E. Temporary wall openings may be provided for access and removal of construction materials from the tank interior subject to the approval of the Engineer.
- F. See Division 03 for additional requirements.

3.05 CONCRETE

- A. All concrete shall be conveyed, placed, finished, and cured as required by pertinent ACI standards.
- B. Weather Limitations:
 - 1. Unless specifically authorized in writing by the Engineer, concrete shall not be placed without special protection during cold weather when the ambient temperature is below 40 degrees Fahrenheit and when the concrete is likely to be subjected to freezing temperatures before initial set has occurred and the concrete strength has reached 500 psi. Concrete shall be protected in accordance with ACI 306. The temperature of the concrete shall be maintained in accordance with the requirements of ACI 301 and ACI 306. All methods and equipment for heating and for protecting concrete in place shall be subject to the approval of the Engineer.
 - 2. During hot weather, concreting shall be in accordance with the requirements of ACI 305.
 - 3. Placement of concrete during periods of low humidity (below 50%) shall be avoided when feasible and economically possible, particularly when large surface areas are to be finished. In any event, surfaces exposed to drying wind shall be covered with polyethylene sheets immediately after finishing, or flooded with water, or shall be water cured continuously from the time the concrete has taken initial set. Curing compounds may be used in conjunction with water curing, provided they are compatible with coatings that may later be applied, or they are degradable.
- C. Finishes:
 - 1. The tank shall be given the following finishes:
 - a. The floor slab shall receive a bull float finish or Fresno finish. The top of the wall footing, exterior to the waterstop, shall receive a steel trowel or magnesium trowel finish.
 - b. The surfaces of the wall and underside of the roof shall receive a form finish.
 - c. The exterior of the roof shall receive a light broom finish. The interior of the roof shall receive a form finish.

SECTION 13 21 18 – GROUND-LEVEL AWWA D115 POST TENSIONED CONCRETE
WATER STORAGE TANKS: continued

- d. Bug holes, form tie holes, and other imperfections to be repaired per procedure recommended by tank designer. Submit repair procedure to engineer for approval.
- D. Curing:
 - 1. Concrete shall be cured using water methods, sealing materials, or curing compounds. Curing compounds shall not be used on surfaces to which decorative coatings, mortar, or shotcrete is to be applied. Curing compounds used within the tank shall be suitable for use with potable water.
- E. Testing:
 - 1. For concrete placed in the floor, walls, or roof, two sets of five, 4-inch by 8-inch cylinders for the first 50 cubic yards, and one set of five, 4-inch by 8-inch cylinders for every 100 cubic yards thereafter placed in the same day. Two cylinders shall be tested at seven days, two at twenty-eight days, and one held as a spare.
 - 2. Slump, air content and temperature testing shall be performed on each truck where cylinders are taken.
 - 3. All concrete testing shall be in accordance with ASTM C31 and C39.
 - 4. An independent material testing service for field testing shall be selected as required in the General Conditions. The material testing service shall furnish test equipment, test cylinder molds, and certified personnel to perform all required field tests, make the required concrete test cylinders, and deliver test cylinders to the testing laboratory.
- 3.06 CONNECTIONS:
 - A. Piping installation requirements are specified in Division 33 sections. Drawings indicate general arrangement of piping, fittings, and specialties.
 - B. Connect tanks to water-distribution piping.
 - C. Connect drains to storm-drainage piping.
 - D. Ground equipment according to Division 26, Section "Grounding and Bonding for Electrical Systems."
 - E. Connect wiring according to Division 26, Section "Low-Voltage Electrical Power Conductors and Cables."
- 3.07 APPURTENANCE INSTALLATION:
 - A. Install and adjust water-level control valves, piping, and alarms.
 - B. Install obstruction lighting according to authorities having jurisdiction.
 - C. Install lightning protection according Division 26, Section "Lightning Protection for Structures."
 - D. Install cathodic protection according to Division 26, Section "Cathodic Protection" and AWWA D104.
 - E. Install tank heaters according to NFPA 22.
- 3.08 FIELD QUALITY CONTROL:
 - A. Leak Test:
 - 1. Upon completion of the tank the tank manufacturer shall perform water tightness testing of the tank.

SECTION 13 21 18 – GROUND-LEVEL AWWA D115 POST TENSIONED CONCRETE
WATER STORAGE TANKS: continued

- a. Water for testing shall be supplied by the Owner.
- b. Leak test to be conducted to the level of the overflow.
- c. The procedures and criteria for watertightness testing and acceptance shall be as defined in ACI 350.1. The maximum allowable loss is 0.0125% of the tank volume per day.
- d. Repair leaks and retest until no leaks exist.
- e. All labor and materials required for testing and evaluation, except for fill water, shall be furnished by the tank supplier.
- B. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- C. Foundation soil support: Place no concrete for floor until the subgrade is approved by the Geotechnical Engineer.

3.09 CLEANING:

- A. Clean interior and exterior of surface water-storage tanks.
- B. Disinfect surface water-storage tanks per Section 13 08 41.

END OF SECTION 13 21 18

SECTION 13 21 19 – GROUND-LEVEL AWWA D110 TYPE III PRESTRESSED CONCRETE WATER STORAGE TANKS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS:

- A. Drawings and general provisions of the Contract, including General and Special Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY:

- A. This Section includes AWWA D110 circular, wire- or strand-wound (prestressed) concrete, surface water-storage tanks for storage of domestic and fire-suppression water.
- B. The work performed under these specifications includes furnishing all engineering design, supervision, labor, materials, equipment, tools, inspection and testing necessary for the construction.
- C. Furnish all labor, materials, equipment, and incidentals required to complete the work to the limits shown on the drawings and as specified herein.
- D. Furnish and install appurtenances including inlet and outlet piping, overflow piping, wash down piping, piping supports, roof vents, access ladders, railings, hatches, and all other internal and external features required for full operation.

1.03 RELATED SECTIONS INCLUDE THE FOLLOWING:

- 1. DIVISION 03: Concrete and Reinforcing.
- 2. DIVISION 05: Metal ladders, supports and miscellaneous framing.
- 3. DIVISION 06: FRP Assemblies and Framing.
- 4. DIVISION 08: Access Doors and Frames.
- 5. DIVISION 09: Protective Coatings.
- 6. DIVISION 13: Disinfection and Testing
- 7. DIVISION 31: Site preparation, excavation, fill, backfill, grading.

1.04 REFERENCE STANDARDS:

- A. The materials, design, fabrication, erection and inspection of the tank and foundation, shall conform to the latest editions of the following Standards, Codes, and Guides:

- 1. American Concrete Institute (ACI):
 - a. 117 – Standard Tolerances for Concrete Construction and Materials
 - b. 228.1R – In-Place Methods to Estimate Concrete Strength
 - c. 301 - Specification for Structural Concrete.
 - d. 305 – Hot Weather Concreting.
 - e. 306 – Cold Weather Concreting.
 - f. 309R – Guide for Consolidation of Concrete.
 - g. 318 - Building Code Requirements for Structural Concrete and Commentary.
 - h. 350 – Code Requirements for Environmental Engineering Concrete Structures and Commentary.
 - i. 350.1 - Tightness Testing of Environmental Concrete Structures
 - j. 350.3 - Seismic Design of Liquid Containing Concrete Structures and Commentary.

SECTION 13 21 19 – GROUND-LEVEL AWWA D110 TYPE III PRESTRESSED
CONCRETE WATER STORAGE TANKS: continued

- k. 506.2 – Specification for Shotcrete
- l. 506R – Guide to Shotcrete.
- 2. American Society for Testing and Materials (ASTM)
 - a. A185 - Specification for Steel Welded Wire, Fabric, Plain for Concrete.
 - b. A475 - Standard Specification for Zinc-Coated Steel Wire Strand.
 - c. A615 or A615M - Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement.
 - d. A821 - Specification for Steel Wire, Hard Drawn for Prestressing Concrete Tanks.
 - e. A1008/A1008M - Specification for Steel, Sheet, Cold-Rolled, Carbon, Structural, High-Strength Low-Alloy and High-Strength Low-Alloy with Improved Formability.
 - f. C31 - Standard Practice for Making and Curing Concrete Test Specimens in the Field.
 - g. C33 - Standard Specification for Concrete Aggregates.
 - h. C39 - Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens.
 - i. A123/A123M - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
 - j. A421/A421M - Standard Specification for Uncoated Stress-Relieved Steel Wire for Prestressed Concrete
 - k. A615/A615M - Standard Specification for Deformed and Plain Carbon Steel Bars for Concrete Reinforcement.
 - l. A653/A653M - Standard Specification for Steel Sheet, Zinc-coated (Galvanized) or Zinc-iron Alloy-coated (Galvanealed) by Hot Dip Process
 - m. A706/A706M - Standard Specification for Low-alloy Steel Deformed and Plain Bars for Concrete Reinforcement.
 - n. C231 - Test Method for Air Content of Freshly Mixed Concrete by Pressure Method
 - o. D698 - Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 Ft. – lbf/ft³) (600 KN-M/M³)
 - p. C618 – Type F Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete.
 - q. C920 – Specification for Elastomeric Joint Sealants.
 - r. D1056 – Standard Specification for Flexible Cellular Materials – Sponge or Expanded Rubber.
 - s. D1556 - Standard Test Method for Density and Unit Weight of Soil in Place by the Sand-Cone Method.
 - t. D1557 – Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 Ft. – lbf/ft³) (2700 KN-M/M³).
 - u. D2000 - Classification System for Rubber Products in Automotive Applications.
- 3. American Society of Civil Engineers (ASCE)
 - a. ASCE7 – Minimum Design Loads for Buildings and Other Structures

SECTION 13 21 19 – GROUND-LEVEL AWWA D110 TYPE III PRESTRESSED
CONCRETE WATER STORAGE TANKS: continued

4. American Society of Mechanical Engineers (ASME)
 - a. B31.1- Code for Pressure Piping - Power Piping.
5. American Water Works Association (AWWA):
 - a. C219 – Bolted, Sleeve-type Couplings for Plain-End Pipe
 - b. C652 – Disinfection of Water Storage Facilities
 - c. D115 – Tendon Prestressed Concrete Water Tanks
6. International Code Council (ICC):
 - a. International Building Code 2021 Edition with local amendments.
7. National Fire Protection Association (NFPA)
 - a. NFPA 22 – Standard for Water Tanks for Private Fire Protection.

1.05 QUALITY CONTROL:

- A. It is the express intent of this specification to create a singular responsibility for the design and construction of the prestressed concrete tank. The design and construction of all aspects of the foundation, floor slab, wall, prestressing, shotcrete, roof and appurtenances of the prestressed concrete tank shall be performed by the tank manufacturer.
- B. Tank manufacturers, other than acceptable tank manufacturers listed below, shall submit qualifications no later than 15 days prior to Bid. Acceptable tank manufacturers below do not need to submit qualifications.
 1. Acceptable Tank Manufacturers:
 - a. DN Tanks - El Cajon, California.
 - b. Preload Tanks – Hauppauge, New York.
 2. The Qualification Submittal shall include the following:
 - a. Preliminary design drawings and calculations showing the dimensions of the tank, details of the type of construction, wire-wound prestressing methods, and sizes of the principal members. Drawings and calculations shall be of sufficient detail to show compliance with the specifications and all required standards and shall be signed and sealed by an engineer licensed in the state where the project is being constructed. The licensed engineer shall certify the design is in conformance with the specifications.
 - b. A complete record of their experience in the design and construction of precast, wire-wound, prestressed concrete tanks conforming to AWWA D110- Type III. The record shall indicate a minimum of ten (10) tanks constructed over the past five (5) years of similar size and construction, the name and address of the owner, the year of construction, and the name of the engineer for each project.
 - c. Experience in the design and construction of only AWWA D110 Type I, Type II or Type IV tanks is not acceptable.
 - d. The Engineer shall approve the qualification submittal for general design intent and criteria prior to bid. Changes to the submittal qualification package shall be approved by the Engineer prior to construction.
- C. Welding: Qualify procedures and personnel according to the following:
 1. AWS D1.1/D1.1M, "Structural Welding Code - Steel."
 2. AWS D1.3, "Structural Welding Code - Sheet Steel."

SECTION 13 21 19 – GROUND-LEVEL AWWA D110 TYPE III PRESTRESSED
CONCRETE WATER STORAGE TANKS: continued

3. AWS D1.4, "Structural Welding Code - Reinforcing Steel."
- D. Pipe Welding: Qualify procedures and personnel according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."
- E. 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.
- F. Comply with AWWA D110, "Wire- and Strand-Wound, Circular, Prestressed Concrete Water Tanks," for concrete, surface water-storage tanks.
- G. Comply with NFPA 22, "Water Tanks for Private Fire Protection," for surface water-storage tanks for fire-suppression water supply.

1.06 SUBMITTALS:

- A. The following information shall be submitted with Bid:
 1. Qualification requirements listed in "Quality Control" for contractors that are not prequalified.
 2. Resume of the proposed project manager and site superintendent.
 3. Resume of the proposed on-site superintendent responsible for the construction with list of qualifying projects.
 4. Resume of the proposed engineer in responsible charge of the project with list of qualifying projects.
 5. Preliminary construction schedule.
 6. Preliminary drawings indicating limits of excavation.
 7. Preliminary tank drawings and details showing methods of construction and details of architectural features.
- B. The following shall be submitted after execution of the contract:
 1. Proposed manufacturers, materials and details of appurtenances, including, but not limited to:
 - a. Waterstops.
 - b. Roof hatch.
 - c. Access manway.
 - d. Guardrail (including gate and hardware).
 - e. Ladder.
 - f. Roof vent and enclosure.
 - g. Overflow.
 - h. Protective coatings.
 - i. Mill certificates for mild reinforcing, prestressing steel, and any other steel components.
 - j. Warranty documents.
 - k. Safety program.
 2. Submitted manufacturers, materials, and appurtenances shall include technical data including product manufacturer's information, specifications, and installation instructions.
 3. Design calculations shall be submitted with clear indication of loads used in design. These shall be submitted for information and verification only.
 4. Specifications and shop drawings showing details and procedures of construction shall be submitted for acceptance.

SECTION 13 21 19 – GROUND-LEVEL AWWA D110 TYPE III PRESTRESSED
CONCRETE WATER STORAGE TANKS: continued

5. Approval by the Engineer of the drawings and calculations submitted by the Contractor will not in any way relieve the Contractor of full responsibility for the accuracy and completeness of the drawings and calculations.
 6. Design calculations and shop drawings shall be sealed by a professional engineer experienced in the design of wire-wound, prestressed concrete tanks and licensed in the State of Colorado.
 - C. Construction Submittals for Review Prior to Use
 1. Design proportions for all concrete and shotcrete. Concrete strengths of trial mixes.
 2. Admixtures to be used in the concrete or shotcrete and their purpose.
 3. Reinforcing steel shop drawings showing fabrication and placement.
 4. Catalog cuts or shop drawings of all appurtenances, i.e. hatch, vent, ladders, waterstops.
 - D. Welding certificates.
 - E. Bacteriological test results.
 - F. Field quality control test reports.
 - G. Operation and Maintenance Data: For the following to include in emergency, operation, and maintenance manuals:
 1. Obstruction lighting.
 2. Lightning protection.
 3. Cathodic protection.
 4. Tank heaters.
 - H. Submit as-constructed drawings at completion in accordance with DIVISION 1 and as follows:
 1. Submit one (1) 22"x34" computer source copy of as-constructed drawings in pdf format.
- 1.07 PREINSTALLATION MEETINGS:
- A. Preinstallation Conference: Contractor to conduct conference at Project Site or remotely at Contractor's option. Contractor shall prepare agenda and provide to project team a minimum of 24 hours in advance of scheduled meeting.
- 1.08 PERFORMANCE REQUIREMENTS:
- A. The prestressed concrete tank shall be designed and constructed in accordance with the provisions of AWWA D110, Type III- Standard for Wire Wound Circular Prestressed-Concrete Water Tanks: Precast Concrete with a steel diaphragm, ACI 318 and ACI 350.
 - B. Horizontal prestressing shall be continuous. Discontinuous prestressing tendons or strands will not be allowed.
 - C. Required dimensions and capacities:
 1. Tank Capacity:
 - a. Treated Water Storage Tank: 5.0 million gallons (active storage).
 2. Tank Dimensions: As indicated on Drawings.
 3. Vent Capacity Requirements (size as indicated at a minimum):
 - (1) Maximum Fill Rate: 1430 gpm.
 - (2) Maximum Draw Down Rate: 3400 gpm.

SECTION 13 21 19 – GROUND-LEVEL AWWA D110 TYPE III PRESTRESSED
CONCRETE WATER STORAGE TANKS: continued

4. Overflow Design Capacity: Designed to accommodate maximum fill rate as indicated.
- D. Structural Performance: Surface water-storage tank, including structural reinforcement and foundation, shall be capable of withstanding the effects of the following loads:
 1. Dead Loads: Estimated of all permanent imposed loads.
 2. Live Loads: Weight of all the liquid when the reservoir is filled to overflowing. Unit weight of liquid 62.4 pounds per cubic foot.
 3. Roof Live Loads: 100 psf plus the weight of soil on roof.
 4. Roof Snow Loads: 46 psf.
 5. Wind Loads: As required by ASCE 7
 - a. Ultimate Design Wind Speed: 113 mph.
 6. Backfill Soil Pressure: 70 pcf.
 7. Geotechnical Requirements: As indicated on Drawings.
 - a. A geotechnical investigation has been carried out at the site. Pertinent geotechnical information has been included on the drawings. The report will be provided “for reference only” and is not considered or made part of the contract documents. The allowable capacity of deep foundation elements has been defined in this report. The Contractor shall be responsible for securing any further geotechnical information required beyond the provided in this report.
8. Seismic Performance: Surface water-storage tank, including structural reinforcement and foundation, shall be capable of withstanding the effects of earthquake motions determined according to authorities having jurisdiction.
 - a. Risk Category: III
 - b. Mapped Spectral Accelerations for Short Periods, S_s : 0.193
 - c. Mapped Spectral Accelerations for 1-Second Period; S_1 : 0.056
 - d. Site Class: C
 - e. Long-period Transition Period, TL: 4 sec.
 - f. Sloshing Height: The sloshing height shall be calculated using AWWA D110, but need not exceed the fluid displacement calculation when determined using ACI 350.3, TID 7024 or ASCE 7. The effects of the “sloshing wave” shall be accounted for by increasing the freeboard between the normal operating surface and the underside of the roof, or a roof capable of resisting the uplift of such a wave designed. A minimum freeboard height of 11 inches above the design liquid level shall be utilized. Any confined portion of the convective (sloshing) mass shall be calculated and applied as an additional impulsive mass.
 - g. Dynamic Effects of Backfill: Seismic design shall consider the additive effects of the dynamic backfill loading.
 - h. Base Restraint Cable Design:
 - (1) When allowable shear resistance of the bearing pad is less than the total base shear obtained from the maximum values of impulsive and convective components and the dynamic effects of backfill, base restraint cables shall be utilized. The allowable cable stress is 0.75 fpu

SECTION 13 21 19 – GROUND-LEVEL AWWA D110 TYPE III PRESTRESSED
CONCRETE WATER STORAGE TANKS: continued

- (2) For the total base shear obtained from the loading conditions of ASCE 7 that incorporate an overstrength factor (Omega Factor), the allowable bearing pad shear or seismic cable stress (if required by design) shall be increased by 20%. The Omega factor shall be incorporated in accordance with ASCE 7 for all loading cases.
- 9. Construction Loads: In addition to the design loads listed above, the following load cases shall be considered for the Treated Water Storage Tank:
 - (1) Case 1: Fully buried, empty tank
 - (2) Case 2: Leak test, No backfill, full tank
- E. Thermal Movements: Surface water-storage tank, including structural reinforcement and foundation, shall allow for thermal movements resulting from the following maximum change (range) in ambient and surface temperatures by preventing buckling, opening of joints, overstressing of components, failure of connections, and other detrimental effects. Base engineering calculations on surface temperatures of materials due to both solar heat gain and nighttime-sky heat loss.
 - 1. Temperature Change (Range): 120°F (67°C), ambient; 180°F (100°C), material surfaces.
- F. The Tank Contractor shall design the composite concrete wall with steel diaphragm and closure steel slot plate in combination with vertical mild steel reinforcement based on the following design criteria and requirements:
 - 1. The prestressed tank wall shall be considered as a cylindrical shell with partial edge restraint.
 - 2. The prestressed tank wall shall be reinforced vertically by deformed steel reinforcing bars. The steel diaphragm can be taken as effective vertical reinforcing.
 - 3. The prestressed tank wall shall be of precast construction. The minimum core wall thickness shall be 4 inches. The core wall is that area of the wall interior to all circumferential prestressing. Shotcrete or cast-in-place concrete core walls are not permitted.
 - 4. For wire wound tanks, a stress plate shall be required at all above grade locations where prestress wires are displaced 24 inches or greater. The stress plate shall be designed to transfer stress across the opening.
 - 5. No reduction in ring compression or tension in the wall will be taken due to restraint at the bottom.
 - 6. The long-term prestressing losses caused by shrinkage, creep, and relaxation in the prestressed reinforcement of the tank walls shall not be assumed less than 25,000 psi.
 - 7. Lateral soil pressures shall not be considered in resisting seismically generated shear forces between the wall footing and the wall.
- G. Floor Slab
 - 1. The floor slab shall be designed as a membrane floor not less than 12 inches thick. Construction joints will only be allowed as shown on the shop drawings and as approved by the Engineer. Construction joints shall incorporate a horizontal 6-inch PVC waterstop.

SECTION 13 21 19 – GROUND-LEVEL AWWA D110 TYPE III PRESTRESSED
CONCRETE WATER STORAGE TANKS: continued

2. Wall footings may be constructed above or below floor grade. If required, the floor shall have thickened regions to facilitate transitions from under slab concrete pipe encasements into the floor, appurtenance loadings and temporary bracing requirements.
 3. Minimum cross sectional area ratio of floor reinforcement to concrete shall be in accordance with ACI 350.
 4. Polypropylene or cellulose fibers may be used at the Tank Contractor's discretion.
- H. Flat Roof:
1. The roof shall be connected to the tank wall and supported by interior columns as required.
 2. The roof shall have a minimum thickness of 12".
 3. Minimum cross sectional area ratio of roof reinforcement to concrete shall be in accordance with ACI 350.
 4. Polypropylene or cellulose fibers may be used at the Tank Contractor's discretion.

1.09 WARRANTY:

- A. The Contractor shall guarantee the structure against defective materials or workmanship for a period of one year from the date of completion. If any materials or workmanship (including leakage beyond the specification) prove to be defective within one year, they shall be replaced or repaired by the Contractor at the Contractor's expense.

PART 2 - PRODUCTS

2.01 CONCRETE

- A. Concrete shall conform to ACI 301.
- B. Cement shall be Portland cement conforming to ASTM C150 Type II or ASTM C595 any type with MS designation.
- C. Admixtures, other than air-entraining, superplasticizers, shrinkage reducing and water reducing admixtures will not be permitted unless approved by the Engineer.
- D. Concrete for tank wall and roof construction shall have a minimum compressive strength of 4,500 psi at twenty-eight days and be air-entrained.
- E. Concrete for the tank floor, footings, pipe encasement, and all other work shall have a minimum compressive strength of 4,500 psi at twenty-eight days, shall not be air-entrained, unless exposed to freeze thaw conditions.
- F. The coarse and fine aggregate shall meet the requirements of ASTM C33 with a maximum coarse aggregate size of 1".
- G. If fibers are used, they shall be virgin poly-propylene or cellulose fibers, Microfiber by Grace, Fibermesh 150 by Propex, UltraFiber 500 by Buckeye, or equal. Fiber lengths shall be a maximum of ¾ inches. The amount of fibers added to the concrete mix shall conform to the Manufacturer's recommendations.
- H. Proportioning for concrete shall be in accordance with ACI 301.
 1. The allowable w/(c+p) range shall be 0.36 to 0.42.

SECTION 13 21 19 – GROUND-LEVEL AWWA D110 TYPE III PRESTRESSED
CONCRETE WATER STORAGE TANKS: continued

2. Concrete slump at maximum w/(c+p) shall be 5"-7" maximum per ASTM C143.
3. The water shall be potable, clean and free from injurious amounts of oils, acids, alkalis, salts, organic materials, or other substances that may be deleterious to concrete, reinforcing steel, or other embedded items.
- I. All concrete shall have a maximum water soluble chloride ion concentration of 0.08% by weight of cementitious material.
- J. All concrete mix designs shall be submitted to the engineer for approval. Alternate mixes cold weather conditions, or self-consolidating concrete shall be considered.
- K. Dry shrinkage shall not exceed 0.040 percent when tested in accordance to ASTM C157 for concrete used in liquid and chemical retaining structures.

2.02 SHOTCRETE

- A. Shotcrete shall conform to ACI Standard 506, except as modified herein.
- B. The wet mix process shall be employed for shotcreting.
- C. Shotcrete used for covering prestressed wire or strand shall consist of not more than three parts sand to one part Portland cement by weight. Additional coats of shotcrete shall consist of not more than four parts sand to one part Portland cement by weight. Polypropylene fibers shall be included in the shotcrete used for the finish cover coat. Fibers shall be Fibercast 500 by Propex, Fibermesh or equal. Fibers shall be virgin polypropylene and comply with ASTM C-1116 performance level I. Fiber length shall be ¼ inch. The amount of the fibers added to the shotcrete used for the finish cover coat shall conform to the Manufacturer's recommendations. Fly ash may be incorporated into the finish cover coat. Fly ash shall conform to ASTM C618, Type F. Shotcrete shall have a minimum strength of 4,500 psi at twenty-eight days and have a maximum water to cementitious ratio of 0.42.
- D. Rebound material shall not be reused in any form for shotcrete.
- E. If used by the Tank Contractor, the total volumetric air content of the shotcrete before placement shall not exceed 7% (±1%) as determined by ASTM C-173 or ASTM C-231.
- F. Fine Aggregates:
 1. The fineness modulus shall be between 2.7 and 3.0. A well-graded coarse sand shall be used for all shotcrete applications.
 2. The gradation for the fine aggregates shall adhere to the "Grading No. 1" requirements listed in "Table 1.1 – Grading Limits for Combined Aggregates" of ACI 506.
- G. All shotcrete shall have a maximum water soluble chloride ion concentration of 0.06% by weight of cementitious material.

2.03 MORTAR FILL AND NON-SHRINK GROUT

- A. Mortar fill and non-shrink grout shall have a minimum compressive strength of 4,000 psi at twenty-eight days, have a maximum water to cementitious ratio of 0.42 and meet all requirements for concrete contained in this specification.
- B. Portland cement grout will not be accepted.

SECTION 13 21 19 – GROUND-LEVEL AWWA D110 TYPE III PRESTRESSED
CONCRETE WATER STORAGE TANKS: continued

2.04 REINFORCING STEEL

- A. Reinforcing steel shall be new billet steel Grade 60, as shown on the Drawings, meeting the requirements of ASTM A615. Welded wire fabric and weldable reinforcing steel shall conform to ASTM A185 and ASTM A706, respectively.
- B. Reinforcing steel shall be accurately fabricated and shall be free from loose rust, scale, and contaminants, which reduce bond.
- C. Reinforcing steel shall be accurately positioned on supports, spacers, hangers, or other reinforcements and shall be secured in place with wire ties or suitable clips. Rebar chair supports may be either steel with plastic tips, turned up legs or plastic.
- D. Continuous reinforcing is required through floor and cast in place roof construction joints, where applicable.

2.05 BASE RESTRAINT CABLES

- A. Where required by design, the tank designer shall use base restraint cables to resist earthquake and/or wind loads. Base restraint cables shall be hot-dipped galvanized seven-wire strand and shall be manufactured in accordance with ASTM A416 prior to galvanizing, and ASTM A475 after galvanizing. Only seven-wire strand will be allowed.
- B. Hot-dipped galvanized seven-wire strand shall have a nominal strand diameter of 0.375 in, 0.50 in or 0.60 in. 0.375 inch diameter strand shall have an MUS after galvanization of 21.36 kips and a min. yield at 1% extension of 15.60 ksi. 0.50 inch diameter strand shall have an MUS after galvanization of 38.25 kips and a min. yield at 1% extension of 28.00 ksi. 0.60 inch diameter strand shall have an MUS after galvanization of 54.20 kips and a min. yield at 1% extension of 40.70 ksi. All strands shall have a minimum of weight of Zinc Coating of 0.85 oz/sq-ft.
- C. Neoprene sleeves for base restraint cables shall be closed-cell conforming to ASTM D1056, Type 2, Class A, and Grade 3. The sleeves shall have a compression deflection limited to 25% at 9 to 13 psi, hardness of 60 to 80 durometer, a minimum tensile strength of 175 psi, a minimum elongation of 180%, and a maximum compressive set of 35%.

2.06 STEEL DIAPHRAGM

- A. The steel diaphragm shall conform to ASTM A1008 and shall be a minimum thickness of 0.017 inches. It shall be vertically ribbed with reentrant angles. The back of the channels shall be wider than the front, providing a mechanical keyway anchorage with the concrete and shotcrete encasement.
- B. The steel diaphragm shall extend to within 1 inch of the full height of the wall panel with no horizontal joints. Vertical joints within a wall panel shall be roll seamed or otherwise fastened in a fashion that results in a firm mechanical lock. Joints between wall panels that are not roll seamed shall be edge sealed with polysulfide or polyurethane sealant.
- C. No punctures will be permitted in the diaphragm except those required for pipe sleeves, temporary construction openings, or special appurtenances. The Engineer shall approve details of the openings. All openings shall be completely edge sealed with polysulfide or polyurethane sealant.

SECTION 13 21 19 – GROUND-LEVEL AWWA D110 TYPE III PRESTRESSED
CONCRETE WATER STORAGE TANKS: continued

- D. Diaphragm steel may be considered as contributing to the vertical reinforcement of the wall.
- E. Steel closure plates shall be used at wall slots between precast wall panels on the exterior face to create a continuous steel diaphragm.

2.07 CIRCUMFERENTIAL PRESTRESSING STEEL

- A. Steel for prestressing shall either be cold drawn, high carbon wire or galvanized seven wire strand.
- B. The wire shall meet the requirements of ASTM A821 and have a minimum ultimate tensile strength of 210,000 psi.
- C. Galvanized strand shall meet the requirements of ASTM A416 prior to galvanizing with zinc coating for galvanizing meeting the requirements of ASTM A641/641M or ASTM A475. Each wire shall be individually hot-dipped galvanized before being stranded. The minimum weight of zinc coating per unit area of uncoated wire surface area shall be no less than 0.85 ounces per square foot.
- D. Splices for horizontal prestressed reinforcement shall be ferrous material compatible with the reinforcement and shall develop the full strength of the wire or strand. Wire or strand splice and anchorage accessories shall not nick or otherwise damage the prestressing.

2.08 ELASTOMERIC MATERIALS

- A. A 9 inch minimum waterstop with centerbulb shall be polyvinyl chloride meeting the requirements of the Corps of Engineers Specification CRD-C 572. Splices shall be made in accordance with the Manufacturer's recommendations subject to the approval of the Engineer. Waterstop shall be manufactured by Greenstreak Plastic Products Company, Inc., or equal.
- B. Bearing pads shall be natural rubber or neoprene.
 - 1. Natural rubber bearing pads shall contain only virgin natural polyisoprene as the raw polymer and the physical properties shall comply with ASTM D2000, Type A Shore, 30 to 60 durometer. Prepare concrete surfaces and adhere pads to concrete per manufacturer's recommendations..
 - 2. Neoprene bearing pads shall have a hardness of 40 to 50 durometer, a minimum tensile strength of 1,500 psi, a minimum elongation of 500%, and a maximum compressive set of 50%. Pads shall meet the requirements of ASTM D2000.
- C. Sponge filler shall be closed-cell neoprene or rubber conforming to ASTM D1056, Type 2, Class A, and Grade 1 or 3. Compression deflection limited to 25% at 2 to 5 psi.
- D. Polysulfide or polyurethane sealant will be a two or three component elastomeric compound meeting the requirements of ASTM C920. Sealants shall have permanent characteristics of bond to metal surfaces, flexibility, and resistance to extrusion due to hydrostatic pressure. Air cured sealants shall not be used.

2.09 APPURTENANCES

- A. The Tank Contractor shall provide and install all appurtenances as shown on the drawings. Appurtenances shall include the following:

SECTION 13 21 19 – GROUND-LEVEL AWWA D110 TYPE III PRESTRESSED
CONCRETE WATER STORAGE TANKS: continued

- a. Inlet-Outlet Piping with mixing system.
- b. Overflow Piping and Weir.
- c. Roof Hatches:
 - (1) Two 5-foot square Bilco Type F aluminum hatch with lockable, hinged cover and curb frame. The hatch shall have a lift handle, padlock tab, padlock and a cover hold open mechanism. All hardware shall be 316 stainless steel. Locate hatches as shown on drawings.
 - (2) Two 8-foot by 9-foot Bilco Type D aluminum hatches with lockable, hinged cover and curb frame. Latch operation shall be interior to the hatch requiring special tools to open similar to the Hilltop Tank. Contractor shall coordinate with owner and hatch manufacturer. The hatch shall have a lift handle, padlock tab, and a cover to hold open the mechanism. All hardware shall be 316 stainless steel. Locate hatches as shown on drawings.
 - (3) Two 3-foot by 6-foot Bilco Type J-AL hatches inside Type D hatch roof curbs. All hardware shall be 316 stainless steel.
- d. Roof Vent: Two 316 stainless steel gooseneck vents with insect screen. Tank manufacturer to determine size of vents. Locate as shown on the drawings.
- e. Interior Ladders: The ladders shall extend from the tank floor to the hatch. The ladder shall be 316 stainless steel and have an OSHA-approved Stainless Steel fall prevention device consisting of a sliding, locking mechanism and safety belt. Location as shown on the drawings.
- f. Floor Sump with Drain Pipe: Location and size of sump as shown on the drawings.

PART 3 - EXECUTION

3.01 EXCAVATION AND BACKFILL:

- A. Refer to DIVISION 31 – Earthwork.

3.02 FLOOR:

- A. All aspects of tank construction shall comply with AWWA D110 and ACI 350.
- B. Prior to placement of the floor reinforcing, a polyethylene moisture barrier shall be placed over the void form. Joints in the polyethylene shall be overlapped a minimum of 6 inches and be taped.
- C. Prior to placement of the floor concrete, all piping that penetrates the floor, shall be set and encased in concrete.
- D. The vertical waterstop shall be placed and secured in position so that the bottom of the center bulb is at the elevation of the top of the footing. The waterstop shall be secured without puncturing any portion of the waterstop unless it is manufactured with holes for tying. The waterstop shall be spliced using a thermostatically controlled sealing iron and each splice shall be successfully spark tested prior to encasement in concrete.

SECTION 13 21 19 – GROUND-LEVEL AWWA D110 TYPE III PRESTRESSED
CONCRETE WATER STORAGE TANKS: continued

- E. The floor may be poured monolithically or divided into roughly equal segments with appropriate water stop detail at each joint.
- F. The floor shall be cured by flooding with water and shall remain saturated for a minimum of 7 days.
- G. For crack control in the floor, the minimum reinforcement in each direction in the horizontal plane shall be as recommended by ACI 350.

3.03 PRECAST WALL PANEL CONSTRUCTION AND ERECTION

- A. The precast wall panel shall be constructed with a continuous waterproof steel diaphragm embedded in the exterior of the precast panel. Horizontal joints in the diaphragm will not be allowed.
- B. No holes for form ties, nails, or other punctures will be permitted in the wall.
- C. Temporary wall openings may be provided for access and removal of construction materials from the tank interior subject to the approval of the Engineer.
- D. Wall beds shall be constructed to provide finished panels with the proper curvature of the tank.
- E. Polyethylene sheeting shall be placed between successive pours to provide a high moisture environment and a long slow cure for the concrete.
- F. The erecting crane and lifting equipment shall be capable of lifting and placing the precast panels to their proper location without causing damage to the panel.
- G. The precast panels shall be erected to the correct vertical and circumferential alignment. The edges of adjoining panels shall not vary inwardly or outwardly by more than 3/8 inch and shall be placed to the tank radius within + 3/8 inch.
- H. Joints between precast wall panels shall be bridged with a 10 gauge steel plate edge sealed with polysulfide or polyurethane and filled with mortar as shown on the drawings. No through-wall ties will be permitted.

3.04 ROOF CONSTRUCTION AND ERECTION

- A. All aspects of tank construction shall comply with AWWA D110 and ACI 350.
- B. The roof shall be poured monolithically unless approved by the owner and engineer.
- C. Construction joints, if approved, shall include appropriate water stop detail at each joint. Joint locations are subject to the approval of the engineer.
- D. The floor shall be cured by flooding with water and shall remain saturated for a minimum of 7 days.
- E. For crack control in the floor, the minimum reinforcement in each direction in the horizontal plan shall be as recommended by ACI 350.
- F. Prior to placement of concrete, all piping and appurtenances that penetrate wall or roof shall be set and securely tied in place.

3.05 CONCRETE

- A. All concrete shall be conveyed, placed, finished, and cured as required by pertinent ACI standards.
- B. Weather Limitations
 - 1. Unless specifically authorized in writing by the Engineer, concrete shall not be placed without special protection during cold weather when the ambient temperature is below 40 degrees Fahrenheit and when the concrete is likely

SECTION 13 21 19 – GROUND-LEVEL AWWA D110 TYPE III PRESTRESSED
CONCRETE WATER STORAGE TANKS: continued

to be subjected to freezing temperatures before initial set has occurred and the concrete strength has reached 500 psi. Concrete shall be protected in accordance with ACI 306. The temperature of the concrete shall be maintained in accordance with the requirements of ACI 301 and ACI 306. All methods and equipment for heating and for protecting concrete in place shall be subject to the approval of the Engineer.

2. During hot weather, concreting shall be in accordance with the requirements of ACI 305.
3. Placement of concrete during periods of low humidity (below 50%) shall be avoided when feasible and economically possible, particularly when large surface areas are to be finished. In any event, surfaces exposed to drying wind shall be covered with polyethylene sheets immediately after finishing, or flooded with water, or shall be water cured continuously from the time the concrete has taken initial set. Curing compounds may be used in conjunction with water curing, provided they are compatible with coatings that may later be applied, or they are degradable.

C. Finishes

1. The tank shall be given the following finishes:
 - a. The floor slab shall receive a bull float finish or Fresno finish. The top of the wall footing, exterior to the waterstop, shall receive a steel trowel or magnesium trowel finish.
 - b. The interior of the precast wall panels shall receive a light broom finish.
 - c. The exterior of the roof shall receive a light broom finish. The interior of the roof shall receive a form finish.
 - d. Exterior shotcrete shall receive a natural gun / nozzle finish.
 - e. Bug holes, form tie holes, and other imperfections to be repaired per procedure recommended by tank designer. Submit repair procedure to engineer for approval.

D. Curing

1. Concrete shall be cured using water methods, sealing materials, or curing compounds. Curing compounds shall not be used on surfaces to which decorative coatings, mortar, or shotcrete is to be applied. Curing compounds used within the tank shall be suitable for use with potable water.

E. Testing

1. For concrete placed in precast panels or wall slots, a set of three. 4-inch by 8-inch cylinders shall be made for each truck load of concrete placed. For concrete placed in the floor or roof, two sets of five, 4-inch by 8-inch cylinders for the first 50 cubic yards, and one set of five, 4-inch by 8-inch cylinders for every 100 cubic yards thereafter placed in the same day. Two cylinders shall be tested at seven days, two at twenty-eight days, and one held as a spare.
2. Slump, air content and temperature testing shall be performed on each truck where cylinders are taken.
3. All concrete testing shall be in accordance with ASTM C31 and C39.
4. An independent material testing service for field testing shall be selected as required in the General Conditions. The material testing service shall furnish test equipment, test cylinder molds, and certified personnel to perform all

SECTION 13 21 19 – GROUND-LEVEL AWWA D110 TYPE III PRESTRESSED
CONCRETE WATER STORAGE TANKS: continued

required field tests, make the required concrete test cylinders, and deliver test cylinders to the testing laboratory.

3.06 SHOTCRETING

A. Weather Limitations

1. Shotcrete shall not be placed in freezing weather without provisions for protection against freezing. Shotcrete placement can start without special protection when the temperature is 40 degrees Fahrenheit and rising, and shall be suspended when the temperature is 40 degrees Fahrenheit and falling. The surface to which the shotcrete is applied shall be free from frost. Cold weather shotcreting shall be in accordance with ACI 506, ACI 301 and ACI 306.
2. Hot weather shotcreting shall be in accordance with the requirements of ACI 506, ACI 301 and ACI 305.

B. Coating of Steel Diaphragm

1. The steel diaphragm shall be covered with a layer of shotcrete at least ½ inch thick prior to prestressing.
2. Total minimum coating over the steel diaphragm shall be 2 inches including diaphragm cover, wire or strand cover, and finish cover coat.

C. Coating Over Prestressing Wire or Strand

1. Each prestress wire or strand shall be individually encased in shotcrete. Shotcrete thickness shall be sufficient to provide a clear cover over the wire and strand of at least ¼ inch and 3/8 inch, respectively.
2. Finish cover coat shotcrete shall be applied as soon as practical after the last application of wire or strand coat.
3. The minimum final shotcrete cover over the outermost prestressing wire or strand layer shall be 1 inch.

D. Placement of Shotcrete

1. Shotcrete shall be applied by an ACI 506 certified nozzleman.
2. Manually applied shotcrete shall be applied with the nozzle held at a small upward angle not exceeding five degrees and constantly moving during application in a smooth motion with the nozzle pointing in a radial direction toward the center of the tank. The nozzle distance from the prestressing shall be such that shotcrete does not build up or cover the front face of the wire or strand until the spaces behind and between the prestressing elements are filled.
3. Unless applied by an automated shotcrete process, total cover coat thickness shall be controlled by shooting guide wires. Vertical wires shall be installed under tension and spaced no more than two feet apart to establish uniform and correct coating thickness. Monofilament line (100 lb. test) or 18 or 20 gauge high tensile strength steel wire shall be used. Guide wires shall be removed after placement of the cover coat.
4. Shotcrete applied by an automated shotcrete process shall be applied using the wet mix only. Nozzles shall be kept mounted on power driven machinery enabling the nozzle to travel parallel to the surface to be sprayed at a uniform linear or bi-directional speed. The nozzle shall be kept at a uniform constant

SECTION 13 21 19 – GROUND-LEVEL AWWA D110 TYPE III PRESTRESSED
CONCRETE WATER STORAGE TANKS: continued

distance from the surface, always insuring a right angle spray of the material to the surface. The high velocity impact shall be developed pneumatically by injecting compressed air at the nozzle.

E. Curing

1. Shotcrete shall be cured using water curing methods, sealing materials or curing compounds at the option of the Tank Contractor. Curing compounds shall not be used on surfaces to which decorative coatings, mortar or shotcrete is to be applied. Curing compounds used within the tank wall shall be suitable for use with potable water. Intermediate layers of shotcrete shall be kept damp by water curing or other means no sooner than twelve hours after the shotcrete has been applied.
2. Water curing is not required should additional shotcrete be applied on the entire wall surface within the following twelve hours.
3. Indiscriminate use of continuous water cure for intermediate layers shall be avoided.
4. Complete shotcrete surfaces, which do not receive any additional coatings, may be water cured for a period of at least seven days by encapsulating the shotcrete inside of plastic sheeting.

F. Testing

1. Testing of shotcrete shall be in accordance with ACI 506, except as specified herein.
2. One test panel shall be made for each of the following operations: core wall, wire or strand cover, and cover coat. Test panels shall be made from the shotcrete as it is being placed, and shall, as nearly as possible, represent the material being applied. The method of making a test sample shall be as follows: A frame of wire fabric (1 foot square, 3 inches in depth) shall be secured to a plywood panel and hung or placed in the location where shotcrete is being placed. This form shall be filled in layers simultaneously with the nearby application. After twenty-four hours, the fabric and plywood backup shall be removed and the sample slab placed in a safe location at the site.
3. The sample slab shall be moist cured in a manner identical with the regular surface application. The sample slab shall be sent to the testing laboratory. Nine 3-inch cubes shall be cut from the sample slab and subjected to compression tests in accordance with current ASTM Standards. Three cubes shall be tested at the age of seven days, three shall be tested at the age of twenty-eight days, and three shall be retained as spares. Testing shall be by an independent testing laboratory, approved by the Engineer and at the Tank Contractor's expense.
4. At the Tank Contractor's option testing of shotcrete applied with an automated process shall be in accordance with ACI 301 and conform to "Concrete Testing" of these specifications.

3.07 CIRCUMFERENTIAL PRESTRESSING

- A. Prestressing shall be performed utilizing continuous wire or strand. Prestressing wire/strand will be placed on the wall with a machine capable of consistently

SECTION 13 21 19 – GROUND-LEVEL AWWA D110 TYPE III PRESTRESSED
CONCRETE WATER STORAGE TANKS: continued

- producing a stress in the wire/strand within a range of minus 7% to plus 7% of the stress required by the design. No circumferential movement of the prestressing along the tank wall will be permitted during or after stressing. Stressing may be accomplished by drawing the wire through a die or by another process that results in uninterrupted elongation, thus assuring uniform stress throughout its length and over the periphery of the tank.
- B. Each coil of prestressing shall be temporarily anchored at sufficient intervals to minimize the loss of prestress in case a wire/strand breaks during wrapping.
 - C. Minimum clear space between prestressing wires is 5/16 inch or 1.5 wire diameters, whichever is greater. Minimum clear distance between prestressing strands is 3/8 inch or 1.5 strand diameters, whichever is greater. Any wires or strands not meeting the spacing requirements shall be respaced. Prestressing shall be placed no closer than 2 inches from the top of the wall, edges of openings, or inserts, nor closer than 3 inches from the base of walls or floors where radial movement may occur.
 - D. The band of prestressing normally required over the height of an opening shall be displaced into circumferential bands immediately above and below the opening to maintain the required prestressing force. Bundling of the prestressing steel shall be prohibited.
 - E. For wire wound tanks, a stress plate shall be used at all permanent wall penetrations above grade that results in displacement of wire/strand equal to or greater than 24 inches in height. The stress plate shall accommodate a portion of the prestressing normally required for the height of the opening. The remaining prestressing normally required shall be displaced into circumferential bands immediately above and below the penetration. The effect of banded prestressing shall be taken into account in the design.
 - F. Ends of individual coils shall be joined by suitable steel splicing devices capable of developing the full strength of the prestressing wire/strand.
 - G. The Tank Contractor shall furnish a calibrated stress recording device, which can be recalibrated, to be used in determining wire/strand stress levels on the wall during and after the prestressing process. At least one stress reading per vertical foot or one stress reading for every roll of prestressing, whichever is greater, shall be taken immediately after the wire or strand has been applied on the wall. Readings shall be recorded and shall refer to the applicable height and layer of the prestressing for which the stress is being taken. The Tank Contractor shall keep a written record of stress readings. All stress readings shall be made on straight lengths of wire/strand. If applied stresses fall below the design stress in the steel, additional wire or strand will be provided to bring the force on the core wall up to the required design force. If the stress in the steel is more than 7% over the required design stress, the wrapping operation should be discontinued, and satisfactory adjustment made to the stressing equipment before proceeding.
 - H. When a mechanical stressing system is utilized a continuous electronically (or substantial equivalent) monitored permanent recording of the applied force shall be made during the entire circumferential prestressing application. All such recordings shall be based on a continuous sensing of the applied force on the

SECTION 13 21 19 – GROUND-LEVEL AWWA D110 TYPE III PRESTRESSED
CONCRETE WATER STORAGE TANKS: continued

wire/strand between the tensioning system and the wall when, and as, the strand is being wrapped and laid on the wall.

3.08 CONNECTIONS:

- A. Piping installation requirements are specified in Divisions 33 sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Connect tanks to water-distribution piping.
- C. Connect drains to storm-drainage piping.
- D. Ground equipment according to Division 26, Section "Grounding and Bonding for Electrical Systems."
- E. Connect wiring according to Division 26, Section "Low-Voltage Electrical Power Conductors and Cables."

3.09 APPURTENANCE INSTALLATION:

- A. Install and adjust water-level control valves, piping, and alarms.
- B. Install obstruction lighting according to authorities having jurisdiction.
- C. Install lightning protection according Division 26, Section "Lightning Protection for Structures."
- D. Install cathodic protection according to Division 26, Section "Cathodic Protection" and AWWA D104.
- E. Install tank heaters according to NFPA 22.

3.10 FIELD QUALITY CONTROL:

- A. Testing: Owner will engage a qualified testing agency to perform the following field quality control testing:
- B. Leak Test:
 - 1. Upon completion of the tank the tank manufacturer shall perform water tightness testing of the tank.
 - a. Water for testing shall be supplied by the Owner.
 - b. Leak test to be conducted to the level of the overflow.
 - c. The procedures and criteria for watertightness testing and acceptance shall be as defined in ACI 350.1. The maximum allowable loss is 0.0125% of the tank volume per day.
 - d. Repair leaks and retest until no leaks exist.
 - e. All labor and materials required for testing and evaluation, except for fill water, shall be furnished by the tank supplier.
- C. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

3.11 CLEANING:

- A. Clean interior and exterior of surface water-storage tanks.
- B. Disinfect surface water-storage tanks according to per Section 13 08 41.

END OF SECTION 13 21 19

SECTION 13 21 20 - WATER STORAGE RESERVOIR CLEANING AND TESTING

PART 1 - GENERAL

1.01 SUMMARY:

- A. This section will govern the cleaning and testing of the tank. All appurtenant operations involving cleaning and testing shall be done in strict conformance with the drawings and other terms and conditions of the Contract. All standard specifications made a portion of these Specifications by reference shall be the latest edition and revision thereof.
- B. It is the intent of this Specification to be in conformance with AWWA C652 and all local, State, and Federal standards. In the event a conflict occurs between this Specification and the local, State, or Federal regulation, the local, State, or Federal regulation shall in all cases prevail.

1.02 RELATED WORK:

- A. Post-Tensioned Concrete Water Storage Tanks: SECTION 13 21 18.
- B. Prestressed Concrete Water Storage Tanks: SECTION 13 21 19.

1.03 REFERENCES:

- A. A. American Water Works Association (AWWA)
 - 1. C652 – Disinfection of Water Storage Facilities
 - 2. C655 – Field Dechlorination
- B. American Concrete Institute (ACI):
 - 1. ACI 350.1-10 – Specification for Tightness Testing of Environmental Engineering Concrete Containment Structures and Commentary.

PART 2 - PRODUCTS

2.01 MATERIALS:

- A. General: Materials used in the Work shall conform and meet the requirements of the class and type of material named.
- B. Water: See Special Conditions Section XXIV. WATER.

PART 3 - EXECUTION

3.01 WATER AVAILABILITY:

- A. Water for water tightness test shall be provided by the Owner. See Special Conditions section XXIV. WATER.
- B. The filling of the tank to the full side wall depth (SWD) may not be able to be accomplished solely by utilizing the inlet/outlet line. The Contractor will be responsible for achieving full side wall depth through alternative means, such as local hydrant or system connection(s).

SECTION 13 21 20 - WATER STORAGE TANK CLEANING AND TESTING: continued

3.02 CLEANING:

- A. The tank shall be cleaned upon completion. This shall include all piping, fittings, and appurtenances located on the interior of the tank.
- B. Water used for cleaning shall be potable water.
- C. All scaffolding, tools, and any other material which is not part of the structure or operating facility of the tank shall be removed. After the Engineer has reviewed the tank, the floor shall be swept clean, and the surfaces of the walls, floor, and roof cleaned thoroughly using a high-pressure (200 psi or higher) water jet. All water, dirt, and foreign material accumulated in these cleaning operations shall not be discharged through the floor drain but removed. The inlet and outlet pipe shall be capped to prevent entry of dirt and foreign matter during the cleaning operations.
- D. Following cleaning, the vent screens shall be checked for correct placement to prevent birds and other contaminants from entering the facility. The hatches shall be kept closed after cleaning and locked during non-working hours.

3.03 DISINFECTION:

- A. Perform disinfection after cleaning and concrete structure is complete and capable of resisting the hydrostatic pressure of the water test. The concrete shall have achieved its full design strength (28 days minimum).
- B. After the cleaning operations are complete, Engineer shall review the tank prior to disinfection procedure. After Engineer's review of tank cleaning, Contractor shall disinfect the tank in accordance with AWWA C652, Chlorination Method 2.
- C. A solution of 200 mg/L available chlorine shall be applied directly to all the surfaces of the tank, including the floor, walls, underside of roof, and exposed piping such as the overflow piping and tank mixing system.
- D. The chlorine solution shall be applied by spray equipment, and shall thoroughly coat all surfaces, and shall be applied to any separate draining piping such that it will have available chlorine of not less than ten (10) mg/L when filled with water.
- E. The disinfected surfaces shall remain in contact with the strong chlorine solution for at least thirty (30) minutes, after which time potable water may be added into the tank, the drain pipeline purged of the ten (10) mg/L chlorinated water, and the tank filled to within six (6) inches of the overflow.
- F. Prior to discharge to the environment, all chlorinated water shall be dechlorinated in accordance with AWWA C655. Contractor is required to obtain any associated discharge permits through CDPHE prior to discharge.
- G. Following this procedure, the water quality shall be subjected to bacteriological testing in accordance with AWWA C652, Section 5.1.

3.04 WATER TIGHTNESS TEST:

- A. After the tank has been cleaned and prior to backfilling and painting operations, the Contractor shall conduct the water tightness test under the observance of the Engineer.
- B. Inspect all link-seal type wall penetrations for proper installation prior to leak testing. Install all temporary bulkheads, cofferdams, and pipe blind flanges, and close all valves. Inspect each to see that it provides a complete seal.
- C. Unless otherwise permitted by the Engineer, the tank shall be filled at a rate of no

SECTION 13 21 20 - WATER STORAGE TANK CLEANING AND TESTING: continued

more than 4 feet per day. Higher fill rates may be possible, but depend upon the preliminary water tightness of the tank and the ability of the Owner to provide water for filling and testing and also meet demands of the water system.

- D. Fill reservoir with water to maximum liquid level. Maintain this level for 72 hours prior to the start of the test to allow water absorption, structural deflection, and temperature to stabilize.
 - 1. Visual Testing Procedure:
 - a. Test Shall be performed in accordance with ACI 350.1-01 with the following modifications.
 - b. Testing shall meet the requirements of HST-VIO and HST-100.
 - c. Test shall be performed on all concrete liquid-containment structures, including basins, containment areas, and overflow troughs.
 - d. Perform leakage tests after concrete structure is complete and capable of resisting the hydrostatic pressure of the water test. The concrete shall have achieved its full design strength (28 days minimum-no exceptions).
 - e. Perform leakage test before backfill, brick facing, or other work that will cover concrete wall surfaces.
 - f. Install all temporary bulkheads, cofferdams, and pipe blind flanges, and close all valves. Inspect each to see that it provides a complete seal.
 - g. Measure the water surface at two points 180 degrees apart, when possible where attachments such as ladders exist, at 24-hour intervals.
 - h. Clean all soil and debris from top of exposed base slab edge and power wash for inspection of visual leak test. Heaters or burners may be used to remove standing water on the footing 24 hours prior to visual inspection.
 - i. Contractor shall coordinate with the Owner about discharge of the water back into the water system.
- E. Repairs When Test Fails:
 - 1. Repair cracks and joints visually leaking using a hydrophobic polyurethane grout injected from the outside or as approved by tank designer/Engineer.
 - 2. Hydrophobic polyurethane shall be NSF 61 approved.
 - 3. Follow manufacturer's installation instructions.
 - 4. Drill holes for injection ports at 45° angle to surface intersecting crack at center of wall. Start injection at lowest port. Inject polyurethane until grout appears at adjacent port before continuing on to next port.
 - 5. Cracks shall remain dry for 24 hours prior to continuing the visual leak test.
 - 6. If structure continues to leak after application of polyurethane grout; dewater the structure, repair leaks and wet areas by Engineer approved means and repeat water leakage test in its entirety until the structure successfully passes the test.
 - 7. Visual leak test shall be performed and determined acceptability by Engineer.
 - 8. Acceptance is based on NO visible actively leaking (all wall and floor areas) or damp areas (above grade) on the exterior surface of the reservoir.
- F. Contractor shall dispose of test water in an acceptable manner or arrange with the Owner to discharge into the Owner's transmission system.

3.05 TANK PERFORMANCE PERIOD:

- A. After successful completion of the water tightness test Contractor shall request

SECTION 13 21 20 - WATER STORAGE TANK CLEANING AND TESTING: continued

commencement of tank performance period from the Owner and the Engineer.

B. Tank performance period shall last 7 calendar days.

C. Acceptance of the tank performance period shall be determined acceptable by the Owner and the Engineer.

END OF SECTION 13 21 20

DIVISION 26 – ELECTRICAL

SECTION 26 00 00 – GENERAL ELECTRICAL REQUIREMENTS

PART 1 - GENERAL

1.01 SUMMARY:

- A. This SECTION specifies general administrative and procedural requirements for electrical installations. The following administrative and procedural requirements are included in this SECTION to expand the requirements specified in DIVISION 01:
 - 1. Submittals.
 - 2. Coordination drawings.
 - 3. Record documents.
 - 4. Maintenance manuals.
 - 5. Rough-ins.
 - 6. Electrical installations.
 - 7. Electrical demolition.
 - 8. Cutting and patching.
 - 9. Touch-up painting.
- B. Install and make suitable for operation equipment furnished by others per the Drawings and Specifications.
- C. Provide Equipment as specified in Division 26.
- D. Furnish and install Material for electrical equipment and systems; including supports, conduit, fittings, wiring and connectors.
- E. Furnish all Labor and Materials to complete the Work as specified in accordance with national, state and local governing bodies having jurisdiction.
- F. All Equipment and Material shall be rated for the Project Site conditions as specified in DIVISION 01.
- G. Provide all temporary construction power and lighting.
- H. Provide skilled labor and technical assistance to manufacturer's service representatives for the configuration and startup of electrical Equipment and Systems.
- I. Perform Work in the follow locations at the Project Site:
 - 1. 5 MG Tank & Valve Vaults
 - 2. Existing Hilltop Tank and Antenna Building
- J. Coordinate Work with others as specified in this SECTION PART 3 - EXECUTION. Provide seven days notice to the Engineer and Owner before interruption to existing electrical service, including:
 - 1. Utility power
 - 2. Emergency lighting

1.02 RELATED REQUIREMENTS:

- A. DIVISION 01 - General Requirements.
- B. DIVISION 03 - Concrete.
- C. DIVISION 08 - Openings.
- D. SECTION 09 90 00 - Protective Coatings

SECTION 26 00 00 – General ELECTRICAL REQUIREMENTS: CONTINUED

- E. SECTION 26 05 19 - Low-Voltage Conductors and Cables
- F. SECTION 26 05 26 - Grounding and Bonding for Electrical Systems
- G. SECTION 26 05 29 - Hangers and Supports for Electrical Systems
- H. SECTION 26 05 33 - Raceway and Boxes for Electrical Systems
- I. SECTION 26 05 43 - Underground Ducts and Raceways for Electrical Systems
- J. SECTION 26 05 44 - Sleeves and Sleeve Seals for Electrical Raceways and Cabling
- K. SECTION 26 05 53 - Identification for Electrical Systems
- L. SECTION 26 24 16 - Panelboards
- M. SECTION 26 27 26 - Wiring Devices
- N. SECTION 26 50 00 - Lighting
- O. DIVISION 31 - Earthwork:
- P. SECTION 40 05 57 - Electric Motor Actuators
- Q. SECTION 40 60 00 - Process Control and Instrumentation General Requirements
- R. SECTION 40 66 00 - Process Control Networks
- S. SECTION 40 67 00 - Control System Equipment
- T. SECTION 40 70 00 - Instrumentation For Process Systems

1.03 REFERENCE STANDARDS:

- A. Publication Dates: Comply with standards in effect as of the Issued For Construction (IFC) date of the Contract Documents unless otherwise indicated.
- B. American National Standards Institute (ANSI)
- C. ASTM International (ASTM)
- D. Federal Information Processing Standards Publication (FIPS)
- E. Insulated Cable Engineer's Association (ICEA)
- F. Institute of Electrical and Electronic Engineers (IEEE)
- G. National Electrical Contractors Association (NECA)
- H. National Electric Manufacturers Association (NEMA)
- I. National Electrical Installation Standards (NEIS)
- J. National Fire Protection Association (NFPA)
 - 1. National Electrical Code (NFPA 70)
 - 2. Standard for Electrical Safety in the Workplace (NFPA 70E)
- K. Telecommunications Industry Association (TIA)
- L. Underwriter's Laboratories, Inc (UL)

1.04 SUBMITTALS:

- A. Submit as specified in the General and Special Provisions.
- B. Refer to each SECTION of this DIVISION for specific Product Data, Shop drawing and additional Submittal requirements.
- C. Provide Conforming to Construction Records schematic diagrams and wiring diagrams.
- D. Product Data, manufactured equipment:
 - 1. Include data specification sheets, equipment cut sheets, outline drawings, electrical equipment ratings for pressure temperature and voltage.
- E. Shop Drawings, fabricated equipment:
 - 1. Include fabrication drawings, connection point size type and rating, field wiring and ratings for pressure, temperature, power, current and voltage.

SECTION 26 00 00 – General ELECTRICAL REQUIREMENTS: CONTINUED

2. Clearly specify any components not provided with requirement required for safe and proper operating of equipment.
- F. Coordination Drawings: in accordance with DIVISION 01, for equipment rooms, and other congested areas to a scale of 1/4 inch=1 foot-0 inch or larger if required. Detail major electrical Systems, Equipment and Material indicated on floor plans and section detail. Check for interferences with architectural, structural or mechanical systems, installations, and building components. Do not allow mechanical systems where plumbing or water systems are installed above electrical systems. Drawings shall indicate where space is limited for installation, maintenance access, working clearances. Drawings shall indicate where sequencing and coordination of Work is important for efficient flow of the Work and to reduce any rework. At a minimum include:
 1. Elevation size and route of raceways.
 2. Relationships and clearance distances between components and adjacent architectural, structural, electrical, and mechanical elements.
 3. Working clearances for equipment, including space for equipment disassembly required for periodic maintenance.
 4. Exterior wall and foundation penetrations.
 5. Fire-rated wall and floor penetrations.
 6. Equipment connections and support details.
 7. Size and location of concrete pads, footers and bases.
 8. Support details.
 9. Indicate scheduling, sequencing, movement, and positioning of large equipment into the building during construction.
 10. Elevations, sizes of sleeves to indicate penetrations in floors, walls, and ceilings, and their relationship to other penetrations and installations.
 11. Elevation of ceilings and ceiling components to coordinate and integrate installations, air outlets, air inlets, light fixtures, communications systems' components, sprinklers, heat detectors, smoke detectors, motion detectors, speakers, access panels and other ceiling-mounted devices.
 12. Coordinate chases, slots, inserts, sleeves, and openings with electrical equipment. In general verify all panel connections align with .
- G. As-Built Records:
 1. Redline all Contract Drawings and Shop Drawings to indicate changes after Issued For Construction (IFC) set of drawings.
 2. Include:
 - a. Major raceway systems, size and location for both exterior and interior; locations of control devices; distribution and branch electrical circuitry; disconnects, fuse size and location, circuit breaker sizes and arrangements.
 - b. Equipment locations dimensioned from prominent building lines.
 - c. Approved substitutions, Contract Modifications, and actual equipment and materials installed.
 3. Including changes resulting from:
 - a. Requests for Information (RFI).
 - b. Purchase Change Orders (PCO).

SECTION 26 00 00 – General ELECTRICAL REQUIREMENTS: CONTINUED

- c. Engineering Change Notices (ECN).
 - d. Requests for substitution or alternate products.
 - H. Operation and Maintenance (O&M) manuals: In addition to the requirements specified in DIVISION 01, include the following:
 - 1. Description of function, normal operating characteristics and limitations, performance curves, engineering data, tests, and complete nomenclature and commercial numbers of replacement parts.
 - 2. Manufacturer's printed operating procedures to include start-up, break-in, routine and normal operating instructions; regulation, control, stopping, shutdown, and emergency instructions; lockout/tagout procedures; and summer and winter operating instructions.
 - 3. Maintenance procedures for routine preventive maintenance and troubleshooting; disassembly, repair, reassembly; aligning and adjusting instructions.
 - 4. Product Data
 - 5. Shop Drawings
 - 6. Servicing instructions, lubrication charts and schedules.
 - 7. As-Built Records.
 - I. Field quality-control reports.
- 1.05 QUALITY CONTROL:
- A. Installer Qualifications:
 - 1. Contractor shall have electrical experience in the Water and Wastewater industry for at least 5 years performing similar type of work.
 - B. Materials and Equipment shall be the standard products of a manufacturer regularly engaged in the manufacture of such products and shall be the manufacturer's latest standard design that has been in satisfactory use for at least 1 year prior to Bid opening. Each major component of the equipment shall have the manufacturer's name and type identified on the equipment. All products supplied shall be specifically designed and manufactured for use with plant communications systems. All items of the same class of equipment shall be the products of a single manufacturer unless indicated otherwise.
- 1.06 SOURCE QUALITY:
- A. Tests, inspections: At the shop, factory, plant, or place of manufacture.
 - B. Verification of performance:
 - 1. All Equipment and Material designs furnished shall be identical to equipment and material designs having an acceptable history of domestic service for a period of not less than three years at comparable temperature, voltage, and design stress levels.
 - 2. Equipment and Material designs with less than three years of actual service will be considered from established manufacturers, but shall be furnished only if accepted by Engineer and Owner prior to award of Contract.
 - C. Source Limitations: To the fullest extent possible, provide products of the same kind from a single source.

SECTION 26 00 00 – General ELECTRICAL REQUIREMENTS: CONTINUED

1.07 DELIVERY, STORAGE, AND HANDLING:

- A. Packing, shipping, receiving and onsite storage:
 - 1. Deliver products to the Project Site properly identified with names, model numbers, types, grades, compliance labels, and Engineer's Tag Number indicated on the Contract Drawings.
 - 2. Protect all Equipment shipment from moisture and physical abuse which may cause:
 - a. Damage to movement, mechanisms, or electronics.
 - b. Corrosion.
 - c. Reduced normal operating life.
 - 3. Protect all Equipment connections including, but not limited to, motor electrical connections with suitable end covers to prevent entrance of foreign material.
 - 4. Handle package store all equipment according to the manufacturer's recommendations and requirements.

1.08 SITE CONDITIONS:

- A. All Equipment provided as part of this system shall be rated for the temperature, seismic and elevations as specified.

1.09 WARRANTY:

- A. Provide a minimum one-year warranty on all electrical Equipment and Systems. Warranty period shall begin after Project Site Final Acceptance unless specified otherwise. Contractor shall provide written notification to Owner prior to this warranty start date.

1.10 MAINTENANCE:

- A. Maintenance service.
- B. Extra materials.

PART 2 - PRODUCTS

2.01 GENERAL:

- A. Furnish and install Materials in accordance with NEC and NFPA 70E.
- B. All components and Material shall be new and free of defects using UL recognized components.
- C. All electrical Equipment, motors, panels, systems and skids shall be UL listed.
- D. Fabricated panels and skids in accordance with NEMA standards.
- E. All Equipment conductor termination shall be UL listed for 75°C unless specified otherwise.
- F. Identify and label with permanent labels all Equipment and Material used to complete this Work. Labels clearly indicating design intent in accordance with the Contract Drawings and as specified in DIVISION 26.
- G. Perform all Work Source Limitations: To the fullest extent possible, provide products of the same kind from a single source.

SECTION 26 00 00 – General ELECTRICAL REQUIREMENTS: CONTINUED

2.02 SYSTEMS:

- A. Furnish, install and make suitable for operation the following systems:
 - 1. 240/120 V, 1 phase, 60 hertz, 3 wire: lighting, receptacle power, and small power system.
 - 2. Lighting
 - 3. Grounding and bonding system.
 - 4. Underground duct banks, including handholes and manholes.
 - 5. Fiber Network.

2.03 ELECTRICAL MATERIAL SERVICE REQUIREMENTS:

- A. Refer to electrical drawing 00E-002.

PART 3 - EXECUTION

3.01 GENERAL

- A. Perform all Work in accordance with:
 - 1. NEC and NFPA 70E.
 - 2. NECA National Electrical Installation Standards (NEIS)
- B. Perform all Work necessary to furnish, receive, store, install, connect, tube, wire, pipe and commission electrical equipment:
 - 1. In strict accordance with the manufacturer's recommendations.
 - 2. To power and operate the systems and process.
 - 3. As specified and indicated on the motor schedule, equipment schedule, valve schedule, Process and Instrumentation diagrams (P&IDs), and Electrical Drawings.
- C. Provide all Material to mount on floor or wall.
- D. Concrete work for all electrical equipment pads, foundations, duct banks and other DIVISION 26 applications shall conform to DIVISION 03 – Concrete.
 - 1. Provide concrete mounting pads for equipment located outdoors.
 - 2. Provide housekeeping pads for Equipment located indoors.
- E. Install systems, Equipment and Material level, plumb, parallel, and perpendicular to other building systems and components, where installed in finished spaces.
- F. Install electrical Equipment and Material to facilitate servicing, maintenance, and repair or replacement of equipment components. As much as practical, connect equipment for ease of disconnecting with minimum of interference with other installations.
- G. Install raceways, cables, wireways, cable trays and busways clear of obstructions and clear of the required working space of equipment.
- H. Install systems, materials, and equipment giving right-of-way priority to systems required to be installed at a specified slope.
- I. Provide all equipment, materials, scaffolding, rigging, and tools to complete the Work.
- J. Provide all labor, including expert and common, specialized personnel, fitters, electricians, and attendance of such personnel.
- K. Electrical Plan Drawings shall be used to determine approximate location of Equipment to be installed and cable lengths. Contractor shall advise the Engineer of interferences.

SECTION 26 00 00 – General ELECTRICAL REQUIREMENTS: CONTINUED

- L. Equipment not indicated on the Electrical Plan Drawings but listed in the Equipment schedule, shall be field located by the Contractor with the assistance of the Engineer.
- M. Install permanent equipment labels for all Equipment, Material and devices or as directed by the Engineer.

3.02 COORDINATION AND SCHEDULING:

- A. Coordinate all installation activities involving others. Identify restraints caused by others which affect performance of the Work. Resolve such restraints where possible, and notify the Engineer when additional action is required to complete the Work.
- B. Provide a complete construction sequence document to:
 - 1. List construction milestones
 - 2. List electrical decommissioning activities
 - 3. List electrical commissioning activities
 - 4. Outline the needs for temporary construction power
 - 5. Demonstrate that all construction activities will not result in a loss of power or interruption to the system process.
- C. Coordinate connection of electrical systems with exterior underground and overhead utilities and services. Comply with requirements of governing regulations, franchised service companies, and controlling agencies. Provide required connection for each service.

3.03 PREPARATION:

- A. Verify existing Site conditions match the specifications.
- B. Verify the Contract Documents are consistent with the existing equipment and material installation. Notify Engineer of discrepancies.
 - 1. Verify all existing dimensions by field measurements.
 - 2. Arrange for chases, slots, and openings in other building components during progress of construction to allow for electrical installations.
 - 3. Coordinate the installation of required supporting devices and sleeves to be set in poured-in-place concrete and other structural components as they are constructed.
- C. Sequence, coordinate, and integrate installations of electrical materials and equipment for efficient flow of the Work. Give particular attention to large equipment requiring positioning prior to closing in the building. Coordinate concrete pads, bases, roof curbs, and related items.
- D. Verify final locations for rough-ins with field measurements and with the requirements of the actual equipment to be connected.
- E. Refer to equipment specifications in DIVISIONS 26 through 46 and the equipment submittals for rough-in requirements.

3.04 WORK ON EXISTING EQUIPMENT:

- A. Do not remove any equipment from service without obtaining permission from Owner and Engineer.
- B. Perform work that requires taking equipment out of service at times designated by Owner to cause minimum interruption in plant operation.

SECTION 26 00 00 – General ELECTRICAL REQUIREMENTS: CONTINUED

- C. Continue work with as many workmen as can be efficiently utilized from the time any equipment is removed from service until equipment is tested and back in service.
- D. Connect electrical Equipment to provide same phasing as existing equipment, unless otherwise specified or indicated.
- E. Disposal of existing fluorescent lamps shall be by Contractor shipping the lamps to an EPA approved recycler for recycling. All shipping and disposal costs will be paid by Contractor at no additional expense to Owner.
- F. Existing pre-1980 fluorescent lamp ballasts and ballasts not marked "no PCBs" (or are not dated with manufacturing date) shall be assumed to contain PCBs. Contractor shall dispose of PCB fluorescent ballasts by shipping the ballasts to an EPA approved PCB incineration facility. All shipping and disposal costs will be paid by Contractor at no additional expense to Owner.

3.05 INSTALLATION:

- A. Install systems, materials, and equipment to conform with approved submittal data, including coordination drawings, to greatest extent possible. Conform to arrangements indicated by the Contract Documents, recognizing that portions of the Work are shown only in diagrammatic form. Should coordination requirements conflict with individual system requirements, Notify the Engineer of any conflicts.
- B. Where mounting heights are not specifically detailed, specified, or dimensioned, install systems, materials, and equipment to provide the maximum headroom possible.
- C. All equipment conductor termination provisions and equipment lugs shall be UL listed for 75°C.
- D. All electrical equipment and installations shall be of adequate strength to withstand, without failure, forces encountered in defined Seismic conditions.
- E. Equipment provided by this Contractor motor horsepower, kilowatt or cable sizes is approximate; If the Contractor installs a different size or type, then at no additional cost to the Owner, the Contractor shall provide components, Equipment, and Materials as recommended by the equipment manufacturer or required to stay compliant with the NEC. Including but not limited to:
 - 1. Motor controller.
 - 2. Cables.
 - 3. Cable Lugs.
 - 4. Conduit.
 - 5. Fuses or circuit breakers.

3.06 TESTING:

- A. Test all electrical Equipment upon completion of installation to ensure that the Equipment operates satisfactorily to the Owner and conforms to Contract Documents.
- B. Furnish temporary power sources of proper type for testing purposes when normal supply is not available at the time of testing.

SECTION 26 00 00 – General ELECTRICAL REQUIREMENTS: CONTINUED

3.07 DEMOLITION:

- A. Protect existing electrical equipment and installations indicated to remain. If damaged or disturbed in the course of the Work, remove damaged portions and install new products of equal capacity, quality, and functionality.
- B. Accessible Work: Remove exposed electrical equipment and installations, indicated to be demolished, in their entirety.
- C. Abandoned Work: Cut and remove buried raceway and wiring indicated to be abandoned in place, 2 inches below surface of adjacent construction. Cap raceways and patch surface to match existing surface finish.
- D. Remove demolished material from Project Site.
- E. Remove, store, clean, re-install, reconnect and make operational components indicated for relocation.

3.08 CUTTING AND PATCHING:

- A. General: Cut, channel, chase, and drill floors, walls, partitions, ceilings, and other surfaces required to permit electrical installations. Perform cutting by skilled mechanics of the trades involved. In addition to the requirements specified in DIVISION 01, the following requirements apply:
 - 1. Perform cutting and patching for electrical equipment and materials required to:
 - a. Uncover work to provide for installation of ill-timed work.
 - b. Remove and replace defective work.
 - c. Remove and replace work not conforming to requirements of the Contract Documents.
 - d. Remove samples of installed work as specified for testing.
 - e. Install equipment and materials in existing structures.
 - f. Upon written instructions from Engineer, uncover and restore work to provide for Engineer's observation of concealed work if installed without using the proper specified procedures.
- B. For work in existing installations, the Contractor shall cut, remove, and legally dispose of selected electrical equipment, components, and materials as indicated, including, but not limited to, removal of electrical items indicated to be removed and items made obsolete by the new work.
- C. Protect the structure, furnishings, finishes, and adjacent materials not indicated or scheduled to be removed.
- D. Provide and maintain temporary partitions or dust barriers adequate to prevent the spread of dust and dirt to adjacent areas.
- E. Protection of Installed Work: During cutting and patching operations, protect adjacent installations.
- F. All penetrations through fire-rated walls, ceilings and floors shall be sealed with a UL listed and FM Global approved sealant system that matches the fire rating of the surface penetrated.
- G. Patch existing finished surfaces and building components that must be cut for the electrical installation or are damaged by Contractor using new materials matching existing materials.

SECTION 26 00 00 – General ELECTRICAL REQUIREMENTS: CONTINUED

3.09 FINISHES:

- A. Clean damaged and disturbed areas and apply primer, intermediate, and finish coats to suit degree of damage at each location.
- B. Follow paint manufacturer's written instructions for surface preparation and for timing and application of successive coats.
- C. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.
- D. Repair damage to PVC or paint finishes with matching touchup coating recommended by manufacturer.
- E. Repair damage to protective coatings in accordance with SECTION 09 90 00 - Protective Coatings.

3.10 CLEANING:

- A. On completion of installation, including outlets, fittings, and devices, inspect exposed finish. Remove burrs, dirt, paint spots, and construction debris.

3.11 PROTECTION:

- A. Protect equipment and installations and maintain conditions to ensure that coatings, finishes and cabinets are without damage or deterioration at time of Substantial Completion.

3.12 CLOSEOUT:

- A. Instructions, training, and manufacturer's service representative:
 - 1. Provide on-site instructions and training of Owner's personnel as specified.
 - 2. Provide on-site services of a manufacturer's authorized service representative as specified.

END OF SECTION 26 00 00

SECTION 26 05 19 – LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLE

PART 1 - GENERAL

1.01 RELATED DOCUMENTS:

- A. Drawings and general provisions of the Contract, including General and Special Conditions and DIVISION 01 Specification Sections, apply to this SECTION.

1.02 SUMMARY:

- A. This SECTION includes the requirements for furnishing and installing (including terminations) all low-voltage electrical conductors, cable, and accessories.

1.03 RELATED REQUIREMENTS:

- A. SECTION 26 00 00 - Electrical
- B. SECTION 26 05 26 - Grounding and Bonding for Electrical Systems
- C. SECTION 26 05 33 - Raceway and Boxes for Electrical Systems
- D. SECTION 26 05 36 - Cable Trays for Electrical Systems
- E. SECTION 26 05 43 - Underground Ducts and Raceways for Electrical Systems
- F. SECTION 26 05 44 - Sleeves and Sleeve Seals for Electrical Raceways and Cabling
- G. SECTION 26 05 53 - Identification for Electrical Systems
- H. SECTION 31 23 16 - Excavation and filling for structures.
- I. SECTION 40 66 00 - Process Control Networks.

1.04 REFERENCE STANDARDS:

- A. Publication Dates: Comply with standards in effect as of the date of the Contract Documents unless otherwise indicated.
- B. ASTM International (ASTM):
 - 1. ASTM B3 – Standard Specification for Soft or Annealed Copper Wire.
 - 2. ASTM B8 – Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft.
 - 3. ASTM B33 – Tin-Coated Soft or Annealed Copper Wire for Electrical Purposes.
 - 4. ASTM B172 – Rope-Lay Stranded Copper Conductors Having Bunch-Stranded Members, for Electrical Conductors.
- C. Insulated Cable Engineers Association (ICEA):
 - 1. ANSI/ICEA S-81-570 – 600Volt Rated Cables of Ruggedized Design for Direct Burial Installations as Single Conductors or Assemblies of Single Conductors.
 - 2. ANSI/ICEA S-105-692 – 600Volt Single Layer Thermoset Insulated Utility Underground Distribution Cables.
 - 3. ICEA T-29-520 – Vertical Cable Tray Flame Tests at 210,000 Btu.
- D. Institute of Electrical and Electronics Engineers (IEEE):
 - 1. IEEE 1202 – Flame-Propagation Testing of Wire and Cable.
- E. International Electrical Testing Association (NETA):
 - 1. ANSI/NETA ATS – Acceptance Testing Specifications for Electrical Power Equipment and Systems.

SECTION 26 05 19 – LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLE: continued

- F. National Electric Manufacturers Association (NEMA) and Insulated Cable Engineers Association (ICEA):
 - 1. ANSI/NEMA WC 53/ICEA T-27-581 – Standard Test Methods for Extruded Dielectric Power, Control, Instrumentation, and Portable Cables for Test
 - 2. NEMA WC57/ ICEA S-73-532 – Standard for Control, Thermocouple Extension, and Instrumentation Cables.
 - 3. ANSI/NEMA WC 70/ICEA S-95-658 – Nonshielded Power Cables Rated 2000 Volts or Less for the Distribution of Electrical Energy
- G. National Fire Protection Association (NFPA):
 - 1. NFPA 70 – National Electrical Code (NEC).
- H. Underwriters Laboratories, Inc. (UL):
 - 1. UL 44 – Thermoset Insulated Wires and Cables.
 - 2. UL 83 – Thermoplastic Insulated Wires and Cables.
 - 3. UL 854 – Service Entrance Cables.
 - 4. UL 1277 – Standard for Electrical Power and Control Tray Cables with Optional Optical Fiber Members.
 - 5. UL 1581 – Reference Standard for Electrical Wires, Cables, and Flexible Cords
 - 6. UL 1651 – Optical Fiber Cable.
 - 7. UL 1666 – Flame Propagation Height of Electrical and Optical Fiber Cables Installed in Vertical Shafts.
 - 8. UL 1685 - Vertical-Tray Fire-Propagation and Smoke-Release Test for Electrical and Optical-Fiber Cables

1.05 SUBMITTALS:

- A. Product Data: For each type of product submit the following marked for intended location and use:
 - 1. Data sheets for each wire and cable type specified.
 - 2. Data sheets for wire and cable accessories.
 - 3. Cable manufacturer's approval of splicing and terminating materials.
 - 4. Cable manufacturer's approval of pulling compounds.
 - 5. Cable manufacturer's installation requirements such as maximum pulling tensions, sidewall pressures, minimum bending radii, and other considerations.
 - 6. Other Equipment and Materials to be used.
- B. Special Procedure Submittals:
 - 1. Test Plan:
 - a. Provide a complete and detailed test plan for the fiber optic and network cabling system including a complete list of test equipment.
 - 2. Include procedures for certification, validation, and testing.

1.06 DELIVERY, STORAGE, AND HANDLING:

- A. Packing and shipping: Cable shall be shipped on reels such that it is protected from mechanical injury. Each end of each length of cable shall be hermetically sealed with manufacturer's end caps and securely attached to the reel. Cable

SECTION 26 05 19 – LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLE: continued

reels shall be delivered vertically to allow for easy unloading. There shall be a minimum of six (6) inches between the top of the cable and the edge of the reel. Any cable reels that are not shipped vertically may be rejected upon delivery.

- B. Storage and protection: Cable stored and/or cut on site shall have the ends turned down, and sealed with cable manufacturer's standard cable end seals, or field-installed heat-shrink cable end seals.
- C. Cable shall be stored on-site in a fashion that will prevent mechanical damage to the cable. Cable shall be stored away from areas that may have splashing or airborne debris. If necessary, cable shall be protected from hazards by visqueen, tarps, or similar materials.

1.07 QUALITY CONTROL:

- A. Factory Tests:
 - 1. Quality Control Test Protocol: The manufacturer shall conduct tests according to industry standard requirements. These tests shall be performed routinely on sample sizes sufficient to verify quality and continuity or as specified.
 - 2. The end-to-end attenuation of each reel of fiber optic cable supplied shall be tested. All of the fibers per reel shall be tested. The results shall be recorded and provided with the cable when shipped. A copy of these test reports shall be submitted to Contractor.
- B. Fiber Optic Cable Site Tests:
 - 1. Upon delivery of the fiber optic cable to the specified location, the Contractor shall perform acceptance testing.
 - 2. Perform optical fiber end to end attenuation tests using an optical light meter and manufacturer's recommended test procedures.
 - 3. Perform tests in accordance with TIA-526-14-B, Method B for horizontal, multimode optical fiber.
 - 4. Copies of the tests showing the attenuation results for each fiber shall be submitted to the Contractor no later than 5 days after acceptance of the cable.
 - 5. Any visible damage to the cable construction should be brought to the Contractor's attention immediately.
 - 6. Refer to PART 3 – EXECUTION for additional site testing requirements.
- C. Installer Qualifications:
 - 1. Prior to installation, submit data of installer's experience and qualifications.
 - 2. Network equipment installers shall be a Building Industry Consulting Service International (BICSI) Registered Cabling Installation Technician or have experience which shall include 3 years on projects of similar complexity.
 - 3. Include names and locations of two projects successfully completed using managed Ethernet switches, optical fiber and copper communications cabling systems.
 - 4. Include written certification from users that systems have performed satisfactorily for not less than 18 months.

SECTION 26 05 19 – LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLE: continued

5. Include specific experience in installing and testing structured communications distribution systems using managed Ethernet switches, optical fiber, and Category 6 cabling systems.

PART 2 - PRODUCTS

2.01 MANUFACTURERS:

- A. Cable Connectors for Control and Instrument Cable:
 1. TE Connectivity Ltd.
 2. Hollingsworth Solderless Terminal Company.
 3. Panduit Corporation.
 4. 3M Company.
 5. Thomas and Betts Company, Inc.
- B. Cable Connectors for Power Cable:
 1. TE Connectivity Ltd.
 2. Thomas and Betts Company, Inc.
 3. 3M Company.
 4. Panduit Corporation.
- C. Termination and Splice Kits:
 1. 3M Company.
 2. Raychem.
- D. Tape and Insulation Putty:
 1. 3M Company.
- E. Cable Ties:
 1. TE Connectivity Ltd.
 2. Avery-Dennison Corporation.
 3. Panduit Corporation.
 4. 3M Company.
 5. Thomas and Betts Company, Inc.
- F. Cable Supports:
 1. Emerson - O. Z./ Gedney Company.
 2. Hubbell, Kellems Grips.
- G. Terminal Blocks:
 1. Allen Bradley.
 2. Buchanan.
 3. Phoenix Contact.
 4. Square D Company.
 5. Weidmuller.
- H. Cable Identification Tags:
 1. Allen Marking Products.
 2. Panduit.
 3. Specialty Products Company.
 4. Thomas and Betts.
 5. Brady Corporation.
- I. Fiber-Optic Cables:

SECTION 26 05 19 – LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLE: continued

1. AFL.
2. Avaya Inc.
3. Belden Inc.
4. Berk-Tek, Nexans.
5. Draka Cableteq USA Corporation, Prysmian Group.
6. Corning Optical Communications.
7. CommScope Inc.
8. General Cable Technologies Corporation.
9. Mohawk, Belden Inc.
10. Optical Cable Corporation.
11. Superior Essex Inc.
- J. Fiber-Optic Cable Connectors, Duplex Jumpers, Patch Panels and Accessories:
 1. AFL.
 2. Avaya Inc.
 3. Black Box Corporation
 4. Corning Optical Communications.
 5. Optical Cable Corporation.
 6. Ortronics, Legrand.
 7. Panduit.

2.02 WIRE AND CABLE:

- A. General:
 1. All cables surface printing on the cable shall show manufacturer's name, cable type and size, number of conductors, insulation type, and Underwriters Laboratories (UL) Listed.
 2. All cable shall be tested and certified to be in conformance with UL1581 and UL 1685 for the following:
 - a. Flame exposure
 - b. Riser cable
 - c. Crush
 - d. Impact
 - e. Flex
 - f. Pull
 3. For location and area classification refer to SECTION 26 00 00, Electrical Material Service Requirements table:
 - a. For cables routed through a dry, wet or corrosive environments, cable insulation shall be:
 - (1) Cross-linked polyethylene "XLPE" and rated as Type XHHW-2.
 - (2) XHHW-2 tested and certified to be in conformance with UL 44.
 - b. For cables routed through cable tray cable insulation shall be TC tested and certified to be in conformance with UL 1277.
 - c. All cables shall be suitable for operation under the following maximum conductor temperatures:
 - (1) 90°C --- Continuous, dry locations
 - (2) 75°C --- Continuous, wet locations

SECTION 26 05 19 – LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLE: continued

- d. For corrosive environments all conductors and terminations should be tin coated.
 - e. For cables that enter into a hazardous location the cables shall meet or exceed the hazardous area location rating.
 - 4. All thermocouple extension cables shall be tested and certified to be in conformance with ANSI/NEMA WC 57.
- B. Communication Cables: As specified in the Cable Schedule.
 - 1. Tested and certified to be in conformance with UL 444, UL 1666, UL 1685 and ANSI/TIA-568-C.2.
 - 2. Suitable for transmitting 1000BASE-TX Gigabit Ethernet, 100BASE-T Fast Ethernet.
 - 3. Provide industrial ethernet cables as specified for the areas indicated below:
 - a. For plant process areas and electrical rooms (Category 6 SF/UTP):
 - (1) 300 V RMS.
 - (2) Overall foil shield plus tinned copper braid shield.
 - (3) Solid bare 26 AWG stranded copper conductors.
 - (4) Bonded pairs.
 - (5) Polyethylene insulation.
 - (6) Riser type CMR/CMX outdoor rated (non-plenum).
 - (7) Black UV resistant PVC jacket, with rip cord.
- C. Control Cables: As specified in the Cable Schedule.
 - 1. All Control and Instrument cables shall be tested and certified to be in conformance with ANSI/NEMA WC 53.
 - 2. 600 V RMS.
 - 3. Conductor Size #14 AWG
 - 4. Provide cables with shields based on application:
 - a. Unshielded for 120 VAC control signals.
 - b. Shielded for 24 VDC control signals. Aluminized mylar or polyester tape and tinned copper drain wire.
 - 5. Single conductor cable:
 - a. Class B stranded annealed copper.
- D. Fiber Optic Cables: as specified in the cable schedule
 - 1. Provide fiber with number of strands as indicated on the cable schedule.
 - 2. All cable supplied shall meet the flame test requirements of UL 1666 and the crush, impact, and flex resistance test requirements of TIA-455-41 and flex resistance testing TIA-455-104.
 - 3. ICEA-S-83-596, ICEA-S-104-696 , ANSI/TIA-568.3-D, UL Listed Type OFNR (UL 1666) and FT4, NEC SECTION 770.179(b) OFNR for use in vertical runs in building riser shafts from floor to floor.
 - 4. Provide overall armored fiber for exposed or trenched fiber which may be accessible to rodents.
 - 5. Provide Fiber type based on the length of run:
 - a. Less than one mile: Multimode
 - (1) Distribution class grade.
 - (2) 900 micrometer Tight Buffered low smoke PVC.

SECTION 26 05 19 – LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLE: continued

- (3) Acrylate Fiber Coating. Water Blocking Aramid Yarn Strength Members.
 - (4) Flame retardant PVC for riser applications.
 - (5) Indoor/Outdoor water and fungus resistant PVC outer jacket with rip cord.
 - (6) OM3 ISO/IEC 11801 with Core Cladding Diameter 62.5 micrometer, color coding according to TIA-598-C. 10 Gb/s.
 - (7) Max attenuation 4.1 db/km @ 850 / 1.2 db/km @ 1300nm
- b. Greater than one mile: Single mode Fiber
 - (1) Distribution class grade.
 - (2) Loose Buffered
 - (3) Outdoor harsh environment rated for direct burial and wet environments.
 - (4) Medium density polyethylene jacket.
 - (5) Indoor/Outdoor water and fungus resistant PVC outer jacket with rip cord.
 - (6) OS2 ISO/IEC 24702 with Core Cladding Diameter 125 micrometer, color coding according to TIA-598-C.
 - (7) Max attenuation 0.4 db/km @ 1310 / 0.3 db/km @ 1550nm.
- E. Ground Conductors: Applies to all cables as specified in SECTION 26 05 26 - Grounding and Bonding for Electrical Systems and as indicated on the electrical Grounding Drawings.
 - 1. Annealed, bare copper
 - a. Uncoated for general service
 - b. Tin-coated for corrosive environments
 - 2. Solid in sizes 4 AWG and smaller. (ASTM B3)
 - 3. Class B stranded in sizes 2 AWG and larger (ASTM B8)
- F. Instrument Cables: As specified in the Cable Schedule
 - 1. All Control and Instrument cables shall be tested and certified to be in conformance with ANSI/NEMA WC 53.
 - 2. 600 V RMS.
 - 3. Conductor Size #16 AWG
 - 4. Class B or C stranded annealed copper.
 - 5. Color coding shall be Method 1 (NEMA WC57/ICEA S 73-532 Appendix E, Paragraph. E3.1) using color pigmented compounds with colors as designated by Table E-2 (K-2).
 - 6. Polyvinyl chloride "PVC" and rated for outdoor use.
- G. Power Cables: Applies to all cables to provide power for Wiring Devices and Lighting fixtures and as specified in the Cables schedule.
 - 1. All Power cables shall be tested and certified to be in conformance with ANSI/NEMA WC 70.
 - 2. Individual conductors or multi-conductor cables shall be identified by means of solid colors, stripes, or printing, and in accordance with NEMS WC 70.
 - 3. Conductor sized as specified in the cable schedule, with a minimum of #12 AWG or larger.

SECTION 26 05 19 – LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLE: continued

4. Single conductor cable shall be used as specified in the cable schedule, outdoors and in underground duct bank applications:
 - a. Class B stranded annealed copper.
5. Polyvinyl chloride "PVC" oil resistant jacket, rated for outdoor use.

2.03 CONNECTORS:

- A. General Requirements:
 1. Designed and sized for specific cable being connected.
 2. Solderless, pressure type connectors constructed of non-corrodible tin plated copper.
 3. Application tooling for connectors shall contain die or piston stops to prevent over crimping and cycling or pressure relief to prevent under crimping. Dies of all application tooling shall provide dot or wire size coding for quality control verification. All tooling shall be manufactured by the connector manufacturer.
- B. Power Connectors (10 AWG and Smaller) 600V and Below:
 1. "Scotchlok" pre-insulated spring wire connectors.
 2. Buchanan open end copper splicing caps, applied with "Lok Seal" tool, with nylon snap on insulators.
- C. Power Connectors (sizes 8 to 4 AWG) 600V and Below:
 1. Non-insulated ring tongue type.
 2. Ring tongue sized to match terminal stud size.
 3. Brazed barrel seam.
 4. Application tooling designed to crimp the wire barrel (conductor grip) with a one-step crimp.
- D. Power Connectors (sizes 2 AWG to 750 MCM) 600V and Below:
 1. Non-insulated one hole rectangular tongue for sizes 2 AWG through 3/0 AWG and two hole rectangular tongue for 4/0 AWG through 750 MCM.
 2. Acceptable manufacturers' cross reference chart is listed at end of this SECTION.
- E. Power Connectors (sizes 2 AWG to 750 MCM) above 600V:
 1. Non-insulated one hole rectangular tongue for sizes 2 AWG through 3/0 AWG and two hole rectangular tongue for 4/0 AWG through 750 MCM.
 2. Voltage rating equal or greater than that of the cable being used.
 3. Application tooling shall be hydraulically operated.
- F. Control, Instrument, and Specialty Cable Connectors:
 1. Tin plated copper.
 2. Vinyl or nylon pre-insulated ring tongue type.
 3. Vinyl pre-insulated spring type spade terminals. (Hollingsworth "Mini Spring Spades"; Thomas and Betts "Locking Fork"; Panduit "Locking Fork.")
 4. Sized to match terminal stud size.
 5. Have insulation grip sleeve to firmly hold to cable insulation.
 6. Insulation grip sleeve shall be funneled to facilitate wire insertion and prevent turned back strands.
 7. Application tooling designed to crimp the wire barrel (conductor grip) and the insulation grip sleeve with a one-step crimp.

SECTION 26 05 19 – LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLE: continued

2.04 MOTOR LEAD TERMINATION/SPLICE (LOW VOLTAGE, 600 V AND BELOW, POWER CABLE):

- A. Splices shall be made using compression type connectors bolted together. The compression type connectors shall be properly sized for the cables. Reference acceptable connector manufacturer's cross reference chart.
- B. Splice to be covered with heat shrinkable tubing connector insulators or slip-on rubber boot or sleeve.
- C. Splicing shall be done in accordance with the instructions provided with the Raychem brand MCK Motor Connector Kit or 3M Company 5300 Series Motor Lead Splice Kit.

2.05 CABLE SUPPORTS:

- A. Cable supports for cables in vertical conduit risers shall be Emerson – O.Z. Gedney Type "R" wedging plug type or approved equal.

2.06 CABLE TIES:

- A. Nylon self-locking type.
- B. Have a normal service temperature range of 40°C to 85°C.
- C. Be weather resistant type for outdoor use.
- D. TE Connectivity "AMP TY," Avery-Dennison "BAR LOK," Panduit Corporation "PAN TY," Thomas & Betts "TY RAP," or 3M Brand cable ties.

2.07 TERMINAL BLOCKS:

- A. For mounting in terminal boxes (TBs):
 - 1. Designed and sized for the cables being terminated.
 - 2. Block rated 600V.
 - 3. Binding screw type terminals for power cables and strap screw or tubular clamp terminals for control and instrument cables.
 - 4. Rated current carrying capacity equal to or greater than the cable being terminated.
 - 5. Marking strip.
- B. For Mounting in Cabinets, Panels, Control Boards, etc.:
 - 1. Designed and sized for the cables being terminated.
 - 2. Block rated 600V.
 - 3. Binding screw type terminals for power cables and current transformer circuits and strap screw or tubular clamp terminals for control and instrument cables.
 - 4. Rated current carrying capacity equal to or greater than the cable being terminated.
 - 5. Marking strip on blocks for power cables and control and instrument cables.
 - 6. Short circuit strips with one shorting screw for each terminal for current transformer circuits.
 - 7. Shorting type terminal blocks rated for 10 AWG shall be used for all cables connected to current transformers (CTs).

SECTION 26 05 19 – LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLE: continued

2.08 CABLE IDENTIFICATION TAGS:

- A. Provide cable tags identification as specified in SECTION 26 05 53.

2.09 FIBER-OPTIC PATCH PANELS:

- A. Shall be a complete system of components by a single manufacturer, and shall provide termination, splice storage, routing, radius limiting, cable fastening, storage, and cross connection.
- B. Shall be capable of terminating number of fibers indicated.
- C. Shall be equipped with strain-relief and routing guides for incoming cables to ensure minimum bend radius is not exceeded.
- D. Patch panels shall be provided with adapter plates loaded with LC connectors that utilize zirconia ceramic alignment sleeves. Connectors shall be provided with dust covers.
- E. Epoxyless crimp style LC connectors compatible with the fiber and shall have maximum attenuation of not more than 0.5 dB.
- F. Shall be provided with labeling space, panel directory and warning labels.
- G. Panel Mounted:
 - 1. Single compartment enclosure with fiber optic adaptors mounted in the side of unit.
 - 2. Shall be mounted in NEMA 12 enclosure or control panels as indicated.
 - 3. Coordinate size of patch panel with control panel manufacturer.

PART 3 - EXECUTION

3.01 INSTALLATION:

- A. General Requirements:
 - 1. Conceal cables in finished walls, ceilings, and floors unless otherwise indicated.
 - 2. Install exposed cables parallel and perpendicular to surfaces of exposed structural members, and follow surface contours where possible.
 - 3. Install in conduit, duct system, or direct burial as indicated.
 - 4. Cable shall not be subjected to pulling tensions or sidewall pressures in excess of the manufacturer's recommendations.
 - 5. Attach pulling grips over the cable sheath to prevent slipping of the insulation.
 - 6. Do not subject cable to bending radius less than those recommended by the cable manufacturer or as noted below (whichever is greater) during or after installation:
 - a. Eight times the cable outside diameter for 600V or lower rated cables.
 - 7. Install intermediate pull boxes as indicated or as required to avoid subjecting cable to excessive pulling tension or sidewall pressures.
 - 8. Support cables at connections or termination points such that any strain on cable will not be transmitted to the connection or termination.
 - 9. Install cable supports in vertical runs of conduit, at boxes and at terminations in equipment, and as required to meet intermediate support requirements of National Electrical Code (NEC).

SECTION 26 05 19 – LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLE: continued

10. All pulling compounds shall be approved by wire and cable manufacturer as being compatible with cable materials.
11. Attach a cable identification tag to each cable at all termination or end points.
12. Install fire and smoke stop fittings at all cable penetrations of fire rated walls, floors, and ceilings.
13. Install conduit seals for conduits that terminate in a junction box located in an area identified as Hazardous (Classified) Location on the Contract Drawings.
- B. Power (600V and Below), Control, Instrument, and Specialty Cable:
 1. Install metallic barrier in all boxes to separate power, control, and instrumentation from low level signal (50V or less) instrumentation circuits where run in the same box.
 2. Tie together with cable ties all single conductor cable on each individual circuit in each junction box, and equipment or manhole at intervals not to exceed 6 feet.
 3. Attach a cable identification tag to each cable.
 - a. At each terminal to identify the circuit and cable.
 - b. Attach fiber tags with cable ties.
 - c. Use nylon ties and identification tabs color coded as follows:
 - (1) 480V circuits – Red.
 - (2) 277, 240, or 208Vac circuits – Orange.
 - (3) 120V circuits – White.
 - (4) Control cables – Natural Nylon.
 4. Insulation Color Coding for Phase Identification:
 - a. Color code 600-volt insulated, service entrance, feeder, and branch circuit conductors with factory-applied colored insulation for No. 8 AWG and smaller (except: No. 6 AWG and smaller for green ground wire); 1-inch band of colored tape at all splices and terminations for No. 6 AWG and larger (except: No. 4 AWG and larger for green ground wire) as follows:

<u>Phase</u>	<u>208Y/120</u> <u>Volts</u>	<u>480Y/277</u> <u>Volts</u>
A	Black	Brown
B	Red	Orange
C	Blue	Yellow
Neutral	White	Gray
Ground	Green	Green

- b. Tag each individual conductor or wire with wire markers as follows:
 - (1) With terminal designation indicated on schematic diagrams or given on manufacturer's equipment drawings.
 - (2) At each terminal.
 - (3) In addition to specified circuit tags.

SECTION 26 05 19 – LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLE: continued

- c. Terminate and ground, control, instrument, and specialty cable shields as indicated and recommended by the manufacturer of the equipment being connected. In general, ground the shields at the control panels.
- d. Intermediate cable splices shall not be allowed when installing power, control, and instrument wiring except when spicing to lead wires provided with the equipment or device, or unless approved by the Engineer prior to cable installation.
- e. Control and instrument and thermocouple cable splices shall be as follows:
 - (1) Made only in junction or terminal boxes.
 - (2) Made on terminal blocks with marking strips.
 - (3) Conductor color coding shall be maintained.
 - (4) For shielded cables, shield continuity and isolation shall be maintained.
 - (5) Thermocouple cable splices to be made only on terminal blocks which correspond to thermocouple type used.
- f. Power cable (600V or below) splices and motor terminations shall be as follows:
 - (1) Made only in junction or terminal boxes.
 - (2) Splices shall be made using compression type connectors bolted together.
 - (3) Splice to be covered with a heat shrinkable connector insulator.
- g. High-Temperature Wiring:
 - (1) Install from device to a terminal box for all devices which by their location have the body of the device or electrical connection subject to ambient temperatures in excess of 185°F. Typical locations are feed water heaters, burner fronts, boiler penthouse, and deaerator.
 - (2) Locate terminal box far enough from the source of heat so that the temperature does not exceed 175°F. This distance generally is between 3 and 5 feet.
 - (3) Replace with high-temperature wire any wiring installed by this Contract that is damaged by excessive heat.
- 5. Lighting Cable: Install as specified in DIVISION 26.
- 6. Ground Cable: Install as specified in DIVISION 26.
- 7. Control and Instrument Cable: Install as specified in this SECTION.
- 8. Communications Cable: Install as specified in this SECTION.
- C. Direct buried cables:
 - 1. Excavation and backfilling shall be as specified in DIVISION 31.
 - 2. Installation:
 - a. Install in trenches at least 36 inches below finished grade, except at railroad crossings and under roads or other paved areas exceeding 5 feet in width.
 - b. Where direct burial cable crosses under railroad tracks, roads, or other paving exceeding 5 feet in width, install cable in concrete encased Schedule 40 PVC conduit. If railroad tracks or paving are in place when

SECTION 26 05 19 – LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLE: continued

the cable is to be installed, a wrought iron pipe driven under the tracks or paving may be used in lieu of the nonmetallic conduit. Extend conduit or pipe at least 5 feet beyond each side of railroad tracks and at least 1 foot beyond the edge of paving.

- c. The bottom of the trench shall be smooth and free of stones and sharp objects. Where bottom of trench comprises material other than sand or earth, place a 3 inch layer of sand- or stone free earth on the bottom of the trench and compact to the approximate density of the surrounding firm soil.
 - d. Unreel the cables in place along the side of or in the trench and carefully place on the sand or earth bottom. Prereeling cables into the trench from a fixed reel position will not be permitted, except as required to pull the cables through conduits under railroad tracks or paving.
 - e. Where cables cross, provide a separation of at least 3 inches, unless the cables are protected by nonmetallic sleeves at the crossing.
 - f. The radius of bends in cables shall be not less than 10 times the diameter of the cable. In no case shall cables be left under longitudinal tension.
 - g. The first layer of backfill shall be of sand- or stone free earth.
 - h. Place a 1 inch treated plank, not less than 8 inches wide, or approved equal protection, approximately 3 inches above the cable.
 - i. Place a 6 inch wide yellow Mylar marking tape approximately 12 inches above the buried cable. The tape shall have the following wording printed at intervals along the tape: "Caution Electrical Lines Buried Below." Tape shall be as manufactured by Allen Marking Products.
 - j. Where cuts are made in paving, restore the paving and subbase to original condition.
 - k. Center direct burial cable in an entrance to a conduit or duct line. An approved waterproof non-hardening mastic compound shall be used to facilitate the centering.
3. Locate cable markers and splice markers:
- a. Locate as indicated.
 - b. Place approximately 2 feet to the right of the cable or splice when facing the longitudinal axis of the cable and in the direction of the electrical load.
 - c. The marker shall be Class B concrete, 6 inch square or round section by 3 feet long. The top edge of the marker shall have a 1/2 inch chamfer all around. The letter "C" with two arrows shall be impressed or cast on top of the marker. One arrow shall be located below the letter and shall point toward the cable or splice. When pointing toward a splice, the circle shall be impressed in the shaft of the arrow. The second arrow shall be located adjacent to the letter and shall point in a direction parallel to the cable. The letter and arrow adjacent to it shall each be approximately 3 inches long. The arrow under the letter shall be approximately 2 inches long. The letter and arrows shall be V shaped

SECTION 26 05 19 – LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLE: continued

- and shall have a width of stroke at least 1/4 inch at the top and depth of 1/4 inch.
- d. Where the cable changes direction, the arrow located adjacent to the letter shall be cast or impressed with an angle in the arrow approximately the same as the angular change of the cable run. The top of the marker shall protrude not more than 2 inches above finished grade.
- D. Cable Connections and Terminations:
 - 1. Make up clean and tight to assure a low-resistance joint.
 - 2. Make only in terminal boxes, equipment or other accepted enclosures and not in conduit.
 - 3. Install all connectors with tooling manufactured by the connector manufacturer and as specified.
- E. Fiber Optic Cable:
 - 1. Contractor shall exercise due caution during installation of the fiber-optic cable to prevent damage to glass fibers. Follow manufacturer's recommendations for maximum cable lengths.
 - 2. Fiber optic cable shall not be spliced, pull continuous run of cables from patch panel to patch panel as specified in the cable schedule.
 - 3. Install cables in conduit and underground duct bank as indicated and specified.
 - 4. All pull boxes and termination cabinets shall be clearly identified as containing fiber-optic cable.
 - 5. Install pull boxes as required and patch panels at the end of each fiber cable.
 - 6. Terminate each strand of fiber on a patch panel to complete and protect the Work. No strands should be left unterminated.
 - 7. Cable Bends:
 - a. Make gradual bends of cable, where necessary.
 - b. Do not allow cable to be sharply bent or kinked at any time.
 - c. Maximum bending radius per the cable manufacturer.
 - d. Verify that after installation the cable tie support do not places excessive strain on fiber or over time cause the fiber to exceed its bend radius.
 - 8. Cable Pulling:
 - a. Do not exceed manufacturer's recommended pulling tension.
 - b. Tension shall be monitored at all times with a dynamometer or with a pulling wheel.
 - 9. Cable identification tags shall be installed at each pull box.
 - 10. Label cable at each termination points with unique number for each cable segment.
 - 11. Cable Ties: Dress cables neatly with cable ties using low to moderate pressure.
 - 12. Testing Cables: Testing shall be performed in accordance with TIA-568-C.0.
 - a. Clean all connections and adapters at each optical test point prior to taking measurements, as per TIA-526-14-B.
 - b. The recommended test method shall be TIA-526-14B method B.

SECTION 26 05 19 – LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLE: continued

13. Cable Slack:
 - a. Leave extra slack on cables, neatly coiled-up in patch panel box.
 - b. Leave a minimum of 10 feet of cable slack at each manhole and fiber patch panel.
14. Do not install cables taut.
- F. Fiber Optic Patch Panels:
 1. Install rack mounted patch panels in equipment racks and as indicated.
 2. Install panel mounted enclosures in NEMA rated enclosure or control panels as specified and indicated. For panels installed in equipment manufacturer's control panels coordinate with supplier for required panel space and location.
 3. Arrange with proper clearances from other equipment and material to obtain accessibility for operation and maintenance.
 4. Install adaptor plates and connectors in accordance with manufacturer's recommendations.
 5. Utilize panel spools for slack management of individual fibers.
 6. Mount plumb and level.
 7. Complete panel directory and labeling.

3.02 FIELD QUALITY CONTROL:

- A. Perform tests and inspections and prepare test reports. Submit test reports as specified.
- B. General Requirements:
 1. Test all wire, cable, and electrical equipment installed or connected by Contractor to assure proper installation, setting, connection, and functioning as indicated or to conform to Contract Documents and manufacturer's instructions.
 2. Conduct all tests except megger insulation testing in the presence of Engineer and/or Owner and under the supervision of Equipment manufacturer's field engineer.
 3. Include all tests recommended by the Equipment manufacturer unless specifically waived by Engineer.
 4. Include all additional tests issued by Engineer that he deems necessary because of field conditions to determine that Equipment and Material and systems meet requirements of Contract Documents.
 5. Include all tests recommended by the NETA Acceptance Testing Specifications.
 6. The contractor shall be responsible for all damage to Equipment or Material due to improper test procedures or test apparatus handling.
- C. Cable Testing Requirements:
 1. Megger all 600V insulated power cable with a 1000Vdc megger for one minute, and values must not be less than 50 megohms per NETA ATS 7.3. Determine the values with all switchboards, panelboards, fuse holders, switches, and overcurrent devices in place. Do not connect motors and transformers during meggering. Megger wire and cable after installation and not on the cable reel.

SECTION 26 05 19 – LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLE: continued

2. Cables with conductors failing this test shall be removed and replaced.
 3. Provide all phasing tests and make all changes necessary to assure proper rotation of all motors, the correct phasing and phase sequence of all circuits susceptible to being paralleled, the proper polarity on all instrument transformer wiring, and such other phasing tests as may be required for the equipment being connected under this Contract.
- D. 600V Control Cable:
1. Check all control cable for rightness of terminal contacts.
 2. Megger the specific control cables selected by Engineer. The quantity of cables required to be meggered will not exceed 10% of the control cable installed by this Contract. Megger as described for 600V power cable after installation, but with cables disconnected from control panels and other equipment.
 3. All control cables shall have a continuity check performed on each conductor to ensure the conductance of each wire before the wires are terminated.
 4. Cables with conductors failing this test shall be removed and replaced.
- E. Quality Control:
1. Test Reports:
 - a. Submit as specified in DIVISION 01.
 - b. Maintain a written record of all tests showing date, personnel making tests, equipment used, Equipment or Material tested, tests performed, and results.
 - c. Notify Engineer two weeks prior to commencement of all testing except for megger tests.

END OF SECTION 26 05 19

SECTION 26 05 26 – GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS:

- A. Drawings and general provisions of the Contract, including General and Special Conditions and DIVISION 01 Specification SECTIONS, apply to this SECTION.

1.02 SUMMARY:

- A. This SECTION specifies electrical grounding and bonding Work by this Contract.
- B. Provide a grounding system as indicated on Drawings and schedules and as specified herein.
- C. Ground each System specified in SECTION 26 00 00 PART 2 SYSTEMS. To protect the systems from lightning, line surges or high voltage to stabilize the systems.
- D. Bond each conduit and electrical equipment enclosure with the source to create a low impedance ground-fault current path facilitating operation of the overcurrent protection devices.
- E. Type of electrical grounding and bonding Work specified in this SECTION includes solidly grounded systems.
- F. Applications of electrical grounding and bonding Work in this SECTION includes the following:
 - 1. Underground metal piping.
 - 2. Underground metal water piping.
 - 3. Underground metal structures.
 - 4. Metal building frames.
 - 5. Electrical power systems.
 - 6. Grounding electrodes.
 - 7. Ground test wells.
 - 8. Counterpoise grounding loops.
 - 9. Separately derived systems.
 - 10. Cable tray.
 - 11. Raceways.
 - 12. Service equipment.
 - 13. Boxes and enclosures.
 - 14. Equipment.
 - 15. Lighting standards and poles.
 - 16. Lightning protection systems.
 - 17. Antenna Masts.
 - 18. Chain-link fences and gates.

1.03 RELATED REQUIREMENTS:

- A. SECTION 26 00 00 - Electrical
- B. SECTION 26 05 19 - Low-Voltage Conductors and Cables
- C. SECTION 26 05 33 - Raceway and Boxes for Electrical Systems
- D. SECTION 26 05 53 - Identification for Electrical Systems
- E. SECTION 26 24 16 - Panelboards
- F. SECTION 26 27 26 - Wiring Devices

SECTION 26 05 26 – GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS:
continued

- G. SECTION 26 50 00 - Lighting
- H. DIVISION 28 - Access Control.
- I. DIVISION 31 - Earthwork:
- J. SECTION 40 05 57 - Electric Motor Actuators
- K. SECTION 40 05 93 - Common Motor Requirements for Process Equipment
- L. SECTION 40 60 00 - Process Control and Enterprise Management Systems
- M. SECTION 40 63 00 - Control System Equipment
- N. SECTION 40 66 00 - Process Control Networks
- O. SECTION 40 67 00 - Control System Equipment Panels
- P. SECTION 40 70 00 – Instrumentation for Process Systems
- Q. SECTION 31 23 33 - Trenching and Backfilling for Utilities
- R. SECTION 31 20 50 – Site Preparation and Earthwork.

1.04 REFERENCE STANDARDS:

- A. Publication Dates: Comply with standards in effect as of date of the Contract Documents unless otherwise indicated.
- B. ASTM International (ASTM):
 - 1. ASTM B3 - Soft or Annealed Copper Wire.
 - 2. ASTM B8 - Concentric Lay Stranded Copper Conductors, Hard, Medium-Hard, or Soft.
 - 3. ASTM B33 - Tin-Coated Soft or Annealed Copper Wire for Electrical Purposes.
- C. Institute of Electrical and Electronic Engineers (IEEE):
 - 1. IEEE 80 - Guide for Safety in Substation Grounding.
 - 2. IEEE 81 - Guide for Measuring Ground Resistance, and Potential Gradient in the Earth.
 - 3. IEEE 3003.1 - Recommended Practice for the System Grounding of Industrial and Commercial Power Systems.
 - 4. IEEE 3003.2 - Recommended Practice for Equipment Grounding and Bonding in Industrial and Commercial Power Systems.
- D. National Electrical Contractors Association (NECA) Installation Standards.
- E. National Fire Protection Association (NFPA):
 - 1. NFPA 70 - National Electrical Code (NEC)
- F. Underwriters Laboratories (UL):
 - 1. UL 467 - Standard for Safety Grounding and Bonding Equipment.
 - 2. UL 486A - Wire Connectors and Soldering Lugs for Use with Copper Conductors.
 - 3. UL 869 - Electrical Service Equipment.
 - 4. UL 891 - Switchboards.

1.05 SUBMITTALS:

- A. Product Data: Submit manufacturer's data on all grounding and bonding components and associated accessories.
- B. Qualification Data: For Qualified Testing Agency and testing agency's field Supervisor.

SECTION 26 05 26 – GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS:
continued

C. All field test reports.

1.06 QUALITY CONTROL:

- A. Testing Agency Qualifications: Must be a member company of NETA or an NRTL.
 - 1. Testing Agency's Field Supervisor: Currently certified by NETA to supervise on-site testing.
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- C. Comply with UL 467 for grounding and bonding materials and equipment.

PART 2 - PRODUCTS

2.01 MANUFACTURERS:

- A. Subject to compliance with requirements, provide grounding and bonding products of one of the following (for each type of product):
 - 1. Grounding Products:
 - a. Anderson Electrical Products, Hubbell Inc.
 - b. Burndy LLC.
 - c. Cadweld, Erico, nVent Electric, plc.
 - d. Crouse-Hinds, Eaton.
 - e. Erico, nVent Electric, plc.
 - f. Copperweld Bimetallics, LLC.
 - g. Harger Lightning and Grounding.
 - h. Ideal Industries, Inc.
 - i. Joslyn, MacLean Power Systems.
 - j. Myers, Crouse-Hinds, Eaton.
 - k. O-Z/Gedney, Emerson Electric Company.
 - l. Preferred Lightning Protection, Inc.
 - m. Thomas & Betts, ABB Group.
 - n. Engineer-approved equal.

2.02 GROUNDING AND BONDING:

- A. Materials and Components:
 - 1. General: Except as otherwise indicated, provide electrical grounding and bonding systems indicated; with assembly of materials, including, but not limited to, cables/wires, connectors, solderless lug terminals, grounding electrodes, bonding jumper braid, surge arresters, and additional accessories needed for a complete installation. Where more than one type component product meets indicated requirements, selection is Contractor's code-compliance option. Where materials or components are not indicated, provide products which comply with NEC, UL, and IEEE requirements and with established industry standards for those applications.
 - 2. Conductors: as specified in SECTION 26 05 19.
 - a. For buried and exposed grounding conductors as specified for Grounding Conductors.

SECTION 26 05 26 – GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS:
continued

- b. Bonding conductors shall be the same as specified for Power Cables.
- c. Equipment grounding conductors shall be as specified for Power Cables and in the cable schedule.
- 3. Separately derived systems: Ground each separately derived system as required by the NEC Article 250.
- 4. Service Surge Protection: Refer to SECTION 26 43 13. Ground according to manufacturer's installation requirements and recommendations.
- 5. Grounding Bus: Predrilled rectangular bars of annealed copper, 1/4 by 4 inches (6.3 by 100 mm) in cross section, with 9/32-inch (7.14-mm) holes spaced 1-1/8 inches (28 mm) apart. Stand-off insulators for mounting shall comply with UL 891 for use in switchboards, 600V. Lexan or PVC, impulse tested at 5,000V.
- 6. Bonding Plates, Connectors, Terminals, and Clamps: Provide electrical bonding plates, connectors, terminals, lugs, and clamps as recommended by bonding plate, connector, terminal, and clamp manufacturers for indicated applications.
 - a. Bolted Connectors for Conductors and Pipes: Copper or copper-alloy, pressure type with at least two silicon bronze or stainless-steel bolts and lock washers.
 - b. Bolted Service Connectors for Structural Steel: Shall have high-conductivity bronze alloy bolts and corrosion-resistant copper alloy nuts.
 - c. Irreversible Compression Fittings: Pure wrought copper extrusion clamps and connectors, made to be held in the dies of an installation tool. Connectors must be factory filled with an oxide inhibitor.
 - d. Welded Connectors: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.
 - e. Bus-Bar Connectors: Mechanical type, cast silicon bronze, solderless exothermic-type wire terminals and long-barrel, two-bolt connection to ground bus bar.
- 7. Ground Rods or Ground Electrodes:
 - a. Ground Rods or Grounding Electrodes: Copper-clad steel or copper-alloy, sectional type rods. One end pointed to facilitate driving, 3/4-inch diameter by 10 feet.
- 8. Electrical Grounding Connection Accessories: Provide electrical insulating tape, heat-shrinkable insulating tubing, welding materials, bonding straps, as recommended by accessories manufacturers for type service required or indicated.
- 9. Mastic Coatings:
 - a. Sonneborn-Sonoshield Mastics (BASF Construction Chemicals LLC).
 - b. W.R. Meadows - Sealmastic.

SECTION 26 05 26 – GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS:
continued

PART 3 - EXECUTION

3.01 INSTALLATION:

- A. Install electrical grounding and bonding systems as indicated, in accordance with manufacturer's instructions and applicable portions of NEC, NECA's "Standards of Installation," and in accordance with recognized industry practices to ensure that products comply with requirements.
- B. A grounding electrode shall be installed at each building or structure as indicated.
 - 1. Grounding electrodes shall consist of the following:
 - a. Ground rod and cable system.
 - b. Concrete-encased electrode.
 - c. Grounded metal frame of the building or structure.
 - d. Metal underground water pipe.
 - e. Other systems or structures as indicated.
- C. Ground Rods:
 - 1. Install rods as indicated by driving and not by drilling or jetting.
 - 2. Drive rods into unexcavated portion of the earth where possible.
 - 3. Where rods must be installed in excavated areas, drive rods into earth after compaction of backfill is completed.
 - 4. Drive to a depth such that top of rods will be approximately 18 inches below final grade or subgrade, and connect main grid ground cable thereto.
 - 5. Interconnect ground rods with grounding electrode conductor below grade and as otherwise indicated. Make connections without exposing steel or damaging coating if any.
 - 6. Separation between ground rods shall be equal to or greater than the length of the rods.
 - 7. The ground electrode conductor shall not contain splices between the ground electrode and the service entrance equipment.
 - 8. For grounding electrode system, install at least three rods spaced at least one-rod length from each other and located at least the same distance from other grounding electrodes, and connect to the service grounding electrode conductor.
- D. Counterpoise Ring: Install a grounding conductor, electrically connected to each building structure ground rod and to each indicated item, extending around the perimeter of building area or item indicated.
 - 1. Install a ground conductor for the ground ring and for taps to building steel.
 - 2. Bury ground ring not less than 24 inches (600 mm) from building's foundation.
- E. Test Wells: Test well handholes shall be at least 12 inches (300 mm) deep, with cover.
 - 1. Ground rod driven through drilled hole in bottom of handhole.
 - 2. Install at least one test well for each service unless otherwise indicated. Install at the ground rod electrically closest to service entrance.
 - 3. Set top of test well flush with finished grade or floor.
- F. Grounding Conductors:

SECTION 26 05 26 – GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS:
continued

1. Install solid conductor for No. 8 AWG and smaller, and stranded conductors for No. 6 AWG and larger unless otherwise indicated.
2. Install using as few joints as possible. Route along shortest and straightest paths possible unless otherwise indicated or required by Code.
3. Avoid obstructing access or placing conductors where they may be subjected to strain, impact, or damage. Suitably protect cable against damage during construction.
4. Replace or suitably repair cable if damaged by anyone before final acceptance.
5. In Exposed Installations:
 - a. Route runs as indicated.
 - b. Route along the webs of columns and beams, and in corners where possible for maximum physical protection.
 - c. Where physical protection is required, install in PVC conduit unless indicated otherwise.
 - d. Support at intervals of 3 feet or less with nonmagnetic clamp-type supports.
6. In Buried Installations:
 - a. Conductor sizes shall be as indicated for specific connections. For required connections not indicated, use conductor size not less than No. 3/0 AWG if buried in the earth or cast in concrete, or No. 6 AWG at other locations.
 - b. Lay in bottom of trench or in other excavations at the depth of the top of the ground rod.
 - c. Bury at least 30 inches (600 mm) below grade.
 - d. Maintain clearance of at least 12 inches from all underground metal piping or structures, except where connections thereto are specifically indicated.
 - e. Ground cable shall enter the bottom of electrical gear or panels sitting on a slab through a PVC sleeve.
7. Backfill as specified in DIVISION 31
8. Duct-Bank Grounding Conductor: Bury 12 inches (300 mm) above duct bank when indicated as part of duct-bank installation.
- G. Ground Bonding Common with Lightning Protection System: Comply with NFPA 780 and UL 96A when interconnecting with lightning protection system. Bond electrical power system ground directly to lightning protection system grounding conductor at closest point to electrical service grounding electrode. Use bonding conductor sized same as system grounding electrode conductor, and install in conduit.
- H. Bonding Straps and Jumpers: Install in locations accessible for inspection and maintenance except where routed through short lengths of conduit.
 1. Bonding to Structure: Bond straps directly to basic structure, taking care not to penetrate any adjacent parts.
 2. Bonding to Equipment Mounted on Vibration Isolation Hangers and Supports: Install bonding so vibration is not transmitted to rigidly mounted equipment.

SECTION 26 05 26 – GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS:
continued

3. Use exothermic-welded connectors for outdoor locations; if a disconnect-type connection is required, use a bolted clamp.
- I. Conductor Terminations and Connections:
 1. Pipe and Equipment Grounding Conductor Terminations: Bolted connectors with silicon bronze or stainless-steel bolts and lock washers.
 2. Underground Connections: Provide exothermic welded connections where grounding conductors connect to underground grounding conductors and underground grounding electrodes.
 3. Connections to Ground Rods at Test Wells: Bolted connectors.
 4. Connections to Structural Steel:
 - a. Exothermically welded connectors where allowed by the structural steel.
 5. Clean metal contact surfaces of clamp-on connectors to ensure electrical conductivity and circuit integrity.
 6. Exothermic terminations:
 - a. Conform to manufacturer's instructions.
 - b. Chemically degrease and dry completely before welding.
 - c. Apply one coat of mastic coating to all exothermic-welded connections to be buried.
 7. Bond grounding conductor to reinforcing steel mat in at least four locations using compression fittings designed for the intended purpose.
 8. The grounding connection to the supplemental electrode shall be bonded by either exothermic welding or irreversible compression fittings.
 9. Extend a bonding conductor from concrete-encased electrode, below grade and out to building's grounding grid and bond.
 10. Extend a bonding conductor from at least one concrete-encased electrode out of the concrete and bond to the grounding electrode.
- J. Grounding for Steel Building Structure:
 1. Install a driven ground rod – part of the counterpoise system - at base of each corner column and at intermediate exterior columns at distances not more than 60 feet (18 m) apart.
 2. Extend a bonding conductor from the counterpoise system to the structural steel and exothermically weld or connect with an irreversible compression fitting to the hold-down bolts securing the structural steel column to the support footing or foundation.
 3. Exothermically weld to connect the counterpoise system to the steel building column.
 4. Extend a bonding conductor from the counterpoise system to the structural steel as indicated. Drill and tap a preinstalled, grounding plate welded to the structural steel and secure the bonding conductor to the building steel with a service post.
- K. Grounding Bus: Install in electrical equipment rooms, in rooms housing service equipment, and elsewhere as indicated.
 1. Install bus horizontally, on insulated spacers 2 inches (50 mm) minimum from wall, 6 inches (150 mm) above finished floor unless otherwise indicated.

SECTION 26 05 26 – GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS:
continued

2. Where indicated on both sides of doorways, route bus up to top of door frame, across top of doorway, and down to specified height above floor; connect to horizontal bus.
3. Insulate and support grounding bus at intervals not to exceed 2 feet on centers or as indicated.
- L. Grounding and Bonding of Metal Underground Water Pipe:
 1. Metal Water Service Pipe: Install insulated copper grounding conductors, in conduit, from building's main service equipment, or grounding bus, to main metal water service entrances to building. Connect grounding conductors to main metal water service pipes. Use a bolted clamp connector or bolt a lug-type connector to a pipe flange by using one of the lug bolts of the flange. Where a dielectric main water fitting is installed, connect grounding conductor on street side of fitting. Bond metal grounding conductor conduit or sleeve to conductor at each end.
 2. Water Meter Piping: Use braided-type bonding jumpers to electrically bypass water meters. Connect to pipe with a bolted connector.
 3. Gas Piping: If installed in, or attached to, a building or structure, bond each aboveground portion of gas piping system downstream from equipment shutoff valve. Metal underground gas piping systems shall NOT be used as a grounding electrode.
 4. Metal Process Water Pipes:
 - a. For a small or medium-sized pipe, connect the pipe to the ground system at an exposed location using a mechanical bolted clamp connector with silicon bronze hardware.
 - b. Follow manufacturer's instructions for cleaning pipe and applying oxide inhibiting compound around perimeter of connector.
- M. Grounding Manholes and Handholes:
 1. Install a driven ground rod through manhole or handhole floor, close to wall, and set rod depth so 4 inches (100 mm) will extend above finished floor.
 2. If necessary, install ground rod before manhole is placed and provide No. 1/0 AWG minimum bare, tinned-copper conductor from ground rod into manhole through a waterproof sleeve in manhole wall.
 3. Protect ground rods passing through concrete floor with a double wrapping of pressure-sensitive insulating tape or heat-shrunk insulating sleeve from 2 inches (50 mm) above to 6 inches (150 mm) below concrete.
 4. Seal floor opening with waterproof, non-shrink grout.
- N. Grounding Connections to Manhole Components:
 1. Bond exposed-metal parts such as inserts, cable racks, pulling irons, ladders, and cable shields within each manhole or handhole, to ground rod or grounding conductor.
 2. Make connections with No. 4 AWG minimum stranded, hard-drawn copper bonding conductor.
 3. Train conductors level or plumb around corners and fasten to manhole walls.
 4. Connect to cable armor and cable shields according to written instructions by manufacturer of splicing and termination kits.

SECTION 26 05 26 – GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS:
continued

- O. All grounding system components shall be bonded to form one continuous grounding electrode.
- P. Ground electrical service system neutral at service entrance equipment to grounding electrodes.
- Q. Ground each separately derived system neutral to the main building ground system:
- R. Bond the system neutral to service entrance equipment enclosures.
- S. Ground all exposed noncurrent carrying metal parts of electrical equipment, metal raceway systems, grounding conductors in raceways and cables, receptacle ground conductors, and metallic plumbing systems.
- T. Tighten grounding and bonding connectors and terminals, including screws and bolts, in accordance with manufacturer's published torque tightening values for connectors and bolts. Where manufacturer's torqueing requirements are not indicated, tighten connections to comply with tightening torque values specified in UL 486A to assure permanent and effective grounding.
- U. Apply mastic coating to field connections, buried metallic grounding and bonding products, and places where factory applied protective coatings have been destroyed, which are subjected to corrosive action.

3.02 INSTALLATION - EQUIPMENT GROUNDING:

- A. Install insulated equipment grounding conductors with all feeders and branch circuits.
- B. Terminate feeder and branch circuit insulated equipment grounding conductors with grounding lug on substation, switchgear, switchboard, motor control center, or panelboard ground bus. When conduit enters from below and is not connected to the enclosure, ground equipment grounding conductor on conduit grounding bushing and then bond to ground bus (or grounded enclosure if there is no ground bus).
- C. Install insulated equipment grounding conductors with the following items, in addition to those required by NFPA 70:
 - 1. Feeders and branch circuits.
 - 2. Lighting circuits.
 - 3. Receptacle circuits.
 - 4. Single-phase motor and appliance branch circuits.
 - 5. Three-phase motor and appliance branch circuits.
 - 6. Flexible raceway and power cords runs.
 - 7. Busway Supply Circuits: Install insulated equipment grounding conductor from grounding bus in the switchgear, switchboard, or distribution panel to equipment grounding bar terminal on busway.
 - 8. Computer and Rack-Mounted Electronic Equipment circuits.
- D. Ground wireway at least once and at 10-foot intervals.
- E. Pad-Mounted Transformers and Switches: Install two ground rods and ground ring around the pad. Ground pad-mounted equipment and noncurrent-carrying metal items associated with substations by connecting them to underground cable and grounding electrodes. Install tinned-copper conductor not less than No. 2

SECTION 26 05 26 – GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS:
continued

- AWG for ground ring and for taps to equipment grounding terminals. Bury ground ring not less than 6 inches (150 mm) from the foundation.
- F. Bonding Interior Metal Ducts: Install insulated equipment grounding conductor to duct-mounted electrical devices operating at 120V and more, including air cleaners, heaters, blowers, fans, dampers, humidifiers, and other duct electrical equipment. Bond conductor to each unit and to air duct and connected metallic piping. Install copper bonding jumper to bond across flexible duct connections to achieve continuity.
 - G. Water Heater and Heat-Tracing Cables: Install a separate insulated equipment grounding conductor to each electric water heater and heat-tracing cable. Bond conductor to heater units, piping, connected equipment, and components.
 - H. Isolated Grounding Receptacle Circuits: Install an insulated equipment grounding conductor connected to the receptacle grounding terminal. Isolate conductor from raceway and from panelboard grounding terminals. Terminate at equipment grounding conductor terminal of the applicable derived system or service unless otherwise indicated.
 - I. Isolated Equipment Enclosure Circuits: For designated equipment supplied by a branch circuit or feeder, isolate equipment enclosure from supply circuit raceway with a nonmetallic raceway fitting listed for the purpose. Install fitting where raceway enters enclosure, and install a separate insulated equipment grounding conductor. Isolate conductor from raceway and from panelboard grounding terminals. Terminate at equipment grounding conductor terminal of the applicable derived system or service unless otherwise indicated.
 - J. Signal and Communication Equipment: In addition to grounding and bonding required by NFPA 70, provide a separate grounding system complying with requirements in TIA/ATIS J STD-607-A.
 - 1. For telephone, alarm, voice and data, and other communication equipment, provide No. 4 AWG minimum insulated grounding conductor in raceway from grounding electrode system to each service location, terminal cabinet, wiring closet, and central equipment location.
 - 2. Service and Central Equipment Locations and Wiring Closets: Terminate grounding conductor on a 1/4- by 4- by 12-inch (6.3- by 100- by 300-mm) grounding bus.
 - 3. Terminal Cabinets: Terminate grounding conductor on cabinet grounding terminal.
 - K. Metal and Wood Poles Supporting Outdoor Lighting Fixtures: Install a separate grounding conductor with branch-circuit conductors.
 - L. Ground fence enclosures at each post with Burndy Type GK and GAR connectors. Install flexible braid straps across all hinge points and gates for fence enclosures. Bond fence posts, gates, and fence material to ground where crossed above by a utility line.
 - M. Bond all motors and equipment 100 Hp or larger to the grounding electrode system with a minimum No. 6AWG bare copper wire.
 - N. Bond all motors with “identified” equipment grounding conductor. Route in conduit with phase conductors.

SECTION 26 05 26 – GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS:
continued

- O. Enclosure Grounds: Bond all enclosures by direct copper connection to the grounding electrode system.
- P. Building Grounding Conductors: Support at intervals not to exceed 3 feet on center or as indicated.

3.03 LABELING:

- A. Comply with requirements in Section 26 05 53 - Identification for Electrical Systems for instruction signs. The label or its text shall be green.
- B. Install labels at the telecommunications bonding conductor and grounding equalizer and at the grounding electrode conductor where exposed.
 - 1. Label Text: "If this connector or cable is loose or if it must be removed for any reason, notify the facility manager."

3.04 INSPECTION:

- A. Do not cover up connections before they are inspected by Engineer.
- B. Compression-type connections shall be inspected for embossment of proper die index per manufacturer's instructions.

3.05 FIELD QUALITY CONTROL:

- A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.
- C. Perform tests and inspections.
- D. Tests and Inspections:
 - 1. After installing grounding system but before permanent electrical circuits have been energized, test for compliance with requirements.
 - 2. Inspect physical and mechanical condition. Verify tightness of accessible, bolted, electrical connections with a calibrated torque wrench according to manufacturer's written instructions.
 - 3. All compression-type connections shall be inspected for proper die index number.
 - 4. Test completed grounding system at each location where a maximum ground-resistance level is specified, at service disconnect enclosure grounding terminal, at ground test wells, and at individual ground rods. Make tests at ground rods before any conductors are connected.
 - a. Measure ground resistance no fewer than two full days after last trace of precipitation and without soil being moistened by any means other than natural drainage or seepage and without chemical treatment or other artificial means of reducing natural ground resistance.
 - b. Perform tests by fall-of-potential method according to IEEE 81 for the following:
 - (1) Testing and commissioning of new grounds, not yet connected to the utility power supply.

SECTION 26 05 26 – GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS:
continued

- (2) Testing complex ground systems that include a metallic loop.
- c. A clamp-on ground tester may only be used if the Owner does not require strict adherence to IEEE 81 and for the following situations:
 - (1) To test installed grounds without disconnecting them from the utility.
 - (2) To test a grounding electrode configuration where the return path includes the earth. (This does not include a ground system that includes a metallic loop.)
 - (3) To test the resistance of a single rod in a series or array.
 - (4) To check errant current flow to ground for operator safety.
- 5. Prepare dimensioned Drawings locating each test well, ground rod and ground-rod assembly, and other grounding electrodes. Identify each by letter in alphabetical order, and key to the record of tests and observations. Include the number of rods driven and their depth at each location, and include observations of weather and other phenomena that may affect test results. Describe measures taken to improve test results.
- E. Prepare test and inspection reports.
- F. Maximum grounding values:
 - 1. Power and Lighting Equipment or System with Capacity of 500 kVA and Less: 10 ohms.
 - 2. Power and Lighting Equipment or System with Capacity of 500 to 1,000 kVA: 5 ohms.
 - 3. Power Distribution Units or Panelboards Serving Electronic Equipment: 1 ohm(s).
 - 4. Substations and Pad-Mounted Equipment: 5 ohms.
 - 5. Manhole Grounds: 10 ohms.
- G. Grounding system will be considered defective if any maximum grounding values are exceeded. Provide additional grounding grounding rods as necessary so that no maximum grounding value is exceeded.

END OF SECTION 26 05 26

SECTION 26 05 29 – HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS:

- A. Drawings and general provisions of the Contract, including General and Special Conditions and DIVISION 01 Specification SECTIONS, apply to this SECTION.

1.02 SUMMARY:

- A. This SECTION specifies hangers, supports, anchors, sleeves, and seals for electrical equipment and systems as well as construction requirements for concrete bases as indicated by Drawings and schedules and/or specified in other DIVISION 26 SECTIONS.
- B. Types of hangers, supports, anchors, sleeves, and seals specified in this SECTION include the following:
 - 1. Clevis hangers.
 - 2. Riser clamps.
 - 3. Steel rod coupling.
 - 4. C-clamps.
 - 5. I-beam clamps.
 - 6. One-hole conduit straps.
 - 7. Two-hole conduit straps.
 - 8. Hexagonal nuts.
 - 9. Round threaded steel rods.
 - 10. Conduit clamps.
 - 11. U-bolts.
 - 12. Lead expansion anchors.
 - 13. Toggle bolts.
 - 14. Wall, ceiling, roof and floor seals.
 - 15. Conduit cable supports.
 - 16. U-channel strut system.
 - 17. Fire and smoke stop compounds.

1.03 RELATED REQUIREMENTS:

- A. Concrete materials, reinforcement, and placement requirements are specified in DIVISION 03 – Concrete.
- B. SECTION 26 00 00 - General Electrical Requirements
- C. SECTION 26 05 26 - Grounding and Bonding for Electrical Systems
- D. SECTION 26 05 33 - Raceway and Boxes for Electrical Systems

1.04 REFERENCE STANDARDS:

- A. Publication Dates: Comply with standards in effect as of date of the Contract Documents unless otherwise indicated.
- B. ASTM International (ASTM):
 - 1. ASTM-A780 - Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings.

SECTION 26 05 29 – HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS:
continued

- 2. ASTM-E814 REV A - Standard Test Method for Fire Tests of Penetration Firestop Systems, pertaining to fire stop components.
- C. American Welding Society (AWS):
 - 1. AWS D1.1/D1.1M - Structural Welding Code - Steel.
- D. National Fire Protection Association (NFPA):
 - 1. NFPA-70 - National Electrical Code (NEC).
- E. National Electrical Contractors Association (NECA):
 - 1. NECA 1 – Standard Practice of Good Workmanship In Electrical Construction.
- F. Society of Protective Coatings (SSPC):
 - 1. SSPC-PA 1 - Shop, Field and Maintenance Painting of Steel.
- G. Underwriters Laboratories (UL):
 - 1. Provide electrical devices, components, and fire stops which are UL-listed and labeled.

1.05 PERFORMANCE/DESIGN CRITERIA:

- A. Delegated Design: Design supports for multiple raceways, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.
- B. Design supports for multiple raceways capable of supporting combined weight of supported systems and its contents.
- C. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.
- D. Rated Strength: Adequate in tension, shear, and pullout force to resist maximum loads calculated or imposed for this Project, with a minimum structural safety factor of five times the applied force.

1.06 SUBMITTALS:

- A. Product Data:
 - 1. Submit manufacture's data on supporting devices including catalog cuts, specifications, and installation instructions, for each type of support, anchor, sleeve, and seal.
- B. Shop Drawings:
 - 1. Submit dimensioned drawings of fabricated products, indicating weights, strength, details of fabrication, and details of materials.

1.07 QUALITY CONTROL:

- A. Welding: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."
- B. Comply with NEC.

SECTION 26 05 29 – HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS:
continued

1.08 COORDINATION:

- A. Coordinate size and location of supports. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified together with concrete specifications.
- B. Coordinate installation of roof curbs, equipment supports, and roof penetrations.

PART 2 - PRODUCTS

2.01 MANUFACTURERS:

- A. Anchor Manufacturers: Subject to compliance with requirements, provide anchors of one of the following manufacturers.
 - 1. Hilti, Inc.
 - 2. Ideal Industries, Inc.
 - 3. Joslyn Manufacturing Co., Inc.
 - 4. Eaton/Cooper; McGraw Edison Co.
 - 5. Unistrut; Atkore International.
- B. Channel System Manufacturers: Subject to compliance with requirements, provide channel system of one of the following manufacturers.
 - 1. Allied Tube & Conduit Corp.
 - 2. Eaton/Cooper; B-Line Systems, Industries.
 - 3. Erico International Corp.
 - 4. Kindorf; Thomas & Betts Corp.
 - 5. Power-Strut; Power Engineering Co.
 - 6. Unistrut; Atkore International.
- C. Fire and Smoke Stop Compounds: Subject to compliance with requirements, provide channel system of one of the following manufacturers.
 - 1. 3M Company.
 - 2. Hilti, Inc.

2.02 STEEL SUPPORT SYSTEMS:

- A. General: Provide supporting devices which comply with manufacturer's standard materials, design, and construction in accordance with published product information, as required for complete installation, and as herein specified. All supports shall be designed for the support of the maximum number of conduits and their maximum conductor weights for maximum conduit loading. Where more than one type of supporting device meets indicated requirements, selection is Contractor's option. Do not use perforated metal straps for supports.
- B. Provide as required to rigidly support all conduit runs, boxes, and equipment.
- C. Support conduit within 12 inch of enclosures to which conduits are attached.
- D. Do not exceed the manufacturers recommended distance between supports on horizontal or vertical runs.
- E. Supports: Supporting devices of types, sizes, and materials indicated, and having the following construction features.

SECTION 26 05 29 – HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS:
continued

1. Clevis Conduit Hangers: For supporting conduit; galvanized steel; with 3/8-, 1/2-, 5/8- or 3/4-inch rod, size of clevis and rod as required.
2. Riser Clamps: For supporting conduit, galvanized steel, with two bolts and nuts.
3. Steel Rod Couplings: Provide 3/8-, 1/2-, 5/8- or 3/4-inch straight rod couplings, size as required.
4. C-Beam Clamps: Galvanized steel, 3/8-, 1/2-, 5/8-, or 3/4-inch rod, size as required.
5. I-Beam Clamps: Galvanized steel, with 3/8, 1/2-, 5/8-, or 3/4-inch rod, size as required; 3/8-inch horizontal "J" hook safety rod that bolts across the flange, flange width as required.
6. One-Hole Conduit Straps: For supporting conduit; galvanized steel, size as required.
7. Two-Hole Conduit Straps: For supporting conduit, galvanized steel, size as required.
8. Hexagonal Nuts, Flat Washers and Lock Washers: For 3/8-, 1/2-, 5/8-, or 3/4-inch rod, size as required; galvanized steel.
9. Round Threaded Steel Rod: Galvanized steel, 3/8-, 1/2-, 5/8-, or 3/4-inch diameter, size as required. Minimum size is 3/8-inch diameter.
10. Conduit Clamps: For supporting conduit; galvanized stamped steel, size as required.
11. U-Bolts: For supporting conduit; galvanized, size as required.
- F. Fabricated supports:
 1. from structural steel or manufactured framing members equal to "Unistrut" P-3000 (1-5/8 inch by 1-3/8 inch) series as manufactured by Unistrut Corporation, Kindorf B-995 (1-1/2 inch by 1-1/2 inch) series as manufactured by Thomas and Betts, or Superstrut A-1200 (1-5/8 inch by 1-5/8 inch) series as manufactured by Thomas and Betts.
 2. Minimum 12 gauge.
- G. Hot-Dipped Galvanized Supports:
 1. Channel shall be hot-dipped galvanized after all manufacturing operations are complete.
 2. Channel shall have a minimum of 2.5 mils or 1.5 ounces of coating per square foot on each side of the steel and conform to ASTM A123 and ASTM A153.
 3. Provide conduit clamps and hangers finished with same process as the support and sized for the specific conduit size.
 4. Provide stainless-steel rods, anchors, inserts, bolts, washers, nuts with all other support hardware hot-dipped galvanized.
- H. Stainless-Steel Supports:
 1. Channel Type 304 stainless steel conforming to ASTM A240.
 2. Stainless-steel conduit clamps and hangers, sized for the specific conduit diameter.
 3. Provide stainless-steel rods, anchors, inserts, bolts, washers, nuts, and support hardware.

SECTION 26 05 29 – HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS:
continued

- I. Anchors: Anchors of types, sizes and materials indicated, with the following construction features.
 - 1. Lead Expansion Anchors: 1/2, 5/8, or 3/4 inch as required.
 - 2. Toggle Bolts: Springhead, 3/16 by 4 inch or larger size as required.
- J. Conduit Cable Supports: Cable supports with insulating wedging plug for nonarmored type electrical cables in risers; construct for rigid metal conduit (size as required) number of wires as required, type wire as specified; construct body of malleable-iron casting with hot-dip galvanized finish.
- K. U-Channel Strut Systems: Unless indicated otherwise, U-channel strut system for supporting electrical equipment, 12-gauge steel hot-dip galvanized after fabrication for wet and outdoor locations, 12-gauge standard green paint finish for dry and indoor locations, of types and sizes indicated; construct with 9/16-inch diameter holes, 8 inch o.c. on top surface, and with the fittings as required which mate and match with U-channel.
- L. Fire and Smoke Stop Compounds: Provide one of the following:
 - 1. 3M Fire Barrier 2000+.
 - 2. Hilti, Inc. FS-ONE MAX.

PART 3 - EXECUTION

3.01 ERECTION, INSTALLATION, APPLICATION:

- A. Install hangers, anchors, sleeves, and seals as specified, required, indicated, in accordance with manufacturer's written instructions and with recognized industry practices to insure supporting devices comply with requirements. Comply with requirements of NECA and NFPA 70 for installation of supporting devices.
- B. Install hangers, supports, clamps, and attachments to support conduit properly from building structure. Arrange for grouping of parallel runs of horizontal conduits to be supported together on trapeze type hangers where possible. Install supports with spacing indicated and as required by NFPA 70 or as indicated when less than NFPA 70 required spacing.
- C. Torque sleeve seal nuts, complying with manufacturer's recommended values. Ensure that sealing grommets expand to form watertight seal.
- D. Design trapeze type supports, including fasteners to the structure to carry the following loads:
 - 1. Outdoor supports shall have the following added to the calculated load:
 - a. Ice weighing 57 pounds per cubic foot to a thickness of 0.25 inches over the projected area of the supports and conduit being supported.
 - b. Snow weighing 8 pounds per square foot over the projected area of the conduit being supported.
 - c. Wind at 25 pounds per square foot acting in a downward direction.
 - 2. The greater of the following:
 - a. The total calculated load multiplied by a factor of 4.
 - b. The total calculated load +200 pounds.
- E. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.

SECTION 26 05 29 – HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS:
continued

- F. Repair damage to painted finishes with paint recommended by manufacturer.
- G. Install fire and smoke stop compounds at all penetrations of fire rated walls, floors, ceilings and roofs. Install fire and smoke stop compounds in accordance with manufacturer's instructions to provide a fire seal rating equal to or greater than that of the surface penetrated.
 - 1. Testing shall be performed in accordance with ASTM-E814 REV A and applicable local codes.
- H. Provide seismic support and bracing for all multiple conduit support trapezes plus individually supported conduit 2-1/2 inches and larger such that the supports shall resist the forces of a Seismic Factors event without collapse.
- I. Provide seismic support and bracing for all busway and cable tray such that the support shall resist the forces of Seismic Factors event without collapse.

3.02 CONCRETE BASES:

- A. Construct concrete bases of dimensions indicated but not less than 4 inches (100 mm) larger in both directions than supported unit, and so anchors will be a minimum of 10 bolt diameters from edge of the base.
- B. Use 3000-psi (20.7-MPa), 28-day compressive-strength concrete. Concrete materials, reinforcement, and placement requirements are specified in DIVISION 03 - Concrete.
- C. Anchor equipment to concrete base.
 - 1. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 - 2. Install anchor bolts to elevations required for proper attachment to supported equipment.
 - 3. Install anchor bolts according to anchor-bolt manufacturer's written instructions.

3.03 SUPPORTS:

- A. Construct with sufficient rigidity to hold all mounted equipment and material in permanent and neat alignment.
- B. Design to provide 1/4-inch space between equipment housings and walls or columns upon which they are mounted.
- C. Do not exceed load requirements in NEC and NEMA standards.
- D. Provide individual conduit hangers for supporting individual conduits.
- E. Provide trapeze hangers to support multiple conduit runs. Use trapeze hangers that are designed to support a load equal to or greater than the sum of the weights of the conduits, wires, hanger itself, and an additional 90 kg (200 lbs). Attach each conduit with U bolts or other approved fasteners.
- F. Support conduit independently of junction boxes, pull-boxes, fixtures, suspended ceiling T bars, angle supports, and similar items.

SECTION 26 05 29 – HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS:
continued

- G. Vertical Supports: Vertical conduit runs shall have riser clamps and supports in accordance with the NEC and as shown. Provide supports for cable and wire with fittings that include internal wedges and retaining collars.
- H. For galvanized members after Power Tool Cleaning SSPC-SP11, paint all welds, field cuts, and damaged areas with organic zinc-rich primer at 3-mils dry film thickness.
 - 1. Ameron - 68HS.
 - 2. Carboline - Carbozinc 859.
 - 3. International - Interzinc 52 HS.
 - 4. Tnemec - Tnemezinc 90-97.
- I. For coated supports, paint all welds, field cuts, and damaged areas with manufacturer's recommended paint.
- J. Use epoxy- or acrylic-coated supports, clamps, and straps, and zinc-plated hardware to support steel conduit.
- K. Use stainless-steel supports, clamps, and straps, and stainless-steel hardware to support steel conduit.
- L. Use stainless-steel or PVC-coated conduit straps to support PVC-coated rigid steel conduit. Use stainless-steel clamps for supporting PVC coated rigid steel conduit on stainless-steel supports.
- M. Use nonmagnetic conduit clamps to support nonmagnetic conduit.

3.04 PAINING:

- A. Touchup: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.
 - 1. Apply paint by brush or spray to provide minimum dry film thickness of 2.0 mils (0.05 mm).
- B. Clean and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal as required.
- C. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A780.

END OF SECTION 26 05 29

SECTION 26 05 33 – RACEWAYS, BOXES, SEALS, AND FITTINGS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS:

- A. Drawings and general provisions of the Contract, including General and Special Conditions and DIVISION 01 Specification SECTIONS, apply to this SECTION.

1.02 SUMMARY:

- A. This SECTION specifies raceway Work for this Contract.
- B. Provide raceway and material including:
 - 1. Conduit.
 - 2. Outlet and device boxes.
 - 3. Pull and junction boxes.
 - 4. Fittings.
 - 5. Bushings and ground bushings.
 - 6. Locknuts.
 - 7. Knockout closures.
 - 8. Grout.

1.03 RELATED REQUIREMENTS:

- A. SECTION 26 00 00 - General Electrical Requirements
- B. SECTION 26 05 26 - Grounding and Bonding for Electrical Systems
- C. SECTION 26 05 29 - Hangers and Supports for Electrical Systems
- D. SECTION 26 05 44 - Sleeves and Sleeve Seals for Electrical Raceways and Cabling
- E. SECTION 26 05 53 - Identification for Electrical Systems

1.04 REFERENCE STANDARDS:

- A. Publication Dates: Comply with standards in effect as of the Issued For Construction (IFC) date of the Contract Documents unless otherwise indicated.
- B. American National Standards Institute (ANSI):
 - 1. ANSI C80.1 - Electrical Rigid Steel Conduit (ERSC).
 - 2. ANSI C80.3 - Electrical Metallic Tubing – Steel (EMT-S).
 - 3. ANSI C80.6 - Electrical Intermediate Metal Conduit (EIMC).
- C. American Welding Society (AWS):
 - 1. AWS D1.1/D1.1M - Structural Welding Code - Steel.
- D. ASTM International (ASTM):
 - 1. ASTM A123/A123M - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
 - 2. ASTM A153/A153M. - Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
 - 3. ASTM A240/A240M - Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications.
 - 4. ASTM A780/A780M - Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings.

SECTION 26 05 33 – RACEWAYS, BOXES, SEALS, AND FITTINGS FOR ELECTRICAL SYSTEMS: continued

5. ASTM B117 -Standard Practice for Operating Salt Spray (Fog) Apparatus.
6. ASTM C1107/C1107M REV A - Standard Specification for Packaged Dry, Hydraulic-Cement Grout (Non-shrink).
7. ASTM D3917 REV A - Standard Specification for Dimensional Tolerance of Thermosetting Glass-Reinforced Plastic Pultruded Shapes.
8. ASTM D4385 - Standard Practice for Classifying Visual Defects in Thermosetting Reinforced Plastic Pultruded Products.
9. ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials.
10. ASTM F2160 - Standard Specification for Solid Wall High Density Polyethylene (HDPE) Conduit Based on Controlled Outside Diameter (OD).
- E. Joint Industrial Council (J.I.C.):
 1. Comply with standards for Oil and Dust Tight Lay-In Wireway.
- F. National Fire Protection Association (NFPA):
 1. NFPA 70 - National Electrical Code (NEC).
- G. National Electrical Contractor's Association (NECA):
 1. NECA NEIS 1 - Standard for Good Workmanship in Electrical Construction.
- H. National Electrical Manufacturers Association (NEMA):
 1. NEMA RN 1 - Polyvinyl-Chloride (PVC) Externally Coated Galvanized Rigid Steel Conduit and Intermediate Metal Conduit.
 2. NEMA TC 2 - Electrical Polyvinyl Chloride (PVC) Conduit.
 3. NEMA TC 3 - Polyvinyl Chloride (PVC) Fittings for Use with Rigid PVC Conduit and Tubing.
 4. NEMA TC 6 and 8 - Polyvinyl Chloride (PVC) Plastic Utilities for Underground Installation.
 5. NEMA TC 14.AG - Aboveground Reinforced Thermosetting Resin Conduit (RTRC) and Fittings.
 6. NEMA TC 14.BG - Belowground Reinforced Thermosetting Resin Conduit (RTRC) and Fittings.
 7. NEMA TC 14.XW - Extra Heavy Wall Aboveground Reinforced Thermosetting Resin Conduit (RTRC) and Fittings.
 8. NEMA OS 1 - Sheet-Steel Outlet Boxes, Device Boxes, Covers and Box Supports.
 9. NEMA OS 2 - Nonmetallic Outlet Boxes, Covers, and Box Supports.
 10. NEMA 250 - Enclosures for Electrical Equipment (1,000V Maximum).
- I. Society of Protective Coatings (SSPC):
 1. SSPC-PA 1 - Shop, Field and Maintenance Painting of Steel.
 2. SSPC-SP3 - Power Tool Cleaning.
- J. Underwriters' Laboratories, Inc. (UL):
 1. Provide all devices, components, and equipment that are UL listed and labeled.
 2. UL 1 - UL Standard for Safety Flexible Metal Conduit.
 3. UL 5 - UL Standard for Safety Surface Metal Raceways and Fittings.
 4. UL 5C - UL Standard for Safety Surface Raceways and Fittings for Use with Data, Signal, and Control Circuits.
 5. UL 6 - UL Standard for Safety Electrical Rigid Metal Conduit – Steel.

SECTION 26 05 33 – RACEWAYS, BOXES, SEALS, AND FITTINGS FOR ELECTRICAL SYSTEMS: continued

6. UL 6A - UL Standard for Safety Electrical Rigid Metal Conduit - Aluminum, Red Brass and Stainless Steel.
7. UL 50 - UL Standard for Safety Enclosures for Electrical Equipment, Non-Environmental Considerations.
8. UL 50E - UL Standard for Safety Enclosures for Electrical Equipment, Environmental Considerations.
9. UL 360 - UL Standard for Safety Liquid-Tight Flexible Metal Conduit.
10. UL 514A - UL Standard for Safety Metallic Outlet Boxes.
11. UL 514B - UL Standard for Safety Conduit, Tubing, and Cable Fittings.
12. UL 514C - UL Standard for Safety Nonmetallic Outlet Boxes, Flush-Device Boxes, and Covers.
13. UL 651 - UL Standard for Safety Schedule 40, 80, Type EB and A Rigid PVC Conduit and Fittings.
14. UL 651A - UL Standard for Safety Schedule 40 and 80 High Density Polyethylene (HDPE) Conduit.
15. UL 797 - UL Standard for Safety Electrical Metallic Tubing – Steel.
16. UL 797A - UL Standard for Safety Electrical Metallic Tubing – Aluminum and Stainless Steel.
17. UL 1203 - UL Standard for Safety Explosion-Proof and Dust-Ignition-Proof Electrical Equipment for Use in Hazardous (Classified) Locations
18. UL 1242 - UL Standard for Safety Electrical Intermediate Metal Conduit - Steel
19. UL 2024 - Optical Fiber Cable Raceway.
20. UL 2515 - UL Standard for Safety Aboveground Reinforced Thermosetting Resin Conduit (RTRC) and Fittings.

1.05 SUBMITTALS:

A. Product Data:

1. Submit manufacturer's technical product data, including conduit ratings, specifications, recommended installation applications (i.e. horizontal bore, direct burry, open trench) and installation instructions, for each type of product required. Include data substantiating that materials complies with the Contract Documents.
2. Submit manufacturer's data on supporting devices including catalog cuts, specifications, and installation instructions, for each type of support, anchor, sleeve, and seal.

B. Certifications:

1. Submit certifications for personnel responsible for installing conduit and fittings with PVC coated jackets.

1.06 QUALITY CONTROL:

- A. Welding: Qualify procedures and personnel according to AWS D1.1/D1.1M, Structural Welding Code - Steel.
- B. Comply with NEC.
- C. Installations shall follow standard practices of NECA NEIS 1.
- D. Installers of the PVC-coated galvanized rigid conduit system shall be certified by the manufacturer and be able to present a valid, unexpired certified installer card

SECTION 26 05 33 – RACEWAYS, BOXES, SEALS, AND FITTINGS FOR ELECTRICAL SYSTEMS: continued

prior to starting installation. All clamping, cutting, threading, bending, and assembly instructions given during the manufacturer's certified installation training shall be followed.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS:

- A. Rigid Galvanized-Steel Conduit (RGS) and Intermediate Metal Conduit:
 - 1. Allied Tube and Conduit, Atkore International.
 - 2. Western Tube and Conduit Corporation.
 - 3. Wheatland Tube Company, JMC Steel Group.
 - 4. Republic Conduit, Tenaris.
- B. Fittings for Rigid Steel Conduit and Intermediate Metal Conduit:
 - 1. Heavy-Duty Cast Malleable Iron Fittings:
 - a. Appleton, Emerson Electric Company.
 - b. Crouse-Hinds, Eaton.
 - c. Thomas & Betts, ABB Group.
 - 2. Conduit Expansion and Deflection Fittings:
 - a. O-Z/Gedney, Emerson Electric Company.
 - b. Thomas & Betts, ABB Group.
- C. Rigid Steel Conduit and Fittings with Bonded Polyvinyl Chloride (PVC) Jacket:
 - 1. OCAL, Thomas & Betts, ABB Group.
 - 2. Robroy Industries.
- D. Rigid Polyvinyl Chloride (PVC) Conduit and Fittings:
 - 1. IPEX Inc.
 - 2. North American Specialty Products.
 - 3. Carlon, Thomas & Betts, ABB Group.
 - 4. Cantex Inc.
- E. Reinforced Thermosetting Resin Conduit and Fittings:
 - 1. Champion Fiberglass, Inc.
 - 2. United Fiberglass of America, Inc.
- F. Surface Metal Raceway:
 - 1. Hubbell Wiring Systems.
 - 2. MonoSystems, Inc.
 - 3. Panduit.
 - 4. Wiremold; Legrand.
- G. Liquid-Tight Flexible Metal Conduit:
 - 1. AFC Cable Systems, Atkore International.
 - 2. Anamet Electrical, Inc.
 - 3. Electri-Flex Company.
 - 4. Southwire Company, LLC.
 - 5. Thomas & Betts, ABB Group.
- H. Flexible Metal Conduit:
 - 1. AFC Cable Systems, Atkore International.
 - 2. Anamet Electrical, Inc.
 - 3. Electri-Flex Company.
 - 4. Southwire Company, LLC.

SECTION 26 05 33 – RACEWAYS, BOXES, SEALS, AND FITTINGS FOR ELECTRICAL SYSTEMS: continued

- 5. Thomas & Betts, ABB Group.
- I. Outlet and Device Boxes:
 - 1. Appleton, Emerson Electric Company.
 - 2. Crouse-Hinds, Eaton.
 - 3. Killark, Division of Hubbell, Inc.
 - 4. Leviton Manufacturing Company, Inc.
 - 5. O-Z/Gedney, Emerson Electric Company.
 - 6. Thomas & Betts, ABB Group.
- J. Pull and Junction Boxes:
 - 1. Metallic Indoor and Outdoor Boxes:
 - a. B-Line, Eaton.
 - b. Hoffman, nVent Electric, plc.
 - c. Wiegmann, Hubbell Inc.
 - 2. Fiberglass Boxes:
 - a. Crouse-Hinds, Eaton, Krydon type.
 - b. Schneider Electric, Krydon type.
 - c. Hoffman, nVent Electric, plc.
- K. Conduit Hubs and Bodies:
 - 1. Appleton, Emerson Electric Company.
 - 2. Myers Industries, Inc. (ITT).
 - 3. Crouse-Hinds, Eaton.
 - 4. O-Z/Gedney, Emerson Electric Company.
 - 5. Thomas & Betts, ABB Group.
- L. Fittings:
 - 1. Crouse-Hinds, Eaton.
 - 2. Appleton, Emerson Electric Company.
 - 3. Thomas & Betts, ABB Group.
- M. Bushings, Grounding Bushings, and Locknuts:
 - 1. Arrow Hart, Eaton.
 - 2. Appleton, Emerson Electric Company.
 - 3. O-Z/Gedney, Emerson Electric Company.
 - 4. Raco, Hubbell, Inc.
 - 5. Steel City, Thomas & Betts, ABB Group.
- N. Electrical Enclosures:
 - 1. Hoffman, nVent Electric, plc.
 - 2. Saginaw Control and Engineering.
 - 3. Wiegmann, Hubbell, Inc.
- O. Anchor Manufacturers: Subject to compliance with requirements, provide anchors of one of the following manufacturers.
 - 1. Hilti, Inc.
 - 2. B-line, Eaton.
 - 3. Powers, DeWalt.
 - 4. Red Head, ITW.
 - 5. Unistrut, Atkore International.

2.02 DESIGN REQUIREMENTS:

- A. Conduit:

SECTION 26 05 33 – RACEWAYS, BOXES, SEALS, AND FITTINGS FOR ELECTRICAL SYSTEMS: continued

1. Each length of threaded conduit furnished with coupling on one end and metal or plastic thread protector on other end.
 2. Provide UL listed and labeled conduit, on each length, fittings, and accessories.
 3. Sizes of conduit, fittings, and accessories as indicated, specified, or as required by Electrical Codes and Standards.
- B. Supports: refer to SECTION 26 05 29.

2.03 RIGID GALVANIZED STEEL CONDUIT:

- A. Raceway:
1. Conform to ANSI C80.1, and UL 6.
 2. Mild ductile steel, circular in cross section with uniform wall thickness sufficiently accurate to cut clean threads.
 3. Each length threaded on both ends with threads protected.
 4. All scale, grease, dirt, burrs, and other foreign matter removed from inside and outside prior to application of coating materials.
 5. Galvanized by the hot-dip process as follows:
 - a. Interior and exterior surfaces coated with a solid, unbroken layer of 99% virgin zinc by dipping.
 - b. Coating not to show fixed deposits of copper after four 1-minute immersions in a standard copper sulfate solution.
 - c. One coat of zinc-chromate finish on inside and outside surfaces to prevent oxidation and white rust.
 6. Couplings and elbows fabricated, coated and finished by the same process as conduit.
- B. Fittings:
1. Heavy-Duty Cast Malleable Iron Fittings:
 - a. Mogul type for conduit sizes 1-1/2 inches and larger.
 - b. LBD or roller action type LB for right-angle fittings for conduit sizes 2 inches and larger.
 - c. Full-threaded hubs and rubber-gasketed covers.
 - d. Zinc, cadmium-plated, or bronze hardware bolts and screws for assembly.
 - e. Finished with cadmium plating or galvanizing.
 - f. Form 8 bodies and covers.
 - g. Standard and junction fittings.
 2. Conduit Expansion Fittings:
 - a. Line of Conduit Type:
 - (1) Galvanized expansion fittings for rigid conduit movement up to 4 inches.
 - (2) Insulated metal bushing on ends of the conduit, bonding jumper, and with expansion head sealed with a high-grade graphite packing.
 - (3) O-Z/Gedney, Type AX with Type AJ bonding jumper or Thomas & Betts, Type XJG.
 - b. End Type:

SECTION 26 05 33 – RACEWAYS, BOXES, SEALS, AND FITTINGS FOR ELECTRICAL SYSTEMS: continued

- (1) For conduit terminating in a junction box.
 - (2) O-Z/Gedney, Type EXE with Type BJ-E bonding jumper.
3. Conduit Expansion and Deflection Fittings:
 - a. Provide for movement of 3/4 inch from normal in all directions between two rigid conduits.
 - b. Integral bonding jumper.
 - c. O-Z/Gedney, Type DX.
4. Conform to NEMA Type 1 enclosure in all nonhazardous areas except as specified or indicated otherwise.

2.04 INTERMEDIATE METAL CONDUIT:

- A. Raceway:
 1. Lightweight rigid steel conduit. Conform to ANSI C80.6 and be UL 1242 listed.
 2. Fabricated from Grade 1010 steel and formed on an electric weld line.
 3. Each length threaded on both ends with threads protected.
 4. All scale, grease, dirt, burrs, and other foreign matter removed from inside and outside prior to application of coating materials.
 5. Galvanized by the hot-dip process as described for rigid steel conduit.
 6. No special equipment required for installation; standard bending, cutting, and threading equipment and hanging devices can be used in field installation.
- B. Fittings:
 1. Compatible with standard rigid steel conduit fittings.

2.05 RIGID STEEL CONDUIT AND FITTINGS WITH BONDED POLYVINYL CHLORIDE (PVC) COATING:

- A. General:
 1. The PVC coated conduit system is specifically designed to prevent corrosive conditions from causing early replacement of the conduit. All the conduit, fittings, and supporting products shall be provided by a single manufacturer.
 2. Installers of the PVC-coated galvanized rigid conduit system shall be certified by the manufacturer and be able to present a valid, unexpired certified installer card prior to starting installation. All clamping, cutting, threading, bending, and assembly instructions given during the manufacturer's certified installation training shall be followed.
- B. Raceway:
 1. Conform to hot-dipped galvanized rigid steel conduit as specified in RIGID STEEL CONDUIT, this SECTION, and as follows. Shall comply with NEMA RN1.
 2. PVC coating bonded to the conduit. Extruded PVC jackets are unacceptable.
 3. Coated externally with PVC to a nominal 40 mils, 0.035 inch to 0.045 inch.
 4. Uniformly coated around outside diameter and full length of the conduit.
 5. Pre-threaded ends coated with a urethane coating having a nominal thickness of 2 mils (0.002 inch).
 6. Interior surfaces of all conduits and feed-through fittings coated (except where prohibited by design) with a two-part, chemically cured, urethane coating having a nominal thickness of 2 mils (0.002 inch).

SECTION 26 05 33 – RACEWAYS, BOXES, SEALS, AND FITTINGS FOR ELECTRICAL SYSTEMS: continued

7. The bond strength between the metal and coating must exceed the tensile strength of the coating.
- C. Couplings, Elbows, and Fittings:
 1. Couplings, elbows, and other conduit fittings, boxes, cover plates, supports, hardware, and related items shall be treated and coated with the same process as conduit.
 2. Each coupling and fitting to include a PVC sleeve that overlaps the conduit.
 3. Length of the overlapping sleeve equals diameter of the conduit or 2 inches, whichever is least.
 4. Final cured PVC coating capable of withstanding a minimum electrical potential of 2,000V.
 5. All conduit accessories, clamps, and hardware that are uncoated shall be stainless steel.
 6. All fittings intended for wet, outdoor, or wash-down application shall carry a NEMA 4X water-tight rating or have an equivalent v-seal design.
 7. Form 8 bodies and covers.
- 2.06 RIGID POLYVINYL CHLORIDE (PVC) CONDUIT:
 - A. Fabricated from self-extinguishing high-impact polyvinyl chloride designed for aboveground and underground installations.
 - B. Shall meet NEMA TC2, TC6 and TC8, and UL 651.
 - C. Type EPC Schedule 40 heavy-wall rigid conduit.
 - D. Fittings and accessories fabricated from same material as conduit. Shall meet NEMA TC3.
 - E. Solvent-cement-type joints as recommended by manufacturer.
- 2.07 SURFACE METAL RACEWAYS:
 - A. Surface Metal Raceways shall comply with UL 5 and UL 5C and be UL labeled.
 1. Type 1 Raceway: Multi-outlet assembly for prewired outlets, lengths as indicated. Provide 3-wire, single circuit with outlets on 18-inch centers. Provide green insulated ground as third wire.
 2. Type 2 Raceway: Multi-outlet assembly for prewired outlets, lengths as indicated. Provide 4-wire, double circuit with outlets on 18-inch centers. Provide green insulated ground as fourth wire.
 3. Type 3 Raceway: Two-piece type with single compartment, lengths as indicated. Provide nominal 2-3/4 inch by 1-7/16 inch with flush, snap-on cover. Install devices as indicated in raceway.
 4. Type 4 Raceway: Two-piece type, divided for power and communication use, lengths as indicated. Provide nominal 4-3/4 inch by 1-3/4 inch with two 2-3/8-inch compartments.
 5. Type 5 Raceway: Surface-mounted type for power use, lengths as indicated. Provide nominal 3/4 inch wide, depth as required, single-piece type.
 6. Type 6 Raceway: Two-piece type with single compartment, length as indicated. Provide nominal 4-3/4 inch by 3-9/16 inch with flush, snap-on cover. Install devices as indicated in raceway.
 7. Boxes for Surface Raceways: Designed, manufactured, and supplied by raceway manufacturer for use with specified raceway.

SECTION 26 05 33 – RACEWAYS, BOXES, SEALS, AND FITTINGS FOR ELECTRICAL SYSTEMS: continued

2.08 LIQUID-TIGHT FLEXIBLE METAL CONDUIT:

- A. Liquid-tight conduit with flexible galvanized-steel core and a synthetic rubber, polyvinyl chloride, or thermoplastic covering.
- B. Shall comply with UL 360.
- C. Spiral encased copper bonding conductors for conduit in sizes 1-1/4 inches and smaller.
- D. External grounding jumper as required.
- E. Provide hot-dipped galvanized fittings for connections to rigid steel conduit, or PVC-coated fittings for connections to aluminum and PVC-coated rigid steel conduit.
- F. Fittings for liquid-tight flexible metal conduit shall comply with UL 514B.
- G. Polyvinyl chloride (PVC) jacket, "Hi-Temp Liguatite Type H.T. Electri-Flex" where installed in a low or high temperature area, -40°F, or high 220°F, as specified or indicated.
- H. Polyvinyl chloride (PVC) jacket, Type HA or Type O.R. "Seal-Tite" for oil-resistant applications.

2.09 FLEXIBLE METAL CONDUIT:

- A. Spiral wound steel.
- B. Reduced wall.
- C. Shall be UL 1 listed.
- D. Fittings for flexible metal conduit shall comply with UL 514B.

2.10 OUTLET AND DEVICE BOXES:

- A. Surface Mounted:
 - 1. Cast hub device boxes for receptacles and switches.
 - 2. Cast malleable iron and as applicable to match connecting conduit. Metallic boxes shall meet UL 514A and NEMA OS 1.
 - 3. PVC boxes for PVC conduit. PVC boxes shall meet UL 514C and NEMA OS 2.
 - 4. FS or FD single or multiple gang boxes as required.
 - 5. Outlet boxes intended for use in classified areas shall be UL 886 listed.
- B. Flush Mounted in Plaster Walls:
 - 1. Galvanized, flat-rolled, sheet-steel gangable device boxes.
 - 2. Conduit knockout openings in bottom and sides.
 - 3. Threaded screw holes for fastening devices and box covers.
 - 4. Corrosion-resistant screws for equipment grounding.
 - 5. Include mounting brackets, device extensions plaster ears, and plaster board expandable grip fasteners (for existing plaster walls) compatible with box.
 - 6. Shall meet UL 514A and NEMA OS 1.

2.11 PULL AND JUNCTION BOXES:

- A. Steel Boxes - Indoors:
 - 1. Hot-dipped galvanized steel.
 - 2. Galvanized-steel covers.
 - 3. Cadmium-plated or bronze screws and bolts.

SECTION 26 05 33 – RACEWAYS, BOXES, SEALS, AND FITTINGS FOR ELECTRICAL SYSTEMS: continued

4. For special boxes where it is not possible to provide hot-dip galvanizing, apply organic zinc-rich primer at 3-mils dry film thickness after SSPC-SP3 Power Tool Cleaning.
5. Minimum gauge requirements:

<u>No surface area exceeds</u>	<u>No single dimension exceeds</u>	<u>Gage steel</u>
1,000 sq. inches	40 inches	14
1,500 sq. inches	60 inches	12
over 1,500 sq. inches	over 60 inches	10

6. Minimum of 14-gauge steel.
7. Conform to NEMA Type 1 enclosure in all nonhazardous areas except as specified or indicated otherwise.
 - a. Junction boxes may be standard type with knock outs except as indicated otherwise.
8. Include piano-hinged, gasketed cover and interior mounting panel where oil-tight J.I.C boxes are used for enclosing terminal blocks and control relays.
9. Waterproof hubs in areas subject to moisture as indicated.
- B. Steel Boxes - Outdoor:
 1. 11-gauge minimum galvanized steel with drip lip and galvanized-steel covers fastened with bronze or cadmium-plated screws or bolts, or cast iron with galvanized finish and flanged bolted covers.
 2. For special boxes where it is not possible to provide hot-dip galvanizing, apply organic zinc-rich primer at 3-mils dry film thickness after SSPC-SP3 Power Tool Cleaning.
 3. Threaded conduit entrances or rigid conduit hubs on all boxes.
 4. Rubber or neoprene gasket for cover.
 5. Conform to NEMA Type 3R enclosure in all outdoor installations unless indicated otherwise.
 6. Conform to NEMA Type 4 enclosure where indicated or specified.
 7. Cast NEMA Type 4 in lieu of sheet steel.
 8. Include piano-hinged, gasketed cover, and interior mounting panel when used for enclosing terminal blocks and control relays.
 9. Oil-tight J.I.C boxes modified for NEMA Type 3R or Type 4 enclosure.
- C. Steel Boxes - Outdoor:
 1. Type 304 or 316 stainless steel with stainless-steel cover and stainless-steel clamps and screws.
 2. Minimum 16 gauge for boxes with no dimension exceeding 6 inches and minimum 14 gauge for all other boxes.
 3. Continuously welded seams shall be ground for a smooth finish.
 4. Seamless gasket for cover.

SECTION 26 05 33 – RACEWAYS, BOXES, SEALS, AND FITTINGS FOR ELECTRICAL SYSTEMS: continued

5. Conform to NEMA Type 4X.
 6. Provide continuous hinge, gasketed cover, and interior mounting plate when used for enclosing terminal blocks and control relays.
 7. Provide rigid weatherproof conduit hubs for all boxes.
 - D. Metallic Barriers:
 1. Designed not to separate phases of a power circuit.
 2. Provide as indicated for the isolation of power circuits from other type circuits
 - E. Bushings: Provide threaded, nylon-insulated metallic bushings. Provide steel bushings for conduit sizes 1-1/2 inches and smaller. Provide malleable iron bushings for conduit sizes 2 inches and larger.
 - F. Grounding Bushings: Provided where indicated, specified and required by NEC. Provide threaded, insulated, malleable iron bushing with lay-in screw clamp lug.
 - G. Locknuts: Provide steel locknuts for conduit sizes 2 inches and smaller. Provide malleable iron for conduit sizes 2.5 inches and larger. Locknut material shall match conduit type.
 - H. Sealing Hub: Provide watertight, threaded, insulated sealing hub connectors for all outdoor and indoor wet locations where conduit enters into enclosures. Sealing hub threaded lengths shall be adequate to allow installation of bushing.
 - I. Knockout Closures: Provide steel press-in knockout seals for all unused punched out knockouts 2 inches and smaller. Provide steel two-piece bolt on knockout seals for all unused punched out knockouts 2-1/2 inches and larger.
 - J. Fittings: Provide all threaded nipples, insulated short elbows, offset nipples, offset connectors, enlargers and reducers as required.
 1. For EMT Conduit: Provide EMT compression-type connectors with insulated throat. Provide EMT compression-type insulated short elbows as required. Provide EMT set-screw type offset connectors as required.
 - K. Hinged-Cover Enclosures:
 1. Comply with UL 50 and NEMA 250, Type 4X
 2. Provide with continuous-hinge cover with flush latch unless otherwise indicated.
 3. Metal Enclosures: Stainless-Steel
 4. Nonmetallic Enclosures: Plastic.
 5. Interior Panels: Steel; all sides finished with manufacturer's standard enamel.
 6. Metal barriers to separate wiring of different systems and voltage.
 7. Gasketed enclosures shall meet UL 50E.
- 2.12 SUPPORT SYSTEM:
- A. Provide as Specified in SECTION 26 05 29.
- 2.13 FIRESTOPPING, WALL AND DUCT SEAL:
- A. Provide as specified in SECTION 26 05 44 for sleeves, seal fittings, silicone sealants and duct seal.
- 2.14 GROUT:
- A. Description: Non-shrink; recommended for interior and exterior sealing openings in non-fire-rated walls or floors.

SECTION 26 05 33 – RACEWAYS, BOXES, SEALS, AND FITTINGS FOR ELECTRICAL SYSTEMS: continued

- B. Standard: ASTM C1107/C1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.
- C. Design Mix: 5,000-psi (34.5-MPa), 28-day compressive strength.
- D. Packaging: Premixed and factory packaged.

PART 3 - EXECUTION

3.01 GENERAL

- A. Comply with manufacturer's published instructions.
- B. Follow the applicable NECA NEIS articles for installation of all conduit.
- C. Provide stub-ups through floors with coupling threaded inside for plugs, set flush with finished floor. Prior to pouring concrete plug coupling until conduit is extended above floor to final destination or a minimum of 2 ft above finished floor.
- D. Conceal conduit within finished walls, ceilings, and floors unless otherwise indicated. Install conduits parallel or perpendicular to building lines.
- E. Cut conduit perpendicular to the length. Use roll cutter or a guide to make cut straight and perpendicular to the length. Ream inside of conduit to remove burrs.
- F. Threaded Conduit Joints, Exposed to Wet, Damp, Corrosive, or Outdoor Conditions: Apply listed compound that maintains electrical conductivity to threads of duct raceway and fittings before making up joints. Follow compound manufacturer's published instructions.
- G. Install firestopping at all conduit penetration of fire-rated walls, ceilings, and floors. Firestopping system shall equal or exceed fire rating of wall, ceiling, or floor in which it is installed. Refer to SECTION 07 84 13 for fire stopping requirements.
- H. Clean out all conduits before pulling wire.
- I. Clean out all conduits immediately after concrete work is finished.
- J. Install pull wires in empty duct raceways. Provide polypropylene or monofilament plastic line with not less than 200 lb tensile strength. Leave at least 12 inch of slack at both ends of pull wire. Cap underground duct raceways designated as spare above grade alongside duct raceways in use.

3.02 RACEWAYS INSTALLATION:

- A. General Requirements:
 - 1. Location:
 - a. Install conduit as near as possible to the routing indicated.
 - b. Shift locations as required to avoid interference with other equipment and piping being installed.
 - c. Route raceway so stubs up are located according to the equipment submittals next to indicated equipment connections or motor terminal boxes.
 - d. Where routing of conduit is not indicated, such as for lighting home run circuits and other systems requiring small conduit runs, route conduit as specified subject to approval by Engineer.
 - 2. Install horizontal runs as high above floor as possible, and in no case lower than 7 feet above floor, walkway, or platform in passage area.
 - 3. Run conduit parallel or perpendicular to walls, ceiling, beams, and columns unless indicated otherwise.

SECTION 26 05 33 – RACEWAYS, BOXES, SEALS, AND FITTINGS FOR ELECTRICAL SYSTEMS: continued

4. Follow manufacturer's recommendations for field bending of conduit or use conduit fittings provided by manufacturer.
5. Route to clear all doors, windows, access wells, and openings.
6. Group parallel runs in neatly aligned banks where possible with minimum of 1-inch clearance between exposed conduits and three conduits OD between concealed or encased conduits.
7. Do not install duct raceways or electrical items on "explosion-relief" walls or rotating equipment.
8. Do not install conduits within 2 inch of the bottom side of a metal deck roof.
9. Maintain 6-inch clearance between conduit and coverings on all hot lines; steam, hot water, and the like.
10. When terminating at cable tray, firmly attach conduit to tray and electrically bond conduit with ground wire to cable tray.
11. Do not use conduit in sizes smaller than 3/4 inch, except 1/2 inch may be used for connections to control devices and thermocouples as indicated.
12. Route the raceway through wall floor and ceiling penetrations, provide holes and sleeves as specified in SECTION 26 05 44.
13. Complete duct raceway installation before starting conductor installation.
14. Install no more than equivalent of three 90-degree bends in conduit run. Support within 12 inch of changes in direction.
15. Make bends in duct raceway using large-radius preformed ells except for parallel bends. Field bending must be in accordance with NFPA 70 minimum radii requirements. Provide only equipment specifically designed for material and size involved.
16. Make connections to boxes, panels, and other equipment as follows:
 - a. Indoor Dry Locations: Double locknuts, one inside and one outside.
 - b. Outdoor and Damp Locations: Rigid weatherproof conduit hubs.
 - c. Bushings:
 - (1) Threaded malleable iron or steel.
 - (2) Insulated with Bakelite, molded and bonded into the bushing.
 - (3) Placed on end of conduit in addition to locknuts.
 - (4) Install with integral grounding connector and conductor where all conduits pass through multiple concentric panel knockouts and where the conduit must be bonded to equipment it is not attached to.
17. Running threads will not be permitted.
18. Coat all field cut threads in galvanized conduit with cold galvanizing paint.
19. Comply with applicable requirements of NEC pertaining to installation of conduit systems.
20. Place drainage fittings or weep holes at unavoidable low points where moisture can collect.
21. Install an entire conduit system that is electrically continuous with bonding jumpers provided as necessary to conform to NEC.
22. Install expansion fittings at all building expansion joints and every 100 feet of continuous conduit.

SECTION 26 05 33 – RACEWAYS, BOXES, SEALS, AND FITTINGS FOR ELECTRICAL SYSTEMS: continued

23. Flattened, dented, or deformed conduit is not permitted. Remove and replace the damaged conduits with new conduits.
24. Provide identification of all raceways, including conduit and wireways as specified in SECTION 26 05 53.
25. Ground all raceways as specified in SECTION 26 05 26.
- B. Rigid Steel Conduit:
 1. Install exposed in building interior spaces or above grade outdoors.
 2. Concealed:
 - a. Install conceal conduit for lighting, convenience outlets, and other circuits in walls, ceiling, and floors where possible.
 - b. Do not install conduit in concrete where conduit outside diameter exceeds one-third of concrete thickness.
 - c. Use expansion and deflection fitting with bonding jumpers at all concrete expansion joints.
 - d. Tie securely in place to prevent movement when concrete is poured.
 - e. Install in floor slabs in as straight a run as possible. Conduit crossovers are not permitted unless conduit total outside diameter is one-third of the concrete thickness or less.
- C. PVC-Coated Rigid Steel Conduit:
 1. Install in areas specified as corrosive, wet and damp or where indicated.
 2. Installers of PVC Coated Conduit must be certified by the manufacturer and be able to present a valid, unexpired Certified installer card prior to installation of conduit system.
 3. Coat field cut threads with manufacturer's standard product in accordance with manufacturer's recommendations.
 4. Use bender one size larger for conduit sized 1 inch or less and conventional bender for conduit sized above 1 inch.
 5. Use strap wrench to tighten conduit. Repair damaged coating with liquid patching compound recommended by conduit manufacturer.
 6. Buried:
 - a. Install in as straight a run as possible between termination points of exact routing to be determined in the field and subject to approval by Engineer.
 - b. Bury conduits a minimum of 30 inches below finish grade unless indicated otherwise.
 - c. Slope conduit away from building conduit risers down to handholes or manhole drains.
 - d. Maintain 6-inch separation from underground piping.
 - e. Use for conduit risers where routed through concrete slabs.
 - f. After trench bottom has been finished to grade, lay conduit. Backfilling shall be as specified in DIVISION 31.
 - g. Cap ends of all conduit risers before backfilling.
- D. Rigid PVC Conduit:
 1. Install PVC above ground exposed or in underground services or concrete encasement, except where PVC coated is provided for ells and risers to prevent burn through or where indicated.

SECTION 26 05 33 – RACEWAYS, BOXES, SEALS, AND FITTINGS FOR ELECTRICAL SYSTEMS: continued

2. Make all joints watertight with cement compound furnished by the conduit manufacturer.
3. Buried:
 - a. Install in as straight a run as possible between termination points of exact routing to be determined in the field and subject to approval by Engineer.
 - b. Bury conduits a minimum of 30 inches below finish grade unless indicated otherwise.
 - c. Slope conduit away from building conduit risers down to handholes or manhole drains.
 - d. Maintain 6-inch separation from underground piping.
 - e. Use PVC-coated rigid steel elbows at all risers and at any bend greater than 45 degrees unless indicated otherwise.
 - f. All risers shall be PVC-coated rigid steel conduit.
 - g. After trench bottom has been finished to grade, lay conduit. Backfilling shall be as specified in DIVISION 31.
 - h. Cap ends of all conduit risers before backfilling.
- E. Liquid-Tight Flexible Metal Conduit.
 1. Use between rigid conduit and motor terminal boxes except where conduit runs down from above and cannot be conveniently supported by a floor flange.
 2. Place between rigid conduit or conduit box and control device cases where direct connection is not desirable for reasons of equipment movement, vibration, or for ease of maintenance.
 3. Install at all points of connection to equipment mounted on supports to allow for expansion and contraction.
 4. Conform to NEC with installation of conductors.
 5. Install at locations where rigid conduit connections are impractical.
 6. Use minimum length consistent with manufacturer's standard lengths, the acceptable bending radius, and with required movement of equipment.
 7. Maximum length of 3 feet unless otherwise approved by Engineer.
 8. Install an external bonding jumper to conform to NEC on conduit sized 1-1/2 inches and larger.
 9. Install flex conduit with 15% extra length to allow the conductors and conduit room for vibration and expansion.
- F. Flexible Metal Conduit:
 1. Use for installation of luminaires only.
 2. Do not use with vapor-tight fixtures. Use in accordance with the National Electrical Code Article 350.
 3. Use minimum length consistent with manufacturer's standard lengths and acceptable bending radius.
 4. Maximum length of 3 feet unless otherwise approved by Engineer.
- G. Conduit Fittings:
 1. Installations of special fittings are indicated.
 2. Install as required.

SECTION 26 05 33 – RACEWAYS, BOXES, SEALS, AND FITTINGS FOR ELECTRICAL SYSTEMS: continued

3.03 SURFACE METAL RACEWAYS AND WIREWAYS:

- A. Mechanically assemble metal enclosures and surface metal raceways for conductors to form continuous electrical conductor, and connect to electrical boxes, fittings, and cabinets to provide effective electrical continuity and rigid mechanical assembly.
- B. Provide only where indicated. Avoid use of dissimilar metals throughout system to eliminate possibility of galvanic corrosion. Where dissimilar metals are in contact, coat all surfaces with corrosion-inhibiting compound or isolation materials before assembling.
- C. Install expansion fittings in all raceways, surface metal raceways, and wireways wherever structural expansion joints are crossed.
- D. Make changes in direction of surface metal raceway and wireway with proper fittings supplied by raceway manufacturer. No field bends of surface metal raceway or wireway sections will be permitted.
- E. Properly support and anchor surface metal raceways for their entire length with structural materials. Surface metal raceways are not to span any space unsupported.
- F. Use boxes as supplied by surface metal raceway manufacturer wherever junction, pull or devices boxes are required. Standard electrical "handy" boxes, etc., shall not be permitted for use with surface metal raceway installations.
- G. Provide tap location nameplates for wireways when used as auxiliary gutters as specified in SECTION 26 05 53 - Electrical Identification.
- H. Ground wireways at 10-foot intervals per SECTION 26 05 26 - Grounding.

3.04 BOXES AND FITTINGS:

- A. Install electrical boxes, bushings, locknuts, nipples, connectors, sealing hubs, and fittings as required, indicated, in accordance with applicable requirements of NEC and in accordance with recognized industry practices to fulfill Project requirements.
- B. Coordinate installation of electrical boxes and fittings with wire/cable, wiring devices, and raceway installation work.
- C. Provide weatherproof boxes for interior and exterior locations exposed to weather or moisture.
- D. All boxes containing emergency power and lighting circuits shall be identified as specified in SECTION 26 05 53 - Electrical Identification.
- E. Provide (oil-tight) knockout closures to cap unused knockout holes where blanks have been removed.
- F. Install electrical boxes in only those locations which ensure ready accessibility to enclosed electrical wiring.
- G. Maximum box size in a fire-rated wall shall be 4 inches by 4 inches square. Do not install boxes back-to-back in walls. In walls that are not fire-rated or acoustic-rated, provide not less than 6 inches (150 mm) horizontal separation between boxes installed in opposite sides of wall. Provide not less than 24 inches (610 mm) horizontal separation between boxes installed in opposite sides of fire-rated and acoustic-rated walls.
- H. Do not install aluminum products in concrete.

SECTION 26 05 33 – RACEWAYS, BOXES, SEALS, AND FITTINGS FOR ELECTRICAL SYSTEMS: continued

- I. Position recessed outlet boxes accurately to allow for surface finish thickness.
- J. Set floor boxes level and flush with finish flooring material.
- K. Fasten electrical boxes firmly and rigidly to the surfaces to which attached, structural surfaces to which attached, or solidly embed them in concrete or masonry.
- L. Provide electrical connections for installed boxes.
- M. Properly ground metallic electrical boxes in compliance with the NEC. Bond all non-isolated equipment grounding conductors to all electrical boxes.
- N. Subsequent to installation of boxes, protect boxes from construction debris and damage.
- O. Install special boxes as indicated of size required for conduits and cables entering and leaving box.
- P. Ground boxes and fittings per SECTION 26 05 26 - Grounding.

3.05 PAINTING:

- A. Touchup: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.
 - 1. Apply paint by brush or spray to provide minimum dry film thickness of 2.0 mils (0.05 mm).
- B. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A780.

END OF SECTION 26 05 33

SECTION 26 05 43 – UNDERGROUND DUCT BANKS AND HANDHOLES

PART 1 - GENERAL

1.01 RELATED DOCUMENTS:

- A. Drawings and general provisions of the Contract, including General and Special Conditions and DIVISION 01 Specification SECTIONS, apply to this SECTION.

1.02 SUMMARY:

- A. This SECTION includes the following:
 - 1. Complete underground duct systems consisting of banks of nonmetallic ducts encased in reinforced concrete, and precast concrete handholes.
 - 2. All necessary earth and rock excavation and backfill.
 - 3. Removal and disposal of all excess excavation material.

1.03 RELATED REQUIREMENTS:

- A. SECTION 26 00 00 - General Electrical Requirements
- B. SECTION 26 05 26 - Grounding and Bonding for Electrical Systems
- C. SECTION 26 05 33 - Raceway and Boxes for Electrical Systems
- D. SECTION 26 05 44 - Sleeves and Sleeve Seals for Electrical Raceways and Cabling
- E. SECTION 26 05 53 - Identification for Electrical Systems

1.04 REFERENCE STANDARDS:

- A. American Concrete Institute (ACI):
 - 1. 318-14 – Building Code Requirements for Structural Concrete.
- B. American Society for Testing and Materials (ASTM):
 - 1. A48 – Standard Specification for Gray Iron Castings.
 - 2. C857 – Minimum Structural Design Loading for Underground Precast Concrete Utility Structures.
 - 3. C858 – Standard Specification for Underground Precast Concrete Utility Structures.
 - 4. D3917 – Dimensional Tolerance of Thermosetting Glass Reinforced Plastic Pultruded Shapes.
 - 5. D4385 – Practice for Classifying Visual Defects in Thermosetting Reinforced Plastic Pultruded Products.
 - 6. F512 – Standard Specification for Smooth Wall Polyvinyl Chloride (PVC) Conduit and Fittings for Underground Installation.
- C. Federal Specifications:
 - 1. W-C-1094A – Conduit and Conduit Fittings Plastic, Rigid.
- D. National Electrical Manufacturer's Association (NEMA):
 - 1. TC-2 – Electrical Plastic Tubing (EPT) and Conduit (EPC-40 and EPC-80).
 - 2. TC 6 – PVC and ABS Plastic Utilities Duct for Underground Installation.
 - 3. TC 8 – Extra Strength PVC Plastic Utilities Duct for Underground Installation.
 - 4. TC-14 – Reinforced Thermosetting Resin Conduit (RTRC) and Fittings.
- E. Underwriters Laboratories, Inc. (UL):
 - 1. 651 – Schedules 40, 80, Type EB and A Rigid PVC Conduit and Fittings
 - 2. 651A – Schedule 40 and 80 High Density Polyethylene (HDPE) Conduit.
 - 3. 1684 – Reinforced Thermosetting Resin Conduit (RTRC) and Fittings.

SECTION 26 05 43 – UNDERGROUND DUCT BANKS AND HANDHOLES: continued

1.05 SUBMITTALS:

- A. Product Data: Submit the following for each type of product specified and included as minimum:
 - 1. Data sheets for each product supplied.
- B. Shop Drawings: Provide the following as minimum:
 - 1. Submit shop drawings for fabrication and installation of pre-cast concrete structures and cast-in-place concrete structures including the following:
 - a. Steel reinforcement drawings.
 - b. Elevation showing openings, pulling irons, cable supports, sump, steps, covers, frames and other details.
- C. Closeout Submittals: Final documentation shall include the following as minimum:
 - 1. Certified "As-Built"/"As-Installed" drawings.
 - 2. Copies of all approved Product Data.

1.06 QUALITY CONTROL:

- A. Manufacturer Qualifications:
 - 1. The manufacturer shall be by a company specializing in providing precast products and services normally associated with precast-concrete construction. Design of precast handholes shall be prepared by a professional engineer licensed in the state associated with the project to conform to the procedures set forth in ACI 318 and applicable standards of this specification and of the size, shape, and details indicated or specified.

PART 2 - PRODUCTS

2.01 MANUFACTURERS:

- A. Ducts:
 - 1. Carlon.
 - 2. Certain-Teed.
 - 3. Cantex.
- B. Duct Spacers:
 - 1. Carlon.
 - 2. CertainTeed.
 - 3. Formex.
- C. Concrete Inserts:
 - 1. Unistrut Corporation.
 - 2. B Line Systems, Inc.
- D. Precast Handholes:
 - 1. Barbour Concrete Co.
 - 2. Champion Precast Inc.
 - 3. Old Castle.
 - 4. Engineer approved equal.

2.02 DUCTS:

- A. Conduit Types for Concrete Encasement:
 - 1. Type EB:
 - a. Tested to Underwriters' Laboratories, Inc. (UL) Standard UL 651A.

SECTION 26 05 43 – UNDERGROUND DUCT BANKS AND HANDHOLES: continued

- b. Type EB35, Heavy Wall, Thickness conforming to NEMA TC-8 and ASTM F512.
 - B. Rated for use with 90°C conductors.
 - C. Provide with all necessary end bells, couplings, offset couplings, elbows, plugs, and other fittings.
 - D. Sizes as indicated.
 - E. Install PVC coated rigid galvanized steel elbows for all duct termination risers and all non-sweeping 90 degree bends.
 - F. Provide prefabricated, interlocking type plastic duct spacers for duct spacing as indicated.
- 2.03 REINFORCING STEEL:
- A. Provide as specified in Division 03.
- 2.04 CONCRETE:
- A. Provide as specified in DIVISION 03.
 - B. Provide with red pigment to indicate buried electrical duct bank.
- 2.05 HANDHOLES:
- A. Meets ANSI/SCTE 77.
 - B. Polymer concrete consisting of sand, aggregate and fiberglass reinforcement bound together with a polymer resin.
 - C. Box: Sizes as indicated. Open bottom.
 - D. Cover: One-piece, non-skid, bolted with lifting provisions, marked as indicated.
 - E. Design Load: ANSI Tier 22 or as indicated.
 - F. Hardware shall be SST with hex head bolts and nuts.
 - G. Handholes with openings greater than 400 square inches shall be provided with cable racks.
 - H. UL listed.
- 2.06 CASTINGS:
- A. Manhole Frames and Covers:
 - 1. ASTM A48, Class 30B. Cover shall be marked with "Electric."
 - 2. Watertight bolt-down type with drop handles.
 - 3. Machine-bearing surfaces to provide an even seating.
 - 4. Coat with coal-tar pitch varnish.
- 2.07 WARNING TAPE:
- A. Standard detectable warning tape, 4-mil 3 inch wide tape, red with black letters imprinted with "CAUTION BURIED ELECTRIC CABLE BELOW".
 - B. Metallic marker tape and 12 awg uf single strand tin coated copper tracer
- 2.08 "PULLING IN" ROPE:
- A. Nylon or nylon equivalent composite.
 - B. Minimum average breaking strength: 2000 pounds.

PART 3 - EXECUTION

3.01 EXCAVATION AND TRENCHING FOR DUCT BANKS AND HANDHOLES

- A. Perform as specified in Division 31.
- B. Work with extreme care near existing underground utilities to avoid damaging them.
- C. Pitch the trench uniformly toward handholes or both ways from high points between handholes for required drainage.
- D. Notify the Owner's representative for inspection prior to any duct bank installation and prior to concrete placement.

3.02 INSTALLATION:

- A. Duct Banks:
 - 1. Ducts:
 - a. Assemble as follows:
 - (1) On spacers to maintain horizontal and vertical separation indicated.
 - (2) With joints in adjacent ducts staggered.
 - (3) All joints watertight by application of joint sealer compound furnished by duct manufacturer.
 - (4) No reinforcing steel or other ferrous material between individual ducts.
 - b. Securely tie overall at 5 foot or closer intervals as required.
 - c. Secure to anchors after assembling to prevent flotation when placing concrete.
 - d. Slope towards handholes with a minimum continuous slope of 1/2 percent.
 - e. Align ducts for each 100 feet not greater than 4 inches horizontal.
 - f. All risers and non-sweeping bends shall be PVC coated rigid galvanized steel as specified.
 - g. Install end bells flush with face of concrete at each handhole and termination point unless indicated otherwise.
 - h. Immediately after cleaning, install a "pulling in" rope in each duct, and plug each end of all ducts.
 - 2. Install warning tape along the entire length of duct banks at a depth of 12 inches below grade or as indicated on drawings.
 - 3. Run warning tape tracer wire to handhole with tracer wire test station.
 - 4. Reinforcing: Place as specified in Division 03.
 - 5. Concrete:
 - a. Do not place prior to inspection and approval of duct and reinforcing installation by Engineer.
 - b. Place as specified in Division 03.
- B. Precast Handholes:
 - 1. Install a minimum of 6 inches of compacted granular material on undisturbed soil below handhole.
 - 2. Place at location and alignment as indicated.
 - 3. Top slab and handhole shall be set flush with finished grade.

SECTION 26 05 43 – UNDERGROUND DUCT BANKS AND HANDHOLES: continued

- 4. Install conduits as indicated.
 - 5. Provide sufficient cable slack during installation to rack and secure cabling around the handhole walls.
 - 6. Clearances
 - C. Cable Rack:
 - 1. Install in manholes where cable tray is not specified or indicated to provide support for cables in or passing through the manhole.
 - 2. Install at intervals of 2 feet maximum.
 - 3. Cinch anchor to manhole wall unless wall inserts are indicated.
 - 4. Use different arms to segregate power cables, low voltage power cables, control cables, and instrument cables.
 - D. Duct and Conduit Sealing:
 - 1. Seal the ducts and conduits at building entrances and at outdoor equipment with a suitable non-hardening compound to prevent the entrance of moisture and gases.
- 3.03 BACKFILLING:
- A. Provide backfill and compaction as specified in Division 31.
- 3.04 ADJUSTING AND CLEANING:
- A. Rod and clean all ducts with suitable cleaners, swabs and mandrels after completion of the duct bank.

END OF SECTION 26 05 43

SECTION 26 05 44 – SLEEVES AND SLEEVE SEALS FOR ELECTRICAL RACEWAYS AND CABLING

PART 1 - GENERAL

1.01 RELATED DOCUMENTS:

- A. Drawings and general provisions of the Contract, including General and Special Conditions and DIVISION 01 Specification SECTIONS, apply to this SECTION.

1.02 SUMMARY:

- A. This SECTION specifies the sleeves and seals Work by this Contract.
- B. Provide raceway and duct seals including:
 - 1. Sleeves for raceway and cable penetration of non-fire-rated construction walls and floors.
 - 2. Sleeve-seal fittings.
 - 3. Seal fittings.
 - 4. Silicone sealants.
 - 5. Duct seal.

1.03 RELATED REQUIREMENTS:

- A. SECTION 26 00 00 - General Electrical Requirements
- B. SECTION 26 05 33 - Raceway and Boxes for Electrical Systems

1.04 REFERENCE STANDARDS:

- A. ASTM International (ASTM):
 - 1. ASTM A 53/A 53M - Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
 - 2. ASTM D1785 - Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120
 - 3. ASTM C1107/C1107M - Standard Specification for Packaged Dry, Hydraulic-Cement Grout (Nonshrink)
- B. Joint Industrial Council (J.I.C.):
- C. National Fire Protection Association (NFPA):
 - 1. 70 - National Electrical Code (NEC).
- D. National Electrical Contractor's Association (NECA):
 - 1. NECA NEIS 1 - Standard for Good Workmanship in Electrical Construction.
- E. National Electrical Manufacturers Association (NEMA):
 - 1. NEMA VE 2 - Cable Tray Installation Guidelines

1.05 SUBMITTALS:

- A. Product Data:
 - 1. Submit manufacturer's technical product data, including specifications and installation instructions, for each type of product required. Include data substantiating that materials comply with requirements.
 - 2. Submit manufacturer's data on supporting devices including catalog cuts, specifications, and installation instructions, for each type of support, anchor, sleeve, and seal.

SECTION 26 05 44 – SLEEVES AND SLEEVE SEALS FOR ELECTRICAL RACEWAYS AND CABLING: continued

1.06 COORDINATION:

- A. Coordinate size and location of sleeves. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified together with concrete specifications.
- B. Coordinate installation of roof curbs, equipment supports, and roof penetrations.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS:

- A. Wall Entrance Seals: O.Z./Gedney, Emerson Electric Company.
- B. Duct Seal:
 - 1. Ideal Industries, Inc.
 - 2. The 3M Company.
 - 3. Engineer-approved equal.

2.02 SLEEVES:

- A. Round Sleeves:
 - 1. Steel Wall Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, zinc coated, plain ends.
 - 2. Cast-Iron Wall Sleeves: Cast or fabricated "wall pipe," equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop unless otherwise indicated.
 - 3. PVC-Pipe Sleeves: ASTM D1785, Schedule 40.
 - 4. Molded-PVC Sleeves: With nailing flange for attaching to wooden forms.
 - 5. Molded-PE or -PP Sleeves: Removable, tapered-cup shaped, and smooth outer surface with nailing flange for attaching to wooden forms.
- B. Rectangular Sleeves:
 - 1. Rectangular, galvanized-steel, sheet metal sleeves.
 - 2. Minimum Metal Thickness:
 - a. For sleeve cross-section rectangle perimeter less than 50 inches and with no side larger than 16 inches, thickness shall be 0.052 inch.
 - b. For sleeve cross-section rectangle perimeter 50 inches or more and one or more sides larger than 16 inches, thickness shall be 0.138 inch.

2.03 SLEEVE-SEAL SYSTEMS

- A. Options:
 - 1. Sealing Elements: EPDM rubber interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
 - 2. Pressure Plates: Stainless steel.
 - 3. Connecting Bolts and Nuts Stainless steel of length required to secure pressure plates to sealing elements.
- B. General Characteristics: Manufactured plastic, sleeve-type, waterstop assembly made for embedding in concrete slab or wall. Unit must have plastic or rubber waterstop collar with center opening to match piping OD.

SECTION 26 05 44 – SLEEVES AND SLEEVE SEALS FOR ELECTRICAL RACEWAYS AND CABLING: continued

2.04 GROUT:

- A. Nonshrink; recommended for interior and exterior sealing openings in non-fire-rated walls or floors.
- B. Standard: ASTM C1107/C1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.
- C. Design Mix: 5,000-psi (34.5-MPa), 28-day compressive strength.
- D. Packaging: Premixed and factory packaged.

2.05 CONDUIT WALL ENTRANCE SEALS:

- A. Provide where required or indicated.
- B. Use O.Z./Gedney Company Type FSK for new walls.
- C. Use O.Z./Gedney Company Type CSM for penetration in existing walls.

2.06 SEAL FITTINGS AND COUPLINGS FOR RIGID STEEL, ALUMINUM AND PVC-JACKETED RIGID STEEL CONDUIT:

- A. Fittings:
 - 1. Cast malleable iron fittings (for rigid steel conduit).
 - 2. Cast aluminum fittings (for aluminum conduit).
 - 3. Explosionproof.
 - 4. Cast malleable iron.
 - 5. Threaded cover to conform to NEC.
 - 6. Full thread hubs.
 - 7. Seal compound well for seal.
 - 8. Drain seals as indicated or required to provide a continuous automatic drain of water.
 - 9. "Chico" compound for all sealing fittings.
 - 10. PVC jacketed in corrosive areas where PVC-jacketed conduit is used.
- B. Couplings:
 - 1. Explosionproof.
 - 2. Flexible.
 - 3. Conform to NEC.
 - 4. Threaded steel end fittings securely fastened to the core and braided to ensure electrical continuity.
 - 5. PVC jacketed in corrosive areas where PVC-jacketed conduit is used.

2.07 DUCT SEAL:

- A. Duct Seal:
 - 1. Noncorrosive, permanently soft compound.
 - 2. Nontoxic.
 - 3. Provide flexible re-enterable and repairable seal around cables in conduits.
 - 4. Prevent air movement and drafts through conduits.
 - 5. Provide Ideal Industries Duct Seal, 3M® Moldable Putty, or Engineer-approved equal.

SECTION 26 05 44 – SLEEVES AND SLEEVE SEALS FOR ELECTRICAL RACEWAYS AND CABLING: continued

2.08 SILICONE SEALANTS:

- A. Silicone Sealants: Single-component, silicone-based, neutral-curing elastomeric sealants of grade indicated below.
 - 1. Grade: Pourable (self-leveling) formulation for openings in floors and other horizontal surfaces that are not fire rated.
- B. Silicone Foams: Multicomponent, silicone-based liquid elastomers that, when mixed, expand and cure in place to produce a flexible, nonshrinking foam.

PART 3 - EXECUTION

3.01 SEAL FITTINGS:

- A. Comply with NECA 1.
- B. Comply with NEMA VE 2 for cable tray and cable penetrations.
- C. Install duct sealing fittings at accessible locations in accordance with NFPA 70 and fill them with listed sealing compound. For concealed duct raceways, install fitting in flush steel box with blank cover plate having finish similar to that of adjacent plates or surfaces. Install duct sealing fittings in accordance with NFPA 70.
- D. Install devices to seal duct raceway interiors at accessible locations. Locate seals so no fittings or boxes are between the seal and the following changes of environments. Seal interior of duct raceways at the following:
 - 1. Conduits pass from warm to cold locations.
 - 2. Underground service duct raceway enters a building or structure.
 - 3. Conduit extending from interior to exterior of building.
 - 4. Around cables at all conduit terminations at control panels
 - 5. Boxes containing terminations and splices.
 - 6. Where otherwise required by NFPA 70
 - 7. Install necessary fittings where not indicated but required by code.
- E. Wall, Roof and Floor Seals: Provide sleeves for conduit which penetrate foundation walls below grade, floors, ceilings, or exterior walls. Caulk between sleeve and conduit with nontoxic, UL-classified caulking material to ensure watertight seal.
- F. Sleeve Seals: Provide modular mechanical type seals, consisting of interlocking synthetic rubber links shaped to continuously fill annular space between pipe and sleeve, connected with bolts and pressure plates which cause rubber sealing elements to expand when tightened, providing watertight seal and electrical insulation. Seal fire rating shall equal or exceed that of the wall or floor penetrated.
- G. Provide a fire-rated sleeve and seal equal to or exceeding the fire rating of the ceiling, floor or wall being penetrated.
- H. Provide through floors, walls, and roofs as necessary for conduit or cable tray runs, including approved flashing and weather proofing at outside walls and on roofs.
- I. Install sleeves or forms for all openings in new Work.

SECTION 26 05 44 – SLEEVES AND SLEEVE SEALS FOR ELECTRICAL RACEWAYS
AND CABLING: continued

- J. Provide the required inserts and holes, completely sleeved, bonded, curbed, flashed, and finished off in an approved manner, whether in concrete, steel grating, metal panels, or roofs.
- K. Core-drill all holes required in existing building work using a dustless method.
- L. Place non-shrinking grout or Dow Corning 3-6548 Silicone RTV or equivalent General Electric RTF 762 sealant as specified, in the following locations:
 - M. All holes in concrete, walls, floor, and roof slabs after installation of conduit.
 - N. All unused holes and sleeves as approved by Engineer.
 - O. Install wall entrance seals where conduit enters the building or vaults from exterior underground.
- P. Sleeves for Conduits Penetrating Above-Grade, Non-Fire-Rated, Concrete and Masonry-Unit Floors and Walls:
 - 1. Size pipe sleeves to provide 1/4 inch annular clear space between sleeve and raceway or cable, unless sleeve-seal system is to be installed.
 - 2. Install sleeves for floor penetrations. Extend sleeves installed in floors 2 inch above finished floor level. Install sleeves during erection of floors.
- Q. Aboveground, Exterior-Wall Penetrations: Seal penetrations using steel pipe sleeves and mechanical sleeve-seal systems. Size sleeves to allow for 1 inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.
- R. Underground, Exterior-Wall and Floor Penetrations:
 - 1. Install steel pipe sleeves with integral waterstops. Size sleeves to allow for 1 inch annular clear space between raceway or cable and sleeve for installing sleeve-seal system. Install sleeve during construction of floor or wall.
 - 2. Install steel pipe sleeves. Size sleeves to allow for 1 inch annular clear space between raceway or cable and sleeve for installing sleeve-seal system. Grout sleeve into wall or floor opening.

END OF SECTION 26 05 44

SECTION 26 05 53 – IDENTIFICATION FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS:

- A. Drawings and general provisions of the Contract, including General and Special Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY:

- A. This Section specifies electrical identification work including the following:
 - 1. Buried cable and duct bank warnings.
 - 2. Electrical power, control, and communication conductors (and raceways).
 - 3. Operational instructions and warnings.
 - 4. Danger, caution and warning signs.
 - 5. Equipment/system identification nameplates.

1.03 RELATED REQUIREMENTS:

- 1. Division 26 - Electrical

1.04 REFERENCE STANDARDS:

- A. Applicable Standards: Comply with the applicable requirements of the following standards.
 - 1. American Society of Mechanical Engineers (ASME):
 - a. A13.1 - Scheme for the Identification of Piping Systems.
 - 2. Federal Specifications (FS):
 - a. FS L-P-387 - Polyethylene Low and Medium Density – Molding Material (for designation plates).
 - 3. National Electrical Manufacturers Association (NEMA):
 - a. Z535.1 - Safety Colors.
 - b. Z535.4 - Product Safety Signs and Labels.
 - 4. National Fire Protection Association (NFPA):
 - a. 70 - National Electrical Code (NEC), as applicable to installation of identifying labels and markers for wiring and equipment.
 - b. 70E - Electrical Safety in the Workplace.
 - c. 72 - National Electric Safety Code (NESC) – IEEE C2.
 - 5. Occupational Safety and Health Administration (OSHA):
 - a. 29 CFR 1910.144 - Safety Color Code for Marking Physical Hazards.
 - b. 29 CFR 1910.145 - Specifications for Accident Prevention Signs and Tags.
 - 6. Underwriters Laboratories (UL), pertaining to electrical identification systems:
 - a. 969 - Standards for Marking and Labeling Systems.

1.05 SUBMITTALS:

- A. Product Data: Submit manufacturer's data on electrical identification materials and products.

SECTION 26 05 53 – IDENTIFICATION FOR ELECTRICAL SYSTEMS: continued

- B. Samples: Submit samples of each color, lettering style, and other graphic representation required for each identification material or system.

1.06 QUALITY CONTROL:

- A. Comply with ASME A13.1 and IEEE C2.
- B. Comply with NFPA 70.
- C. Comply with 29 CFR 1910.144 and 29 CFR 1910.145.
- D. Comply with NEMA Z535.4 for safety signs and labels.
- E. Adhesive-attached labeling materials, including label stocks, laminating adhesives, and inks used by label printers, shall comply with UL 969.

1.07 COORDINATION:

- A. Coordinate identification names, abbreviations, colors, and other features with requirements in other sections requiring identification applications, Drawings, Shop Drawings, manufacturer's wiring diagrams, and the Operation and Maintenance Manual; and with those required by codes, standards, and 29 CFR 1910.145. Use consistent designations throughout Project.
- B. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.
- C. Coordinate installation of identifying devices with location of access panels and doors.
- D. Install identifying devices before installing acoustical ceilings and similar concealment.

PART 2 - PRODUCTS

2.01 MANUFACTURERS:

- A. Subject to compliance with requirements, provide electrical identification products of one of the following (for each type marker):
 - 1. Brady Worldwide, Inc.
 - 2. Panduit Corp.
 - 3. Seton Identification Products.
 - 4. Thomas & Betts Corp.

2.02 ELECTRICAL IDENTIFICATION MATERIALS:

- A. General: Except as otherwise indicated, provide manufacturer's standard products of categories and types required for each application. Where more than single type is specified for an application, selection is Installer's option; but provide single selection for each application.
- B. Orange "Emergency" and "()-VOLT" Conduit, Equipment, Box, and Cable Tray Markers:
 - 1. General: Self-adhesive vinyl tape marker not less than 3 mils thick. Provide 1-1/8 inch wide by 4-1/2 inch long marker for 2 inch and smaller conduit. Provide 2-1/4 inch wide by 9 inch long marker for 2-1/2 inch and larger conduit and all cable tray. Except as otherwise indicated, provide black

SECTION 26 05 53 – IDENTIFICATION FOR ELECTRICAL SYSTEMS: continued

- lettering which indicates highest voltage of cables(s) in conduit or cable tray. Provide black lettering that indicates "Emergency" power circuit is in conduit or cable tray.
2. Colors: Unless otherwise indicated or required by governing regulations, provide orange background tape marker.
- C. Underground Type Plastic Line Marker:
1. General: Permanent, bright-colored, continuous-printed plastic tape marker, intended for direct-burial service; not less than 6 inches wide by 4 mils thick. Provide tape marker with printing which most accurately indicates type of service of buried cable or duct bank. (Provide embedded continuous metallic strip or core when used with non-metallic conduit and fiber optic cable to enable locating.)
- D. Conduit, wireway and cable tray identification tags:
1. Instrument, 600V Control, and Power: Use labels with 2-inch black letters identifying cable tray number.
 2. 2 kV or Higher Voltage:
 - a. Use labels with 2-inch red letters identifying cable tray number.
 - b. Use labels with 2-inch red letters identifying voltage (example for 5 kV, "DANGER 5,000 VOLTS").
 - c. Use labels with 2-inch red letters with the following wording: "DANGER - HIGH VOLTAGE - KEEP AWAY".
 3. Label adhesive to be able to hold on curved surfaces and withstand temperatures up to 150°F, in indoor or outdoor environments.
 4. Labels to be resistant to oil, dirt, and abrasion.
 5. A broad-tipped permanent ink-type marker shall be used to identify cable trays until the permanent labels are installed.
 6. Made by Brady Corporation:
 - a. Numbers generated with the BBP31 or BBP33 printer, with each raceway number on a continuous white background strip.
 - b. Text size of 2 inches high with 1 character per inch on white background.
 - c. Label size of 2.25 inches high.
 - d. Utilize B-595 indoor/outdoor vinyl.
 7. Made by Electromark Company:
 - a. Each cable tray number generated on a continuous white background strip.
 - b. C-1003 series.
 - c. Label size of 2.5 inch high.
 - d. Text size of 2 inches high with 1 character per inch on a white background of 6-mil polyester film.
 - e. Suitable for outdoor installation in all environments.
 - (1) Long lasting performance in all environments.
 - (2) Permanent adhesive for cold weather installation.
 - (3) UV resistant ink.
 - (4) Furnish with wrap around bands to insure that the identification tags will not lift off.

SECTION 26 05 53 – IDENTIFICATION FOR ELECTRICAL SYSTEMS: continued

8. Engineer shall provide an electronic file with raceway numbers in a Microsoft Excel spreadsheet, if requested by Contractor.
9. Owner approved equal.
10. All conduit and cable trays shall be labeled with the unique number included in the SECTION 26 00 00 - Appendix A - Cable Schedule.
- E. Wire/Cable Identification Bands:
 1. General: Vinyl-cloth self-adhesive cable/conductor markers of wrap-around type, print-on type with clear plastic self-adhesive cover flap; numbered to show circuit identification number indicated on Drawings or Shop Drawings.
- F. Plasticized Tags:
 1. General: Preprinted or partially preprinted accident-prevention and operational tags, on plasticized card stock with matt finish suitable for writing, approximately 3-1/4 inches by 5-5/8 inches, with brass grommets and wire fasteners, and with appropriate preprinted wording, including large-size primary wording, e.g., "DANGER, DO NOT OPERATE." Tags shall comply with OSHA requirements.
- G. Self-Adhesive Plastic Signs:
 1. General: Self-adhesive or pressure-sensitive, preprinted, flexible vinyl signs for operational instructions or warnings; of sizes suitable for application areas and adequate for visibility, with proper wording for each application, e.g., "EXHAUST FAN."
 - a. Colors: Unless otherwise indicated or required by governing regulations, provide white signs with black lettering.
- H. Baked Enamel "Danger" Signs:
 1. "DANGER" signs of baked enamel finish on 20-gauge steel (unless specified otherwise); of standard safety red, safety black, and safety white as defined by NEMA Z535.1; 14 inches by 10 inches size, except where 10 inches by 7 inches is the largest size which can be applied where needed, and except where larger size is needed for adequate vision; with recognized standard explanation wording, e.g., "____ VOLTS, KEEP AWAY." Sign shall conform to OSHA and NEMA Z535.4.
- I. Baked Enamel "Caution" Signs:
 1. "CAUTION" signs of baked enamel finish on 20-gauge steel (unless specified otherwise); of standard safety yellow with safety black letters; 14 inches by 10 inches size, except where 10 inches by 7 inches is the largest size which can be applied where needed, and except where larger size is needed for adequate vision; with recognized standard explanation wording, e.g., "Caution for Ear Protection Required in this Area."
- J. Based Enamel "WARNING" Signs:
 1. "WARNING" signs of baked enamel finish on 20-gauge steel (unless specified otherwise); of standard safety orange with safety black letters; 14 inches by 10 inches size, except where 10 inches by 7 inches is largest size that can be applied where needed and except where larger size is needed for adequate vision; with recognized standard explanation wording. Sign shall conform to OSHA and NEMA Z535.4.

SECTION 26 05 53 – IDENTIFICATION FOR ELECTRICAL SYSTEMS: continued

- K. Engraved Plastic-Laminate Nameplates:
 - 1. General: Engraving stock melamine plastic laminate nameplates, in sizes (minimum height of characters shall be 1/8 inch) and thicknesses specified or indicated, engraved with engraver's standard letter style of sizes and wording indicated, white face and black core plies (letter color) except as otherwise indicated, specified or required. Colors shall comply with OSHA and NEMA Z535.1. Nameplate shall be punched for mechanical fastening except where adhesive mounting is necessary because of the surface type it is mounted to, or where mechanical fastening will compromise the enclosure protection ratings.
 - a. Thickness: 1/16-inch, for units up to 20 square inches or 8 inch length; 1/8-inch for larger units.
 - b. Fasteners: Self-tapping stainless steel screws, except contact-type permanent adhesive where screws cannot or should not penetrate surface it is mounted to.
 - 2. Lettering and Graphics:
 - a. Coordinate names, abbreviations, and other designations used in electric identification work with corresponding designations shown, specified, or scheduled. Provide numbers, lettering, and wording as indicated or, if not otherwise indicated, as recommended by manufacturer or as required for proper identification and operation/maintenance of electrical systems and equipment. Comply with ASME A13.1 pertaining to minimum sizes for letters and numbers. Comply with OSHA requirements. Comply with design requirements of NEMA Z535.4.

PART 3 - EXECUTION

3.01 APPLICATION AND INSTALLATION:

- A. General Installation Requirements:
 - 1. Install electrical identification products as indicated, in accordance with manufacturer's written instructions and requirements of NEC.
 - 2. Coordination: Where identification is to be applied to surfaces which require finish painting, install identification after completion of painting.
 - 3. Regulations: Comply with governing regulations and requests of governing authorities for identification of electrical work.
- B. Conduit, wireway and cable tray identification tags:
 - 1. General: Where exposed, apply identification markers at 20 foot intervals (visible from the floor) and within 3 feet of all panelboards, switchboards, switchgear, automatic transfer switches, emergency generators, substations, switches, devices, and circuit breakers (readily visible when standing in front of equipment). Identification on wireway or cable tray shall be on outside of both sidewalls at 20 foot intervals.
- C. Underground Cable, Conduit, and Duct Bank Identification Marker:
 - 1. General: During back-filling/top-soiling of each exterior underground direct buried electrical, signal or communication cable, conduit and duct bank,

SECTION 26 05 53 – IDENTIFICATION FOR ELECTRICAL SYSTEMS: continued

install continuous underground-type plastic line marker, located directly over the direct buried cable, conduit or duct bank at 12 inches below finished grade. Where multiple small direct buried cables are buried in a common trench and do not exceed an overall width of 16 inches, install a single line marker.

2. Install line marker for every cable below grade, regardless of whether direct-buried, protected in conduit, or conduit in duct bank.
- D. Wire/Cable Identification Bands:
1. General: Apply cable/conductor identification bands, including circuit number, on each wire/cable in each box/enclosure/cabinet where wires of more than one circuit or communication/signal system are present. Match identification with marking system used in panelboards, shop drawings, contract documents, and similar previously established identification for project's electrical work.
- E. Operational Identification and Warning Plasticized Tags and Metal Signs and Plastic Signs:
1. General: Wherever reasonably required to ensure safe and efficient operation and maintenance of electrical systems, and electrically connected mechanical systems and general systems and equipment, including prevention of misuse of electrical facilities by unauthorized personnel, install signs with instruction or warnings. When signs are installed on switches, outlets, controls, devices and covers of electrical enclosures they may be self-adhesive vinyl or plastic. Where detailed instructions or explanations are needed, provide plasticized tags with clearly written messages adequate for intended purposes.
 2. Where switchboards, switchgear, motor control centers, and panelboard are supplied by a feeder, provide an informational sign indicating each device or piece of equipment from where the power originates.
- F. Danger Signs:
1. General: In addition to installation of danger signs specified, indicated, and required by governing regulations and authorities, install appropriate danger signs at locations indicated and at locations subsequently identified by Installer of electrical work as constituting similar dangers for persons in or about Project.
 2. XXXX Volts: Install danger signs (with actual circuit voltage) on all building doors, substations, switchgear, switchboards, panelboards switches, circuit breakers, etc., wherever it is possible (under any circumstances) for persons to come into contact with electrical voltages to ground greater than 277V.
 3. Critical Switches/Controls: Install danger signs on switches and similar controls, regardless of whether concealed or locked up, where untimely or inadvertent operation (by anyone) could result in significant danger to persons or damage to or loss of property.
 4. Provide the following danger sign on the equipment indicated:
 - a. "Danger This Machine Starts Automatically" on all fire pumps, air compressors and emergency generators.

SECTION 26 05 53 – IDENTIFICATION FOR ELECTRICAL SYSTEMS: continued

5. Provide the following danger signs on the doors leading to the equipment indicated:
 - a. "Danger Hearing Protection Required" on all emergency generator room doors.
 - b. "Danger: No Smoking, Matches or Open Flames" on all emergency generator room doors (, personnel doors opening into aircraft hangar,) and battery room doors.
- G. Warning Signs:
 1. Provide an orange background sign with black letters reading "WARNING: LOAD SIDE OF SWITCH MAY BE ENERGIZED BY BACKFEED" on all tie switches and tie circuit breakers.
 2. Provide cable tray warning signs with 1-1/2-inch high black letters on an orange background that reads: "Warning! Not to be used as a walkway, ladder or support for ladders for personnel." Provide on each side of cable tray at 10-foot intervals, visible from the floor below.
 3. Provide Arc Flash Warning signs on electrical equipment such as switchboards, switchgear, panelboards, industrial control panels, motor control centers and meter socket enclosures that are likely to require examination, adjustment, servicing, or maintenance while energized. Marking shall be permanently affixed and of a durable nature to withstand the environment within which it is installed.
 4. Provide Available Fault Current Warning signs on electrical equipment as specified in Section 26 05 73. Label shall include possible incident energy exposure within arc flash boundary in front of equipment as well as meet NFPA 70E for additional content.
- H. Caution Signs:
 1. Provide yellow background caution signs with black letters on the doors leading to the equipment indicated:
 - a. "Caution Ear Protection Required in this Area" on all emergency generator room doors.
 2. Provide the following yellow background caution sign with black letters on all panelboards, substations, switches, circuit breakers, and switchboards where turning off a circuit will automatically start an emergency generator:
 - a. "Caution Turning Off this Circuit will Automatically Start Emergency Generator AAA-GEN-XXX"
 3. Provide the following yellow background caution sign with black letters on all automatic transfer switches, switches, circuit breakers, equipment, and emergency panelboards that are energized by the emergency power system:
 - a. "Caution Automatically Energized by the Emergency Power System."
- I. Equipment/System Identification Nameplates:
 1. General: Install engraved plastic-laminated nameplates on each major unit of electrical equipment in the building; including central or master unit of each electrical system including communication/control/signal/alarm systems, unless unit is specified with its own self-explanatory identification or signal system. Except as otherwise indicated, provide single line of text, 1/2-inch high lettering on 1-1/2-inch high sign (2 inches high were two lines are

SECTION 26 05 53 – IDENTIFICATION FOR ELECTRICAL SYSTEMS: continued

required), black lettering on white field. Provide text matching terminology and numbering of the contract documents and shop drawings. Nameplate shall include unit designation, normal source circuit number ("Fed from..."), circuit voltage, and other data specifically indicated. Nameplate shall indicate normal source circuit number ("Fed from..."), and emergency source circuit number ("Fed from..."), when the equipment is a transfer switch or fed directly from a transfer switch. Provide nameplates for each unit of the following categories of electrical work:

- a. Switchboards, panelboards, electrical cabinets, and enclosures. (Include main bus ampacity on the nameplate.)
- b. Access panel/doors to electrical facilities.
- c. Major electrical switchgear (Include main bus ampacity on the nameplate.)
- d. Electrical substations (Include main bus ampacity on the nameplate.)
- e. Motor control centers, (Include main bus ampacity on the nameplate.) and individual motor starters.
- f. Disconnect switches.
- g. Push buttons, selector switches, indicating lights. (Circuit number and voltage not required on nameplate).
- h. Power transfer equipment: Contactors and transfer switches.
- i. Lighting control equipment and contactors.
- j. Remote controlled switches, dimmer modules, and control devices.
- k. Transformers (Include primary voltage, secondary voltage, number of phases, feeder, and panelboards or equipment supplied by the secondary.)
- l. Inverters. (Include input voltage, output voltage, number of input phases.)
- m. Rectifiers. (Include input voltage, output voltage, and number of phases.)
- n. Frequency converters. (Include input and output frequency.)
- o. Battery racks.
- p. Power generating units.
- q. Telephone cabinets and switching equipment. (Circuit number and voltage not required on nameplate.)
- r. Clock/program master equipment.
- s. TV/audio monitoring master station.
- t. Fire alarm and mass notification systems master station.
- u. Security monitoring master station.
- v. Public address system.
- w. Uninterruptible power supplies (UPS).
- x. Wireway used as auxiliary gutter tap locations with circuit number of circuit being tapped. Provide on outside of wireway.
- y. Provide "EMERGENCY" conduit markers on all conduit and pull boxes that contain emergency power conductors.
- z. Switchboard main switches and circuit breakers.

SECTION 26 05 53 – IDENTIFICATION FOR ELECTRICAL SYSTEMS: continued

2. Install markers, tags, nameplates, and signs at locations indicated or, where not otherwise indicated, at location for best convenience of viewing without interference with operation and maintenance of equipment. Secure the identification with fasteners, except use adhesive where fasteners should not or cannot penetrate surface.

END OF SECTION 26 05 53

SECTION 26 24 16 - PANELBOARDS

1.01 RELATED DOCUMENTS:

- A. Drawings and general provisions of the Contract, including General and Special Conditions and DIVISION 01 Specification SECTIONS, apply to this SECTION.

1.02 SUMMARY:

- A. This SECTION specifies panelboards including cabinets and boxes, as indicated by Drawings and Schedules, and as specified herein.
- B. Types of panelboards and enclosures required for the Project include the following:
 - 1. Service entrance panelboards.
 - 2. Lighting and appliance branch-circuit panelboards.

1.03 RELATED REQUIREMENTS:

- A. SECTION 26 00 00 - General Electrical Requirements
- B. SECTION 26 05 26 - Grounding and Bonding for Electrical Systems
- C. SECTION 26 05 53 - Identification for Electrical Systems

1.04 REFERENCE STANDARDS:

- A. Publication Dates: Comply with the latest standards revision in effect as of the date of the Contract Documents unless otherwise indicated.
- B. Code of Federal Regulations (CFR):
 - 1. 10 CRF Part 429 – Certification, Compliance, and Enforcement for Consumer Products and Commercial and Industrial Equipment.
 - a. 429.47 – Distribution Transformers.
 - 2. 10 CFR Part 431 – Energy Efficiency program For Certain Commercial and Industrial Equipment, Subpart K – Distribution Transformers.
 - a. 431.193 – Test procedures for measuring energy consumption of distribution transformers.
 - b. 431.196 – Energy Conservation Standards.
- C. Institute of Electrical and Electronic Engineers (IEEE):
 - 1. IEEE C62.41.1 – Surge Environment in Low-Voltage (1000V and less) AC Power Circuits.
 - 2. IEEE C62.41.2 – Characterization of Surges in Low-Voltage (1000V and less) AC Power Circuits.
 - 3. IEEE C62.45 – Surge Testing on Equipment Connected to Low Voltage (1000V and less) AC Power Circuits.
 - 4. IEEE C62.62 – Test Specification for Surge Protective Devices for Low Voltage AC Power Circuitry.
- D. National Electrical Manufacturers Association (NEMA):
 - 1. NEMA 250 – Enclosures for Electrical Equipment (1,000V Maximum).
 - 2. NEMA PB 1 – Panelboards.
 - 3. NEMA PB 1.1 – General Instructions for Proper Installation, Operation, and Maintenance of Panelboards Rated 600V or Less.
 - 4. NEMA PB 2.2 – Application Guide for Ground-Fault Protective Devices for Equipment.
 - 5. NEMA ST 20 – Dry Type Transformers for General Applications.

SECTION 26 24 16 - PANELBOARDS: continued

- E. National Fire Protection Association (NFPA):
 - 1. NFPA 70 - National Electrical Code (NEC): Comply with applicable local code requirements of the authority having jurisdiction and NEC as applicable to installation and construction of electrical panelboards and enclosures.
 - F. Underwriters Laboratories (UL): Provide panelboard units which are UL listed and labeled.
 - 1. UL 50 - Electrical Cabinets and Boxes.
 - 2. UL 67 - Electrical Panelboards.
 - 3. UL 486A - Wire Connectors and Soldering Lugs for Use with Copper Conductors.
 - 4. UL 489 - Molded-Case Circuit Breakers and Circuit Breaker Enclosures.
 - 5. UL 869A - Electrical Service Equipment.
 - 6. UL 1053 - Ground-Fault Sensing and Relaying Equipment.
 - 7. 1283 – Electromagnetic Interference Filters.
 - 8. 1449 – Safety for Surge Protective Devices.
 - 9. Special Use Markings: Provide panelboards constructed for special use with appropriate UL markings which indicate that they are "Suitable for Use as Service Equipment" where applicable.
 - G. Federal Specification (FS) Compliance: Comply with applicable requirements of the following standards.
 - 1. FS W-C-375 Series – Molded-Case Circuit-Breakers, Branch Service and Circuit.
 - 2. FS W-P-115C – Panel, Power Distribution.
 - 3. FS W-C-375 – Circuit Breakers, Molded Case; Branch Circuit and Service.
- 1.05 SUBMITTALS:
- A. Submit as specified in the General and Special Conditions and SECTION 26 00 00 – General Electrical Requirements for administrative and procedural requirements for submittals.
 - B. Submittals shall be custom prepared by the panelboard manufacturer for this specific application.
 - C. Product Data: Submit for each type of product specified and included, with the following as a minimum:
 - 1. Data sheets for all components furnished as part of the system package.
 - D. Shop Drawings: Provide the following as a minimum:
 - 1. Panelboard dimensions and weight. Provide center-of-gravity information for each seismic rated panelboard.
 - 2. Complete data on circuit breakers. Submit time - current characteristic curves of all devices.
 - 3. Panelboard short-circuit interrupting capacity, and information on buses: Phase, neutral, and ground.
 - 4. Information on whether panelboard is fed from top or bottom.
 - 5. Data on maximum and minimum incoming and outgoing feeder and branch circuit wire size.
 - 6. Data on door, locks, and mounting: Surface or flush.
 - 7. Data on total number of poles and number of unused poles that is available for future use.

SECTION 26 24 16 - PANELBOARDS: continued

- E. Closeout Submittals: Final documentation shall include the following as minimum:
 - 1. Operation and Maintenance Manuals including the following:
 - a. Operation and maintenance manuals for all components furnished.
 - b. Certified "As-Built" drawings of all equipment with information listed above.
 - c. Copies of all approved Product Data.
 - d. Copies of all approved Test Reports.
 - e. Warranty Information.
- F. Maintenance Material Submittals:
 - 1. Furnish extra materials and spare parts that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - a. Keys: Two spares for each type of panelboard cabinet lock.
 - b. Circuit Breakers Including GFCI and Ground Fault Equipment Protection (GFEP) Types: Two spares for each panelboard.

1.06 QUALITY CONTROL:

- A. Testing Agency Qualifications: Member company of NETA or a NRTL.
 - 1. Testing Agency's Field Supervisor: Currently certified by NETA to supervise on-site testing.
- B. Materials and Equipment shall be the standard products of a manufacturer regularly engaged in the manufacture of such products and shall be the manufacturer's latest standard design that has been in satisfactory use for at least one year prior to Bid opening.
- C. Source Limitations: Obtain panelboards, overcurrent protective devices, components, and accessories from single source from single manufacturer.
- D. Product Selection for Restricted Space: Drawings indicate maximum dimensions for panelboards including clearances between panelboards and adjacent surfaces and other items. Comply with indicated maximum dimensions.
- E. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- F. Panelboards shall comply with NEMA PB 1.
- G. Comply with NFPA 70.
- H. Mini-power centers shall conform to the applicable requirements of 10 CFR 429.47 – Distribution Transformers and 10 CFR 431.193 – Test procedures for measuring energy consumption of distribution transformers.

1.07 DELIVERY, STORAGE, AND HANDLING:

- A. Panelboards shall be stored according to the manufacturer's instructions and in a conditioned space to avoid condensation, dust, and other environmental contaminants.
- B. Remove loose packing and flammable materials from inside panelboards; install temporary electric heating (Approximately 250 watts per panelboard for average conditions) to prevent condensation.
- C. Handle and prepare panelboards for installation according to NEMA PB 1 and manufacturer's instructions.

SECTION 26 24 16 - PANELBOARDS: continued

1.08 PROJECT SITE CONDITIONS:

A. Environmental Limitations:

1. Do not deliver or install panelboards until spaces are enclosed, weathertight, dry, work above panelboards is complete, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.
2. Service Conditions: Rate equipment for continuous operation conditions defined in DIVISION 1.

1.09 COORDINATION:

- A. Coordinate the layout and installation of panelboards and components with other types of equipment including raceways, piping, encumbrances to workspace clearance requirements, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.
- B. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in DIVISION 03.

1.10 WARRANTY:

- A. All equipment furnished under this SECTION shall be warranted by the Contractor and the equipment manufacturer(s) for a minimum period of one year after substantial completion.
- B. Warranty shall include all parts, labor, and expenses to perform necessary work.

PART 2 - PRODUCTS

2.01 MANUFACTURERS:

- A. Subject to compliance with requirements, provide panelboard and mini-power center products of one of the following (for each type and rating of panelboard and enclosure):
 1. Eaton.
 2. Square D, Schneider Electric.

2.02 GENERAL REQUIREMENTS FOR PANELBOARDS:

- A. Except as otherwise indicated, provide panelboards, enclosures, and ancillary components of types, size, and ratings indicated, which comply with manufacturer's standard materials and with the design and construction in accordance with published product information.
- B. Where types, sizes, or ratings are not indicated, comply with NEC, UL, and established industry standards for those applications indicated.
- C. Equip with proper number of panelboard switching and protective devices as required for complete installation.
- D. Provide ground fault circuit interrupter type circuit breakers where indicated.
- E. Enclosures: Flush- and surface-mounted cabinets as indicated.
 1. Provide enclosures fabricated by same manufacturer as panelboards which mate and match properly with panelboards.

SECTION 26 24 16 - PANELBOARDS: continued

2. Rated for environmental conditions at installed location. Provide NEMA type as described below and as defined by NEMA 250, unless indicated or specified otherwise.
 - a. Outdoor Locations: NEMA, Type 4X.
 - b. Other Wet or Damp Indoor Locations: NEMA, Type 4X.
 3. Materials: Galvanized sheet steel cabinet type enclosures, in sizes required. Provide code gage (minimum 16-gage) thickness steel.
 4. Must be UL 50 listed.
 5. Front: Secured to box with adjustable, concealed trim clamps. For surface-mounted fronts, match box dimensions; for flush-mounted fronts, overlap box.
 6. Hinged Front Cover: Entire front trim hinged to box and with standard door within hinged trim cover. Front doors shall have flush locks with three keys per panelboard, all panelboard enclosures keyed alike.
 7. Finishes:
 - a. Color: Baked gray enamel finish over a rust inhibitor coating.
 - b. Panels and Trim: Galvanized steel, factory finished immediately after cleaning and pretreating with manufacturer's standard two-coat, baked-on finish consisting of prime coat and thermosetting topcoat.
 - c. Back Boxes: Stainless Steel for NEMA 4X panelboards
 - d. Fungus Proofing: Permanent fungicidal treatment for overcurrent protective devices and other components.
 8. Directory Card: Inside panelboard door, equip with interior circuit directory frame and removable card with clear plastic covering.
- F. Phase, Neutral, and Ground Buses:
1. Bus shall be braced to withstand available short-circuit currents as indicated.
 2. Provide suitable lugs on neutral bus for incoming and outgoing feeders requiring neutral connections.
 3. Equipment Ground Bus: Bare, uninsulated, adequate for feeder and branch-circuit equipment grounding conductors; bonded to box.
 4. Material: Hard-drawn copper, 98% conductivity.
- G. Conductor Connectors: Suitable for use with conductor material and sizes indicated and specified.
1. Material: Hard-drawn copper, 98% conductivity.
 2. Main and Neutral Lugs: Mechanical type.
 3. Ground Lugs and Bus-Configured Terminators.
 4. All lugs shall be mechanical type.
 5. Provide terminals UL rated for 75°C (minimum) conductors.
- H. Service Equipment Label: NRTL labeled for use as service equipment for panelboards with one or more main service disconnecting and overcurrent protective devices.
- I. Future Devices: Mounting brackets, bus connections, filler plates, and necessary appurtenances required for future installation of devices.
- J. Panelboard Short-Circuit Current Rating: Fully rated to interrupt symmetrical short-circuit current available at terminals as indicated.

SECTION 26 24 16 - PANELBOARDS: continued

- K. Final equipment selection: Review the short circuit equipment study. Provide only equipment that meets or exceeds the recommendation of that short circuit study specified in SECTION 26 05 73.
- L. Surge Protection Devices: When indicated, Provide an integral surge protection device for each panelboard as specified. Refer to SECTION 26 43 13 – Surge Protection Devices for Low-Voltage Electrical Power Equipment for device requirements.
- M. Provide panelboard nameplate as indicated.

2.03 SERVICE ENTRANCE AND] POWER DISTRIBUTION PANELBOARDS:

- A. Panelboards: NEMA PB 1, dead front, safety type, power and feeder distribution type, 120/240V 1 phase, 3 wire, 60 hertz, with full-sized neutral bus as indicated.
- B. Panelboard switching and protective devices in quantities, ratings, types, and with arrangements shown.
- C. Anti-turn, solderless, pressure-type main lug connectors approved for use with copper conductors.
- D. Provide panelboards with UL markings which indicate "suitable for use as service entrance equipment". Shall meet UL 869A.
- E. Incoming Mains Location: Top or bottom as indicated.
- F. Mains: Circuit breaker or lugs only as indicated.
- G. Branch Overcurrent Protective Devices:
 - 1. Bolt-on, molded-case circuit breakers.
 - 2. Molded-case circuit breakers shall have toggle handles that indicate when tripped.
 - 3. Where multiple pole breakers are indicated, provide with common trip so overload on one pole will trip all poles simultaneously.
 - 4. Circuit breakers shall be replaceable without disturbing adjacent units.
- H. Furnish an integral metal locking device for each circuit breaker provided. Locking device shall be padlockable and allow breakers to be individually locked in the OFF position.
- I. Provide an integral surge protection device to protect the panelboard.
- J. Doors: Secured with vault-type latch with tumbler lock; keyed alike.
 - 1. For doors more than 36 inches high, provide two latches, keyed alike.

2.04 LIGHTING AND APPLIANCE BRANCH-CIRCUIT PANELBOARDS:

- A. Panelboards: NEMA PB 1, dead front, safety type 120/240V, single phase, 3 wire, 60 hertz with full-sized neutral bus.
- B. Lighting and appliance branch-circuit type as indicated with switching and protective devices in quantities, ratings, types, and arrangements shown.
- C. Incoming Mains Location: Top or bottom as required.
- D. Mains: Circuit breaker or lugs only as indicated.
- E. Branch Overcurrent Protective Devices:
 - 1. Bolt-on, molded-case circuit breakers.
 - 2. Molded-case circuit breakers shall have toggle handles that indicate when tripped.
 - 3. Where multiple pole breakers are indicated, provide with common trip so overload on one pole will trip all poles simultaneously.

SECTION 26 24 16 - PANELBOARDS: continued

- 4. Circuit breakers shall be replaceable without disturbing adjacent units.
- F. Doors: Concealed hinges; secured with flush latch with tumbler lock; keyed alike.
- G. Provide an integral surge protection device to protect the panelboard as specified in SECTION 26 43 13.

2.05 PANELBOARD INTEGRAL SURGE PROTECTION DEVICE:

- A. Provide surge protection device (SPD) designed for installation within the panelboard. The SPD shall connect directly to the bus bar and have an integral disconnect. SPD shall be approved by panelboard manufacturer for installation within the panelboard. Indicating lights shall be mounted in the face of the panelboard. The unit shall provide the following modes of protection: line-to-line (L-L), line-to-ground (L-G), line-to-neutral (L-N), and neutral to ground (N-G).
- B. Provide SPD as specified in SECTION 26 43 13.
- C. SPDs shall have the following characteristics:
 - 1. UL 1449 Fourth Edition listed and labeled.
 - 2. The surge environment and surge characteristics for the SPD shall be as defined by IEEE C62.41.1 and IEEE C62.41.2.
 - 3. Shall be of a parallel design using fast-acting transient energy protection that will divert and dissipate the surge energy.
 - 4. Shall use metal oxide varistor technology. (Spark gaps, gas tubes, selenium cells and SCRs shall not be acceptable.)
 - 5. Shall include internal fuses and thermally protection over every suppression component of every mode, including N-G for wye configurations.
 - 6. Shall be factory-installed by the panelboard manufacturer via a direct bus bar connection immediately following the load side of the main breaker. SPDs installed in main lug only panelboards shall be installed immediately following the incoming main lugs.
 - 7. The panelboard shall be capable of re-energizing upon removal of the SPD.
 - 8. Shall have integral, panel-front status monitors or remote status panel ability as a minimum to indicate a continuous positive status of all protected modes. Diagnostics shall be electrically isolated to prevent damage by surges.
 - 9. The maximum continuous operating voltage at 60 Hz shall be capable of sustaining at least 115% of the peak voltages continuously without degrading.

SECTION 26 24 16 - PANELBOARDS: continued

10. The maximum UL 1449 Third Edition Voltage Protection Ratings (VPR) for the device must not exceed the following:

Service	L-N	L-G	N-G	L-L	MCOV
120/240Vac, 3-Wire + Gnd	700V	700V	700V	1200V	150V
208/120Vac, 3-phase, 4-wire	700V	700V	700V	1200V	150/276 V
480 Vac 3-phase, 3-wire Delta	NA	1800V	NA	1800V	550V
480/277 Vac, 3-phase, 4-wire	1200V	1200V	1200V	2000V	550/320 V

11. Shall be UL labeled with 20kA I-n for compliance to UL 96A Lightning Protection Master Label and NFPA 780.
12. Shall be UL labeled as a Type 1 or Type 2 device and shall not require external or supplemental overcurrent safety controls to meet UL 1449 3rd Edition.
13. Warranty: SPD manufacturer shall provide free replacement of the entire model with a minimum warranty period of 10 years from date of shipment. This warranty shall be limited only by failure to comply with manufacturer's installation instructions and applicable national or local code and may not exclude lightning or temporary overvoltage (TOV).
- D. Service Entrance and Distribution Panelboard Surge Protection Device:
1. The SPD unit shall be tested according to UL 1449, associated IEEE C62.45 and IEEE C62.62 testing specifications, and demonstrate suitability for application within IEEE C62.41 Category C3 environments.
 2. The SPD shall be suitable for 120/240V 1-phase, 3-wire, 60 Hz.
 3. Shall have a minimum peak surge current of 50kA per phase.
 4. Shall include EMI/RFI filtering (sometimes called sine-wave tracking filtering technology) for ring wave suppression.
 5. Shall have a minimum EMI/RFI filtering of -50dB at 100 kHz.
 6. UL 1283 Listed. (Latest Edition)
 7. Filters in the N-G mode shall not be allowed.
- E. Accessories:
1. Green LED status indicator per phase.
 2. Red LED service indicator.
 3. Test function for LEDs and audible alarm.
 4. Internal audible alarm with mute switch.
 5. Surge event counter.

SECTION 26 24 16 - PANELBOARDS: continued

PART 3 - EXECUTION

3.01 EXAMINATION:

- A. Receive, inspect, handle, and store panelboards according to NEMA PB 1.1.
- B. Examine panelboards before installation. Reject panelboards that are damaged or rusted or have been subjected to water saturation.
- C. Verify Site conditions are suitable for installation of equipment.
- D. Examine elements and surfaces to receive panelboards for compliance with installation tolerances and other conditions affecting performance of the work.
- E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 INSTALLATION OF PANELBOARDS:

- A. Install panelboards, mini-power centers, and enclosures as indicated, providing NEC required working space, in accordance with manufacturer's written instructions, applicable requirements of NEC and in compliance with recognized industry practices to ensure that products fulfill requirements.
- B. Tighten connectors and terminals, including screws and bolts, in accordance with equipment manufacturer's published torque tightening values for equipment connectors. Where manufacturer's torquing requirements are not indicated, tighten connectors and terminals to comply with tightening torques specified in UL 486A.
- C. Fasten enclosures firmly to walls and structural surfaces, ensuring that they are permanently and mechanically anchored.
- D. Provide properly wired electrical connections for panelboards within enclosures.
- E. Install numbers on all circuit breakers and type the panelboard's circuit directory card upon completion of installation work. Clearly identify the load on each circuit and the circuit number according to the Contract Drawings.
- F. Provide filler plates in all unused spaces.
- G. Provision for future circuits at all flush mounted panelboards (unless indicated otherwise): Extend four 1-inch empty conduits from panelboard into accessible ceiling space or space designated to be ceiling space in the future. Extend four 1-inch conduits into raised floor space or below floor slab (not required for slabs on grade or basement floor slabs).

3.03 GROUNDING:

- A. Provide equipment grounding connections for panelboard enclosures as indicated and as required by NEC. Tighten connections to comply with tightening torques specified in UL 486A to assure permanent and effective grounds. Provide grounding as specified in SECTION 26 05 26.

3.04 IDENTIFICATION:

- A. Provide all warning signs, nameplates, labels, and markers as specified in SECTION 26 05 53.
- B. Label field-installed conductors, interconnecting wiring, and components;
- C. Provide Equipment and conduit warning signs.
- D. Provide Equipment nameplates.
- E. Create a directory to indicate installed circuit loads; incorporate equipment served and room designations as indicated on the Drawings. Use a computer printer to

SECTION 26 24 16 - PANELBOARDS: continued

create directory; handwritten directories are not acceptable. Directory shall be subject to approval by the Engineer and Owner.

3.05 FIELD QUALITY CONTROL:

- A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.
- C. Perform tests and inspections as specified and as recommended by the equipment manufacturer.
 - 1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
- D. Acceptance Testing Preparation:
 - 1. Test insulation resistance for each panelboard bus, component, connecting supply, feeder, and control circuit.
 - 2. Test continuity of each circuit.
- E. Tests and Inspections:
 - 1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
 - 2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
 - 3. Prior to energization of electrical circuitry, check all accessible connections to manufacturer's tightening torque specifications.
 - 4. Prior to energization, check panelboard circuits for short circuits, electrical continuity of circuits, enclosure grounding and neutral grounding at service entrance and at incoming derived source transformer.
 - 5. Prior to energization of panelboards, check with insulation resistance tester the phase-to-phase and phase-to-ground insulation resistance levels of each phase bus to ensure requirements are fulfilled. Record and submit test results.
 - 6. Panelboards will be considered defective if they do not pass tests and inspections.
 - 7. Prepare test and inspection reports, including a certified report that identifies panelboards included and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.06 FINISHES:

- A. Equipment coatings shall be free from scratches, rust, or other defects.
- B. All damaged or defective coatings shall be repaired prior to final acceptance.
- C. Field Painting:
 - 1. Touch Up:
 - a. Contractor shall prepare surfaces and touch up manufacturer applied coatings as required for any damage during shipment and installation.

SECTION 26 24 16 - PANELBOARDS: continued

- b. Field painting shall be performed based on manufacturer's recommended procedures.
- c. Panelboard manufacturer shall furnish Contractor with an adequate quantity of touch-up paint to match the factory applied finish.

3.07 ADJUSTING AND CLEANING:

- A. Adjust moving parts and operable components to ensure normal function as recommended by manufacturer.
- B. Upon completion of installation, clean interior and exterior of panelboards. Remove paint splatters, spots, dirt, and debris.
- C. Touch-up scratched or marred surfaces to match original finishes.

3.08 PROTECTION:

- A. Temporary Heating: Apply temporary heat to maintain temperature according to manufacturer's written instructions.

3.09 DEMONSTRATION:

- A. Subsequent to final wire and cable hook-ups, energize panelboards and demonstrate functioning in accordance with requirements. Where necessary, correct malfunctioning units, and then retest to demonstrate compliance.

END OF SECTION 26 24 16

SECTION 26 27 26 –WIRING DEVICES

PART 1 - GENERAL

1.01 RELATED DOCUMENTS:

- A. Drawings and general provisions of the Contract, including General and Special Conditions and DIVISION 01 Specification SECTIONS, apply to this SECTION.

1.02 SUMMARY:

- A. This SECTION covers wiring devices for lighting and utilization equipment including but not limited to the following:
 - 1. Receptacles.
 - 2. Switches.
 - 3. Wall Plates.
 - 4. Plugs.

1.03 RELATED REQUIREMENTS:

- A. SECTION 26 05 26 – Grounding and Bonding for Electrical Systems.
- B. SECTION 26 05 33 – Raceways, Boxes, Seals and Fittings for Electrical Systems.

1.04 REFERENCE STANDARDS:

- A. Publication Dates: Comply with standards in effect as of date of the Contract Documents unless otherwise indicated.
- B. National Electrical Manufacturers Association (NEMA):
 - 1. NEMA WD 1 – General Color Requirements for Wiring Devices.
 - 2. NEMA WD 6 – Wiring Devices - Dimensional Specifications.
 - 3. NEMA 410 – Performance Testing for Lighting Controls and Switching Devices with Electronic Drivers and Discharge Ballasts.
- C. National Fire Protection Association (NFPA):
 - 1. NFPA 70 – National Electrical Code (NEC).
- D. Underwriters Laboratories (UL):
 - 1. UL 20 – General-Use Snap Switches.
 - 2. UL 486A-486B – Wire Connectors.
 - 3. UL 498 – Attachment Plugs and Receptacles.
 - 4. UL 514D – Cover Plates for Flush-Mounted Wiring Devices.
 - 5. UL 943 – Ground-Fault Circuit-Interrupters.
 - 6. UL 1203 – Explosion-Proof and Dust-Ignition-Proof Electrical Equipment for Use in Hazardous (Classified) Locations.
 - 7. UL 1310 – Class 2 Power Units.
 - 8. UL 1472 – Solid State Dimming Controls.
 - 9. UL 1682 – UL Standard for Safety Plugs, Receptacles, and Cable Connectors of the Pin and Sleeve Type.
 - 10. UL 1686 – UL Standard for Safety Pin and Sleeve Configurations.
- E. Federal Specification (Fed. Spec.):
 - 1. Fed. Spec. W-C-596 – Connector, Electrical, Power, General Specifications.
 - 2. Fed. Spec. W-S-896 – Switches, Toggles (Toggle and Lock), Flush-Mounted.

SECTION 26 27 26 – WIRING DEVICES: continued

1.05 SUBMITTALS:

- A. Refer to the General and Special Conditions and SECTION 26 00 00 – General Electrical Requirements for administrative and procedural requirements for submittals.
- B. Product Data for each product specified.

1.06 QUALITY CONTROL:

- A. Conform to the requirements of NFPA 70.
- B. Manufacturer Qualifications: Company specializing in manufacturing the products specified in this SECTION with minimum 3 years documented experience.

1.07 DELIVERY, STORAGE, AND HANDLING:

- A. Wiring devices shall be packaged and shipped to the project site to avoid damage.
- B. Store in a clean, dry space in original manufacturer's packing to avoid condensation, dust, and other environmental contaminants until ready for installation.

1.08 SEQUENCE AND SCHEDULING:

- A. Schedule installation of wiring devices and associated wall plates after the surface upon which they are installed has received the final finish.

PART 2 - PRODUCTS

2.01 MANUFACTURERS:

- A. Appleton, Emerson Electric Co.
- B. Cooper, Crouse-Hinds, Division of Eaton.
- C. Hubbell, Inc.
- D. Leviton Manufacturing Co., Inc.
- E. Pass & Seymour, Legrand North America, Inc.
- F. Russellstoll, Thomas & Betts.
- G. Woodhead, Molex.
- H. Source Limitation: Wiring device and associated wall plate shall be supplied from a single manufacturer for each type of device for consistency throughout project.

2.02 RECEPTACLES:

- A. General:
 - 1. All receptacles shall be heavy-duty type and shall bear a UL 498 label and comply with NEMA WD 1 and WD 6 as applicable.
 - 2. Provide all necessary wiring and accessories as required for complete installation.
- B. Flush-Mounted and Surface-Mounted Receptacles:
 - 1. Rated 20A at 125Vac.
 - 2. Duplex, arc-resistant, back and side-wired, 3-wire grounding type. NEMA reference 5-20R.
 - 3. Receptacle and wall plates shall be as follows:
 - a. Flush-mounted receptacles in all other areas shall be gray with 302 stainless steel wall plates.

SECTION 26 27 26 – WIRING DEVICES: continued

- b. Surface-mounted receptacles shall be gray and have cast malleable iron FS or FD single or multiple gang boxes with matching 302 stainless steel cover plate.
- 4. "Specification" grade type 5362, Fed. Spec. W-C-596 compliant, NEMA reference 5-20R.
- 5. Locations as indicated.
- 6. When indicated provide GFCI type as specified in this SECTION.
- C. Ground Fault Circuit Interrupter (GFCI) Receptacles:
 - 1. Flush or surface mounted as indicated.
 - 2. Rated 20A at 125Vac, Fed. Spec. W-C-596.
 - 3. Back and side wired terminals with feed-through design.
 - a. Terminal installation unless indicated otherwise.
 - 4. UL Standard 943 Class A, Group 1.
 - 5. Leakage current sensitivity: 5 mA $\pm$ 1 mA.
 - a. Opens circuit within 25 milliseconds of reaching 5 mA.
 - 6. Duplex, arc resistant and pre wired.
 - 7. Cover plate materials and colors shall match standard receptacles as specified in this SECTION.
 - 8. FD box.
 - 9. Locations as indicated.
- D. Weatherproof Receptacles:
 - 1. Flush or surface mounted as indicated.
 - 2. Rated 20A at 125Vac, Fed. Spec. W-C-596. NEMA reference 5-20R.
 - 3. GFCI receptacle as specified in this SECTION when indicated.
 - 4. Provide a gray receptacle with a cast aluminum weather-proof cover.
 - a. Provide while in use cover for outdoor locations insert other locations unless indicated otherwise.
 - b. Provide hinged self-closing, gasketed type covers for indoor damp locations.
 - 5. FS or FD boxes.
 - 6. Locations as indicated.
- E. Twist Locking Receptacles:
 - 1. Flush or surface mounted as indicated.
 - 2. Rated 20A at 125Vac, NEMA reference L5-20.
 - 3. Cover plate materials and colors shall match standard receptacles as specified this SECTION.
 - 4. Provide matching plug assembly when required for application indicated. Coordinate with Plugs this SECTION.
 - 5. applicable.
- F. Special Receptacles:
 - 1. Provide with ratings as indicated.
 - 2. For flush mounted applications provide a gray receptacle with 302 stainless steel wall plate for flush mounted applications.
 - 3. Provide with cast malleable iron FS or FD single or multiple gang boxes with matching aluminum cover plate for surface mounted applications.

SECTION 26 27 26 – WIRING DEVICES: continued

4. Provide with a NEMA 4X stainless steel mounting enclosure sized for the receptacle and necessary cable terminations.
5. Mounting hardware and cover screws shall be stainless steel.

2.03 SWITCHES:

- A. General:
 1. All switches and associated materials shall bear a UL 20 label and comply with NEMA WD 1.
 2. Provide all necessary wiring and accessories as required for complete installation.
- B. All single-pole, double-pole, three-way, and four-way switches as indicated.
- C. Flush-Mounted, Tumbler, Self-Grounding, Heavy-Duty Switches:
 1. Rated 20A at 120 or 277Vac.
 2. Quiet type.
 3. "Specification" grade, Fed. Spec. W-S-896.
 4. Gray toggle in all other areas with 302 stainless steel wall plates.
 5. Back and side wired design.
 - a. Screw terminal installation unless indicated otherwise.
 6. With grounding lug.
- D. Surface-Mounted, Tumbler, Self-Grounding, Heavy-Duty Switches:
 1. Rated 20A at 120V or 277Vac.
 2. "Specification" grade (Fed. Spec. W-S-896) switch with gray toggle.
 3. FS and FD single or multiple gang cast boxes.
 4. Cast aluminum cover plates and matching countersunk screws.
 5. Locations indicated.
- E. Weatherproof, Self-Grounding, Heavy-Duty Switches:
 1. Rated 20A at 120V or 277Vac.
 2. Gray toggle.
 3. Flush or surface mounted as indicated.
 4. FS or FD boxes with PVC gasketing.
 5. "Specification" grade. Fed. Spec. W-S-896.
 6. Lever-type, cast aluminum, gasketed cover plate.
 - a. Cooper, Crouse-Hinds No. DS185 or engineer approved equal.
 7. Locations indicated.

2.04 PLUGS:

- A. Rated 20A at 125Vac 250Vac.
- B. Industrial grade, straight blade design.
- C. Provide with cord clamp to accept a cord range of 0.23-0.72- inches minimum.
- D. Integral cable grip with offset cable gripping jaws secured with two screws.
- E. Grounding type.
- F. NEMA WD 6 ratings to match associated source receptacle.
- G. Provide for locations indicated.

SECTION 26 27 26 – WIRING DEVICES: continued

PART 3 - EXECUTION

3.01 INSTALLATION:

A. General:

1. Install wiring devices and accessories in accordance with manufacturer's written instructions, and in accordance with recognized industry practices.
2. Coordinate with other work, including painting, electrical boxes, and wiring installation.
3. Tighten connectors and terminals, including screws and bolts, in accordance with equipment manufacturer's published torque tightening values for wiring devices. Where manufacturer's torquing requirements are not indicated, tighten connectors and terminals to comply with tightening torques specified in UL 486A-486B.
4. Install wiring devices only in electrical boxes which are clean - free from building materials, dirt, and debris.
5. Wiring devices shall not be installed in boxes until wire pulling is completed.
6. Painting work shall be completed prior to device wall plate installation.

B. Receptacles:

1. Mount receptacles outlets 1'-6" (450 mm) above floor, walkways, or finished grade unless indicated otherwise.

C. Switches:

1. Mount 4 feet (1.2 meters) above floor, walkways, or finished grade unless indicated otherwise.
2. Install close to trim on lock side when located near doors.

D. Wiring Circuits:

1. Home Run Groupings:
 - a. Group in home runs with not more than one conductor of each phase and 100% sized neutral and ground wire in one conduit.
 - b. Circuits which are protected by ground fault circuit interrupter (GFCI) devices shall use their own separate and isolated neutral between the GFCI device and load.
2. Use circuit numbers as indicated.
3. Use type SVN3 wire for lighting and receptacle circuits unless indicated otherwise.
4. Do not install wire smaller than No. 12 AWG.
5. Install larger size wire as indicated or required to conform to requirement of NFPA 70 (NEC).
6. Install in concealed and exposed conduit systems as indicated.

3.02 PROTECTION:

A. Protect installed devices from damage.

B. Devices and wall plates that are damaged, stained, or painted shall be replaced prior to final acceptance.

SECTION 26 27 26 – WIRING DEVICES: continued

3.03 FIELD QUALITY CONTROL:

A. Testing:

1. Prior to energizing circuits, test wiring for electrical continuity and for short-circuits. Ensure proper polarity of connections is maintained.
2. After circuits are energized, test wiring devices and demonstrate compliance with requirements.
 - a. Test each receptacle with a receptacle tester to ensure proper polarity.
 - b. Test ground fault circuit interrupters with the local test button and with a receptacle tester to simulate a remote ground fault.
 - c. Verify the phase rotation is identical on all multi-phase receptacles.

END OF SECTION 26 27 26

SECTION 26 42 13 - PASSIVE CATHODIC PROTECTION FOR UNDERGROUND AND SUBMERGED PIPING

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.
- B. Related Work Specified Elsewhere:
 - 1. Protective Coatings: SECTION 09 90 00.
 - 2. Water Utility Transmission Piping: SECTION 33 14 11.

1.02 SCOPE OF WORK:

- A. The corrosion control shall consist of monitoring and cathodic protection systems which shall include the furnishing and installation of all wiring, test stations, anodes, exothermic welding and all other work and items required for a complete and functioning system for the specified buried piping.
- B. The corrosion control systems shall be installed as shown on the Drawings and as specified herein.
- C. The cathodic protection systems shall be tested by a NACE International certified Corrosion Specialist or Cathodic Protection Specialist (NACE International Specialist) engaged by the Contractor. Approval of the NACE tester shall be subject to the approval of the Owner and the Engineer.

1.03 REFERENCES:

- A. The cathodic protection installation 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. American Society for Testing and Materials (ASTM):
 - a. A 153 – Zinc Coating (Hot Dip) on Iron and Steel Hardware.
 - b. B843, Standard Specification for Magnesium Alloy Anodes for Cathodic Protection.
 - c. D 1248, Class C, Grade 5 – Polyethylene Plastics Extrusion Materials for Wire and Cable.
 - d. D 785 Type 1, Grade 1 – Polyvinyl Chloride (PVC) Plastic Pipe.
 - 2. National Association of Corrosion Engineer's International (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.
 - 3. National Electric Manufacturers Association (NEMA):
 - a. Enclosures - Type 3, 3R, 3X, 4, and 4X.

SECTION 26 42 13 - PASSIVE CATHODIC PROTECTION FOR UNDERGROUND AND SUBMERGED PIPING: continued

- b. TC2 - Electrical Polyethylene Chloride (PVC) Conduit.
- c. TC3 - Polyvinyl Chloride (PVC) Fittings.
- 4. National Electrical Code (NEC).
- 5. Underwriters Laboratory (UL).

1.01 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.

1.02 DEFINITIONS:

- A. 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.
- B. Cathodic Protection Criteria: Conform to NACE SP0169.
- C. 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.
- D. 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.
- E. Electrical Isolation: The condition of being electrically isolated from other metallic structures and the environment as defined in NACE RP0286.
- F. 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).
- G. Foreign-Owned: Buried pipe or cable not specifically owned or operated by the Client.
- H. 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.
- I. Lead, Lead Wires, Joint Bond, and Cable: Insulated copper conductor; the same as wire.
- J. Manufacturer's Representative: An employee of the manufacturer who is factory trained and knowledgeable in the technical aspects of their products and systems.
- K. Raceways: Conduit, plastic or metal pipe, or electrical metallic conduit (EMT) for the casing of electrical or cathodic protection cables.
- L. Structure-to-Reference Electrode Potential (also Structure-to-Reference Electrode

SECTION 26 42 13 - PASSIVE CATHODIC PROTECTION FOR UNDERGROUND AND SUBMERGED PIPING: continued

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.

1.03 SUBMITTALS:

A. Products and Manufacturers:

1. As soon as practicable and within thirty (30) days after the date of receipt of 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. 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 wire conductors
 - d. Joint bond wire
 - e. Joint bond clips
 - f. Test station enclosures, terminal boards, and shunts
 - g. Exothermic welding equipment
 - h. Exothermic weld connection coating systems
 - i. Reference Electrodes
 - j. Wire splice kits
 - k. Wire marker tags
 - l. Wire terminals
2. As soon as practicable and within thirty (30) days after the date of receipt of notice to proceed, and before any material or equipment is purchased, the contractor shall submit for approval:
 - a. Qualifications and certification of NACE International Specialist
 - b. The NACE International Specialist's Test Plan.
3. After completion of the cathodic protection installation work, and in compliance with the data submittal requirements of the contract documents, the Contractor shall submit the following:
 - a. As-Built drawings.
 - b. Record drawings of installation and construction of CPS; accurate location and type of anodes, wires, conduits, insulators, pipe connections, and junction boxes.
 - c. Field test reports.
 - d. Cathodic protection system test report and O&M manual.

B. Performance Requirements:

1. Show evidence of UL approval where UL standards exist and product listings are available.
2. Conform to National Electrical Code (NEC) and applicable federal, state, and

SECTION 26 42 13 - PASSIVE CATHODIC PROTECTION FOR UNDERGROUND AND SUBMERGED PIPING: continued

- local laws, codes, and regulations.
- 3. When requirements of specification or drawings exceed those of codes or the manufacture's instruction, requirements of Specifications or Drawings prevail.
 - a. Procedures for verifying complete test station installation.
- C. Certification:
 - 1. The cathodic protection systems shall be tested by a NACE International certified Corrosion Specialist or Cathodic Protection Specialist (NACE International Specialist). The NACE International Specialist shall have successfully completed a minimum of ten Contracts of similar nature and scope as that indicated in this Specification.
 - 2. The NACE International Specialist shall insure the proper installation of the galvanic cathodic protection system indicated on the Contract Drawings, verify electrical continuity of the pipeline, verify the effectiveness of insulating fittings, and obtain test results of the cathodic protection system. Test shall include cathodic protection anode currents and pipe-to-soil potentials at the location of the work.
 - 3. The NACE International Specialist 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:
 - a. Procedures for verifying electrical continuity of pipe joints provided with continuity bond cables after construction.
 - b. Procedures for measuring the cathodic protection potentials and galvanic anode currents for the structure.
 - c. Methods for determining the effectiveness of dielectric fittings.

1.04 DELIVERY, STORAGE, AND HANDLING:

- A. Cathodic Protection Material:
 - 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 wires.
 - 5. Replace equipment or materials damaged in shipment or installation.
- B. Reference electrodes:
 - 1. Do not allow to freeze.
 - 2. Utilize before shelf life expires.
- C. Anodes:
 - 1. Coil anode wires and secure and package the anode in crates as required to prevent damage during shipping.
 - 2. Verify that the wire is not damaged and that the anodes or lead connection are not physically stressed.

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

SECTION 26 42 13 - PASSIVE CATHODIC PROTECTION FOR UNDERGROUND AND SUBMERGED PIPING: continued

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.

2.02 MATERIALS AND EQUIPMENT:

A. Magnesium 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. Anodes shall be furnished prepackaged in special backfill material consisting of 75% ground hydrated gypsum, 20% powdered bentonite and 5% anhydrous sodium sulfate. The backfill shall have a grain size such that 100% is capable of passing through a 20-mesh screen and 50% 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.
3. Anode lead wires shall be
- No. 12 AWG solid copper conductors with Type RHW/ USE-2 wire.
 - Black insulation.
 - Lead wires shall be a minimum of 50 feet in length. 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.
 - Sufficient in length to reach test station without being spliced.
4. The anode weight/dimensions shall be as follows:
- Ductile Iron Pipe and Fittings:
 - Weight – 32 lbs. (minimum bare weight)
 - Ingot length – 20 inches
5. Anodes shall be shipped in waterproof bags or wrapping and shall remain dry until installation.
6. Acceptable Manufacturers:
- Farwest Corrosion Control (Denver, CO)
 - Mesa Products (Denver, CO)
 - Engineer approved equal.

B. Test Stations:

1. Post Style:

SECTION 26 42 13 - PASSIVE CATHODIC PROTECTION FOR UNDERGROUND AND SUBMERGED PIPING: continued

- a. Test station top: Model 917, 5 or 7 Terminal, Threaded 3" by Gerome Electric.
 - b. Test station post: 6' x 3" OD, .216" thick zinc-coated steel pipe, threaded one end with 1" OD weep hole 4" from end of threads
 - c. Labels: Install Panduit label tags on all wires
 - a. Pipe Diameter and material
 - b. Wire function
2. Flush-mount Style:
 - a. Flush-to-ground test stations shall consist of test station enclosure, cast iron lid, terminal block with studs, and shunt.
 - b. Flush-to-ground test stations shall be concrete valve box enclosures with an H20 traffic rating such as Christy Mfg. Model "G5" with the lid inscribed with the words "CP TEST".
 - c. Flush-to-ground test stations shall be furnished with an insulated terminal board made of fiberglass reinforced polyester laminate similar to that as manufactured by CP Test Services, Inc. (test station model NM-5 or NM-7 terminal board). Terminal board hardware shall be stainless steel or nickel-plated brass and consist of a minimum of five 1/4 inch dia. by 1-1/4 inch long studs with double nuts, flat washers, and lock washers.
 - d. Labels: Install Panduit label tags on all wires
 - a. Pipe Diameter and material
 - b. Wire function
3. Each test station shall also be furnished with a Cott Mfg. Co. calibrated 0.01 ohm – 8 ampere (color code yellow) test station shunt or approved equal.
Exception: shunts are not required at Insulating Fitting Test Stations.
- C. Stationary Reference Electrodes:
 1. Copper/copper sulfate reference electrode material designed for minimum 20-year useful life as manufactured by GMC.
 2. Reference electrode to be pre-packaged in cloth sack with a low resistivity backfill formulated to retain moisture and maintain stability.
- D. Metallic Coupons:
 1. Suitable sized metallic with a minimum exposed surface area of 10 cm² for DC.
 2. Coupon shall contain two (2) cables for connection.
 3. Ensure metallic coupon is the same material and composition as the structure under cathodic protection.
 4. Approved manufacturers:
 - a. McMiller Co. Inc
 - b. Engineer or approved equivalent
- E. Exothermic Welds:
 1. All electrical cable connections to the buried piping shall be made by an exothermic weld. Exothermic type weld materials including the proper size and type of weld cartridges and welder molds for use on ductile-iron or steel pipe.
 2. Acceptable Manufacturers:
 - a. Erico Products Inc. "CADWELD"
 - b. Burndy "THERMOWELD"

SECTION 26 42 13 - PASSIVE CATHODIC PROTECTION FOR UNDERGROUND AND SUBMERGED PIPING: continued

- c. Engineer approved equal.
- 3. Weld materials shall be compatible with the pipe material as recommended by the manufacturer.
- 4. 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.
- F. Di-Electric Coating:
 - 1. Exothermic weld coatings
 - a. Royston Handy Caps.
 - b. Denso Protal 7125 or 7200 epoxy.
 - c. Engineer approved equal.
 - 2. Weld caps using an integrated primer such as Royston Handicap IP may also be used.
 - 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.
- G. Plastic Conduit for Cathodic Protection Sheathing for Lead Wires:
 - 1. Diameter: Sized to match application.
 - 2. Schedule 80 ASTM 1785 polyvinyl chloride (PVC) plastic pipe.
- H. Wire:
 - 1. Insulated stranded or solid copper wire as specified.
 - 2. Wire size, type, and insulation type: As specified in this SECTION and as depicted on Drawings.
 - a. Joint Bonds: Sized per bonding details Stranded, RHW/USE-2
 - b. Test leads: #8 AWG, Stranded, RHW/USE-2
 - c. Metallic Coupons: #12 AWG, Stranded, THHN/THWN
 - d. Anodes: #10 AWG, Solid, RHW/USE-2
 - e. Reference Electrode: #14 AWG, Stranded, RHW/USE-2
 - 3. Wire insulation color: Indicate the function of each wire as shown on the Drawings.
 - a. Blue: Project structure
 - b. White: Non-project structure owned and operated by OWNER
 - c. Red: Foreign structure owned and operated by others
 - d. Yellow: Stationary Reference Electrode
 - e. Green: Coupon
 - f. Black: Anodes or joint bonds
 - g. Orange: Casing
- I. In-Line Tap Slices for Cathodic Protection Cables (use only if approved by ENGINEER):
 - 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 #10 AWG or smaller

SECTION 26 42 13 - PASSIVE CATHODIC PROTECTION FOR UNDERGROUND AND SUBMERGED PIPING: continued

- splices.
- 5. Electrical Splicing Tape and Coating:
 - a. Acceptable manufacturers:
 - a. 3M Products
 - 1) Scotch 130C tape,
 - 2) Scotch Super 88 tape,
 - 3) and Scotchkote
 - b. Engineer 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.
- J. Wire Terminals:
 - 1. Burndy YAV series.
- K. Shunts:
 - 1. 0.01 ohm, yellow
 - 2. Acceptable Manufacturers:
 - a. Cott
 - b. Engineer approved equal.
- L. 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. Engineer approved equal.
- M. Polyethylene Wrap
 - 1. Specified in SECTION 33 14 11
- N. Wire Marker Tags and Pens:
 - 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" of termination. Marking sleeve shall be clearly visible.
 - 2. Acceptable Manufacturers:
 - a. Epson LabelWorks
- O. CP Warning Tape:
- P. 3" plastic, APWA yellow, non-detectable, marked "Caution Cathodic Protection Cable Buried Below" Electrical Isolation Devices:
 - 1. Electrical isolation of the underground piping shall be accomplished by the use of isolation flange kits, couplings, unions, non-metallic piping, modular seals,

SECTION 26 42 13 - PASSIVE CATHODIC PROTECTION FOR UNDERGROUND AND SUBMERGED PIPING: continued

- or other devices specified herein or shown on the Drawings. In the event an isolation coupling is restrained using harness rods, each rod shall be isolated using a properly sized isolation sleeve and washer with steel backing washer.
2. Isolation devices shall be ordered according to size and pressure rating of the piping and shall be installed per the manufacturer's instructions. Care shall be exercise so as not to damage the isolation bolt sleeves and washers during installation.
 3. Required applications of isolation flanges, couplings, unions, 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. ductile main connection to copper water service line).
 - c. Cased segments of piping.
 - d. Connections to electrically grounded components such as actuated valves, pump stations, tank piping, and other facilities.
 - e. Concrete encased segments of piping such building risers and valve vault penetrations.
 - a. Materials: Isolation Flange Gaskets
 - a. Provide G-10 fiberglass reinforced epoxy retainers (Line Backer Series) with seal suitable for type of pipeline product, Type 'E' full face gasket as manufactured by GPT Industries. or approved equivalent.
 - b. Isolation Couplings
 - a. Approved manufacturers: Dresser "Style 39", Rockwell "416", Romac "IC501", Baker "Series 216" without pipe stop, or approved equivalent
 - c. Isolation Sleeves and Washers
 - a. Provide full length G-10 sleeves and washers as manufactured by GPT Industries. or approved equivalent.
 - 1) For direct buried isolation device applications, install single washer sets on the existing or uncathodically protected side of the connection so that the metallic flange bolts, nuts, and washers are electrically continuous with the new or cathodically protected piping.
 - 2) For above grade or vaulted isolation device applications, install double washer sets.
 - d. Coat all bare, underground 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.

PART 3 - EXECUTION

3.01 GENERAL

- A. Complete anode placement, wire connections, joint bonding, installation of electrical isolation devices 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°F and rising in order to minimize

SECTION 26 42 13 - PASSIVE CATHODIC PROTECTION FOR UNDERGROUND AND SUBMERGED PIPING: continued

damage to materials and insulation.

- C. Buried all cathodic protection wiring, conduits, and other components with a minimum of 3 feet of cover.
- D. 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 of when line crossings will occur.

3.02 INSTALLATION:

A. Magnesium Anodes:

- 1. Install anodes as shown on Drawings and CP tables.
- 2. Provide a minimum anode spacing of 3 feet from all buried metallic structures.
- 3. Install anodes equally along each side of pipeline spaced 5 feet on center.
- 4. Anodes should be placed at or below the springline of the pipeline.
- 5. The specified magnesium anodes shall be installed horizontally or vertically, completely dry and shall be lowered into the excavated (augured or otherwise) by rope sling or by grasping the closest gather. The anode lead wire shall not be used in lowering the anodes. The anode shall be backfilled with fine native excavated soil (imported sand or other select backfill shall not be allowed) in 6-inch layers and each layer shall be hand tamped around the anode. Care must be exercised not strike the anode or lead wire with the tamper. After the anode has been backfilled approximately halfway, a minimum of five gallons of fresh water shall be added and allowed to soak into and around the anode. After water absorption by the anode and surrounding soil, continue backfilling and tamping with native soil to a point approximately 6-inches above the anode. Add another 5 gallons minimum of fresh water and allow it to soak into the soil. After water has soaked in, backfilling and soil compaction may be completed to the top of the hole.
- 6. Install warning tape 12 inches above all anodes and anode wires.

B. Stationary Reference Electrodes:

- 1. Install reference electrodes as shown on Drawings.
- 2. Route electrode wires along excavation to test station. Bury wires a minimum of 36 inches below grade.
- 3. Thoroughly compact native backfill around each electrode to a point 1 foot above electrode.
- 4. Saturate the electrode and backfill with approximately 5 gallons of clean water prior to completion of backfilling.
- 5. Install warning tape 12 inches above all electrodes and wires.

C. Metallic Coupons:

- 1. Install metallic coupons as shown on Drawings.
- 2. Route coupon wires along excavation to test station. Bury wires a minimum of 36 inches below grade.
- 3. Thoroughly compact native backfill around each coupon to a point 1 foot above coupon.
- 4. Saturate the coupon and backfill with approximately 5 gallons of clean water

SECTION 26 42 13 - PASSIVE CATHODIC PROTECTION FOR UNDERGROUND AND SUBMERGED PIPING: continued

prior to completion of backfilling.

5. Install warning tape 12 inches above all coupons and wires.

D. Test Stations:

1. See Drawings for Test Station locations.
2. Test stations shall be installed outside of the roadways and away from traffic.
 - a. Location of the test station will be as directed in the field by the Engineer, Owner, or Owner's Representative.
 - a. Locations will typically be in landscaped area behind the edge of road, shoulder, or median.
 - b. When routing test stations away from the protected pipe, all test station and anode wires shall be installed in a minimum 1" diameter PVC conduit routed from the edge of the pipe trench to the test station box location.
 - c. Minimum burial depth of the conduit shall be four (4) feet.
 - d. Plastic warning tape a minimum of 4 mil thick and 3 inches wide shall be placed a minimum of 18 inches above all offset test station wiring conduit. The warning tape shall have the following wording: "CAUTION: BURIED CATHODIC PROTECTION CABLE BELOW" or similar.
3. Test station wiring shall be configured as indicated on the Drawings.
4. Test station wires shall be attached to buried piping via exothermic welding.
5. Test station wires shall be color coded as shown on the drawings and specified herein and each wire shall be permanently identified using nylon marker tags and plastic cable ties as shown on the drawings and specified herein. Marker tag identification shall be completed by using a waterproof ink nylon marker marking pen and using block type lettering with the letter size to be a minimum of 1/8-inch high and shall specify test station number, pipe diameter, pipe material, and pipe service or other pertinent information. Test station wiring shall have enough extra wire slack to extend a distance eighteen inches above the top of the test station box.

Examples:

TS #140	TS #105	TS #160
36"- 45° DI	48" Steel	48 lb. Mag
Bend	Casing Pipe	Anode

E. Wiring:

1. All wiring shall be as shown on the Drawings.
2. 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.
3. After cooling, remove all weld slag and visually inspect wire connection. Remove and replace any defective connections.
4. Install pre-fabricated thermite weld cap over each completed connection. Repair exposed metal surfaces not covered by thermite weld cap in accordance with coating manufacturer's recommendations.
5. Maintain a minimum of 12 inches of separation between any two wire

SECTION 26 42 13 - PASSIVE CATHODIC PROTECTION FOR UNDERGROUND AND SUBMERGED PIPING: continued

connections.

1. Buried wire with damaged insulation shall be replaced at the Contractor's cost.
2. Wire splices shall only be accepted upon approval of the Owner's Representative.

F. Exothermic Welding:

1. Exothermic welding techniques shall comply with the manufacturer's recommendations. Only properly sized cartridges and welders will be permissible. The type of weld material to be used is different for ductile iron pipe and steel pipe. The Contractor shall ensure that the appropriate weld metal charges are used for each type of material.
2. The surface of the pipe shall be cleaned with a grinder or metal file to a bright, shiny condition. The exothermic weld shall be completed using the proper weld charge and welder as per the manufacturer's recommendations. A properly sized copper wire sleeve shall be installed around the bare wire end prior to welding to improve weld strength and thermal capacity. Completed welds shall withstand moderate hammer blows.
3. The slag shall be removed from the completed braze with a hammer.
4. The adequacy of each weld shall be demonstrated by sharply striking the top of the connection with a one-pound hammer.
5. After cooling, the weld and surrounding cleaned metal surface shall be primed. After the primer has dried, the weld shall be covered with an exothermic weld cap. The weld cap shall then be secured to the pipe with tape wrap as necessary.

G. Joint Bonding:

1. General:
 - a. All underground metallic piping systems, which contain mechanical or non-metallurgical (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 pipe joint, in accordance with the following:

Nominal Pipe Diameter	Wire Size	# of Wires Per Bond
12" or Less	#8 AWG	2
13" to 36"	#4 AWG	2
Greater than 36"	#2 AWG	3

- b. Exothermic welding shall be used to attach wire type joint bonds to buried pipe and fittings.
 - c. Electrical continuity shall be provided on all underground metallic piping, valves and fittings and component parts thereof (except bolts) by bonding

SECTION 26 42 13 - PASSIVE CATHODIC PROTECTION FOR UNDERGROUND AND SUBMERGED PIPING: continued

across every non-welded pipe joint (except for designated dielectric fittings).

- d. Flexible couplings shall have the follower rings and barrel bonded to the pipeline as shown on the drawings. Bonding must be done in a fashion to avoid shorting out Style 39 type couplings.
- e. Mechanical joint (MJ) follower gland rings shall be bonded as shown on the Drawings.
- f. 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.
- g. 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.

H. Electrical Isolation:

- 1. Accomplish electrical isolation using insulating flange kits or insulating mechanical couplings where shown on the Drawings. In the event an insulating coupling is restrained using harness rods, insulate each rod using a properly sized one-piece insulating sleeve and washer with steel backing washer.
- 2. All insulating flanges shall be tested prior to backfilling to ensure proper electrical isolation.

3.02 QUALITY CONTROL:

- A. Prior to construction, the contractor shall compile and present submittal information required under Submittals.
- B. During construction, the contractor shall be responsible for ensuring that all cathodic protection work is performed in accordance with the Drawings and Specifications.
- C. After completion of construction, the contractor shall be responsible for all repairs of the system as may be required to assure correct and proper operation as determined by the Owner's Representative. The contractor shall submit as-built drawings with dimensioned locations for anodes and test stations.

3.03 TESTS AND MEASUREMENTS:

- A. Upon completion of the cathodic protection system installation work, the Contractor shall perform testing to ensure proper operation of the system.
- B. All cathodic protection system tests shall be conducted by the Contractor's Corrosion Specialist, Cathodic Protection Specialist or Corrosion Engineer. All testing shall be conducted in the presence of the Owner's Representative.
- C. 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 Cathodic Protection Specialist shall develop a test plan and submit to the Engineer and Owner for approval prior to completing any testing.

SECTION 26 42 13 - PASSIVE CATHODIC PROTECTION FOR UNDERGROUND AND SUBMERGED PIPING: continued

- 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
2. The pipeline shall be tested for electrical isolation at key elements to include but not limited to the following:
 - a. Transfer of ownership locations.
 - b. Connections between dissimilar metals (i.e. ductile main connection to copper water service line).
 - c. Connections of old, existing metallic piping to newly installed metallic piping.
 - d. Cased segments of piping.
 - e. Connections to electrically grounded components such as actuated valves, pump stations, tank piping, and other facilities.
 - f. Concrete encased segments of piping such building risers and valve vault penetrations.
3. Record Tests of each Electrical Isolation Component:
 - a. Description and location of pipeline and electrical isolation
 - b. component under test;
 - c. Test method(s) utilized;
 - d. Date of test;
 - e. Summary of findings;
4. The Contractor shall assist the Engineer 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.

D. 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. Underground piping requiring such testing shall be piping which has non-welded or mechanical joints, such as ductile iron piping or steel piping with o-ring gaskets.
3. Testing Prior to Backfill (Digital Low Resistance Ohmmeter Test Method):
 - a. General:
 - b. The Contractor shall test completed continuity bonds for electrical continuity using a digital low resistance ohmmeter (DLRO).
 - c. Continuity bond quality control test shall be performed on all bonded joints after the bonds are installed but before backfilling.
 - d. Furnish all equipment and materials as required for test.
4. Required Equipment and Materials:
 - a. One Biddle Model DLROHD digital low resistance ohmmeter (or equal).
 - b. One set of duplex helical current and potential handspikes, Biddle Model No.6111-517, cable length as required.
5. Test Procedure:

SECTION 26 42 13 - PASSIVE CATHODIC PROTECTION FOR UNDERGROUND AND SUBMERGED PIPING: continued

- a. Measure the resistance of continuity 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 continuity bond resistance on the test form included in the Cathodic Protection Testing Plan prepared by the CONTRACTOR's Cathodic Protection Specialist.
 - d. Repair any damaged pipe coating in accordance with these specifications.
6. Continuity Bond Acceptance
- a. Continuity 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"	#8	870	435	290
18"	#8	1304	652	435
24"	#8	1740	870	580
30"	#8	2174	1087	725
36"	#8	2610	1305	870
12"	#4	518	259	172
18"	#4	776	388	259
24"	#4	1036	518	346
30"	#4	1294	647	432
36"	#4	1554	777	518
12"	#2	325	162	108
18"	#2	486	243	162
24"	#2	648	324	216
30"	#2	810	405	270
36"	#2	972	486	324

- 1) The Contractor shall remove and replace all continuity bonds on a joint

SECTION 26 42 13 - PASSIVE CATHODIC PROTECTION FOR UNDERGROUND AND SUBMERGED PIPING: continued

that exceeds the maximum allowable resistance and/or install additional continuity bonds until the original maximum allowable resistance value is obtained. Replacement continuity bonds shall be retested for compliance with the specified bond resistance.

- b. Record Tests of Each Bonded Pipeline:
 - 1) Utilize form provided in the Cathodic Protection Testing Plan.
 - 2) Stationing, description and diameter, of pipeline or fitting under test;
 - 3) Date of continuity bond installation / test;
 - 4) Joint type and bond wire information (quantity, size, length);
 - 5) Measured continuity bond resistance using specified DLRO meter;
 - 6) Results and comments.
- 7. Testing After Backfill (Calculated Resistance Method or similar)
 - a. The pipeline shall be tested for electrical continuity along its entire length using the calculated resistance method, anode influence, or similar test plan developed under the direction of the CONTRACTOR's Cathodic Protection Specialist. The test plan shall be submitted to the ENGINEER and OWNER for approval prior to completing any testing.
 - b. If anode influence method is utilized:
 - 1) At each test station, perform the following test.
 - 2) Test and record anode potentials and pipe native potentials at all test stations.
 - 3) Connect anodes at the influencing test station.
 - 4) At test stations on either side (adjacent) of the influencing test station, test and record pipe potentials.
 - 5) If influence is observed at adjacent test stations around the influencing test station, anode influence test passes.
 - 6) Disconnect anodes at influencing test station and perform influence test at next test station. Repeating testing for every test station installed. If only a single test station is installed on a pipeline segment, utilize suitable test points to verify influence at tie-ins, within buildings or vaults, etc. as available.
 - 7) Contractor is responsible for any repairs, modifications, or identified discrepancies at no cost to Owner.
 - 8) Thoroughly document the results and included them in the final report and closeout documents.
 - c. If calculated resistance method is utilized:
 - 1) Apply suitable current (minimum 15 amps) along segments not to exceed 2,000 feet.
 - 2) 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.
 - 3) 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. If only a single test station is installed on a segment under test, utilize suitable test points or contact points (tie-ins, within buildings or vaults, service laterals, etc.) as

SECTION 26 42 13 - PASSIVE CATHODIC PROTECTION FOR UNDERGROUND AND SUBMERGED PIPING: continued

- available to verify influence.
- 4) 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 plus the maximum allowable resistance for each continuity bond installed at every pipe joint. 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.
 - 5) 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.
- d. Record Tests of Each Bonded Pipeline:
 - 1) Description and location of pipeline under test;
 - 2) Starting location and ending location of test span;
 - 3) Date of test;
 - 4) Joint type and summary of calculated resistances;
 - 5) Measured continuity bond resistance.
 - e. The Contractor shall assist the Engineer 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.
 - f. The acceptable resistance value obtained after backfill shall be used as the standard for acceptance regardless of the resistance values obtained prior to backfilling.

3.04 CATHODIC PROTECTION COMMISSIONING AND TESTING

- A. When construction is complete, notify the ENGINEER and provide a minimum of 2 weeks' notice that the installation is ready to be turned on.
- B. Contractor's Cathodic Protection Specialist (CP4) shall develop a test plan and submit to the Engineer for approval prior to completing any testing.
- C. Testing to be performed by the Contractor's Cathodic Protection personnel.
- D. Energize installation as per the approved testing plan.
- E. Operating Test: Conduct a series of tests to demonstrate that equipment and material are installed correctly and operating properly for initial approval.
- F. Functional testing (to be completed upon completion of pipeline construction):
 1. Commission all CP devices and measure native, polarized, and AC structure-to-soil potentials of the pipeline at each test station and cathodic protection device using applicable equipment. Include all test stations, isolation devices, bonded segments, above grade appurtenances, surrounding metallic structures, and other identified locations.
 - a. At foreign crossing test stations, do not connect any galvanic 'drain' anodes at this time. Obtain baseline structure-to-soil potentials of both

SECTION 26 42 13 - PASSIVE CATHODIC PROTECTION FOR UNDERGROUND AND SUBMERGED PIPING: continued

- Owner and foreign pipelines.
- b. Note any CP deficiencies, changes, or issues from conformed drawings and specifications. Provide a list of deficiencies to the Owner and correct or repair all items prior to final testing.
- G. 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 cathodic protection levels.
 - a. At foreign crossing test stations, obtain polarized structure-to-soil potential of both Owner and foreign pipelines. Connect any galvanic 'drain' anodes to each pipeline as necessary to remediate any potential stray interference. Obtain shunt readings and new baseline structure-to-soil potentials of both Owner and foreign pipelines.
 - b. Locate, correct, and retest system defects or incomplete work identified.
 - 2. Obtain final polarized and AC structure-to-soil potentials of pipeline at each test station and cathodic protection device using applicable equipment. Include all test stations, isolation devices, bonded segments, above grade appurtenances, surrounding metallic structures, and other identified locations
- H. Warranty Testing (to be completed 30 days prior to end of warranty period or approximately 1 year after installation)
 - 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 cathodic protection levels.
 - a. Locate, correct, and retest system defects or incomplete work identified.
 - 2. Obtain polarized and AC structure-to-soil potentials of pipeline at each test station and cathodic protection device using applicable equipment. Include all test stations, isolation devices, bonded segments, above grade appurtenances, surrounding metallic structures, and other identified locations
- I. Locate, correct, and retest system defects or incomplete work identified during functional and final testing or warranty inspections at no additional cost to the Owner.
 - 1. The Contractor shall assist the Engineer and Owner 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.
- J. Data Analysis
 - 1. Contractor's Cathodic Protection Specialist (CP4) shall analyze and review all cathodic protection data and providing the following minimal items within the analysis:
 - a. Tabular listing of areas where possible structures or segments may be unprotected and/or not meeting criteria in regards to corrosion control. Clearly identify any areas with electrical shorts and deficiencies.
 - b. Possible anomaly areas due to coating defects, stray currents, electrical shorts, failing electrical isolation devices, or other issues.
- K. As-Built, Reporting, and Documentation

SECTION 26 42 13 - PASSIVE CATHODIC PROTECTION FOR UNDERGROUND AND SUBMERGED PIPING: continued

1. Provide a final chronological installation and testing report to include:
 - a. Record drawings of installation and construction of cathodic protection system. Include accurate location and type of anodes, wires, conduits, pipe connections, test stations, and electrical isolation devices.
 - b. NACE qualifications of project personnel and Contractor's Cathodic Protection Specialist (CP4).
 - c. Changes, modifications, and alterations from plans.
 - d. Comments relative to the Project.
 - e. Tabulated reports of the following:
 - 1) Lead wire continuity
 - 2) Open-circuit potentials of anodes
 - 3) Native DC and AC potential measurements
 - 4) Electrical isolation testing results with test methods indicated for prior to and after backfilling operations
 - 5) Electrical continuity testing results for prior to and after backfilling operations
 - 6) Shunt readings/current measurement at all test stations as applicable
 - 7) Polarized DC and AC potential measurements
 - 8) All reports shall contain both permanent reference electrode readings and portable reference electrode readings.
 - f. Failures, defects, and any repairs.
 - g. Retesting information.
 - h. Findings and Recommendations.
 - i. Operations and Maintenance manual.
2. Report should be signed and sealed by the Contractor's NACE certified personnel (Cathodic Protection Specialist CP4) and submitted for approval by the ENGINEER and OWNER.

3.05 GUARANTEE:

- A. The work under this Section shall be guaranteed in accordance with the General and Special Conditions.

END OF SECTION 26 42 13

SECTION 26 50 00 – LIGHTING

PART 1 - GENERAL

1.01 RELATED DOCUMENTS:

- A. Drawings and general provisions of the Contract, including General and Special Conditions and DIVISION 01 Specification Sections, apply to this Section.

1.02 SUMMARY:

- A. This SECTION includes the following:
 - 1. Interior Luminaires:
 - a. Light-emitting Diode (LED).
 - 2. Exterior luminaires.
 - a. Light-emitting diode (LED).
 - 3. Emergency lighting units.
 - 4. Exit signs.
 - 5. Drivers.
 - 6. Emergency drivers
 - 7. Luminaire accessories.

1.03 RELATED REQUIREMENTS:

- A. SECTION 26 05 10 – General Electrical Requirements.
- B. SECTION 26 05 26 – Grounding and Bonding for Electrical Systems.
- C. SECTION 26 05 33 – Raceways, Boxes, Seals, and Fittings for Electrical Systems.
- D. SECTION 26 05 53 – Electrical Identification.
- E. SECTION 26 27 26 – Wiring Devices.

1.04 REFERENCE STANDARDS:

- A. American Association of State Highway and Transportation Officials (AASHTO):
 - 1. AASHTO LTS – Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals; American Association of State Highway and Transportation Officials; 5th Edition, with 2011 Interim Revisions.
- B. American National Standards Institute (ANSI)/Institute of Electrical and Electronic Engineers (IEEE):
 - 1. ANSI/IEEE C62.41.2 – Recommended Practice on Characterization of Surges in Low-Voltage (1000V and less) AC Power Circuits; 2002 (Cor 1, 2012).
 - 2. ANSI/IEEE C136.10 – American National Standard for Roadway and Area Lighting Equipment - Locking-Type Photocontrol Devices and Mating Receptacles - Physical and Electrical Interchangeability and Testing; 2010.
- C. Illuminating Engineering Society of North America (IESNA):
 - 1. IESNA LM-63 – ANSI Approved Standard File Format for Electronic Transfer of Photometric Data and Related Information; 2002 (Reaffirmed 2008).
 - 2. IESNA LM-64 – Photometric Measurements of Parking Areas; 2001 (Reaffirmed 2007).
 - 3. IESNA LM-79 – Electrical and Photometric Measurements of Solid-State Lighting; Latest Edition.

SECTION 26 50 00 – LIGHTING: continued

- D. National Electrical Contractors Association (NECA):
 - 1. NECA 1 – Standard for Good Workmanship in Electrical Construction; National Electrical Contractors Association; 2010.
 - 2. NECA/IESNA 500 –Standard for Installing Indoor Commercial Lighting Systems; National Electrical Contractors Association; 2006.
 - 3. NECA/IESNA 501 – Recommended Practice for Installing Exterior Lighting Systems; 2006.
 - 4. NECA/IESNA 502 – Standard for Installing Industrial Lighting Systems; National Electrical Contractors Association; 2006.
- E. National Electrical Manufacturers Association (NEMA):
 - 1. NEMA LE 4 – Recessed Luminaires, Ceiling Compatibility; National Electrical Manufacturers Association; 2012.
- F. National Fire Protection Associations (NFPA):
 - 1. NFPA 70 – National Electrical Code; National Fire Protection Association; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
 - 2. NFPA 101 – Life Safety Code; National Fire Protection Association; 2012.
- G. Underwriters Laboratories (UL):
 - 1. UL 844 –Luminaires for Use in Hazardous (Classified) Locations; Current Edition, Including All Revisions.
 - 2. UL 924 – Emergency Lighting and Power Equipment; Current Edition, Including All Revisions.
 - 3. UL 1598 – Luminaires; Current Edition, Including All Revisions.
 - 4. UL 8750 – Light Emitting Diode (LED) Equipment for Use in Lighting Products; Current Edition, Including All Revisions.

1.05 ADMINISTRATIVE REQUIREMENTS:

- A. Coordination:
 - 1. Coordinate the installation of luminaires with mounting surfaces installed under other sections or by others. Coordinate the Work with placement of supports, anchors, etc. required for mounting. Coordinate compatibility of luminaires and associated trims with mounting surfaces at installed locations.
 - 2. Coordinate the placement of luminaires with structural members, ductwork, piping, equipment, diffusers, fire suppression system components, and other potential conflicts installed under other sections or by others.
 - 3. Coordinate the placement of exit signs with furniture, equipment, signage or other potential obstructions to visibility installed under other sections or by others.
 - 4. Coordinate placement of poles and associated foundations with utilities, curbs, sidewalks, trees, walls, fences, striping, etc., installed under other Sections or by others. Coordinate elevation to obtain specified foundation height.
 - 5. Notify Engineer of any conflicts or deviations from the contract documents to obtain direction prior to proceeding with work.

SECTION 26 50 00 – LIGHTING: continued

1.06 SUBMITTALS:

- A. Refer to the General and Special Conditions and SECTION 26 05 10 – General Electrical Requirements, for administrative and procedural requirements for submittals.
- B. Shop Drawings:
 - 1. Indicate dimensions and components for each luminaire that is not a standard product of the manufacturer.
 - 2. Provide photometric calculations where luminaires are proposed for substitution upon request.
- C. Product Data: Provide manufacturer's standard catalog pages and data sheets including detailed information on luminaire construction, dimensions, ratings, finishes, mounting requirements, listings, service conditions, photometric performance, installed accessories, and ceiling compatibility; include model number nomenclature clearly marked with all proposed features. Arrange in order of luminaire designation.
 - 1. LED control gear, controllers, arrays, modules, and packages
 - 2. LEDs: Include rated life, color temperature, color rendering index (CRI), initial and mean lumen output, and energy efficiency data.
 - 3. Emergency Lighting Units: Battery and charger data.
 - 4. Exit Signs: Battery and charger data.
 - 5. Provide means of attaching luminaires to supports, and indication that attachment is suitable for components involved.
- D. Manufacturer's Installation Instructions: Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, and installation of product.
- E. Operation and Maintenance Data: Instructions for each product including information on replacement parts.
 - 1. Provide a list of all lamp types used on the Project; use ANSI and manufacturers' codes.
- F. Maintenance Materials: Furnish the following for Owner's use in maintenance of Project.
 - 1. See DIVISION 01 for additional Equipment and Materials provisions.
 - 2. Extra Lenses and Louvers: 2% of total quantity installed for each type, but not less than one of each type.
 - 3. Extra Globes and Guards: 2% of total quantity installed for each type, but not less than one of each type.
 - 4. Extra Fuses: 5% of total quantity installed for each type, but not less than two of each type.
 - 5. Extra LED drivers: 2% of total quantity installed for each type, but not less than one of each type.
- G. Project Record Documents: Record actual connections and locations of luminaires, pole foundations, any associated pull or junction boxes, and any remote components.

1.07 QUALITY CONTROL:

- A. Conform to requirements of NFPA 70.

SECTION 26 50 00 – LIGHTING: continued

- B. Maintain at the Project Site a copy of each referenced document that prescribes execution requirements.
- C. Provide luminaires from a single manufacturer for each luminaire type.
- D. Manufacturer Qualifications: Company specializing in manufacturing the products specified in this SECTION with minimum three years documented experience.
- E. FM Global Compliance: Luminaires for hazardous locations shall be listed and labeled for indicated class and division of hazard by FM Global.

1.08 DELIVERY, STORAGE, AND HANDLING:

- A. Keep products in original manufacturer's packaging and protect from damage until ready for installation.

1.09 FIELD CONDITIONS:

- A. Maintain field conditions within manufacturer's required service conditions during and after installation.

1.10 WARRANTY:

- A. See the General and Special Conditions for Warranty requirements.
- B. Interior Lighting:
 - 1. Provide two year manufacturer warranty for all interior luminaires unless specified otherwise.
 - 2. LED luminaires shall have a minimum 5 year manufacturer warranty.
 - 3. Provide five year pro-rata warranty for batteries for emergency lighting units.
 - 4. Provide ten year pro-rata warranty for batteries for self-powered exit signs.
 - 5. Provide three year full warranty for emergency drivers.
- C. Exterior Lighting:
 - 1. Provide five year manufacturer warranty for all exterior luminaires.
 - 2. Provide five year manufacturer warranty for metal corrosion.
 - 3. Provide five year manufacturer warranty for color retention.
- D. Repair or replace all luminaires and lighting poles that fail in finish, materials, and workmanship within manufacturer's standard warranty period, but not less than three years from date of Substantial Completion.

PART 2 - PRODUCTS

2.01 MANUFACTURERS:

- A. Luminaires:
 - 1. Acuity Brands, Inc.
 - a. Holophane.
 - b. Lithonia.
 - c. Mark Architectural Lighting.
 - d. Peerless.
 - 2. Benjamin Division; Thomas Industries Inc.
 - 3. Cooper Lighting, a division of Eaton.
 - 4. CPM Lighting, Inc. (Columbia-Prescolite-Moldcast).
 - 5. Day-Bright Lighting, Division of Emerson Electric Co.
 - 6. Hubbell Lighting, Inc.

SECTION 26 50 00 – LIGHTING: continued

- 7. KIM Lighting, Inc.
 - 8. Lutron Electronics Company, Inc.
 - 9. HE Williams.
 - 10. Philips Lighting.
 - B. Emergency Lighting Units and Exit Signs:
 - 1. Acuity Brands, Inc.
 - 2. Cooper Lighting, a division of Eaton.
 - 3. Hubbell Lighting, Inc.
 - 4. HE Williams.
 - 5. Philips Lighting.
 - C. Drivers:
 - 1. General Electric Company/GE Lighting.
 - 2. Iota Engineering.
 - 3. Lutron Electronics Company, Inc.
 - 4. Osram Sylvania.
 - 5. Philips Lighting Electronics/Advance.
 - 6. Manufacturer Limitations: Where possible, for each type of luminaire provide Drivers produced by a single manufacturer.
 - D. Emergency Drivers:
 - 1. Iota Engineering, LLC.
 - 2. Lithonia Lighting.
 - 3. Philips Emergency Lighting/Bodine.
 - 4. Manufacturer Limitations: Where possible, for each type of luminaire provide emergency drivers produced by a single manufacturer.
 - E. Lamps:
 - 1. General Electric Company/GE Lighting.
 - 2. Osram Sylvania.
 - 3. Philips Lighting Company.
 - 4. Manufacturer Limitations: Where possible, provide lamps produced by a single manufacturer.
 - F. Light Sensitive Control Devices:
 - 1. Cooper - Crouse-Hinds, a division of Eaton.
 - 2. Intermatic, Inc.
 - 3. Fisher-Pierce, Sunrise Technologies of the Electro Switch Corporation.
- 2.02 LUMINAIRE TYPES:
- A. Furnish products as indicated in the luminaire schedule included on the Contract Drawings.
- 2.03 LUMINAIRES:
- A. Provide products that comply with requirements of NFPA 70.
 - B. Provide products that are listed and labeled as complying with UL 8750, where applicable.
 - C. Provide products listed and classified by Underwriters Laboratories Inc. as suitable for the purpose specified and indicated.

SECTION 26 50 00 – LIGHTING: continued

- D. Provide products complying with Federal Energy Management Program (FEMP) requirements.
- E. Provide products with lamp base complying with ANSI C81.61.
- F. Provide products labeled as vibration and shock resistant and shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
- G. Provide exterior lighting products complying with IESNA RP-8 for parameters of lateral light distribution patterns indicated for luminaires.
- H. Unless otherwise indicated, provide complete luminaires including lamp(s) LED control gear, controllers, arrays, modules, and packages, reflectors, lenses, housings and other components required to position, energize and protect the lamp and distribute the light.
- I. Unless specifically indicated to be excluded, provide all required conduit, boxes, wiring, connectors, hardware, supports, trims, accessories, etc., as necessary for a complete operating system.
- J. Provide products suitable to withstand normal handling, installation, and service without any damage, distortion, corrosion, fading, discoloring, etc.
- K. Interior Luminaire Materials:
 - 1. Metal Parts:
 - a. Free of burrs and sharp corners and edges.
 - b. Sheet metal components shall be steel unless otherwise indicated.
 - c. Form and support to prevent warping and sagging.
 - 2. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping without use of tools. Designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position.
 - 3. Diffusers and Globes:
 - a. Acrylic Diffusers: 100% virgin acrylic plastic, with high resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.
 - b. Glass: Annealed crystal glass unless otherwise indicated.
 - c. Lens Thickness: At least 0.125 inch (3.175 mm) minimum unless otherwise indicated.
 - 4. Housings:
 - a. Extruded-aluminum housing and heat sink.
 - b. Painted finish after fabrication, finish as indicated in luminaire schedule.
 - 5. Conduit: Minimum 3/4 inch (21 mm) in diameter, type as specified.
 - 6. Comply with Comply with UL 8750 and CSA C22.2 No. 250.13. Include recommended LED controlgear, controllers, arrays, modules, and packages. Labels shall be located where they will be readily visible to service personnel, but not seen from normal viewing angles when lamps are in place.
 - a. Label shall include the following lamp characteristics:
 - (1) "USE ONLY" and include specific lamp type.
 - (2) Lamp diameter, shape, size, wattage, and coating.
 - (3) CCT and CRI for all luminaires.
 - 7. Metal Finishes:

SECTION 26 50 00 – LIGHTING: continued

- a. Variations in finishes are unacceptable in the same piece. Variations in finishes of adjoining components are acceptable if they are within the range of approved Samples, and if they can be and are assembled or installed to minimize contrast.
- L. Exterior Luminaire Materials:
 - 1. Metal Parts: Free of burrs and sharp corners and edges.
 - 2. Sheet Metal Components: Corrosion-resistant aluminum unless otherwise indicated. Form and support to prevent warping and sagging.
 - 3. Housings: Rigidly formed, weather- and light-tight enclosures that will not warp, sag, or deform in use. Provide filter/breather for enclosed luminaires.
 - 4. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping without use of tools. Designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position. Doors shall be removable for cleaning or replacing lenses. Designed to disconnect driver when door opens.
 - 5. Exposed Hardware Material: Stainless steel.
 - 6. Plastic Parts: High resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.
 - 7. Light Shields: Metal baffles, factory installed and field adjustable, arranged to block light distribution to indicated portion of normally illuminated area or field.
 - 8. Reflecting surfaces shall have minimum reflectance as follows unless otherwise indicated:
 - a. White Surfaces: 85%.
 - b. Specular Surfaces: 83%.
 - c. Diffusing Specular Surfaces: 75%.
 - 9. Lenses and Refractors Gaskets: Use heat- and aging-resistant resilient gaskets to seal and cushion lenses and refractors in luminaire doors.
 - 10. Luminaire Finish: Manufacturer's standard paint applied to factory-assembled and -tested luminaire before shipping. Where indicated, match finish process and color of pole or support materials.
 - 11. Factory-Applied Labels: Comply with UL 8750 and CSA C22.2 No. 250.13. Include recommended LED controlgear, controllers, arrays, modules, and packages. Labels shall be located where they will be readily visible to service personnel, but not seen from normal viewing angles when lamps are in place.
 - a. Label shall include the following characteristics:
 - (1) "USES ONLY" and include specific lamp type.
 - (2) Driver or Controller information.
 - (3) CCT and CRI for all luminaires.
- M. LED Luminaires:
 - 1. General:
 - a. LED Luminaire Components: UL 8750 recognized or listed as applicable. Tested according to LM-79.
 - b. Luminaires shall be binned with a minimum of a three-step MacAdam Ellipse to ensure color consistency among luminaires.

SECTION 26 50 00 – LIGHTING: continued

2. LED Luminaires with Integral LEDs:
 - a. Correlated Color Temperature (CCT):
 - (1) Indoor: 3,500 (neutral) K unless otherwise indicated.
 - (2) Outdoor: 4,000K unless otherwise indicated.
 - b. Color Rendering Index (CRI): Not less than 80.
 - c. Outdoor rated for full cutout.
 - d. Average Rated Life: Not less than 50,000 hours for an operating cycle of three hours per start.
 - e. LEDs shall be dimmable from 100% to 5% of maximum light output where indicated.
 - f. LED Assembly shall be mounted to die cast aluminum housing for thermal management.
 - g. LED drivers shall have a power factor greater than 0.90 lagging and less than 20 percent total harmonic current distortion (THD).
 - h. Operating temperature of LED assembly and fixture shall be rated for - 30 to +40°C ambient.
 - i. Fixture shall be UL listed for operation in damp locations when indicated.
- N. Luminaires Mounted in Continuous Rows:
 1. Provide quantity of units required for length indicated, with all accessories required for joining and aligning.

2.04 EMERGENCY LIGHTING UNITS:

- A. Description: Emergency lighting units complying with NFPA 101 and all applicable state and local codes and listed and labeled as complying with UL 924.
- B. Operation: Upon interruption of normal power source or brownout condition exceeding 20% voltage drop from nominal, solid-state control automatically switches connected lamps to integral battery power for minimum of 90 minutes of rated emergency illumination, and automatically recharges battery upon restoration of normal power source.
- C. Battery:
 1. Size battery to supply all connected lamps, including emergency remote heads where indicated.
 2. Remote Mounted: Provide NEMA 250, Type 1 enclosure listed for installation inside, on top of, or remote from luminaire. Remote assembly shall be located no less than half the distance recommended by the manufacturer.
- D. Diagnostics: Provide power status indicator light and accessible integral test switch to manually activate emergency operation.
- E. Charger: Fully automatic, solid-state, constant-current type with sealed power transfer relay.
- F. Provide low-voltage disconnect to prevent battery damage from deep discharge.
- G. Self-Diagnostics: Provide units that self-monitor functionality and automatically perform testing required by NFPA 101 where indicated; provide indicator light(s) to report test and diagnostic status.
- H. Where indicated, provide units with integral time delay to maintain emergency illumination for 15 minutes after restoration of normal power source.

SECTION 26 50 00 – LIGHTING: continued

- I. Environmental Limitations: Rate equipment for continuous operation under the following conditions unless otherwise indicated:
 - 1. Ambient Temperature: Less than 0°F (-18°C) or exceeding 104°F (40°C), with an average value exceeding 95°F (35°C) over a 24-hour period.
 - 2. Ambient Storage Temperature: Not less than -4°F (-20°C) and not exceeding 140°F (60°C).
 - 3. Humidity: More than 95% (condensing).
 - 4. Altitude: Exceeding 3,300 feet (1000 m).
- J. Accessories:
 - 1. Provide compatible accessory mounting brackets where indicated or required to complete installation.
 - 2. Provide compatible accessory high impact polycarbonate vandal shields where indicated.
 - 3. Provide compatible accessory wire guards where indicated.
 - 4. Where indicated, provide emergency remote heads that are compatible with the emergency lighting unit they are connected to and suitable for the installed location.
 - 5. Provide compatible accessory remote combination test switch/indicator light where indicated.

2.05 EXIT SIGNS:

- A. Description: Exit signs and similar signs for special purpose applications such as area of refuge/rescue assistance.
- B. All Exit Signs: Internally illuminated with LEDs unless otherwise indicated; complying with NFPA 101 and all applicable state and local codes and listed and labeled as complying with UL 924.
 - 1. Number of Faces: Single or double as indicated or as required for the installed location.
 - 2. Directional Arrows: As indicated or as required for the installed location.
- C. Self-Powered Exit Signs:
 - 1. Operation: Upon interruption of normal power source or brownout condition exceeding 20% voltage drop from nominal, solid-state control automatically switches connected lamps to integral battery power for minimum of 90 minutes of rated emergency illumination, and automatically recharges battery upon restoration of normal power source.
 - 2. Battery: Sealed maintenance-free nickel cadmium unless otherwise indicated.
 - 3. Diagnostics: Provide power status indicator light and accessible integral test switch to manually activate emergency operation.
 - 4. Provide low-voltage disconnect to prevent battery damage from deep discharge.
 - 5. Self-Diagnostics: Provide units that self-monitor functionality and automatically perform testing required by NFPA 101 where indicated; provide indicator light(s) to report test and diagnostic status.
- D. Accessories:

SECTION 26 50 00 – LIGHTING: continued

1. Provide compatible accessory high impact polycarbonate vandal shields where indicated.
2. Provide compatible accessory wire guards where indicated.

2.06 DRIVERS:

A. LED Drivers:

1. Provide LED drivers that are UL recognized complying with UL 8750.
2. Inrush Current: Not exceeding peak currents specified in NEMA 410.
3. Input Voltage: Suitable for operation at voltage of connected source, with variation tolerance of $\pm 10\%$.
4. Total Harmonic Distortion: Not greater than 20%.
5. Power Factor: Not less than 0.95.
6. Sound Rating: Class A, suitable for average ambient noise level of 20 to 24 decibels.
7. Compatibility: Specifically designed for use with the specified LEDs, with no visible flicker and for full light output unless dimmer or bi-level switching control is indicated.
8. Driver Operating Frequency: Greater than 40 kHz.
9. Current Crest Factor: Not greater than 1.5.
10. Surge Tolerance: Capable of withstanding characteristic surges according to IEEE C62.41.2, location category A.
11. Electromagnetic Interference/Radio Frequency Interference (EMI/RFI) Limits: Comply with FCC requirements of CFR, Title 47, Part 18, for Class A, non-consumer applications.
12. Driver Marking: Include wiring diagrams with lamp connections.

2.07 EMERGENCY DRIVERS:

A. LED Emergency Drivers:

1. Description: Self-contained, battery powered, LED emergency driver units suitable for use with indicated luminaires, complying with NFPA 101 and all applicable state and local codes, and listed and labeled as complying with UL 924.
2. Compatibility:
 - a. Drivers: Compatible with AC drivers and LED loads rated for Class 2 output.
 - b. Lamps: Compatible with LED lamp manufacturer supplied.
3. Operation: Upon interruption of normal power source, solid-state control automatically switches connected lamp(s) to the emergency driver for minimum of 90 minutes of rated emergency illumination, and automatically recharges battery upon restoration of normal power source.
4. Emergency drivers shall include sufficient time delays to prevent overcurrent of the LED's in the event both emergency and standard drivers supply load simultaneously.
5. Battery:
 - a. Sealed maintenance-free high-temperature nickel cadmium unless otherwise indicated. Minimum of 7 year life expectancy.

SECTION 26 50 00 – LIGHTING: continued

- b. Recharge time shall be 24 hours or less.
 - 6. Emergency Illumination Output:
 - a. Luminaires with LED Strip lamps:
 - (1) Operate at a minimum of 1,300 lumens unless otherwise indicated with indicated illumination evenly divided between the lamps.
 - 7. Diagnostics: Provide accessible and visible multi-chromatic combination test switch/indicator light to display charge, test, and diagnostic status and to manually activate emergency operation.
 - 8. Self-Diagnostics: Provide units that self-monitor functionality and automatically perform testing required by NFPA 101 where indicated; provide indicator light(s) to report test and diagnostic status and field selectable audible alert.
 - 9. Operating Temperature: From 32°F (0°C) to 122°F (50°C) unless otherwise indicated or required for the installed location.
 - 10. Accessories:
 - a. Provide compatible accessory remote combination test switch/indicator light where indicated.
- 2.08 LAMPS:
- A. All Lamps:
 - 1. Unless explicitly excluded, provide new, compatible, operable lamps in each luminaire.
 - 2. Verify compatibility of specified lamps with luminaires to be installed. Where lamps are not specified, provide lamps per luminaire manufacturer's recommendations.
 - 3. Lamp Bases: Comply with ANSI C81.61.
 - 4. Minimum Efficiency: Provide lamps complying with all current applicable federal and state lamp efficiency standards.
 - 5. Color Temperature Consistency: Unless otherwise indicated, for each type of lamp furnish products which are consistent in perceived color temperature. Replace lamps that are determined by the Engineer to be inconsistent in perceived color temperature.
 - B. LED Lamps: Wattage and bulb type as indicated, with base type as required for luminaire.
 - 1. Correlated Color Temperature (CCT):
 - (1) Indoor: 3,500 (neutral) K unless otherwise indicated.
 - (2) Outdoor: 4,000K unless otherwise indicated.
 - 2. Color Rendering Index (CRI): Not less than 80.
 - 3. Average Rated Life: Not less than 50,000 hours for an operating cycle of three hours per start.
 - 4. Lamps shall be dimmable from 100% to 0% of maximum light output where indicated.
- 2.09 PHOTOELECTRIC CONTROL DEVICES (PHOTOCELLS):
- A. Rated for multiple control of lighting fixtures as indicated.
 - B. Turns lights "on" at 3 footcandles, "off" at 8 footcandles.

SECTION 26 50 00 – LIGHTING: continued

- C. Flush-mounted, weatherproof cell rated 1000-watts at 120Vac.
- D. Operates from -40°C to 70°C (-40°F to 158°F).
- E. Intermatic 4000 Series, Fisher-Pierce FT15, Cooper-Crouse Hinds D2S20, or Engineer approved equal.
- F. Locations as indicated.
- G. Contactors: As specified in Specified in Section 26 29 13 – Enclosed Controllers.

2.10 ACCESSORIES:

- A. Interior Lighting:
 - 1. Stems for Suspended Luminaires: Steel tubing, minimum 1/2 inch size, factory finished to match luminaire or field-painted as directed.
 - 2. Threaded Rods for Suspended Luminaires: Zinc-plated steel, minimum 1/4 inch size, field-painted as directed.
 - 3. Wires for Suspended Luminaires: ASTM A641/A641M, Class 3, soft temper, zinc-coated steel, 12 gauge (2.68 mm).
 - 4. Wires for Suspended Luminaires in Humid Spaces: ASTM A580/A580M, composition 302 or 304, annealed stainless steel, 12 gauge (2.68 mm).
 - 5. Hook Hangers for Suspended Luminaires: Integrated assembly matched to luminaire, line voltage, and equipment with threaded attachment, cord, and locking-type plug. Hook hanger shall include safety latch.

PART 3 - EXECUTION

3.01 EXAMINATION:

- A. Verify that field measurements are as shown on the drawings.
- B. Verify that outlet boxes are installed in proper locations and at proper mounting heights and are properly sized to accommodate conductors in accordance with NFPA 70.
- C. Verify that suitable support frames are installed where required.
- D. Verify that branch circuit wiring installation is completed, tested, and ready for connection to luminaires.
- E. Verify that conditions are satisfactory for installation prior to starting work.

3.02 PREPARATION:

- A. Provide extension rings to bring outlet boxes flush with finished surface.
- B. Clean dirt, debris, plaster, and other foreign materials from outlet boxes.

3.03 INSTALLATION:

- A. Coordinate locations of outlet boxes provided under SECTION 26 05 33 – Raceways, Boxes, Seals, and Fittings for Electrical Systems as required for installation of luminaires provided under this Section.
- B. Install products according to manufacturer's instructions.
- C. Install luminaires plumb and square and aligned with building lines and with adjacent luminaires.
- D. Supports:
 - 1. Sized and rated for luminaire weight.
 - 2. Able to maintain luminaire position after cleaning and relamping.

SECTION 26 50 00 – LIGHTING: continued

3. Provide support for luminaire without causing deflection of ceiling or wall.
4. Luminaire mounting devices shall be capable of supporting a horizontal force of 100% of luminaire weight and vertical force of 400% of luminaire weight.
- E. Suspended Ceiling Mounted Luminaires:
 1. Do not use ceiling tiles to bear weight of luminaires.
 2. Do not use ceiling support system to bear weight of luminaires unless ceiling support system is certified as suitable to do so.
 3. Secure surface-mounted to ceiling support channels or framing members or to building structure.
 4. Secure pendant-mounted luminaires to building structure.
 5. Secure to any required outlet box.
 6. Secure lay-in luminaires to ceiling support channels using UL listed safety clips at four corners.
 7. Fixtures of Sizes Less Than Ceiling Grid: Install as indicated on reflected ceiling plans or center in acoustical panel, and support fixtures independently with at least two 3/4-inch (20-mm) metal channels spanning and secured to ceiling tees.
 8. Install at least one independent support rod or wire from structure to a tab on luminaire. Wire or rod shall have breaking strength of the luminaire weight at a safety factor of 3.
 9. See appropriate DIVISION 09 Section where suspended grid ceiling is specified for additional requirements.
- F. Suspended Luminaires:
 1. Unless otherwise indicated, specified mounting heights are to bottom of luminaire.
 2. Install using the suspension method indicated, with support lengths and accessories as required for specified mounting height.
 3. Provide minimum of two supports for each luminaire equal to or exceeding 4 feet in length, with no more than 4 feet (1.2 m) between supports.
 4. Install canopies tight to mounting surface.
 5. Where longer than 48 inches (1200 mm), brace to limit swinging.
 6. Unless otherwise indicated, support pendants from swivel hangers.
 7. Provide damping of luminaire oscillations where needed.
 8. Continuous Rows of Luminaires: Use tubing or stem for wiring at one point and tubing or rod for suspension for each unit length of luminaire chassis, including one at each end.
- G. Wall-Mounted Luminaires: Unless otherwise indicated, specified mounting heights are to center of luminaire.
 1. Attach luminaire per manufacturer's recommendations.
 2. Do not attach luminaires directly to gypsum board.
 3. Grounding:
 - a. Bond luminaires, metal accessories, metal poles, and foundation reinforcement to branch circuit equipment grounding conductor.
 4. Install separate service conductors, 12 AWG copper, from each luminaire down to handhole for connection to branch circuit conductors.
- H. Corrosion Protection:

SECTION 26 50 00 – LIGHTING: continued

1. Aluminum: Do not use in contact with earth or concrete. When in direct contact with a dissimilar metal, protect aluminum by insulating fittings or treatment.
 2. Steel Conduits: Comply with SECTION 26 05 33 – Raceways, Boxes, Seals and Fittings for Electrical Systems.
 - I. Install accessories furnished with each luminaire.
 - J. Bond products and metal accessories to branch circuit equipment grounding conductor.
 - K. Emergency Lighting Units:
 1. Unless otherwise indicated, connect unit to unswitched power from same circuit feeding normal lighting in same room or area. Bypass local switches, contactors, or other lighting controls.
 2. Install lock-on device on branch circuit breaker serving units.
 3. Emergency lighting conductors shall be routed in conduit separate from the normal per circuits.
 - L. Exit Signs:
 1. Unless otherwise indicated, connect unit to unswitched power from same circuit feeding normal lighting in same room or area. Bypass local switches, contactors, or other lighting controls.
 2. Install lock-on device on branch circuit breaker serving units.
 - M. Emergency Drivers:
 1. For field-installed units, install inside luminaire unless otherwise indicated. Where installation inside luminaire is not possible, install on top of luminaire.
 2. Unless otherwise indicated, connect unit to unswitched power from same circuit feeding normal driver(s) in luminaire. Bypass local switches, contactors, or other lighting controls.
 3. Install lock-on device on branch circuit breaker serving units.
 - N. Remote Drivers: Install in accessible location as indicated or as required to complete installation, using conductors per manufacturer's recommendations not exceeding manufacturer's recommended maximum conductor length to luminaire.
 - O.
 - P. Luminaire Burn-In: Operate luminaires at full output for prescribed period per manufacturer's recommendations prior to use with any dimming controls. Replace luminaires that fail prematurely due to improper luminaire burn-in.
 - Q. Light Sensitive Control Devices:
 1. Direct toward the north sky where possible.
 2. Set the adjustable control to operate at the specified foot-candle level.
 3. Install as indicated.
 4. Connect to control lighting fixtures indicated.
- 3.04 FIELD QUALITY CONTROL:
- A. Inspect each product for damage and defects.
 - B. Operate each luminaire after installation and connection to verify proper operation.
 - C. Test self-powered exit signs, emergency lighting units, and emergency drivers to verify proper operation upon loss of normal power supply.
 - D. Verify operation of photoelectric controls.

SECTION 26 50 00 – LIGHTING: continued

- E. Correct wiring deficiencies and repair or replace damaged or defective products. Repair or replace excessively noisy drivers as determined by Engineer.
- F. Measure illumination levels at night with calibrated meters to verify conformance with performance requirements. Record test results in written report to be included with submittals.
 - 1. Test according to IESNA LM-64 (parking areas).
- G. Prepare a written report of tests, inspections, observations, and verifications indicating and interpreting results. If adjustments are made to lighting system, retest to demonstrate compliance with standards.

3.05 ADJUSTING:

- A. Aim and position adjustable luminaires to achieve desired illumination as indicated or as directed by Engineer. Secure locking fittings in place.
- B. Aim and position adjustable emergency lighting unit lamps to achieve optimum illumination of egress path as required or as directed by Engineer or authority having jurisdiction.
- C. Exit Signs with Field-Selectable Directional Arrows: Set as indicated or as required to properly designate egress path as directed by Engineer or authority having jurisdiction.
- D. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting the direction of aim of luminaires to suit occupied conditions. Make up to two visits to Project during other-than-normal hours for this purpose. Some of this Work may be required during hours of darkness.

3.06 CLEANING:

- A. Clean surfaces according to NECA 500 (commercial lighting), NECA 501 (exterior lighting), NECA 502 (industrial lighting), and manufacturer's instructions to remove dirt, fingerprints, paint, or other foreign material and restore finishes to match original factory finish.

3.07 CLOSEOUT ACTIVITIES:

- A. See General and Special Conditions for submittal requirements.
- B. Demonstration: Demonstrate proper operation of luminaires to Engineer, and correct deficiencies or make adjustments as directed.
- C. Just prior to Substantial Completion, replace all lamps that have failed.

3.08 PROTECTION:

- A. Protect installed luminaires from subsequent construction operations. Replace any damaged luminaires.

END OF SECTION 26 50 00

DIVISION 28 – ELECTRONIC SAFETY AND SECURITY

SECTION 28 10 00 – ELECTRONIC ACCESS CONTROL AND INTRUSION DETECTION

PART 1 - GENERAL

1.01 RELATED DOCUMENTS:

- A. Drawings and general provisions of the Contract, including General and Special Conditions and DIVISION 01 Specification Sections, apply to this SECTION.

1.02 SUMMARY:

- A. This Section describes the requirements for security access control and intrusion detection systems. The systems shall be user-configurable and scalable.
- B. The completed 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 SECTION 08 70 00.
 - 5. Door and gate contacts.
 - 6. Card readers.
 - 7. Gate pedestals
 - 8. Power supplies as required.
- C. The Contractor shall be responsible for providing fully operational security access control and intrusion detection 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 Owner.
- D. The new equipment shall be provided and installed by Key-Rite Security, 5570 E Yale Ave, Denver, CO 80222, (303) 759-5013.
- E. The security monitoring company shall provide monitoring and alarm services. The security monitoring company shall be Central Security, 1117 8th Ave, Greeley, CO 80631, (970) 352-3662.
- F. Coordinate with the door vendor for door lock type and door hardware.
- G. All equipment shall be UL listed.

1.03 RELATED REQUIREMENTS:

- A. SECTION 26 05 19 – Electrical Power Conductors and Cables.
- B. SECTION 26 05 26 – Grounding and Bonding for Electrical Systems.
- C. SECTION 26 05 33 – Raceways, Boxes, and Supports for Electrical Systems.
- D. SECTION 40 95 33 – Process Control Networks.
- E. SECTION 08 70 00 – Finish Hardware.

1.04 REFERENCE STANDARDS:

- A. Electronic Components Industry Association (ECIA):
 - 1. EIA/ECA-310-E – Cabinets, Racks, Panels, and Associated Equipment.
- B. National Fire Protection Association (NFPA):

SECTION 28 10 00 – ELECTRONIC ACCESS CONTROL AND INTRUSION DETECTION:
continued

- 1. 70 – National Electrical Code (NEC).
 - C. National Electrical Manufacturers Association (NEMA):
 - 1. 250 – Enclosures for Electrical Equipment (1,000V maximum).
 - D. Underwriters Laboratories (UL):
 - 1. 50 – Enclosures for Electrical Equipment.
- 1.05 SUBMITTALS:
- A. Submit as specified in the General and Special Conditions.
 - B. Manufacturer with prime responsibility shall assume responsibility for all Compliance Submittals.
 - C. Product Data: Submit the following for each type of product specified and included as minimum:
 - 1. Data sheets for all components furnished.
 - D. Qualification Statements:
 - 1. Fabricator's qualifications.
 - E. Shop Drawings: Provide the following as minimum:
 - 1. Fabrication drawings, front elevation, wiring diagrams, and bills of material for access control panels.
 - 2. Electrical connection diagrams showing termination locations for all field wiring. External connection diagrams shall indicate cable number and wire color for field cables terminated at the panel.
 - 3. Engraving schedule and physical dimensions for nameplates.
 - F. Special Procedure Submittals:
 - 1. Test Plan:
 - a. Provide a complete and detailed test plan for the supplied access control panels.
 - b. Include procedures for certification, validation, and testing.
 - 2. Syllabus for Owner training.
 - G. Test and Evaluation Reports:
 - 1. Factory test reports.
 - 2. Field test reports.
 - H. Closeout Submittals: Final documentation shall include the following as minimum:
 - 1. Operation and Maintenance Manuals including the following:
 - a. Operation and maintenance manuals for all components furnished.
 - b. Certified "As-Built"/"As-Installed" drawings.
 - c. Copies of all approved Product Data.
 - d. Copies of all approved Test Reports.
 - e. Spare parts and supply list.
 - f. Warranty Information.
 - g. Contractor Information.
 - I. Maintenance Material Submittals:
 - 1. Spare Parts:
 - a. Provide five (5) spare fuses of each type used including those used in power supplies.
 - 2. Software:
 - a. Original CD/DVD-ROM disks and/or flash drives containing all software associated with the supplied equipment.

SECTION 28 10 00 – ELECTRONIC ACCESS CONTROL AND INTRUSION DETECTION:
continued

- b. Organize and submit all software copies in a 3-ring binder.

1.06 QUALITY CONTROL:

- A. Materials and Equipment shall be the standard products of a manufacturer regularly engaged in the manufacture of such products and shall be the manufacturer's latest standard design that has been in satisfactory use for at least 1 year prior to Bid opening.

1.07 DELIVERY, STORAGE, AND HANDLING:

- A. Access control panels and associate equipment shall be packaged and shipped to the project site in such a manner as to avoid damage.
- B. All equipment shall be stored according to the manufacturer's instructions and in a conditioned space to avoid condensation, dust, and other environmental contaminants.

1.08 PROJECT SITE CONDITIONS:

- A. Do not store or install the control panel equipment specified herein until designated installation spaces are suitable for intended service.
- B. For indoor control panels 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 panel and shall be maintained for the remainder of the construction period.

1.09 WARRANTY:

- A. All equipment shall be provided with a minimum one-year warranty period.

PART 2 - PRODUCTS

2.01 MANUFACTURERS:

- A. Access Control System (Controllers, control panels, software, and accessories):
 - 1. Honeywell WinPak
- B. Door and Gate Contacts:
 - 1. George Risk Industries, Inc.
 - 2. G.E. Interlogix - Sentrol.
 - 3. Honeywell.
 - 4. Engineer approved equal.
- C. Request-to-Exit (REX) Motion Detectors:
 - 1. G.E. Security.
 - 2. Honeywell.
 - 3. Bosch Security Systems.
 - 4. Engineer approved equal.
- D. Card Readers:
 - 1. HID Global.
 - 2. No approved equal.

SECTION 28 10 00 – ELECTRONIC ACCESS CONTROL AND INTRUSION DETECTION:
continued

2.02 ACCESS CONTROL SYSTEM:

- A. The access control system shall include, but is not limited to, access controllers, communications adapters, access control panels, power supplies, and system software.
- B. The access control system shall be based on the IEI Max 3 Access System.
- C. Each Max 3 cabinet shall have a single backplane capable of supporting four individual Max 3 modules. Module quantities shall be as indicated.
- D. Each Max 3 module shall have the following I/O capabilities:
 - 1. Inputs:
 - a. Front End Readers (IN and OUT): Wiegand.
 - b. Request to Exit (REX): Normally open loop.
 - c. Door Switch: Normally closed loop.
 - 2. 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.
- E. Communications:
 - 1. The system shall support Ethernet (CAT6E) Communication for interconnection of multiple backplanes.
- F. The system shall be expandable for control of up to 64 modules per site and be networked with unlimited sites.
- G. 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.
- H. The network cabling and all required wiring between peripherals and network components shall be provided as recommended by the equipment manufacturers.
- I. The access control system shall be fully operational with programmed information. The Contractor shall coordinate with the Owner for the programming input data.
- J. The access control system components shall be housed in a NEMA 12 lockable enclosure.
 - 1. The enclosure shall be ventilated and sized to accommodate all required components and dissipate the heat generated in the panel.
 - 2. The interconnecting cables and wires shall be neatly arranged and installed in wiring channels.
 - 3. The components shall be DIN rail or shelf mounted inside the enclosure and shall be secured.
 - 4. Provide DIN-railed 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.
- K. 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% spare capacity. All power supplies shall be provided with overload and short circuit protection and shall be mounted in the security panel.

SECTION 28 10 00 – ELECTRONIC ACCESS CONTROL AND INTRUSION DETECTION:
continued

- L. 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.
- M. A tamper switch shall be provided for the enclosure and the switch shall be wired to an input in the plant control system. Provide Sentrol Model 3012 or equal.
- N. Software:
 - 1. Provide all required software installed on the indicated workstations for complete system monitoring and management of the access control system.
 - 2. The software shall store all system transactions in a common database stored on the network server.
 - 3. The System Repository folder shall be located on a Windows Server operating system and the System Manager shall operate on Windows operating system.

2.03 DOOR CONTACTS:

- A. Recessed mounted door contacts shall meet the following requirements:
 - 1. Designed for recessed mounting in the door frame.
 - 2. 3/4-inch diameter.
 - 3. Minimum 1/2-inch gap in steel doors.
 - 4. Hermetically sealed reed switch with matching actuating magnet.
 - 5. Minimum one foot lead length.
 - 6. Normally closed when active (door is closed).
 - 7. Compatible with specified access control modules.
- B. Surface mounted door contacts shall meet the following requirements:
 - 1. Hermetically sealed reed switch with matching actuating magnet.
 - 2. Brushed anodized aluminum housing.
 - 3. Three foot stainless steel armored cable.
 - 4. Mounting bracket as required.
 - 5. Normally closed when active (door is closed).
 - 6. Compatible with specified access control modules.
 - 7. All mounting hardware shall be included for the installation.

2.04 GATE CONTACTS:

- A. The gate contacts shall meet the following requirements:
 - 1. Hermetically sealed reed switch with matching actuating magnet.
 - 2. Brushed anodized aluminum housing.
 - 3. 3-inch wide operation gap distance.
 - 4. Minimum three foot stainless steel armored cable.
 - 5. Mounting bracket as required.
 - 6. Normally open contact.
 - 7. Compatible with specified access control modules.

2.05 MOTION REQUEST TO EXIT (REX) DETECTORS:

- A. The motion REX detector shall meet the following requirements:
 - 1. Dual technology utilizing passive infrared and radar technology.
 - 2. Voltage: 12 to 24 Vac/Vdc.
 - 3. Alarm Output: DPDT Form C contact.

SECTION 28 10 00 – ELECTRONIC ACCESS CONTROL AND INTRUSION DETECTION:
continued

4. Alarm duration: Adjustable from 0.5 – 60 seconds.
5. Adjustable detection range 5-15 feet.
6. Activation LED.
7. Operating temperature: -29°C to 49°C., 0 to 95% non-condensing
8. All mounting hardware (wall mount) shall be included for the installation.

2.06 CARD READER:

- A. The card reader specified herein is based on HID ProxPoint Plus 6005 Model proximity readers.
- B. The card reader shall meet the following requirements:
 1. Read range: Up to 3 inches with compatible card.
 2. Input voltage: 5–16Vdc at reader.
 3. Operating temperature: -30°C to 65°C.
 4. Enclosure: The reader shall be of potted, polycarbonate material, sealed to a NEMA rating of 4X.
 5. LED indicator with tri-color standard (red, green, amber).
 6. Audio tone.
 7. Output format: Wiegand.
 8. Frequency: 125 kHz (excitation).
 9. Factory or field programmable.
 10. Rated for indoor and outdoor installation.
 11. Compatible with specified access control modules.
- C. Provide a minimum of twenty 125 kHz HID Proximity Access Cards compatible with the owners existing system.

2.07 PEDESTALS:

- A. Provide 40-inch gooseneck pedestal with offset for mounting of enclosures for access control, intercom and camera. The stand shall be hollow to allow for the passage of cables and shall be designed for mounting on a concrete foundation as indicated.
- B. Provide lockable NEMA 4 enclosure with rain shield over the face mounted components for mounting of indicated devices. Enclosure shall be sized to accommodate the indicated components.
- C. Pedestal and enclosure shall be provided with a natural aluminum or stainless steel corrosion resistant finish.

2.08 WIRING SYSTEM:

- A. Provide basic wiring materials which comply with SECTION 26 05 19 – Electrical Power Conductors and Cables and SECTION 26 05 33 – Raceways, Boxes, and Supports for Electrical Systems.
- B. Wire and cabling types shall be in accordance with the requirements of the system manufacturer.
- C. Provide multi-conductor cables as indicated on the drawings.

SECTION 28 10 00 – ELECTRONIC ACCESS CONTROL AND INTRUSION DETECTION:
continued

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 INSTALLATION:

- A. The security access control and intrusion detection systems, specified herein, shall be installed by trained and qualified personnel who have minimum of five (5) years of experience installing similar systems. All components shall be installed in accordance with the manufacturer's installation manuals and recognized industry practices.
- B. Provide all labor, materials, startup, programming, etc. for a fully functioning system.
- C. Mount equipment plumb, level, square, and secure.
- D. Installation of basic wiring system materials:
 - 1. Install wiring, raceways, and electrical boxes and fittings in accordance with SECTION 26 05 19 – Electrical Power Conductors and Cables and SECTION 26 05 33 – Raceways, Boxes, and Supports for Electrical Systems.
 - 2. Install all wiring in raceways.
 - 3. Where possible, install wires and cables without splices. Make connections and splices at terminal strips in terminal boxes, cabinets or at equipment terminals.

3.03 PROGRAMMING:

- A. The access control system shall be programmed to allow access to the indicated areas. Coordinate with the Owner for a complete list of employees and access control rights.
- B. Forms shall be developed to allow easy entry of new employees and editing of existing employee rights.
- C. Program the database tags, descriptions, and alarm reports in a clear and concise manner.
- D. The security system shall be programmed to provide the indicated outputs to the plant control system.
- E. The security access control for the entrance/exit automatic gate operators shall meet the following sequence of operations:
 - 1. Normal Request for Entry: The security access control system shall open the gate when the request for entry is made via the entry card reader or when a valid card is presented to the card reader in the control room associated with the entrance gate. Once the gate reaches its full open status, the gate shall be programmed to stay open for 30 seconds before the gate starts its closing cycle. The gate closing cycle shall be inhibited if the gate operator and associated protective devices detect any obstruction along the closing path of

SECTION 28 10 00 – ELECTRONIC ACCESS CONTROL AND INTRUSION DETECTION:
continued

- the gate. Once the obstruction is removed, the gate shall proceed with the closing.
2. Normal Request to Exit: The gate shall be designed for a free exit using an inductive loop request to exit. If the inductive loop detects the presence of a vehicle the request to exit contact shall be activated to the gate access control module and the gate shall open. Once the gate reaches its full open status, the gate shall be programmed to stay open for 30 seconds before the gate starts its closing cycle. The gate closing cycle shall be inhibited if the gate operator and associated protective devices detect any obstruction along the closing path of the gate.
- F. The security access control for a typical man door shall meet the following sequence of operations:
1. 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.
 2. 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.
- 3.04 FIELD QUALITY CONTROL:
- A. Manufacturer's Field Services:
 1. The equipment supplier shall provide the field services of a trained technician for the amount of time required to commission, test and start-up all equipment provided.
 2. All travel and living expenses shall be included for all trips to the site. All equipment required for testing, start-up and performance verification shall be provided by the start-up technician.
 - B. Check all internal and external connections and tighten as required.
 - C. Perform I/O checkout on all points and verify proper operation.
 - D. Verify proper connection of communication cabling and proper communication system configuration.
 - E. Field verify proper operation of all inputs and outputs.
 - F. Record results of I/O checkout and submit test reports as specified in DIVISION 01.
- 3.05 ADJUSTING AND CLEANING:
- 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.
 - C. Prior to Construction Acceptance control panel interior and exterior shall be wiped clean and free from dust and debris.

SECTION 28 10 00 – ELECTRONIC ACCESS CONTROL AND INTRUSION DETECTION:
continued

3.06 TRAINING:

- A. Provide a minimum of 2 hours of training at the customer's facility for operations, maintenance and service personnel.
 - 1. The training session shall include classroom discussion on the theory of operation of the equipment, as well as maintenance and service methods for the purchased equipment.
 - 2. Topics covered shall include safety, hardware layout and functions, power and control wiring, diagnostic indicators, keypad/display interface, faults, diagnostic tools, troubleshooting, and preventive maintenance.
 - 3. Hands-on training shall be provided on equipment.
 - 4. Documentation shall be provided which shall include actual manuals for the equipment and drawings and schematics of equipment supplied for this project.
- B. The Owner at their option shall be allowed to video record all training sessions for future reference.

END OF SECTION 28 10 00

DIVISION 31 – EARTHWORK

SECTION 31 20 00 – SITE PREPARATION AND EARTHWORK

PART 1 - GENERAL

1.01 SUMMARY:

- A. This Section includes Site preparation activities and certain items of earthwork common to other related Work.
- B. Related Work Specified Elsewhere:
 - 1. Subgrade Preparation: SECTION 31 23 13.
 - 2. Excavation and Filling for Structures: SECTION 31 23 16.
 - 3. Trenching and Backfilling for Utilities: SECTION 31 23 33.13.

1.02 REFERENCES:

- A. Applicable Standards:
 - 1. American Association of State Highway and Transportation Officials (AASHTO):
 - a. M80 - Coarse Aggregate for Portland Cement Concrete.
 - b. T104 - Soundness of Aggregate by Use of Sodium Sulfate or Magnesium Sulfate.
 - 2. American Society for Testing and Materials (ASTM):
 - a. D698 - Moisture-Density Relations of Soils and Soil-Aggregate Mixtures Using 5.5-lb. (2.49-kg) Rammer and 12-inch (305-mm) Drop.
 - a. D2167 - Test Method for Density and Unit Weight of Soil In-Place by Rubber Balloon Method.
 - b. D4253 - Test Method for Maximum Index Density and Unit Weight of Soils Using a Vibratory Table.
 - c. D4254 - Test Method for Minimum Index Density and Unit Weight of Soils and Calculation of Relative Density.
 - d. D4318 - Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils.
 - e. D4546 - Test Methods for One-Dimensional Swell/Settlement Potential of Cohesive Soils.
 - f. D6938 - Standard Test Methods for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth).
 - 3. State of Colorado Department of Transportation (CDOT) Standard Specifications for Road and Bridge Construction.

1.03 SUBMITTALS:

- A. Submit as specified in the General and Special Conditions.
- B. Imported fill material data.
- C. On-site material data.
- D. Dewatering Plan, as required.
- E. Sheet piling and Shoring Excavation Plan, as required.

SECTION 31 20 00 - SITE PREPARATION AND EARTHWORK: continued

PART 2 - PRODUCTS

2.01 EARTHWORK:

- A. Materials suitable for use in embankment and fill include material free of debris, roots, organic matter, and frozen matter; and free of stone having any dimension greater than 2 inches in areas requiring a high degree of compaction or 4 inches in other embankment and fill areas:
 - 1. Cohesionless/granular materials include gravels, gravel-sand mixtures, sands, and gravelly sands exclusive of clayey material:
 - a. Free-draining.
 - b. For which generally less than 15% by dry weight, of soil particles pass the No. 200 sieve.
 - 2. Cohesive materials include silts and clays generally exclusive of sands and gravel:
 - a. Materials for which impact compaction will produce a well-defined, moisture-density relationship curve.
- B. Materials unsuitable for use in embankment and fill include all material that contains debris, roots, organic matter, frozen matter, gravel, stone, or shale particles with any dimension greater than 2 inches in areas requiring a high degree of compaction or 4 inches in other embankment and fill areas, or other materials that are determined by Engineer to be too wet or otherwise unsuitable for providing a stable subgrade or stable foundation for structures.
- C. Material for Embankment or Fill:
 - 1. Borrow materials shall not exhibit characteristics of high shrink-swell potential as determined from Atterberg limit tests (ASTM D4318) and/or swell/pressure tests (ASTM D4546).
- D. Waste materials include excess usable materials and materials unsuitable for use in the Work, in accordance with this Specification.
- E. Borrow materials include all fill materials and topsoil obtained from locations off the Site:
 - 1. Material shall be subject to approval of Engineer.
 - 2. Borrow areas shall be as follows:
 - a. Arranged for by Contractor at no additional cost to Owner.
 - b. Subject to approval of Engineer.

PART 3 - EXECUTION

3.01 SITE PREPARATION:

- A. Clearing and Grubbing:
 - 1. Perform clearing and grubbing as indicated or as necessary to perform excavation, trenching, embankment, borrow, and other Work required, and where desired by Contractor for subsidiary purposes subject to approval:
 - a. Clearing:
 - (1) Includes felling and disposal of trees, brush, and other vegetation.
 - (2) Conduct Work in a manner to prevent damage to property and to provide for the safety of employees and others.

SECTION 31 20 00 - SITE PREPARATION AND EARTHWORK: continued

- (3) Keep operations within property lines as indicated.
 - b. Grubbing:
 - (1) Includes removal and disposal of tree stumps and roots larger than 3 inches in diameter.
 - (2) Remove to a depth of at least 18 inches below existing grade elevation.
 - (3) Backfill all excavated depressions with approved material and grade to drain.
 - B. Stripping:
 - 1. Remove topsoil from areas within limits of excavation, trenching, and borrow and areas designated to receive embankment and compacted fill as follows:
 - a. Scrape areas clean of all brush, grass, weeds, roots, and other materials.
 - b. Strip to a sufficient depth to remove excessive roots in heavy vegetation or brush areas and as required to segregate topsoil.
 - c. Stockpile topsoil in areas designated where it will not interfere with construction operations or existing facilities. Stockpiled topsoil shall be reasonably free of subsoil, debris, and stones larger than 2-inch diameter.
 - C. Debris:
 - 1. Dispose of debris from clearing, grubbing, stripping, and demolition at a location off the Site as arranged for by Contractor.
- 3.02 EARTHWORK:
- A. Excavation:
 - 1. Expected site conditions are as documented in the subsurface exploration and geotechnical engineering report named "*Geotechnical Engineering Study and Pavement Thickness Design, Proposed North Water Treatment Plant 5MG Water Tank*", by Kumar & Associates, Inc., dated February 12, 2024.
 - 2. Perform excavation as indicated or as required to complete the Work.
 - 3. Blasting: Blasting shall not be permitted.

SECTION 31 20 00 - SITE PREPARATION AND EARTHWORK: continued

a. General:

- (1) Contractor shall design and provide the dewatering system using accepted and professional methods of design and engineering consistent with the best current practice to eliminate water entering the excavation under hydrostatic head from the bottom and/or sides. The system shall be designed to prevent differential hydrostatic head which may occur from rising water levels from adjoining or nearby bodies of water, proximity of excavation to phreatic groundwater level, or surface runoff, and which would result in floating out soil particles in a manner termed as a "quick" or "boiling" condition. System shall not be dependent solely upon sumps and/or pumping water from within the excavation where differential head would result in a "quick" condition, which would continue to worsen the integrity of the excavation's stability.
- (2) Provide dewatering system of a sufficient size and capacity as required to control ground and surface water flow into the excavation and to allow all Work to be installed in a dry condition, including the obtaining of a licensed well-driller, where required.
- (3) Control, by acceptable means, all water regardless of source and be fully responsible for disposal of the water.
- (4) Confine all discharge piping and/or ditches to the available easement or to additional easement obtained by Contractor. Provide all necessary means for disposal of the water, including the obtaining of all necessary permits and of additional easement at no additional cost to Owner.
- (5) Control groundwater in a manner that preserves the strength of the foundation soils, does not cause instability or raveling of the excavation slopes, and does not result in damage to existing structures. Where necessary to these purposes, lower the water level in advance of excavation, using wells, wellpoints, jet eductors, or similar positive methods. The water level as measured in piezometers shall be maintained a minimum of 3 feet below the prevailing excavation level.
- (6) Commence dewatering with means to provide positive dewatering of all water sources prior to any appearance of water in excavation and continue until Work is complete to the extent that no damage results from hydrostatic pressure, flotation, or other causes.
- (7) Open pumping with sumps and ditches shall be allowed, provided it does not result in boils, loss of fines, softening of the ground, or instability of slopes.
- (8) Install wells and/or wellpoints, if required, with suitable screens and filters, so that continuous pumping of fines does not occur. Arrange the discharge to facilitate collection of samples by Owner or Engineer. During normal pumping, and upon development of well(s), levels of fine sand or silt in the discharge water shall not

SECTION 31 20 00 - SITE PREPARATION AND EARTHWORK: continued

- exceed 5 ppm. Install a sand tester on the discharge of each pump during testing to verify that levels are not exceeded.
- (9) Install, operate, and maintain the dewatering system required to control surface and/or groundwater.
 - (10) Control grading around excavations to prevent surface water from flowing into excavation areas.
 - (11) Drain or pump as required to continually maintain all excavations and trenches free of water or mud from any source, and discharge to approved drains or channels. Commence when water first appears and continue until Work is complete to the extent that no damage will result from hydrostatic pressure, flotation, or other causes.
- b. Damages:
- (1) Contractor shall be responsible for and shall repair without cost to Owner any damage to work in place, other Contractor's equipment, utilities, residences, highways, roads, railroads, private and municipal well systems, adjacent structures, and the excavation, including, damage to the bottom due to heave and including but not limited to, removal and pumping out of the excavated area that may result from Contractor's negligence, inadequate or improper design and operation of the dewatering system, and any mechanical or electrical failure of the dewatering system.
 - (2) Remove subgrade materials rendered unsuitable by excessive wetting and replace with approved backfill material at no additional cost to Owner.
- c. Maintaining Excavation in Dewatered Condition:
- (1) Dewatering shall be a continuous operation.
 - (2) Continuously maintain excavation in a dry condition with positive dewatering methods during preparation of subgrade, installation of pipe, and construction of structures until the critical period of construction and/or backfill is completed to prevent damage of subgrade support, piping, structure, side slopes, or adjacent facilities from flotation or other hydrostatic pressure imbalance.
 - (3) Provide standby equipment on site, installed, wired, and available, for immediate operation if required to maintain dewatering on a continuous basis in event any part of system becomes inadequate or fails. If dewatering requirements are not satisfied due to inadequacy or failure of dewatering system, perform such work as may be required to restore damaged structures and foundation soils at no additional cost to Owner.
- d. System Removal:
- (1) Contractor shall remove all dewatering equipment from the Site, including related temporary electrical service.
 - (2) All wells shall be removed or cut off a minimum of 3 feet below the final ground surface, capped, and abandoned in accordance with regulations by agencies having jurisdiction.

SECTION 31 20 00 - SITE PREPARATION AND EARTHWORK: continued

- (3) Removal work required under this paragraph does not include any of the site cleanup work as required elsewhere in these Specifications.
- 4. Stockpiling:
 - a. Stockpile in amounts sufficient for and in a manner to segregate materials suitable for the following:
 - (1) Topsoiling.
 - (2) Constructing embankments and fills.
 - (3) Backfilling.
 - (4) Waste only.
 - b. Do not obstruct or prevent access to:
 - (1) Roads and driveways.
 - (2) Utility control devices.
 - (3) Ditches or natural drainage channels.
 - c. Perform in a manner to avoid endangering the Work, stability of banks or structures, or health of trees and shrubs to be saved.
 - d. Maintain safe distance between toe of stockpile and edge of excavation or trench.
 - e. Stockpile excess soil on Site in area designated by the drawings.
- 5. Waste Materials:
 - a. Waste materials as described for purposes of this Contract within this Section consist of deleterious soils, rock, and other materials considered unacceptable for compaction or placement fill, and which are not environmentally contaminated. Waste materials shall not include environmental pollutants, hazardous substances, contaminated products, by-products, samples, or waste materials of any kind that are regulated under environmental laws.
 - b. Remove waste materials from Work area as excavated.
 - c. Disposing of Waste Material:
 - (1) Consult the Owner on locations to deposit waste materials.
 - d. Grade waste areas and leave them free draining and with an orderly and neat appearance.
- B. Embankment:
 - 1. Construct embankments to the contours and elevations indicated, using suitable approved material from excavations and borrow areas:
 - a. Borrow:
 - (1) Refers to all fill materials and topsoil obtained from approved locations off the Site.
 - (2) Borrow shall include all excavating, handling, and final disposal of materials as specified.
 - (3) Borrow areas shall be:
 - (a) Arranged for by Contractor at no additional cost to Owner.
 - (b) Subject to approval.
 - (4) Material removed from borrow areas shall be as approved.
 - (5) Leave borrow areas graded to drain and to present a neat appearance.

SECTION 31 20 00 - SITE PREPARATION AND EARTHWORK: continued

- b. Compaction:
 - (1) Compact embankments using equipment as required to obtain reasonable uniformity.
 - (2) Compaction shall be as obtained by normal methods and equipment during the placing and grading of layers and to the minimum density specified for particular locations.
- c. Placement:
 - (1) Place fill material Maximum 8-inch layers in all areas.
 - (2) Place embankment only on subgrades approved by Engineer.
 - (3) Do not place snow, ice, or frozen earth in fill; do not place fill on a frozen surface.
- C. Subgrades:
 - a. Prepare subgrades in accordance with Section 31 23 13 Subgrade Preparation.
- D. Site Grading:
 - 1. Excavate, fill, compact fill, and rough grade to bring Project area outside of structures to subgrades as follows:
 - a. For surfaced areas, to underside of respective surfacing or base course:
 - b. Prepare subgrades as specified in this Section.
 - c. For seeded areas, to 4 inches below finished grade.
 - 2. Rock:
 - a. Includes rock encountered in grading areas outside of structure limits.
 - b. Excavate rock to depths as follows:
 - (1) Under surfaced areas, to 6 inches below the top of respective subgrades.
 - (2) Under seeded areas, to 24 inches below finished grade:
 - (a) Boulder or protruding rock outcrop shall be left undisturbed where approved.
 - c. Backfill to grade with approved earth fill compacted-in-place:
 - (1) Achieve minimum density specified for particular location.
 - 3. Fill:
 - a. Fill as required to raise existing grades outside of structure areas to the new grades as indicated.
 - b. Such fill shall be performed as specified herein.
 - c. Remove all debris subject to termite attack, rot, or corrosion from areas to be filled.
 - 4. Rough Grading:
 - a. All areas within the Project, including excavated and filled sections, and adjacent transition areas shall be reasonably smooth, compacted, and free from irregular surface changes.
 - b. Degree of finish shall be that ordinarily obtained from blade grader or scraper operations, except as otherwise specified.
 - c. Finished rough grades shall generally be not more than 0.5 foot above or below established grade or approved cross sections with due allowance for topsoil and sod.

SECTION 31 20 00 - SITE PREPARATION AND EARTHWORK: continued

- d. Tolerance for areas within 10 feet of structures shall not exceed 0.15 foot above or below established subgrade.
- e. Finish all ditches, swales, and gutters to drain readily.
- f. Unless otherwise indicated, slope the subgrade evenly to provide drainage away from structure walls in all directions at a grade not less than 1/4 inch per foot.
- g. Provide roundings at top and bottom of banks and at other breaks in grade.
- E. Topsoiling:
 - 1. Includes placement of topsoil on all areas not specified to receive paving or other surface treatment including borrow or waste areas.
 - 2. Materials:
 - a. Those obtained from excavation which are most suitable and stockpiles for such purpose:
 - (1) Topsoil shall be a fertile, friable, and loamy soil of uniform quality, free from materials such as hard clods, stiff clay, stone with any dimension greater than 1 inch, and similar impurities. Relatively free from grass, roots, weeds, and other objectionable plant material.
 - b. Borrow when required.
 - 3. Subgrade Treatment:
 - a. Clear Site of vegetation heavy enough to interfere with proper grading and tillage operations.
 - b. Clear surfaces of all stones or other objects larger than 3 inches in thickness or diameter, all roots, brush, wire, grade stakes, or other objectionable material.
 - c. Loosen subgrade by disking or scarifying to a depth of 2 inches wherever compacted by traffic or other causes to permit bonding of the topsoil to the subgrade.
 - 4. Placement of Topsoil:
 - a. Distribute over required areas without compaction in upper 1 foot, other than that obtained with spreading equipment.
 - b. To extent material is available within following limits:
 - (1) Not less than 4 inches in depth.
 - (2) Do not exceed 2 feet in depth.
 - (3) Shape cuts, fills, and embankments to contours indicated.
 - (4) Grade to match contours of adjacent areas and permit good, natural drainage. Provide gentle mound over trenches.
 - 5. Maintenance:
 - a. After topsoil has been spread, clear surface of stones or other objects larger than 1 inch in thickness or diameter and all other objects that might interfere with planting and maintenance operations.
 - b. Protect topsoiled areas from the elements until grass is established and repair eroded areas as required.
 - c. Keep paved areas clean. Promptly remove topsoil or other dirt dropped upon surfacing.

SECTION 31 20 00 - SITE PREPARATION AND EARTHWORK: continued

3.03 FIELD QUALITY CONTROL:

A. Compaction:

1. Engineer will, through services of an independent laboratory, test all embankments, fills, and subgrades under this Contract to determine conformance with specified density relationships.
2. Method of test may be either of the following at Contractor's option:
 - a. ASTM D2167.
 - b. ASTM D6938.
3. Testing frequency:
 - a. 1 density test per 500 sq. ft. per lift.
 - b. 1 moisture content test per 500 sq. ft. per lift.
4. Failed tests requiring re-testing shall be at the cost of the Contractor. Contractor will make arrangements with the Engineer for direct reimbursement.

3.04 PROTECTION OF THE WORK:

A. Maintenance:

1. Protect newly graded and topsoiled areas from actions of the elements.
2. Fill and repair settling or erosion occurring prior to landscaping and reestablish grades to the required elevations and slopes.

END OF SECTION 31 20 00

SECTION 31 23 13 – SUBGRADE PREPARATION

PART 1 - GENERAL

1.01 RELATED DOCUMENTS:

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY:

- A. This Section covers subgrade preparation for asphalt and concrete pavement.

1.03 RELATED REQUIREMENTS:

- A. Crushed Aggregate Base Course: SECTION 32 11 23.

1.04 DEFINITIONS:

- A. Unsuitable Material:
- B. Material encountered in excavation areas classified by Engineer as "organic silt" or "organic clay" when tested to conform to ASTM D2488.
- C. In situ moisture content outside the range necessary for preparation of subgrade will not be cause for classification as unsuitable material.

1.05 REFERENCES:

- A. Applicable Standards:
 - 1. ASTM International (ASTM):
 - a. D698 - Test Method for Laboratory Compaction Characteristic of Soil Using Standard Effort 12,400 ft-lbf/ft³.
 - b. D1556 - Test Method for Density and Unit Weight of Soil in Place by the Sand-Cone Method.
 - c. D2167 - Test Method for Density and Unit Weight of Soil in Place by the Rubber Balloon Method.
 - d. D2488 - Practice for Description and Identification of Soils (Visual Manual Procedure).
 - e. D2937 - Test Method for Density of Soil in Place by the Drive-Cylinder Method.
 - f. D6938 - Standard Test Methods for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth).

PART 2 - PRODUCTS

2.01 GENERAL:

- A. Equipment includes all units necessary to construct subgrade conforming to requirements specified, such as, but not limited to:
 - 1. Scarifiers.
 - 2. Discs.
 - 3. Water distributor.
 - 4. Blade graders.
 - 5. Subgrade planers.

SECTION 31 23 13 – SUBGRADE PREPARATION: continued

6. Templates, straightedges, and other devices necessary to accurately check grade and crown.
7. Pneumatic rollers.
8. Tamping rollers.
9. Self-propelled, steel-wheel rollers.

2.02 PNEUMATIC ROLLERS:

- A. Self-propelled.
- B. Two axles with not less than nine wheels using pneumatic tires.
- C. Rigid steel frame and body suitable for ballast loading.

2.03 TAMPING ROLLERS:

- A. Towed or self-propelled.
- B. Staggered, uniformly spaced knobs or feet exerting not less than 250 psi on combined area in contact with the ground.
- C. Equipped with cleaning fingers maintained at full length to prevent accumulation of material between the feet.

2.04 STEEL-WHEEL ROLLERS:

- A. Self-propelled tandem or three-wheel.
- B. Weight not less than 10 tons.
- C. Equipped with scrapers to prevent accumulation of material on the rollers.

2.05 SUBGRADE PLANERS:

- A. Designed to roll on forms or be electronically controlled by erected stringline or other reference.
- B. Adjustable to produce a subgrade of exact elevation and cross section specified.

PART 3 - EXECUTION

3.01 PREPARATION:

- A. Prepare and maintain subgrade at the time the overlying pavement, base course, curb, walk, subbase course, paved drainage, slab-on-grade, or other surfacing is constructed thereon.
- B. Remove unsuitable material to the limits designated by Engineer and replace with suitable embankment material.

3.02 CONSTRUCTION REQUIREMENTS:

- A. Grade and compact subgrade to meet specified requirements.
- B. Extend subgrade 6 inches, or such greater distance as is necessary, for support of equipment and forms used to place the overlying material beyond the limits of the overlying course.
- C. Moisture Control:
 1. Aerate, dry, or add moisture if necessary to produce a finished subgrade that is nonyielding and meets specified density.

SECTION 31 23 13 – SUBGRADE PREPARATION: continued

2. Scarify and disc subgrade material in both excavation and embankment areas having a moisture content too high to permit preparation of subgrade meeting specified requirements.
 3. Depth of manipulation shall be not less than 6 inches in all areas nor greater than 18 inches in excavation areas.
 4. Contractor may, without cost to Owner, remove and replace or stabilize-in-place by acceptable methods, subgrade materials in lieu of adjusting the moisture content of in situ subgrade materials.
- D. Special Requirements for Portland Cement Concrete Pavement:
1. Accomplish final subgrade shaping by use of subgrade planer.
 2. Remove excess material trimmed by subgrade planer from subgrade.
 3. Recompect all loosened material behind the subgrade planer by rolling with a steel-wheel roller.

3.03 COMPACTION:

A. Degree of Compaction

1. Compacted fill should be placed in maximum 8-inch-thick loose lifts. The compaction criteria on the following table should be followed during construction:

AREA	MINIMUM PERCENTAGE OF STANDARD PROCTOR MAXIMUM DRY DENSITY (ASTM D 698)
Lime Treated Fills Beneath Mat Slab	98%
Foundations	98%
Fills Beneath Pavement and Exterior Flatwork	95%
Utility Trenches	95%
Foundation Wall Backfill	95%

B. Moisture Content of Subgrade:

1. Fill materials should be compacted as outlined below with moisture contents between 1 and 4 percentage points above optimum moisture for clayey soils (including chemically stabilized lime treated soils) and between +/- 2 percent for granular soils. The on-site soils may become somewhat unstable and deform under wheel loads if placed near the upper end of the recommended moisture range, so the upper 2 feet of subgrade fill should be placed towards the lower end of this range.

3.04 SURFACE TOLERANCES:

A. Surface Tolerances:

1. Maximum Compensating Deviation from Grade and Cross Section:
 - a. ± 0.02 ft. for flexible and rigid pavement and bases, except driveways.
 - b. ± 0.04 ft. for all other subgrade.

B. Test the completed subgrade for conformance to specified tolerances by means of straightedge, stringline, template, or other approved devices.

SECTION 31 23 13 – SUBGRADE PREPARATION: continued

- C. Rework areas deviating from the specified tolerances by removing material from high spots and placing material in low areas.

3.05 FIELD QUALITY CONTROL:

- A. Contractor shall, through services of an independent laboratory, test density and moisture content of the completed subgrade.
- B. Tests will conform to ASTM D1556, ASTM D2167, ASTM D2937, or ASTM D6938 at Engineer's option.
- C. Construct succeeding courses on prepared subgrade only after it has been tested and approved by Engineer.
- D. A representative of the geotechnical engineer should observe fill placement on a full-time basis.

3.06 MAINTENANCE:

- A. Maintain completed subgrade in finished condition until the overlying pavement or base course is placed.
- B. Restore all completed subgrade damaged prior to construction of the overlying course.
- C. Engineer's approval of subgrade at the time of its completion does not relieve Contractor of the requirement to maintain subgrade until such time as the overlying material is in place.

END OF SECTION 31 23 13

SECTION 31 23 16 - EXCAVATION, FILLING, AND BACKFILLING FOR STRUCTURES

PART 1 - GENERAL

1.01 SUMMARY:

- A. This Section includes all necessary excavation, filling, and backfilling for structures and all related Work, including duct banks and manholes.
- B. Related Work Specified Elsewhere:
 - 1. Site Preparation and Earthwork: SECTION 31 20 00.
 - 2. Trenching and Backfilling for Utilities: SECTION 31 23 33.
 - 3. Concrete: DIVISION 3.

1.02 REFERENCES:

- A. Applicable Standards:
 - 1. American Association of State Highway and Transportation Officials (AASHTO):
 - a. T104 - Standard Method of Test for Soundness of Aggregate by Use of Sodium Sulfate or Magnesium Sulfate
 - 2. American Society for Testing and Materials (ASTM):
 - a. D698 - Moisture-Density Relations of Soils and Soil-Aggregate Mixtures Using 5.5-lb. (2.49-kg) Rammer and 12-inch (305-mm) Drop.
 - a. D4253 - Test Method for Maximum Index Density and Unit Weight of Soils Using a Vibratory Table.
 - b. D4254 - Test Method for Minimum Index Density and Unit Weight of Soils and Calculation of Relative Density.
 - c. D6938 - Test Methods for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods.
 - 3. Occupational Safety and Health Administration (OSHA):
 - a. Part 1926 - Safety and Health Regulations for Construction.

1.03 SUBMITTALS:

- A. Submit as specified in the General and Special Conditions.
- B. Where selecting an option for excavation, trenching, and shoring in compliance with local, state, or federal safety regulations such as "OSHA Part 1926" or successor regulations, which require design by a registered professional engineer, submit the following:
 - 1. Copies of design calculations and notes for sloping, benching, support systems, shield systems, and other protective systems prepared by or under the supervision of a professional engineer legally authorized to practice in the jurisdiction where the Project is located.
 - 2. Documents provided with evidence of registered professional engineer's seal, signature, and date in accordance with appropriate state licensing requirements.

SECTION 31 23 16 - EXCAVATION, FILLING, AND BACKFILLING FOR STRUCTURES:
continued

PART 2 - PRODUCTS

2.01 GENERAL EARTH BACKFILL:

- A. Use suitable material as specified in SECTION 31 20 00.

2.02 STRUCTURAL FILL:

- A. May consist of reconditioned on-site soils, or imported material consisting of a non-expansive material containing:
1. Maximum of 30% passing the No. 200 sieve.
 2. Liquid limit (LL) less than 30.
 3. Plasticity Index (PI) less than 15.
 4. Materials not meeting the above criteria may be acceptable if they exhibit no more than 1% swell when remolded to 95% of the standard proctor (ASTM D698) maximum dry density at a moisture content between -1 and +3 percentage points of optimum upon wetting under a constant 200 psf surcharge.
 5. Fill material should not contain particles larger than 3-inches and should be free of any organic matter and other deleterious substances that could decay over time.

2.03 STRUCTURAL FILL UNDER WATER STORAGE TANK SLAB

- A. In the 0-2-foot zone beneath the water storage tank, material shall consist of CDOT Class 4 or Class 6 aggregate base course.
- B. On-site overburden soils are acceptable for structural fill beneath the 0-2-foot zone.

2.04 STRUCTURAL FILL FOR PRECAST CONCRETE MANHOLES AND VAULTS

- A. Bedding Material: The bedding material for the pipelines shall consist of a well-graded mineral aggregate mixture which will provide good stability. The size range of the aggregate shall be from 1/2-inch minimum to 3/4-inch maximum, with a maximum amount of fines passing a No. 8 screen not to exceed 5-percent by weight and shall conform to ASTM C33, gradation size No. 67, Class B. That portion greater than 3/8-inch shall contain at least 50-percent of the particle having 3 or more fractured faces.
- B. Bedding Material: Bedding material shall conform to the following limits when tested by means of laboratory sieves.

Per ASTM C33, Size No. 67	
Sieve Size	Percent Passing
3/4 inch	90-100%
3/8 inch	20-55%
No. 4	0-10%
No. 8	0-5%

SECTION 31 23 16 - EXCAVATION, FILLING, AND BACKFILLING FOR STRUCTURES:
continued

- A. Gravel or crushed stone which shall not have a loss of more than 15% after five cycles when tested for soundness with sodium sulfate as described in AASHTO T104.

2.05 CONCRETE:

- A. Includes all concrete used to restore bottom of excavation to proper elevation, and in concrete seal coats.
- B. Concrete shall be as specified in DIVISION 3.

PART 3 - EXECUTION

3.01 EXCAVATION:

- A. Perform as specified in SECTION 31 23 33.13 and as follows:
 - 1. Excavate area adequate to permit efficient erection and removal of forms.
 - 2. Trim to neat lines where details call for concrete to be deposited against earth.
 - 3. Excavate by hand in areas where space and access will not permit use of machines.
 - 4. If loose or soft zones are encountered that do not improve with subgrade preparation, over excavate and restore bottom of excavation to proper elevation with compacted structural fill in areas overexcavated, as approved.
 - 5. Use sides of trenches to form sides of duct banks where possible and where sides of trench are vertical, stable, and excavated to the proper line.
 - 6. Design, furnish, place, maintain, and subsequently remove, to the extent required, a system of temporary supports for cut and cover, open cut, or trench excavations, including bracing, dewatering, and associated items to support the sides and ends of the excavations where excavation slopes might endanger in-place or proposed improvements, extend beyond construction right-of-ways, or where specified or indicated.
 - 7. Space and arrange sheeting and bracing as required to exclude adjacent material and according to the stability of excavation slopes.
 - 8. Contractor shall make his own assessment of existing conditions including adjacent property, the possible effects of his proposed temporary works and construction methods, and shall select and design such support systems, methods, and details as will assure safety to the public, adjacent property, and the completed Work.
 - 9. Modify or relocate Underground Facilities, at no additional cost to Owner or Engineer, if existing Underground Facilities interfere with Contractor's proposed method of support.
 - 10. Employ caution in the areas of Underground Facilities, which shall be exposed by hand or other excavation methods acceptable to Owner.
 - 11. Perform sheeting, shoring, and bracing for trench excavation, for Underground Facilities, and for other purposes in accordance with the safety and protection requirements of the General Conditions.

SECTION 31 23 16 - EXCAVATION, FILLING, AND BACKFILLING FOR STRUCTURES:
continued

12. Provide sheeting, shoring, and bracing for trench excavation in the subgrade of the excavation to prevent movement of the main excavation support system.
13. Provide shoring, sheeting, and bracing as indicated or specified to meet the following requirements:
 - a. Prevent undermining and damage to all structures, buildings, Underground Facilities, pavements and slabs.
 - b. Excavations shall be accomplished with vertical banks where necessary for construction activities or as indicated, and also within all limits of excavation noted on the Drawings.
 - c. Design excavation support system and components to support lateral earth pressures, unrelieved hydrostatic pressures, utility loads, traffic and construction loads, and building and other surcharge loads to allow the safe and expeditious construction of the permanent structures without movement or settlement of the ground, and to prevent damage to or movement of adjacent buildings, structures, Underground Facilities, and other improvements. The design shall account for staged removal of bracing to suit the sequence of concrete placement for permanent structures and backfill.
 - d. Except as otherwise specified herein, shoring and sheeting materials may be extracted and reused at Contractor's option; however, Contractor shall remove and replace any existing structure or Underground Facility damaged during shoring and sheeting. Remove sheeting and bracing as backfill progresses. Fill voids left after withdrawal with sand or other approved material.
 - e. Where shoring and sheeting materials must be left in-place in the completed Work to prevent settlements or damage to adjacent structures or as directed by Engineer, Owner. Owner's Engineer, backfill the excavation to within 3 feet below the finished grade and remove the remaining exposed portion of the shoring before completing the backfill. If soldier piles and wood lagging are used for shoring, remove wood lagging to within 3 feet of finished grade in incremental steps of approximately 6 inches as the backfill is constructed, or to Contractor's design if more stringent. The location of all shoring and sheeting left in-place shall be documented on drawings and provided to Engineer and Owner.
14. Contractor shall be solely responsible for proper design, installation, operation, maintenance, and any failure of any component of the system. Review by Engineer of the design and data submitted by Contractor shall not relieve Contractor from full responsibility for errors therein or from the entire responsibility for complete and adequate design and performance of the sheeting and shoring system.
15. Provision for Contingencies:
 - a. The performance of the components of the support system shall be monitored for both vertical and horizontal movement daily.

SECTION 31 23 16 - EXCAVATION, FILLING, AND BACKFILLING FOR STRUCTURES:
continued

- b. A contingency plan or alternative procedure shall be provided for implementation, if the designed system does not adequately perform.
 - c. The materials and equipment necessary to implement the contingency plan shall be kept readily available.
 - 16. Damages:
 - a. Contractor shall document all existing damage to adjacent facilities and submit the information to Owner prior to performing any excavation. Documentation shall include a written description, diagrams, measurements, and appropriate photographs.
 - b. Repair all damage resulting from Contractor's excavation and remove and replace all undermined pavements with Owner-approved equal, either concrete or asphalt, at Contractor's expense.
- 3.02 FILLING AND BACKFILLING:
- A. Bedding under precast concrete manholes and vaults:
 - 1. Place on prepared subgrade in areas overexcavated as approved, prior to placing manhole or vault.
 - 2. Place in 8 inch maximum uncompacted lifts.
 - B. Structural Backfill under and adjacent to Foundations:
 - 1. Place in maximum of 8-inch uncompacted lifts.
 - 2. For concrete elements that retain unbalanced soil loads (e.g. retaining walls and basins) backfill only after concrete has attained 100% of design strength. For all other concrete elements, backfill only after concrete has attained 70% of the design strength.
 - 3. Backfill adjacent to structures only after, in the opinion of Engineer, a sufficient portion of the structure has been built to resist the imposed load.
 - 4. Remove all debris from excavation prior to placement of material.
 - 5. Perform backfilling simultaneously on all sides of structures.
 - 6. Exercise extreme care in the use of heavy equipment in areas adjacent to structures.
 - 7. Degree of compaction shall be as follows for new site grading fill and structural fill:

a. Beneath shallow foundations	98%
b. Against shallow foundations	95%
c. Beneath floor slabs	95%
d. Utility trench backfill	95%
e. Aggregate base course in 0-2-ft zone under Blending Tank Slab	95%
f. Below-ground wall backfill	
(1) Less than 8 feet thick	95%
(2) More than 8 feet thick	100%
g. All site aggregate base course	95%

SECTION 31 23 16 - EXCAVATION, FILLING, AND BACKFILLING FOR STRUCTURES:
continued

8. Moisture content shall be as follows:
 - a. Granular materials shall be compacted at moisture contents within 2 percentage points of the optimum moisture content.
 - b. Clayey materials shall be compacted at moisture contents between 0 and +3 percentage points of the optimum moisture content.
- 3.03 FIELD QUALITY CONTROL:
- A. Compaction:
 1. Engineer will, through services of an independent laboratory, test all filling and backfilling for structures to determine conformance with density relationships specified.
 2. Method of test shall be as specified in SECTION 31 20 00.
 3. The frequency of tests shall be in compliance with jurisdictional requirements or as otherwise required by Owner.

END OF SECTION 31 23 16

SECTION 31 23 16.26 – ROCK REMOVAL

PART 1 - GENERAL

1.01 SUMMARY:

- A. This Section covers the rock excavation requirements for the installation of waterlines, waterline appurtenances, services, and associated appurtenances in open cut.
- B. Related Work Specified Elsewhere:
 - 1. Earthwork: SECTION 31 00 00.
 - 2. Site Clearing: SECTION 31 10 00.
 - 3. Trenching and Backfilling for Utilities: SECTION 31 23 33.13.
 - 4. Trenching and Backfilling for Utility Structures: SECTION 31 23 33.16.
- C. Description:
 - 1. The work shall consist of excavating rock materials from the pipeline trench, surface grading, sub-cuts, drainage ditches, channel improvements, and approaches. The work shall include excavating rock materials for pipeline and pipeline appurtenance installations. The work shall be completed to the lines, grades, and dimensions shown on the plans or as designated by the Engineer.

1.02 REFERENCES:

- A. The Contractor shall comply with the applicable rules, regulations and standards established by the Regulatory Agencies, codes and professional societies listed herein. These rules and standards include but are not limited to the following:
 - 1. United States Department of Interior, Bureau of Mines; Figure B-1 from Report of Investigation 8507 by D. E. Siskind, et. al.
 - 2. OSHA Construction Industry Standards (29CFR Part 1926) Subpart P, Excavations, Trenching, and Shoring.

1.03 DEFINITIONS:

- A. Rock Excavation:
 - 1. ROCK EXCAVATION – the excavation of all hard, compacted, or cemented materials that requires the use of ripping and excavating equipment larger than defined for common or earth excavation. Rock Excavation shall consist of the removal of igneous, metamorphic, and sedimentary rock which cannot be excavated without the use of a rock saw or rock trencher, including boulders or other detached stones having a volume of 1-cubic yard or more, as determined by physical or visual measurement.
 - 2. ROCK – shall comprise of material found in ledges or masses in its original position or artificial material, which would normally have to be loosened by pneumatic tools, or if excavated by hand, by the continued use of wedges and sledge hammers and in the opinion of the Engineer is incapable of being loosened with a track-type tractor with mounted and drawn ripper of the following description:
 - a. Tractor Unit: Equipment with a minimum mass of 35 tons and net horse power rating of 300-horsepower or more. The tractor unit is to be in good condition and operated by experienced personnel.

SECTION 31 23 16.26 – ROCK REMOVAL: continued

- b. Ripping Unit: The ripper to be attached to the tractor shall be the most efficient parallelogram type recommended by the tractor or ripper manufacturer. The ripper shall be defined as a rear-mounted, heavy duty, single tooth, ripping attachment mounted on a track type tractor having a power rating of at least 250-flywheel horsepower unless otherwise approved by the Engineer.
 - 3. SOLID ROCK – shall comprise all rock found in its original bed, even though it may be loosened from the adjacent underlying rock. Materials designated as solid rock shall be also defined by:
 - a. Solid boulders or detached pieces of rock exceeding 1-cubic yard in volume
 - b. Production rate of less than 50-cubic yards per hour for continuous of 4-hours using 300-horsepower excavator or ripper at full capacity.
 - (1) Rock in trench or pit shall not include material which, in the judgement of the Engineer, can be excavated at a rate of 4-cubic yards solid or more per hour by a 50-horsepower backhoe in good order and efficiently operated.
 - B. Earth Excavation:
 - 1. EARTH EXCAVATION – the excavation of all materials that can be excavated, transported, and unloaded by the use of heavy ripping equipment and wheel tractor-scrapers and pusher tractors or that can be excavated and dumped into place or loaded onto hauling equipment by means of excavators utilized appropriately for the material type, character, and nature.
 - 2. OVER-BREAKAGE – rock or earth excavated in excess of the lines, grades, and dimensions shown on the plans or as designated by the ENGINEER.
- 1.04 SUBMITTALS:
- A. All submittals for rock removal shall be provided in accordance with the requirements of this section and General and Special Conditions.
 - B. Dewatering Plan.
 - C. Submit Construction Schedule and Plans prior to Construction.

PART 2 - PRODUCTS (NOT APPLICABLE)

PART 3 - EXECUTION:

- 3.01 BLASTING:
- A. Blasting will not be allowed on this project.
- 3.02 GENERAL:
- A. Earth materials shall be removed from areas where rock lies in a solid mass, in accordance with the requirements described in this section.
 - B. Excavated rock materials shall be removed from the trench and properly disposed of in accordance with local, state and federal rules and regulations. See 3.03 below.
 - C. The Contractor shall set aside detached rocks and boulders for the purpose of measurement as needed to justify payment.

SECTION 31 23 16.26 – ROCK REMOVAL: continued

- D. The spacing of the drill holes shall not exceed the depth of the cut at the point of drilling.
- E. Rock masses encountered in roadway cuts shall be shattered 1-foot below the rock subgrade for the full width of the cut section including the grade of the ditch bottom.
- F. Drill hole locations shall be indicated by the Contractor sufficiently in advance of the drilling so that the Engineer may stake the exact depth from the rock surface to grade elevation at each drill hole. Holes deeper than the specified depths may be drilled if approved by the Engineer. Holes shall be drilled to the same depth below grade except at grade points, where drilling shall be continued beyond the lower end of the cut on non-level gradients and beyond each end of the cuts on level gradients in order to provide positive drainage of the shattered layer.
- G. The exposed rock surface shall be chocked with small rock fragments and granular material to form a uniform tight surface.
- H. Rock slopes shall be scaled down to remove boulders and rock fragments which may slide or roll down the trench slopes. No rock shall be left projecting within the true slope line. Detached rocks and boulders will be measured before they are incorporated into the embankment. Rock material that is not measured and is incorporated into the embankment will be considered as EARTH EXCAVATION.
- I. The measurement of rock excavation in solid masses may also include unavoidable over-breakage beyond the lines established by the Engineer to an amount not exceeding 10-percent of the volume staked. Over-breakage in excess of these limits will be considered as EARTH EXCAVATION and not subject for payment under the Rock removal pay item.
 - 1. Backfilling of over-breakage points that exceed the limits noted above shall be corrected by filling the voids with a backfill material to be approved by the ENGINEER.

3.03 USE OR DISPOSAL OF EXCAVATED MATERIALS:

- A. To the extent they are needed, all suitable materials from the specified excavations may be used in the construction of required backfill.
 - 1. The suitability of these materials will be determined by the Engineer.
- B. Surplus or unsuitable materials from the specified excavations shall be properly disposed of by the Contractor at sites of his own choosing away from the site in an environmental manner that does not violate local rules and regulations
 - 1. The unsuitability of these materials will be determined by the Engineer.
 - 2. Unsuitable rock material may be crushed and used in bedding or backfill of piping as long as it meets the requirements set forth in these Specifications.

END OF SECTION 31 23 16.26

SECTION 31 23 33.13 - TRENCHING AND BACKFILLING FOR UTILITIES

PART 1 - GENERAL

1.01 SUMMARY:

- A. This Section includes:
 - 1. Excavation, sheeting, bracing, cutoof walls, and all operations necessary for the preparation of trenches for bedding of pipes and pipe appurtenances, conduit, and buried cable.
 - 2. Pipe embedments and encasements.
 - 3. Backfilling of trenches.

1.02 RELATED REQUIREMENTS:

- A. Concrete: DIVISION 3.
- B. Earthwork: SECTION 31 00 00.
- C. Trenching and Backfilling for Structures: SECTION 31 23 33

1.03 REFERENCES:

- A. Applicable Standards:
 - 1. American Association of State Highway and Transportation Officials (AASHTO):
 - a. M147 - Materials for Aggregate and Soil-Aggregate Subbase, Base and Surface Courses.
 - b. T104 - Soundness of Aggregate by Use of Sodium Sulfate or Magnesium Sulfate.
 - 2. American Society for Testing and Materials (ASTM):
 - a. D4253 - Test Method for Maximum Index Density of Soils Using a Vibratory Table.
 - b. D4254 - Test Method for Minimum Index Density and Unit Weight of Soils and Calculation of Relative Density.
 - a. D698 - Moisture-Density Relations of Soils and Soil-Aggregate Mixtures Using 5.5-lb. (2.49-kg) Rammer and 12-inch (305-mm) Drop.
 - 3. Occupational Safety and Health Administration (OSHA):
 - a. Part 1926 - Safety and Health Regulations for Construction.
 - 4. City of Thornton Standards and Specifications.
 - 5. Colorado Department of Transportation (CDOT) Standard Specifications for Road and Bridge Construction.

1.04 SUBMITTALS:

- A. Submit as specified in DIVISION 1.
- B. Includes, but not limited to, the following:
 - 1. Steel reinforcement for concrete encasement.
 - 2. Steel reinforcement for concrete cradle.
 - 3. Concrete Submittals as specified in DIVISION 3.
 - 4. Material submittals and tests to meet specifications (bedding and backfill)
- C. Where selecting an option for excavation, trenching, and shoring in compliance with local, state, or federal safety regulations such as "OSHA Part 1926" or

SECTION 31 23 33.13 - TRENCHING AND BACKFILLING FOR UTILITIES: continued

successor regulations, which require design by a registered professional engineer, submit for information only and not for Engineer approval the following:

1. Copies of design calculations and notes for sloping, benching, support systems, shield systems, and other protective systems prepared by or under the supervision of a professional engineer legally authorized to practice in the jurisdiction where the Project is located.
2. Documents provided with evidence of registered professional engineer's seal, signature, and date in accordance with appropriate state licensing requirements.

PART 2 - PRODUCTS

2.01 GRANULAR PIPE EMBEDMENT:

- A. Bedding Material: The bedding material for the pipelines shall consist of an aggregate mixture which will provide good stability. Bedding material shall conform to the following limits when tested by means of laboratory sieves:

Per ASTM C33, SQUEEGEE SAND	
Sieve Size	Percent Passing
3/8 inch	100%
No. 200	0-5%

2.02 TRENCH STABILIZATION MATERIAL:

- A. Material shall be one of the following:
1. 2-inch minus river-run or pit-run gravel free from clay balls, roots and organic matter, graded from course to fine, with less than 8 percent by weight passing a 1/4-inch sieve.
 2. As approved by the Owner and Engineer.

2.03 TRENCH BACKFILL:

- A. Free from organic matter, refuse, ashes, cinders, frozen, or other unsuitable material.
- B. Gravel, rock, or shale particle size shall not exceed 2 inches in greatest dimension.
- C. Not greater than 15% passing the No. 200 standard square-mesh sieve.
- D. Controlled Low Strength Material (CLSM). Use CLSM where indicated and where proper compaction of backfill cannot be attained.

2.04 GENERAL TRENCH BACKFILL MATERIALS:

- A. Obtain from the following:
1. Trenches and other excavations included in this Contract.
 2. Borrow from location off Site.
 3. Combination of above.

SECTION 31 23 33.13 - TRENCHING AND BACKFILLING FOR UTILITIES: continued

- B. Free from organic matter, refuse, ashes, cinders, frozen, or other unsuitable material.
- C. Gravel, rock, or shale particle size limited as follows:
 - 1. Not to exceed 2 inches in greatest dimension within 12 inches of pipe or conduit.
 - 2. Gravel, rock, or shale not allowed within 12 inches of buried cable.
 - 3. Maximum dimension one-half the depth of layer to be compacted in other areas.
- D. Contain sufficient fine materials to provide a dense mass free of voids and capable of satisfactory compaction.
- E. Have moisture content enabling satisfactory placement and compaction.
- F. Blended or otherwise processed to provide required gradation and obtain moisture content within the moisture content range of 2% below optimum or to 2% above optimum for granular materials and between 1% above and 4% above optimum for clay materials. Optimum moisture and maximum as specified for pipe embedment as determined by ASTM D698.
- G. Use material as specified for pipe embedment, pipe zone fill, upper trench zone backfill, and trench stabilization.
- H. Compaction:
 - 1. Perform at moisture content necessary to achieve required results with equipment used.
 - 2. Perform with spreading equipment supplemented by hand-operated equipment and rollers as required to obtain density specified.
 - 3. Accomplish without inundation or flooding.
 - 4. Backfill material must be placed and compacted in maximum eight inch (8") loose lifts, unless compaction equipment is used that allows larger lift thickness, as approved by the Engineer.
 - 5. Achieve following densities:
 - a. Unless otherwise specified, adequate to prevent significant future settlement.
 - b. Native Earth Backfill:
 - (1) Compact to 95% of maximum dry density within the moisture content range from 2% below optimum to 2% above optimum for granular materials and 1% above optimum to 4% above optimum for clay materials. Optimum moisture and maximum dry density shall be determined by ASTM D698
 - 6. Backfill failing to meet required densities shall be removed and recompacted as necessary to achieve specified results.
- I. Controlled Low Strength Materials (CLSM) or Flow Fill:
 - 1. Proportions:
 - a. Strength: CLSM shall have a minimum twenty-eight (28) day compressive strength of one hundred (100) psi when molded and cured as in conformance with ASTM D4832. 2.
 - b. The CLSM shall have a minimum cement content of fifty (50) pounds per cubic yard. The water-cementitious materials ratio of the mix shall not exceed three and one-half to one (3.5:1).

SECTION 31 23 33.13 - TRENCHING AND BACKFILLING FOR UTILITIES: continued

- c. Air-Entrainment: All CLSM shall be air entrained to a total air content of approximately five percent (5%).
- d. Slump: The minimum slump shall be six (6) inches and the maximum slump shall be eight (8) inches when tested in accordance with ASTM D6103.
- e. Aggregate: Fine aggregate shall be between fifty percent (50%) and sixty percent (60%) by volume of the total aggregates in the CLSM mix.
- f. Consistency:
 - (1) The consistency of the CLSM slurry shall be such that the material flows easily into all openings between the pipe and the lower portion of the trench.
 - (2) When trenches are on a steep slope, a stiffer mix of slurry may be required to prevent CLSM from flowing down the trench.
 - (3) When a stiffer mix is used, vibration shall be performed to ensure that the CLSM slurry completely fills all spaces between the pipe and the lower portion of the trench.

PART 3 - EXECUTION

3.01 TRENCHING:

A. Equipment and Methods:

- 1. Types of Equipment and methods may be at Contractor's option, where structures or other facilities are not endangered.
- 2. Equipment and methods shall be subject to approval of jurisdictional agency where stability or usefulness of other facilities may be impaired.
- 3. Perform by hand methods when required to save or protect trees, culverts, utilities, or other structures above or below ground.
- 4. Maximum length of open trench shall be limited to 50 feet in advance and to 50 feet behind pipe installation, except as approved.

B. Side Walls:

- 1. Make vertical or slope within specified trench-width limitations below a horizontal plane 12 inches above top of pipe.
- 2. Vertical or sloped (stepped) as required for stability, above a horizontal plane 12 inches above top of pipe.
- 3. Sheet and brace where necessary.
- 4. Excavate without undercutting.

C. Trench Depth:

- 1. Depth shall be sufficient to provide the minimum bedding requirements for the pipe being placed.
- 2. Do not exceed the indicated depth where conditions of bottom are satisfactory.
- 3. Increase depth as necessary to remove unsuitable supporting materials.

D. Trench Bottom:

- 1. Protect and maintain when suitable natural materials are encountered.
- 2. Remove rock fragments and materials disturbed during excavation or raveled from trench walls.

SECTION 31 23 33.13 - TRENCHING AND BACKFILLING FOR UTILITIES: continued

3. Restore to proper subgrade with trench-stabilization material or timber mat topped with trench-stabilization material when overexcavated:
 - a. Placement of Trench Stabilization Material:
 - (1) Compact in lifts not exceeding 6-inch loose thickness:
 - (a) With pneumatic or vibratory equipment.
 - (b) To density specified for granular pipe embedment.
 - E. Trench Width:
 1. Excavate trench to a width which will permit satisfactory jointing of the pipe and thorough tamping of the bedding.
 2. Minimum and Maximum Trench Width:
 - a. Maximum trench width shall not be more than 24-inches wider than the diameter of the pipe.
 - b. Minimum trench width shall not be less than 16-inches wider than the diameter of the pipe.
 - c. Maximum trench-width limitations shall apply beginning 3 feet from manhole or structure walls.
 - d. Maximum width shall be as near the minimum specified as can be controlled by construction equipment and methods used.
 - e. Correct when overexcavated at no additional cost to Owner:
 - (1) Use stronger pipe or higher class embedment.
 - F. Trenching in Fill Areas: Perform trenching in fill areas only after compacted fill has reached an elevation of not less than 1 foot above the top of the pipe.
 - G. Test Pits:
 1. Excavate test pits sufficiently in advance of trenching to enable adequate planning of construction procedure.
 2. Locate as follows:
 - a. Where unstable material is suspected that may require special protective measures.
 - b. Where groundwater may require special handling methods.
 - c. Where advisable to assess adequacy of blasting pattern.
 - d. Where indicated or otherwise approved.
 - e. Where interference or conflict with other utilities or structures could affect alignment of pipe.
 3. With lateral dimension not less than minimum trench width specified for location excavated.
 4. To depth required to obtain information desired.
- 3.02 PIPE EMBEDMENTS AND ENCASEMENTS:
- A. Granular Pipe Embedment:
 1. Place granular embedment as follows:
 - a. Level bottom layer at proper grade to receive and uniformly support pipe barrel throughout its length.
 - b. Form shallow depression under each joint to facilitate grouting.
 - c. Form depression under each joint so that no part of bell or coupling is in contact with trench when pipe is placed in position.

SECTION 31 23 33.13 - TRENCHING AND BACKFILLING FOR UTILITIES: continued

- d. Add second layer simultaneously to both sides of the pipe with care to avoid displacement.
 - e. Complete promptly after completion of jointing operations and approval to proceed.
 - 2. Compact granular bedding as follows:
 - a. In lifts not exceeding 12 inches in compacted depth.
 - b. Rod, spade, or use pneumatic or vibratory equipment:
 - (1) As required to obtain not less than 80% relative density as determined by ASTM Method D4253 and D4254.
 - (2) Throughout depth of embedment.
 - (3) Tamp, slice, and chink bedding under pipe haunches to completely fill all voids.
- 3.03 BACKFILLING:
 - A. Soil Placement:
 - 1. Complete promptly after approval to proceed:
 - a. Upon completion of pipe embedment.
 - 2. Use hand methods to a horizontal plane 12 inches above top of pipe-coupling, conduit, or duct banks.
 - 3. Use approved mechanical methods where hand backfill is not required.
 - 4. Place in layers of thickness within compacting ability of equipment used.
 - 5. Until compacted depth over conduit exceeds 3 feet, do not drop fill material over 5 feet. Then distance may be increased 2 feet for each additional 1 foot of cover. Backfill conduit trenches in layers of 4 to 8 inches.
 - B. CLSM Placement:
 - 1. CLSM shall be placed as closely behind pipe laying operations as possible.
 - 2. CLSM shall not be placed when the trench bottom or walls are frozen or contain frozen materials.
 - 3. CLSM shall not be placed when the air temperature is below forty degrees Fahrenheit (40°F) unless the air temperature is thirty five degrees Fahrenheit (35°F) or more and the temperature is rising.
 - 4. Pipe shall be placed on two (2) sandbags and leveled to the proper grade. Precast or other types of rigid pads that constitute a point load are unacceptable.
 - 5. CLSM shall be placed under the pipe from one side so that it flows under the pipe until it appears on the other side.
 - 6. CLSM shall be added to both sides of the pipe until it completely fills the space between the pipe and the sides of the trench, to the depths shown in the DRAWINGS.
 - 7. Rodding, mechanical vibration and compaction of CLSM shall be performed to assist in consolidating the CLSM.
 - 8. When required to prevent uplift, the CLSM shall be placed in two (2) stages as required, allowing sufficient time for the initial set of the first stage before the remainder is placed.

SECTION 31 23 33.13 - TRENCHING AND BACKFILLING FOR UTILITIES: continued

9. CLSM shall be deposited as nearly as practical in its final position and in no way disturb the pipe trench or cause foreign material to become mixed with the CLSM.
 10. Soil backfill shall not be placed until the CLSM has reached the initial set.
 11. If backfill is not to be placed over the CLSM within eight (8) hours, a six-inch (6") cover of moist earth shall be placed over the CLSM surface.
 12. If the air temperature is fifty degrees Fahrenheit (50°F) or less, the moist earth cover should be at least eighteen inches (18") thick.
- C. Soil Compaction:
1. Perform with spreading equipment supplemented by hand-operated equipment and rollers as required to obtain density specified.
 2. Accomplish without inundation or flooding.
 3. Except as indicated otherwise, compact to 95% of maximum dry density within the moisture content range from 2% below optimum to 2% above optimum for granular materials and from 1% above optimum to 4% above optimum for clay materials. Optimum moisture and maximum density shall be as determined by ASTM D698.
 4. Backfill failing to meet required densities shall be removed or scarified and recompacted as necessary to achieve specified results.

3.04 FIELD QUALITY CONTROL:

- A. Compaction: Contractor shall, through the services of an independent laboratory approved by the Owner, test all trench-stabilization material, granular pipe embedment, earth-pipe embedment, cut-off walls, and trench backfill to determine conformance with specified moisture- density relationships:
1. Method of test will be as specified in SECTION 31 20 00, PART 3.
- B. Concrete: Contractor shall test all concrete for use in encasements, cradles, and concrete cut-off walls to determine conformance with Specifications. Method of test shall be as specified in DIVISION 3.

END OF SECTION 31 23 33.13

SECTION 31 73 00 - CONTACT GROUTING

PART 1 - GENERAL

1.01 DESCRIPTION:

- A. This section includes the requirements for filling the annular space between the Jacked Pipe or erected support and the existing ground with Contact Grout.
- B. Labor, material, tools, equipment, and incidentals necessary to complete the work described above.
- C. This is a performance specification. Minimum requirements are presented herein. It is the Contractor's responsibility to develop and implement the design to fulfill the specified requirements. The Contractor shall select and utilize methods and equipment compatible with the dimensions of the tunnels shown and with anticipated geologic conditions.

1.02 REFERENCES:

- A. ASTM International (ASTM):
 - 1. C 109: Standard test method for Compressive Strength of Hydraulic Cement Mortars (using 2-in cube specimens).
 - 2. C 144: Standard specification for Aggregate for Masonry Mortar.
 - 3. C 150: Standard specification for Portland Cement.
 - 4. C 494: Standard specification for Chemical Admixtures for Concrete.
 - 5. C 618: Standard specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use as a Mineral Admixture in Concrete.
 - 6. C 827 Standard Test Method for Change in Height at Early Ages of Cylindrical Specimens of Cementitious Mixtures.
 - 7. C 939: Standard test method for Flow of Grout for Preplaced Aggregate Concrete (Flow Cone Method).
 - 8. C 940: Standard Test Method for Expansion and Bleeding of Freshly Mixed Grouts for Preplaced-Aggregate Concrete in the Laboratory.
 - 9. C 1064: Standard Test Method for Temperature of Freshly Mixed Hydraulic-Cement Concrete.
 - 10. D 4380: Standard Test Method for Density of Bentonitic Slurries.
- B. Applicable Regulations:
 - 1. Perform work in accordance with all applicable federal, state, and local regulations, codes, and standards. In the event of conflict, comply with more stringent requirement.

1.03 DEFINITIONS:

- A. Contact Grouting: The controlled injection of fluid grout at the interface between the Jacking Pipe or erected support and the ground and to fill all voids and achieve continuous contact.
- B. Jacking Pipe: The pipe jacked behind the boring machine.
- C. Initial Support: Temporary ground support installed concurrent with tunnel excavation to maintain ground stability prior to installation of the Carrier Pipe. Initial Support includes both Casing Pipe and erected support.

SECTION 31 73 00 – CONTACT GROUTING: continued

1.04 QUALIFICATIONS:

- A. The Contractor or Subcontractor who performs Contact Grouting shall be experienced in Contact Grouting in tunnels and underground projects with soil conditions, using methods, materials, and equipment comparable to this project. Specifically, Contractor or Subcontractor shall have successfully completed at least five Contact Grouting jobs of which at least two were Contact Grouting staged from underground within the last five years.
- B. The Contact Grouting Expert shall have at least five years of Contact Grouting experience and shall have successfully completed at least two underground Contact Grouting jobs using similar methods and have been in a supervisory position for at least one of those jobs.

1.05 SUBMITTALS:

- A. Submit in accordance with the General and Special Conditions.
- B. All submittals, including drawings and calculations, shall be required for the sole purpose of providing Engineer sufficient details to confirm that the Contractor planned work and work in progress is in accordance with Contract Documents. Engineer's review shall not be construed to relieve Contractor in any way of responsibilities under the Contract. Do not begin work on any item requiring a submittal until the required relevant submittals have been reviewed and approved by the Engineer.
- C. Submittals involving design work requiring a Professional Engineer shall be signed and sealed by a Professional Engineer registered in the State of Colorado.
- D. Preconstruction. At least four weeks prior to the start of the work, submit the following qualifications:
 - 1. The name and qualifications of the Contact Grout Contractor.
 - 2. The name and qualifications of the Contact Grouting Expert.
- E. Preconstruction: At least four weeks prior to the start of the work, submit a Contact Grouting Work Plan, including the following:
 - 1. A schedule for Contact Grouting work identifying all major construction activities as independent items. Include working hours for each activity, and a written description of construction methods and equipment, to be employed in completing work activities shown on the schedule and update weekly. Notify the Engineer at least one working day in advance of schedule changes.
 - 2. Descriptions and shop drawings describing and illustrating methods and equipment proposed for all stages of the Contact Grouting operation including injection methods for Contact Grout including pumping equipment, mixer, agitator, hoses, boosters, pumping distances, return flow lines, flow rates, and pressure gauges. Include methods and description of instrumentation to monitor and control placement of the grout, proposed grout pressures, and procedures to be used to verify complete placement and check for voids.
 - 3. Mix design for the Contact Grout including proportions of all constituents, properties of the wet mix, test results of the wet mix, and test results of the cured backfill. The submittal shall fulfill all the requirements for materials specified herein. Trial contract grout mix tests shall be performed on samples

SECTION 31 73 00 – CONTACT GROUTING: continued

made using the same materials, including water and cement that will be used in production.

4. Drawings and description of Contact Grout ports, plugs, and valves for the ports, and materials used to plug and permanently seal the Contact Grout ports following Contact Grouting.
 5. Calculations and manufacturer information verifying that the proposed Jacking Pipe or erected support will adequately withstand proposed grouting pressures.
- F. Construction. Submit the following during construction within the specified time restrictions:
1. Test results of the Contact Grout. Submittals shall include results of all tests specified herein for the Contact Grout including but not limited to field tests and laboratory tests within 24 hours of the results being available.
 2. Daily Logs as specified herein. Submit logs daily for the previous day's work.

1.06 QUALITY CONTROL:

- A. Contractor shall provide testing of Contact Grout verification of material properties. Samples of Contact Grout shall be obtained at the point of discharge or alternatively at a simulated point of discharge through the same or greater pumping distance.
1. Index Testing of Contact Grout performed on: the first batch of Contact Grout mixed each day; for each additional 150 cf of Contact Grout placed, or fraction thereof; and after a change in mix design. Index tests shall include:
 - a. a set of compression tests
 - b. unit weight
 - c. temperature
 - d. viscosity
 2. Compression Testing of Contact Grout: One set shall include five 2-in. diameter by 4-in. high cylinder samples. Testing shall be in accordance with ASTM C 39. One sample shall be tested at an age of 24 hours, one sample shall be tested at an age of seven days, and two samples shall be tested at an age of 28 days. One sample shall be held in storage.
- B. The proposed Contact Grout mix shall be tested for strength at 24 hours, 7 days, and 28 days. Results of the 24-hour strength tests shall be used as a quality control check on the likely Contact Grout strength at 7 and 28 days.

PART 2 - PRODUCTS

2.01 MATERIALS:

- A. Portland cement shall be in accordance with ASTM C150.
- B. Contact Grout.
1. Contact Grout shall be a mixture of Portland cement and water with a maximum water/cement ratio of 1:1 by volume, where the volume of cement is based on the bulk unit weight where one 94-lb sack equals one cubic foot. Sand shall only be used if approved by the Engineer.
 2. 28-day strength at least 300 psi.

SECTION 31 73 00 – CONTACT GROUTING: continued

3. Contact Grout trial mix shall be exhibit no more than five percent bleed as measured according to ASTM C940.
4. Contact Grout shall have a wet specific gravity between 1.69 and 1.75 when measured with a Baroid Mud Balance in accordance with ASTM D4380.
5. Contact Grout temperature at time of injection shall be between 50° F and 90° F when measured according to ASTM C1064.
6. Contact Grout viscosity shall be measured according to ASTM C939. Flow time at time of injection shall be between 18 and 35 seconds.
7. Water shall be potable.
- C. Contact Grout Port Plugs: Contact Grout port plugs shall be compatible with the Pipe or erected support. The plugs shall be watertight and leave the tunnel interior with a smooth surface. The plugs shall be rated to a pressure of at least 100 psi.

2.02 EQUIPMENT:

- A. Contact Grouting Equipment
 1. The Contractor shall determine the equipment needed to successfully conduct the Contact Grouting and control the work.
 2. As a minimum, the Contractor's Contact Grouting equipment shall consist of:
 - a. If mixed on-site, the water shall be metered, and a high-speed shear mixer used;
 - b. Paddle type agitator;
 - c. Progressing helical cavity (Moyno) grout pump or equivalent pump that provides a constant flow rate;
 - d. Contact Grouting header assembly. The piping shall include a spigot with valve at the injection point for taking Contact Grout samples.
 3. The Contact Grouting equipment shall include controls on the proportioning and mixing of the Contact Grout sufficient to assure the designed mix is achieved.
 4. A flow meter shall be provided at the injection point with a range suitable for the expected Contact Grout flows and measuring the rate of flow to an accuracy of 0.2 gpm or better. A total flow indicator shall be provided at the injection point measuring the Contact Grout injected at each port to an accuracy of 1 gallon or better.
 5. A pressure gauge shall be provided at the injection point with a range selected so that the anticipated grouting pressure is in the middle third and reading to an accuracy of 0.2 psi or better.
- B. Communications Equipment. The Contractor shall provide equipment to communicate between workers in the tunnel at the Contact Grout injection points with workers outside the tunnel.

PART 3 - EXECUTION

3.01 GENERAL:

- A. Perform all work in the presence of the Owner's Project Representative and/or the Engineer, unless the Engineer has granted prior approval in writing to perform such work in his/her absence.

SECTION 31 73 00 – CONTACT GROUTING: continued

- B. The Contractor shall give the Engineer a minimum of ten days advance notice of the start of work so Engineer can plan observation.
- C. Contractor shall provide daily updates to Owner and/or Engineer.
- D. Contact Grouting shall be conducted under the direct supervision of the Contact Grouting Expert.
- E. Contact Grouting of the Casing Pipe shall be started within three days and completed within one week of the completion of tunneling for each tunnel drive.
- F. Contact grouting with liner plates shall be performed no more than 40 ft behind the excavation face. Contact grouting is not required if ribs and wood lagging or ribs and steel channel lagging Initial Support is used.
- G. Contractor shall perform Contact Grouting operations in a manner that will limit ground movements, displacement of the Jacking Pipe or erected support, and the movement of structures and utilities, if any, above and adjacent to the tunnel. Monitoring for ground movement shall be as specified in Section 31 09 13.

3.02 SAFETY REQUIREMENTS:

- A. Methods of construction shall be such as to ensure the safety of the workers, project participants, the public, third parties, and adjacent property, whether public or private. The Contractor is solely and completely responsible for maintaining safe working conditions at the site at all times.

3.03 MAINTENANCE:

- A. Maintain clean working conditions at all times inside the tunnel and shafts. All excess material, slush, Contact Grout spills, ponded water, and any other unused material or byproduct of the work shall be removed from the tunnel and the excavation daily.

3.04 CONTACT GROUTING:

- A. Contact Grouting shall be staged from inside the tunnel and done through preinstalled ports in the Casing Pipe or erected support.
- B. For tunnels where Jacking Pipe or erected support is installed as the initial support in a two-pass system, Contact Grouting shall be completed before installation of carrier pipe.
- C. Pressure gauges of appropriate diameters and ranges for monitoring the Contact Grouting injection pressures shall be located as close as possible to the point of injection in the line transporting the Contact Grout.
- D. Shutoff valves shall be supplied for Contact Grout ports in the vicinity of active Contact Grouting. The Contractor shall supply a sufficient number of shutoff valves to observe Contact Grout communication at least 50 ft in front of the port being Contact Grouted. Additional shutoff valves shall be provided by the Contractor if valves on previously Contact Grouted holes are not replaced with plugs as Contact Grouting progresses.
- E. Contact Grouting at each location shall begin at the lower ports with higher ports used for verification, followed by Contact Grouting through upper ports. Contact Grout using methods and procedures that track the movement of Contact Grout and verify presence of Contact Grout throughout the tunnel by injecting Contact

SECTION 31 73 00 – CONTACT GROUTING: continued

Grout at one port and using nearby ports to detect the presence of Contact Grout. Sequentially close off and move injection points to ensure full Contact Grout coverage.

- F. The volume of Contact Grout injected shall be measured, recorded, and compared with the anticipated volume per foot of Contact Grout expected. The advance of the grout shall be monitored by recording communication at nearby Contact Grout ports.
- G. The Contact Grouting pressure shall be determined by the Contact Grouting Expert and based on recommendations from the Pipe manufacturer or Liner Plate manufacturer; the pressure shall be sufficient for the Contact Grout to fill voids surrounding the Jacking Pipe. Maximum allowable Contact Grouting pressure shall be maintained from the start of Contact Grout injection of each hole to refusal of the hole. The maximum Contact Grout pressure at all locations shall be less than the pressure that would cause ground heave and/or cause hydraulic fracturing or damage to the Pipe or erected support. As a guideline, to avoid ground heave or fracture, injection pressure should be limited to one-half psi per foot of soil over the top of the tunnel crown plus one psi per foot of rock plus the hydrostatic pressure due to groundwater.
- H. Maximum Contact Grout injection port spacing, and hole locations shall as shown on the Contract Drawings.
- I. Refusal. Contact Grouting of any injection port shall be considered complete when the Contact Grout take is 1.5 gallons of Contact Grout or less during a minimum of 5 minutes of pumping at maximum injection pressure.
- J. After completion of Contact Grouting, replace plug, and fill or patch in accordance with manufacturers specifications and recommendations.
- K. Maintain a supply of water in the tunnel at the location of the Contact Grouting operations to facilitate flushing of injection lines or outlets.
- L. All work areas shall have sufficient lighting to facilitate proper performance and inspection of work.

3.05 DAILY LOGS:

- A. Maintain Daily Logs of the work. As a minimum the Daily Logs shall contain the following:
 - 1. Work hours, equipment and crews in use with persons and craft designations.
 - 2. Stations of Contact Grouting.
 - 3. Volume and pressures injected at each location.
 - 4. Contact Grout sequence with take at each port and observations of return from nearby holes.
 - 5. Record of holes Contact Grouted with locations, quantities, pressures, injection times, and verifications used.
 - 6. Problems or unusual conditions encountered, and actions taken to address these situations.

END OF SECTION 31 73 00

SECTION 31 75 00 – CONSTRUCTION SHAFTS

PART 1 - GENERAL

1.01 DESCRIPTION:

- A. This section includes the requirements for designing, furnishing, installing, maintaining, and removing shaft shoring.
- B. This is a performance specification. Minimum requirements are presented herein. It is the Contractor's responsibility to develop and implement the design to fulfill the specified requirements. The Contractor shall select and utilize methods and equipment compatible with the dimensions of the tunnels shown and with anticipated geologic conditions.
- C. The scope of work to be performed under this section includes:
 - 1. Designing and installing temporary shaft shoring. All shaft shoring shall retain the ground such that settlement is minimized, and adjacent improvements are not damaged, disrupted, or moved.
 - 2. Labor, material, tools, equipment, and incidentals necessary to complete the work described above.
 - 3. Removing or abandoning the approved shoring structure.
- D. Underground utilities are present. Prevent the work from entering, clogging, heaving or affecting adjacent underground utilities.

1.02 REFERENCES:

- A. Applicable Standards:
 - 1. All work shall be performed in accordance with applicable regulations of all federal, state and local regulations, codes and standards.
 - 2. American National Standards Institute (ANSI) / American Association of State Highway and Transportation Officials (AASHTO) / American Welding Society (AWS) D1.1 – Structural Welding Code.
 - 3. Burlington Northern Santa Fe (BNSF) and United Pacific Railroad (UPRR) Guidelines for Temporary Shoring (2004).
 - 4. Occupational Safety and Health Administration (OSHA):
 - a. 29 CFR Part 1926 - Safety and Health Regulations for Construction.

1.03 DEFINITIONS:

- A. Launching Shaft: Excavation with ground support for launching and support of tunneling equipment.
- B. Receiving Shaft: Excavation with ground support for retrieval of the tunneling equipment.
- C. Dewatering: Removal of groundwater from the ground outside or inside shafts.
- D. Shoring: A temporary structural system designed to support soil and surcharge loads for purposes of excavation. Sloping of the soil is not shoring. Properly designed trench boxes or slide rail systems are acceptable for shoring except where watertight shafts are required.

1.04 QUALIFICATIONS:

- A. The Contractor performing the work shall have performed shaft construction using similar methods to those proposed for a minimum of five years on at least three separate projects.

SECTION 31 75 00 – CONSTRUCTION SHAFTS: continued

- B. The Contractor's surveyor must be licensed by the State of Colorado and have at least five years of related experience.
- C. Only use welders qualified by tests prescribed in AWS D1.1, as applicable.

1.05 SUBMITTALS:

- A. Submit in accordance with the General and Special Conditions.
- B. All submittals, including drawings and calculations, shall be required for the sole purpose of providing the Engineer enough details to confirm that the Contractor's planned work and work in progress is in accordance with Contract Documents. The Engineer's review shall not be construed to relieve the Contractor in any way of responsibilities under the Contract Documents. Do not begin work on any item requiring a submittal until the required relevant submittals have been reviewed and approved by the Engineer. All other engineered components shall be signed and sealed by a Professional Engineer licensed in the State of Colorado.
- C. At least four (4) weeks prior to the start of work, submit the following qualifications:
 - 1. The name and qualifications of the Contractor that will perform the work with descriptions of reference projects including the Owner's name and contact information.
 - 2. The name and qualifications of the surveyor who will perform the work.
 - 3. The names and qualifications of the shoring welders, if used.
- D. At least four weeks prior to the start of the work, submit a health and safety plan/accident prevention program, including a code of safe practices and an emergency plan.
- E. At least four weeks prior to the start of the work, submit a shaft construction work plan including the following:
 - 1. A detailed description of the shaft construction equipment and procedures to be employed.
 - 2. A schedule for shaft work identifying all major construction activities as independent items.
 - 3. Muck handling, separation, transport, and disposal equipment and procedures including the location of muck disposal sites.
- F. At least four (4) weeks prior to the start of work, submit shop drawings and calculations, including:
 - 1. Shoring design calculations and detailed drawings showing means for safe and stable excavations stamped by a Professional Engineer registered in the State of Colorado (if deeper than 20 feet below the ground surface). The calculations for Launch Shaft shoring shall include the estimated jacking forces transmitted through the thrust block stamped by a Professional Engineer registered in the State of Colorado. The drawings shall also show details of the following:
 - a. Removal or abandonment of the shaft shoring.
 - b. Details on ground support and sealing around utility penetrations.
 - c. The location of the jacking pipe entry and exit seals. Detailed description of the proposed launching and receiving eyes through the support system indicating the ability to prevent water and soil from entering the excavation through the shafts.

SECTION 31 75 00 – CONSTRUCTION SHAFTS: continued

- d. Methods for filling or sealing seepage paths or voids that form around the shafts.
- 2. Manufacture's descriptive product data, current specifications, and installation instructions for materials or systems proposed for the work of this section.
- 3. If pile driving is used, a complete description of the hammer and driving equipment including caps and guides for steel sheet piling and soldier piles.
- 4. Calculations shall include the following:
 - a. Different load, support, and other conditions that occur during the sequence of installation of shoring, construction of facilities.
 - b. The influence of jacking loads on the shoring.
- G. Submit the following to the Engineer during construction within the specified time restrictions:
 - 1. The daily logs shall have field logs submitted to the Engineer within one working day of excavation. As a minimum, the logs shall include:
 - a. The depth of excavation at each shaft.
 - b. The number of people on the crew by craft.
 - c. Method of excavation.
 - d. Shaft support installed.
 - e. Description of the soils encountered, and position of different soil layers.
 - f. Grouting records if used.
 - g. Groundwater inflow rate and/or dewatering pumping rate at each shaft.
 - h. Monitoring, instrumentation and control including survey records.
 - i. Any unusual conditions, breakdowns, and delays.
 - 2. Results of all instrumentation readings and monitoring including but not limited to ground movements specified in Section 31 09 13.
- H. Postconstruction Submittals:
 - 1. Survey of the position and elevation of permanent structures.
 - 2. Record of what shaft support elements remain in the ground with location and top elevation.

PART 2 - PRODUCTS

2.01 MATERIALS:

- A. The Contractor shall determine and provide the materials necessary to construct the shafts.

PART 3 - EXECUTION

3.01 GENERAL:

- A. Perform all work in the presence of the Owner's Project Representative and/or the Engineer, unless the Engineer has granted prior approval in writing to perform such work in his/her absence.
- B. The Contractor shall give the Engineer a minimum of ten days advance notice of the start of work so Engineer can plan observation.
- C. Contractor shall provide daily updates to Owner and/or Engineer.
- D. Should actual field conditions prevent installation of shafts at the approved location, obtain prior acceptance from the the Engineer for new location.

SECTION 31 75 00 – CONSTRUCTION SHAFTS: continued

- E. Where nearby utilities may be disturbed by sheet removal, sheet piles may be abandoned in place at the Contractor's expense if approved by the Engineer.
- F. Where excavations are undertaken near any structure or facility including but not limited to buildings, railroad, highway, streets, or utility, the construction shall not damage, impair, or interfere with the operation of the structure or facility.

3.02 MAINTENANCE:

- A. The Contractor shall always keep the site clean and tidy. Site improvements shall be protected from damage or becoming soiled through suitable temporary covering.
- B. Contractor will be responsible to protect their worksite from flooding. Contractor shall have the ability to have equipment and pumps onsite within 24 hours of a flood event.
- C. Upon completion of work, all waste shall be removed from the site and the site restored to as near its original condition as possible. Any remnants of grout that may have splattered on improvements shall be completely removed.
- D. The Contractor is fully responsible for maintaining and repairing all excavation and support.
- E. Where loss of soil occurs, plug gaps in shoring and replace lost soil with fill material acceptable to the Engineer.
- F. Where measurements and observations indicate possibility of failure or excessive movement of excavation support, take appropriate action immediately and provide a plan and calculations for immediate repair and reinforcing of excavation shoring system that is signed and sealed by a Professional Engineer licensed in the State of Colorado.

3.03 INSTALLATION AND REMOVAL:

- A. The shafts shall be constructed to withstand all imposed loads, including groundwater and saturated soil, as applicable, dynamic loads from equipment and surcharge loads from materials and traffic, as applicable. Shaft design shall consider special framing, bracing or shoring required around trenchless operation, pipe "eyes" and other penetrations.
- B. The ground surface near shafts shall be graded to prevent surface water from entering the excavation.
- C. The locations of the launching and receiving shafts are shown on the Construction Drawings. The excavations for the shafts shall be adequately shored to safeguard existing substructures and surface improvements and to ensure against ground movement near the thrust blocks.
- D. Install means for providing safe and stable excavations as indicated in the submittals. All area disturbed by excavation of the shafts shall be restored in accordance with these specifications, the Construction Drawings, and shall include sidewalk and road restoration.
- E. Any interfering utilities shown on the Construction Drawings within launching and receiving shafts shall be relocated or supported in place at the Contractor's expense, if approved by utility owner. The Contractor shall be responsible for

SECTION 31 75 00 – CONSTRUCTION SHAFTS: continued

- designing support for utilities left in place where details are not provided in the Construction Drawings.
- F. Control ground settlement or heave to the limits specified in Section 31 09 13. Repair damage resulting from surface deformation caused by shaft excavation and dewatering at no additional cost to the Owner.
 - G. Except for concrete encased soldier piles, slurry walls, and similar shoring systems, remove shoring at the completion of the work. Select shoring system and method of removal which shall minimize soil that sticks to shoring, creating large voids and causing settlement. To prevent settlement caused by pulling shoring fill voids with sand, pea gravel, or pressure injected grout. Pressure preservative treated wood lagging may be left in place, if acceptable to the Engineer.
 - H. Provide launching and receiving seals to control the groundwater, prevent loss of ground and loss of lubricants at launching shaft and receiving shafts.
 - I. Verify locations of known or suspected underground utilities by potholing prior to placing temporary piles.
 - J. Shoring systems that retain earth on which the support or stability of existing structures or utilities is dependent shall be left in place at the completion of the work. Cut off piles at elevations directed by the Engineer.
 - K. Sheet piles, trench boxes, slide rail systems and/or soldier piles in the shoring system should be removed entirely upon completion of the excavation backfill at the Contractor's expense if approved by the Engineer. Remove all temporary watertight shaft elements to a minimum of 10 feet below the ground surface.
 - L. The Contractor shall always maintain clean working conditions inside the shafts. All excavated soil, slush, grout spills, ponded water and other material not required for the work shall be removed from the excavation in a timely manner.
 - M. The Contractor shall transport and dispose of all excess excavated materials properly away from the construction site in such a fashion that trucks and other vehicles do not create a dirt nuisance on roads and pathways. Contractor shall secure the required permits and promptly remove and dispose of any spillage. The Contractor shall dispose of muck removed from work area excavations in accordance with all applicable permits, and regulatory requirements.
 - N. After completion of tunneling work, the Contractor shall backfill the shafts in accordance with the Contract Documents.
 - O. Support all faces of shaft excavations and protect structures and improvements in vicinity of excavations from damage and loss of function due to settlement or movement of soils, including vibrations on sensitive soils and changes in groundwater level caused by such excavations and related operations.
 - 1. Where sheet piling is used, use interlocking type sheets. The sheet piles shall be continuous and driven in interlock. If the bottom of the excavation is located below the water table, use "thumb and finger" type interlock.
 - 2. Provide packing between soil retaining members, such as sheet piles and wales and similar members, when the gap exceeds ½-inch before the members are loaded.
 - 3. For excavations greater than 15 feet deep supported with sheet piles, use a template for driving sheet piles to minimize the need for pulling and re-driving sheet piles in attempts to drive them plumb.

SECTION 31 75 00 – CONSTRUCTION SHAFTS: continued

3.04 WELDING REQUIREMENTS:

- A. Perform all welding in accordance with requirements for shielded metal arc welding in accordance with AWS D1.1 for building and other structures.
- B. Reinforce pile tips, if required due to ground conditions, and as approved by the Engineer.
- C. Except where directed by the Engineer, splicing of sheet piles will not be permitted.
- D. All welding shall be done by certified welders, welding operators, and tackers who have had adequate experience in the type of materials to be used.

3.05 SEQUENCING AND SCHEDULING:

- A. Do not begin work on shoring or shaft excavation until submittals have been accepted by the Engineer and until materials necessary for installation are onsite.
- B. Do not begin shaft excavation until all geotechnical instrumentation has been installed and surveyed.

END OF SECTION 31 75 00

DIVISION 32 – EXTERIOR IMPROVEMENTS

SECTION 32 11 23 - CRUSHED AGGREGATE BASE (SURFACE) COURSE

PART 1 - GENERAL

1.01 RELATED DOCUMENTS:

- A. Drawings and general provisions of the Contract, including General and Special Conditions, apply to this Section.

1.02 SUMMARY:

- A. This Section consists of a base course composed of crushed aggregates constructed on a prepared course in accordance with these Specifications and in conformity to the dimensions and typical cross-sections shown on the Plans.

1.03 RELATED REQUIREMENTS:

- A. SECTION 31 20 00 – Site Preparation and Earthwork.
- B. SECTION 31 23 13 – Subgrade Preparation

1.04 REFERENCE STANDARDS:

- A. The publications listed below form a part of this Specification to the extent referenced. The publications are referred to within the text by the basic designation only.
 - 1. ASTM International (ASTM):
 - a. ASTM C29 - Unit Weight of Aggregate.
 - b. ASTM C88 - Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate.
 - c. ASTM C117 - Materials Finer than No. 200 (75-µm) Sieve in Mineral Aggregates by Washing.
 - d. ASTM C131 - Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine.
 - e. ASTM C136 - Sieve Analysis of Fine and Coarse Aggregates.
 - f. ASTM D75 - Sampling Aggregate.
 - g. ASTM D422 - Particle Size Analysis of Soils.
 - h. ASTM D693 - Crushed Aggregate for Macadam Pavements.
 - i. ASTM D698 - Moisture-Density Relations of Soils and Soil-Aggregate Mixtures Using 5.5-lb. (2.49-kg) Rammer and 12-inch (305-mm) Drop.
 - j. ASTM D1556 - Density of Soil in Place by the Sand-Cone Method.
 - k. ASTM D1557 - Test for Laboratory Compaction Characteristics of Soil Using Modified Effort.
 - l. ASTM D2167 - Density and Unit Weight of Soil in Place by the Rubber Balloon Method.
 - m. ASTM D2419 - Sand Equivalent Value of Soils and Fine Aggregate.
 - n. ASTM D6938 - In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods.
 - o. ASTM D3665 - Random Sampling of Construction Materials.

SECTION 32 11 23 – CRUSHED AGGREGATE BASE (SURFACE) COURSE: continued

- p. ASTM D4318 - Liquid Limit, Plastic Limit, and Plasticity Index of Soils.
 - 2. American Association of State Highway and Transportation Officials (AASHTO):
 - a. AASHTO M147 – Standard Specification for Materials for Aggregate and Soil-Aggregate Subbase, Base, and Surface Courses
 - 3. State of Colorado Department of Transportation (CDOT)
 - a. Standard Specifications for Road and Bridge Construction, latest edition.
 - 4. City of Thornton Standards and Specifications
 - a. Section 700 – Roadway Design, Traffic Control Devices and Street Lighting
 - b. Section 900 – Asphalt Mix Design and Construction
- 1.05 SUBMITTALS:
 - A. Submit the following in accordance with the General and Special Conditions.
 - 1. Test results from laboratory testing of imported granular materials.
- 1.06 QUALITY CONTROL:
 - A. Equipment Approval:
 - 1. All plant, equipment, and tools used in the performance of the Work will be subject to approval before the Work is started and shall be maintained in satisfactory working condition at all times. Submit a list of proposed equipment, including descriptive data. Provide adequate equipment having the capability of producing the required compaction, meeting grade controls, thickness control, and smoothness requirements as set forth herein.
 - B. Sampling and Testing:
 - 1. Test to determine conformance with all requirements of this Specification for quality and properties of all Contractor-secured sources of materials shall be performed by an independent commercial laboratory retained and compensated by Contractor and approved by Engineer. In lieu of testing, Contractor may submit certified state test results indicating the aggregate meets Specification requirements to Engineer for approval.
 - 2. Obtain representative samples of material in accordance with ASTM D75/D75M for testing. Furnish laboratory sufficient material for testing from each sample at the time obtained. Copies of reports and certificates regarding tests and inspection of materials shall be distributed as specified in the General and Special Conditions. Furnish specific schedule for sampling to provide Engineer the opportunity to observe sampling.
 - 3. When incorporating materials into the Work, quality control testing will be performed during construction by a testing laboratory retained and compensated by Owner.
 - 4. The Contractor shall engage services of an independent testing agency to test all aggregate base course placement. The Contractor shall be responsible for the scheduling of all testing.
 - 5. Sampling:

SECTION 32 11 23 – CRUSHED AGGREGATE BASE (SURFACE) COURSE: continued

- a. Take samples for laboratory testing in conformance with ASTM D75/D75M. When deemed necessary, the sampling will be observed by the Engineer.
- 6. Tests:
 - a. Perform the following tests in conformance with the applicable standards listed.
 - b. Sieve Analysis:
 - (1) Make sieve analysis in conformance with ASTM C117 and ASTM C136. Sieves shall conform to ASTM E11. Particle-size analysis of the soils shall also be completed in conformance with ASTM D422.
 - c. Liquid Limit and Plasticity Index:
 - (1) Determine liquid limit and plasticity index in accordance with ASTM D4318.
 - d. Moisture-Density Determinations:
 - (1) Determine the laboratory maximum dry density and optimum moisture content in accordance with ASTM D1557
 - e. Field Density Tests:
 - (1) Measure field density in accordance with ASTM D1556, ASTM D2167, or ASTM D6938.
 - (a) Submit certified copies of test results for approval not less than 30 days before material is required for the Work.
 - (b) Submit calibration curves and related test results prior to using the device or equipment being calibrated.
 - (c) Submit copies of field test results within 24 hours after the tests are performed.
 - f. Wear Test:
 - (1) Perform wear tests on aggregate base course material in conformance with ASTM C131.
 - g. Soundness:
 - (1) Perform soundness tests on GCA in accordance with ASTM C88.
- 1.07 ENVIRONMENTAL REQUIREMENTS:
 - A. Perform construction when the atmospheric temperature is above 35°F. When the temperature falls below 35°F, protect all completed areas by approved methods against detrimental effects of freezing. Correct completed areas damaged by freezing, rainfall, or other weather conditions to meet specified requirements.

PART 2 - PRODUCTS

- 2.01 MATERIALS:
 - A. General:
 - 1. Crushed rock base and surface course shall consist of aggregate specified.
 - B. Aggregate:
 - 1. Aggregates shall consist of hard, durable particles or fragments of stone or gravel, crushed to required sizes, containing an appropriate quantity of sand or other finely-divided mineral matter which conform to the requirements of

SECTION 32 11 23 – CRUSHED AGGREGATE BASE (SURFACE) COURSE: continued

AASHTO M 147, and to Section 703.03, CDOT S&S. In addition, the material shall have an R-value of 78 or greater or a CBR of 80 or greater and shall be moisture stable. Moisture stability is determined by R-value testing which shows a drop of 12 points or less in R-value between exudation pressures of 300 psi and 100 psi.

2. Fine aggregate passing the No. 4 sieve shall consist of fines from the operation of crushing the coarse aggregate. If necessary, fine aggregate may be added to produce the correct gradation. The fine aggregate shall be produced by crushing stone, gravel, or slag that meets the requirements for wear and soundness specified for coarse aggregate.
 3. Percentage of wear shall not exceed 45% when tested in accordance with ASTM C131. The sodium sulfate soundness loss shall not exceed 12% after 5 cycles when tested in accordance with ASTM C88.
 4. Portion of aggregate which is retained on a 3/8-inch sieve shall contain 75% by weight of pieces with two or more fractured surfaces if the material is crushed gravel.
 5. Portion of aggregate passing No. 40 sieve shall be as follows:
 - a. Liquid Limit: Not more than 25 determined by ASTM D4318
 - b. Plastic Index: Not more than 4 determined by ASTM D4318
 - c. The fine aggregate shall have a minimum sand equivalent value of 35 when tested in accordance with ASTM D2419.
- C. Aggregate Surface Course:
1. Gradation shall not vary from low limit on one sieve to high limit on adjacent sieve or vice versa. Aggregate for Surface Course shall be Crushed Base Class 5 as specified in Table 703-2 Classification for Aggregate Base Course of the CDOT Standard Specifications for Road and Bridge Construction.
- D. Aggregate Base Course:
1. Gradation shall not vary from low limit on one sieve to high limit on adjacent sieve or vice versa. Aggregate for Base Course shall be Class 6 Aggregate Base Course as Table 703-2 Classification for Aggregate Base Course of the CDOT Standard Specifications for Road and Bridge Construction.
 2. Only aggregate from approved sources shall be used. Approval of sources shall be at the discretion of the Development Engineering Manager and submissions shall, at a minimum, consist of supplying documented gradation, Atterberg limits and CBR/R-value testing on an annual basis. Only two (2) types of crushed aggregate base course are acceptable. The gradation specifications for these two types of base course are listed below:

SECTION 32 11 23 – CRUSHED AGGREGATE BASE (SURFACE) COURSE: continued

TABLE 500-19
AGGREGATE BASE COURSE MATERIALS
AND CDOT SPECIFICATIONS

<u>Sieve Designation</u>	<u>% Passing By Weight</u>	
	<u>Class 5</u>	<u>Class 6</u>
1½"	100	---
1"	95-100	---
¾"	---	100
No. 4	30-70	30-65
No. 8	---	25-55
No.200	3-15	3-12
Liquid Limit (LL)	30, Maximum	30, Maximum

2.02 EQUIPMENT:

A. General Requirements:

1. Maintain all equipment, tools, and machines used in the performance of the Work required by this Section in a satisfactory working condition at all times.
2. Equipment shall be subject to the approval of Engineer.

B. Steel-Wheeled Rollers shall be self-propelled three-wheeled rollers, two-axle tandem rollers, or three-axle tandem rollers.

1. Rollers shall weigh not less than 8 tons and develop contact pressures under the compression rolls of not less than 200-pounds-per-square-inch width.
2. Three-axle tandem rollers shall be so constructed that when locked in position for all treads to be in one plane, the roller wheels are held with such rigidity that if either front or center wheel is unsupported, the other two wheels will not vary from the plane more than 1/4-inch.
3. Roller wheels shall not have flat areas, openings, or projections.
4. All steel wheels shall be equipped with scrappers, so adjusted to keep the wheels clean at all times.

C. Rubber-Tired Rollers:

1. Rollers shall consist of two axles on which are mounted not less than nine pneumatic-tired wheels, mounted so the rear group of tires do not follow in the tracks of the forward wheels but will be centered between the forward wheels.
2. The axles shall be mounted in a rigid frame provided with a loading platform or body suitable for ballast loading.
3. Inflate tires uniformly.
4. May be self-propelled.
5. Tow with pneumatic-tired tractors or other pneumatic-tired equipment.

D. Vibratory Rollers:

1. Have either one or two smooth-surfaced steel drum(s) with a minimum diameter of 42 inches.
2. Have a minimum vibrating force of 300 pounds per cycle per inch of drum width.

SECTION 32 11 23 – CRUSHED AGGREGATE BASE (SURFACE) COURSE: continued

- 3. Have a minimum vibrating frequency of 1,200 cycles per minute and shall be provided with a means of adjusting the resonance of the dynamic force.
- 4. May be self-propelled or towed.
- E. Blade graders shall be self-propelled with a wheelbase of not less than 15 feet, and a blade of not less than 10 feet.
- F. Sprinkling equipment shall consist of tank trucks, pressure distributors, or other similar equipment designed to apply water uniformly and in controlled quantities to variable width of surface.
- G. Hauling equipment shall consist of pneumatic-tired vehicles and dump bodies suitable for dumping materials in windrows or layers on the subgrade.
- H. Tampers shall be mechanical and hand-operated, weigh not less than 50 pounds, and have a face area of not more than 100 square inches.
- I. Miscellaneous equipment shall consist of scarifiers, tractors, spring-tooth or spike-tooth harrows, windrow equalizers, spreaders, and other equipment suitable for construction of select material base course.

PART 3 - EXECUTION

3.01 PREPARING UNDERLYING COURSE:

- A. The underlying course shall be prepared in accordance with Section 31 23 13, checked, and accepted by the Engineer before placing and spreading operations are started. Any ruts or soft yielding places caused by improper drainage conditions, hauling, or any other cause shall be corrected at the Contractor's expense before the base course is placed thereon. Material shall not be placed on frozen subgrade.

3.02 MIXING:

- A. The aggregate shall be uniformly blended during crushing operations or mixed in a plant. The plant shall blend and mix the materials to meet the Specifications and to secure the proper moisture content for compaction.

3.03 PLACING:

- A. The crushed aggregate base material shall be placed on the moistened subgrade in layers of uniform thickness with a mechanical spreader.
- B. The maximum depth of a compacted layer shall be 6 inches. If the total depth of the compacted material is more than 6 inches, it shall be constructed in two or more layers. In multi-layer construction, the base course shall be placed in approximately equal-depth layers.
- C. The previously constructed layer should be cleaned of loose and foreign material prior to placing the next layer. The surface of the compacted material shall be kept moist until covered with the next layer.

3.04 COMPACTION:

- A. Immediately upon completion of the spreading operations, the crushed aggregate shall be thoroughly compacted. The number, type, and weight of rollers shall be sufficient to compact the material to the required density.

SECTION 32 11 23 – CRUSHED AGGREGATE BASE (SURFACE) COURSE: continued

- B. Compaction of each layer shall continue until a density of at least 95 percent of the maximum density has been achieved as determined per AASHTO T 180 as modified by CP 23
 - C. The moisture content shall be at plus or minus 2 percent of optimum moisture content
- 3.05 ACCEPTANCE SAMPLING AND TESTING FOR DENSITY:
- A. At least one (1) sample of aggregate base course for each 1,000 tons of material placed shall be tested to determine gradation and Atterberg limits. Should these tests indicate the material does not meet specifications, the material shall be removed and replaced.
 - B. During placement and compaction, Compaction Curves shall be required for each material used. Field moisture-density tests shall be taken of each lift of material at random locations, at approximate intervals of 250 feet in each travel lane. At least 20% of the tests shall be taken within one (1) foot of manholes, valves and curbs.
 - C. The results of field density tests shall be submitted and reviewed by the Development Engineering Manager provided the tests are acceptable, the aggregate base course materials, placement and compaction shall be approved and the next paving course can be placed. Should testing indicate unsatisfactory work, the necessary reworking, compaction or replacement shall be required prior to continuation of the paving process.
- 3.06 FINISHING:
- A. The surface of the aggregate base course shall be finished by blading or with automated equipment especially designed for this purpose.
 - B. In no case will the addition of thin layers of material be added to the top layer of base course to meet grade. If the elevation of the top layer is 1/2 inch or more below grade, the top layer of base shall be scarified to a depth of at least 3 inches, new material added, and the layer shall be blended and recompact to bring it to grade. If the finished surface is above plan grade, it shall be cut back to grade and rerolled.
- 3.07 SURFACE TOLERANCES:
- A. The finished surface shall not vary more than 3/8 inch when tested with a 16-foot straightedge applied parallel with or at right angles to the centerline. Any deviation in excess of this amount shall be corrected by the Contractor at the Contractor's expense.
- 3.08 THICKNESS CONTROL:
- A. The completed thickness of the base course shall be within 1/2 inch of the design thickness. Four determinations of thickness shall be made for each lot of material placed. The lot size shall be consistent with that specified in Paragraph 3.05. Each lot shall be divided into four equal sublots. One test shall be made for each subplot. Sampling locations will be determined by a random basis in accordance with procedures contained in ASTM D3665. Where the thickness is deficient by more than 1/2 inch, the Contractor shall correct such areas at no additional cost by

SECTION 32 11 23 – CRUSHED AGGREGATE BASE (SURFACE) COURSE: continued

excavating to the required depth and replacing with new material. Additional test holes may be required to identify the limits of deficient areas.

3.09 MAINTENANCE:

- A. The base course shall be maintained in a condition that will meet all specification requirements until the Work is accepted. Equipment used in the construction of an adjoining section may be routed over completed portions of the base course, provided no damage results and provided that the equipment is routed over the full width of the base course to avoid rutting or uneven compaction.
- B. The Contractor shall remove all survey and grade hubs from the base courses prior to placing any bituminous surface course.

END OF SECTION 32 11 23

DIVISION 33 – UTILITIES

SECTION 33 05 07.23 – UTILITY BORING AND JACKING

PART 1 - GENERAL

1.01 SUMMARY:

- A. This Section is intended to serve as an add alternate to open cut installation of the inlet/outlet line from STA 6+00.00 to 11+54.00.
- B. This Section includes tunnel primary liner, boring and jacking, carrier pipe alignment skids (casing insulators), backfill of the annulus between the Carrier Pipe and the Initial Support with cellular concrete, modular wall seals, and end seals where indicated or where constructed at Contractor's option.
- C. This is a performance specification. Minimum requirements are presented herein. It is the Contractor's responsibility to develop and implement the design to fulfill the specified requirements. The Contractor shall select and utilize methods and equipment compatible with the dimensions of the tunnel liner and carrier pipe shown and with anticipated geologic conditions.
- D. Perform all work in the presence of the Resident Project Representative, unless the Owner has granted prior approval in writing to perform such work in their absence.
 - 1. The Contractor shall give the Engineer a minimum of forty-eight (48) hours advance notice of the start of work so Engineer can plan observation.
 - 2. Contractor shall provide daily updates to Owner and/or Engineer.
- E. Related Work Specified Elsewhere:
 - 1. Cathodic Protection: SECTION 26 42 13.
 - 2. Contact Grouting: SECTION 31 73 00
 - 3. Construction Shafts: SECTION 31 75 00
 - 4. Water Utility Transmission Piping: SECTION 33 14 11.

1.02 REFERENCES:

- A. Applicable Standards:
 - 1. All work shall be performed in accordance with applicable regulations of all federal, state and local regulations, codes, and standards.
 - 2. American Water Works Association (AWWA):
 - a. C200 – Steel Water Pipe 6 Inches (150 mm) and Larger.
 - b. C206 – Field Welding of Steel Water Pipe.
 - 3. American Society for Testing and Materials (ASTM):
 - a. A36 - Structural Steel.
 - b. A570 - Hot-Rolled Carbon Steel Sheet and Strip, Structural Quality.
 - c. C32 - Sewer and Manhole Brick (Made from Clay or Shale).
 - d. C270 - Mortar for Unit Masonry.
 - e. C495 – Standard Test Method for Foaming Agents for Use in Producing Cellular Concrete Using Preformed Foam
 - f. C869 – Standard Specification for Foaming Agents Used in Making Preformed Foam for Cellular Concrete
 - 4. Occupational Safety and Health Administration (OSHA):
 - a. 29 CFR Part 1926 – Safety and Health Regulations for Construction

SECTION 33 05 07.23 – UTILITY BORING AND JACKING: continued

- 5. Steel Structures Painting Council (SSPC):
 - a. SP-3 - Power Tool Cleaning.

1.03 DEFINITIONS:

- A. Carrier Pipe: Refers to the 36-inch fully welded steel inlet/outlet line. For this project, one Carrier Pipe shall be installed within the tunnel.
- B. Backfill: Filling of the annular space between the Carrier Pipe and Initial Support.
- C. Bulkhead: Material placed between the Carrier Pipe and the Initial Support. Bulkheads are typically required at both ends of the Initial Support to contain the Cellular Concrete in the annular space between the Carrier Pipe and Initial Support.
- D. Casing Spacers: Prefabricated units that provide necessary separation between Carrier Pipes and the Initial Support while not impeding the flow of backfill grout.
- E. Cellular Concrete: A low density, lightweight, cementitious material that contains stable air or gas cells as preformed foam uniformly distributed throughout the mixture, designed to fill the annular space between the Carrier Pipes and Initial Support.
- F. End Seals: Material placed over the Carrier Pipes and the outer edges of the initial support to contain the Cellular Concrete in the annular space between the Carrier Pipes and Initial Supports.

1.04 QUALIFICATIONS:

- A. The Contractor shall be experienced in the installation and backfilling of pipe with Cellular Concrete in tunnels using methods, materials, and equipment suitable to this project. Specifically, the Contractor shall have successfully completed at least five local projects installing Carrier Pipe of similar diameter in tunnels with initial support. The Contractor may use one person as the expert for all installation and backfill activities or two different persons; one for pipe installation and one for backfilling.
- B. The Contractor's surveyor must be licensed by the State of Colorado and have at least five (5) years related experience.
- C. The Installation Expert shall be thoroughly knowledgeable about the transportation, placement, and securement of prefabricated pipe in tunnels. The Installation Expert shall have experience installing two similar projects using the equipment proposed by the Contractor for this project.
- D. The Backfill Expert shall be thoroughly knowledgeable about the properties, behavior, and placement methods of cellular concrete in underground applications. The Backfill Expert shall have successfully completed at least two similar projects in which the pipe annulus in a tunnel was backfilled with Cellular Concrete.
- E. The Contractor's Safety Supervisor shall have at least five years' experience in safety management on at least three separate projects.

1.05 SUBMITTALS:

- A. Submit as specified in the General and Special Conditions.
- B. Submit the following for acceptance prior to shipment:
 - 1. Initial support (tunnel primary liner) information

SECTION 33 05 07.23 – UTILITY BORING AND JACKING: continued

- a. Material, grade, size, thickness
2. Casing Spacers/Insulators.
3. Annular space grout.
4. Modular pipe seals.
5. End Seals.
6. Pipe alignment guides.
7. Guide spacer bands.
- C. Certificates and Affidavits: Furnish the Following Prior to Shipment:
 1. Affidavit of compliance with applicable standard.
 - a. Casing material.
 - b. Casing paint coating/lining system.
- D. All submittals, including drawings and calculations, shall be required for the sole purpose of providing the Engineer enough details to confirm that the Contractor's planned work and work in progress is in accordance with the Contract Documents. The Engineer's review shall not be construed to relieve the Contractor in any way of responsibilities under the Contract Documents. Do not begin work on any item requiring a submittal until the required relevant submittals have been reviewed and approved by the Engineer. All structural designs and other engineered components shall be signed and sealed by a Professional Engineer licensed in the State of Colorado.
- E. At least four (4) weeks prior to the start of the work, submit the following qualifications:
 1. The name and qualifications of the Contractor(s) that shall perform the work with descriptions of reference projects including Owner's name and contact information and project field superintendent. The name and qualifications of the surveyor who shall perform the work.
 2. The name and qualifications of the Installation Expert. Pipe installation shall be conducted under the direct supervision of the Contractor's Installation Expert.
 3. The name and qualifications of the Backfill Expert.
 4. The name and qualifications of the Safety Supervisor.
- F. At least four (4) weeks prior to the start of the work, submit a health and safety plan/accident prevention program, including a code of safe practices and an emergency plan.
- G. At least four (4) weeks prior to the start of the work, submit a Carrier Pipe installation Work Plan including, as a minimum:
 1. Details of the Carrier Pipe transportation, line and grade surveying, line and grade control, mating, and joint finishing and sealing.
 2. A schedule for the work identifying all major construction activities as independent items. Include working hours for each activity, and a written description of construction methods and equipment, to be employed in completing work activities shown on the schedule. Review schedule with the Engineer and update and resubmit as required by these Specifications.
 3. Spatial layout of the Carrier Pipes within the Initial Support, including all blocking and bracing.
 4. Certification from the Carrier Pipe suppliers that proposed blocking details and backfilling procedures are in accordance with their recommendations and

SECTION 33 05 07.23 – UTILITY BORING AND JACKING: continued

- shall not damage the Carrier Pipe. Provide calculations that the Carrier Pipe shall not deflect, deviated from grade, or otherwise be damaged during backfilling operation, whether blocking is used.
5. Methods, procedures, and equipment for setting, monitoring, controlling, and adjusting the alignment and grade of the Carrier Pipe both during and after installation in the Initial Support but prior to backfilling.
- H. At least four (4) weeks prior to the start of the work, submit a backfilling Work Plan including:
1. Mix design.
 2. Description of equipment and methods proposed to mix cellular concrete, including mixing equipment, quantity controls, and instrumentation. Provide results from another project using the same mix design and same equipment as proposed. At a minimum, the mixture shall have been tested for unit weight (wet density), viscosity, air content at the time of cylinder casting, and results of compression testing. Provide evidence that the cellular concrete was placed properly in the previous project.
 3. A schedule for the work identifying all major construction activities as independent items. Include working hours for each activity, and a written description of construction methods and equipment, to be employed in completing work activities shown on the schedule. Review schedule with the Engineer and update and resubmit as required by these Specifications.
 4. Injection methods for cellular concrete backfill including ports or grout tubes, pumping equipment, hoses, boosters, pumping distances, flow rates, and pressures. Include details for securing the injection pipes, backfill sequence and stages both in length and in elevation, and injection locations. Include methods and description of instrumentation to monitor and control placement of the cellular concrete, and procedures to be used to verify complete placement and check for voids.
 5. Details for backfilling in the presence of water.
 6. Calculations shall be submitted which evaluate:
 - a. Theoretical annulus volume for actual Initial Support ID and Carrier Pipe OD with adjustments for bells and spacers.
 - b. Buoyant forces generated during backfilling of each stage.
 - c. Loads and deflection of internal bracing and spacers.
 - d. Maximum allowable backfill injection pressure.
- I. Submit the following during construction within the specified time restrictions:
1. Written Daily Logs – Daily Logs shall be submitted to the Engineer within one week after performing each item, or before the next construction step, whichever is less, unless specified otherwise. Daily logs shall include, as a minimum, stations and length for Carrier Pipe installed; stations lengths and volumes of cellular concrete placed; the annulus volume versus the actual volume of cellular concrete placed for each pour; plus, the pressures, flow meter, and unusual conditions relative to cellular concrete placement.
 2. Survey Results – Results of surveys of the Initial Support and Carrier Pipe shall be submitted to the Engineer within one week after performing each item, or before the next construction step, whichever is less, unless specified otherwise. One survey shall be made of the Initial Support before Carrier Pipe

SECTION 33 05 07.23 – UTILITY BORING AND JACKING: continued

installation, one shall be made for the Carrier Pipeline and grade after installation but prior to backfilling, and one survey of the Carrier Pipe shall be made after backfilling.

3. Results of field and laboratory testing shall be submitted within three days of the test completion.

1.06 QUALITY CONTROL:

- A. Manufacturers shall be experienced in the design and manufacture of pipe and appurtenances for a minimum period of 5 years.
- B. Observation of the pipe shall be made by the Resident Project Representative or other representatives of the Owner after delivery. The pipe shall be subject to rejection at any time on account of failure to meet any of the Specification requirements, even though pipes may have been accepted as satisfactory at the place of manufacture. Pipe rejected after delivery shall be marked for identification and shall immediately be removed from the job.

1.07 DELIVERY, STORAGE AND HANDLING:

- A. Ship all material to the Site and store in assigned laydown areas or as directed by Engineer.
- B. Ship spare material separately packaged and tagged as spare parts. Spare part tags shall identify type, size, material, and other related information.
- C. Handling and storage shall be in accordance specification requirements.

PART 2 - PRODUCTS

2.01 PIPE REQUIREMENTS:

- A. Steel Casing Pipe: New, smooth wall, welded steel pipe fabricated from ASTM A36 plate or ASTM A570 sheet with a minimum yield point of 36,000 psi, conforming to AWWA C200. Furnish pipe with minimum wall thickness as follows:
 1. Minimum Casing Thicknesses:

Casing Station	Install Method	Drawing	Casing Diameter (inches)	Wall Thickness (in)
STA 6+00.00 to STA 11+54.00	Trenchless	ODP-103	48 (Min)	0.625 (Min)

2. Coatings and Linings:
 - a. Coating and lining of casings are not required.
 - b. Clean to SSPC-SP3
- B. Cathodic protection
 - a. Install test stations per the cathodic protection table.
- C. Carrier Pipe:
 1. Pipe shall be fully restrained (double lap welded) though casing pipe.
- D. Joints:
 1. All joints in steel pipe casings shall be field welded to conform to API 1104 or AWWA C206.
- E. Hydrostatic testing of casing is not required

SECTION 33 05 07.23 – UTILITY BORING AND JACKING: continued

F. Casing Spacers:

1. Casing Spacers shall be supplied by a company specializing in the manufacturing of casing spacers and specifically designed for placing pipe in tunnels and as skids for the pipe to ride on during installation.
2. Casing Spacers shall be non-conducting material that is rigid under the imposed loads and does not damage the Initial Support.
3. The spacers shall cathodically isolate the Carrier Pipe from the Initial Support with a resistive material.
4. The spacers shall be variable in size or adjustable to place the position of the Carrier Pipe considering variations of the Initial Support.
5. Spacers shall be sized to allow no greater than a one-inch gap between the edge of spacers and the inside of the Initial Support at any point.
6. Spacers shall be designed to provide necessary clearances between the Initial Support and the Carrier Pipes, and between Carrier Pipes, to accommodate grout filling equipment and operations. Minimum clearances are provided herein.
7. Stainless Steel
 - a. Spacer Band Material: Type 304 Stainless Steel.
 - b. Spacer Liner Material: PVC or neoprene.
 - c. Spacer Width: Per Drawings or As recommended by spacer manufacturer for the specific application, whichever is more stringent.
8. Space Runners:
 - a. Suitable for supporting weight of carrier pipe.
 - b. Manufactured of material having a low coefficient of friction and designed to support the carrier pipe without damage or excessive wear.
9. Manufacturers:
 - a. Advance Products and Systems, Inc.; Model SS8 and SS12
 - b. Cascade Waterworks Mfg. Co.; Model CCS-12
 - c. Pipeline Seal and Insulator, Inc. (PSI); Model C12G-2
 - d. Power Seal Pipeline Products, Inc.; Model 4810
 - e. CCI Pipeline Systems; Model CSC-8, CSC-12, CSS-8, and CSS-12
 - f. Raci Spacers
 - g. Engineer Approved Equal

G. Annulus Grout

1. Annulus between the carrier pipe and the casing pipe shall be completely filled with a Cellular Concrete.
2. Flowable through delivery lines in tunnel annulus.
3. Cellular Concrete shall be composed of cement, water and foam. No aggregate or fillers are allowed. Additives may be used only with review and approval of the Engineer. Laboratory tests conducted as part of the mix design process must use the same materials as shall be used for the production Cellular Concrete.
4. The foaming agent for Cellular Concrete shall be in accordance with ASTM C 869 and shall be tested in accordance with ASTM C 796.
5. Cellular Concrete shall be a non-shrink mix.
6. Cellular Concrete shall have a minimum pH of 11.5 after curing.

SECTION 33 05 07.23 – UTILITY BORING AND JACKING: continued

7. Cellular Concrete shall have a minimum wet density of 35 pcf unless in the presence of water where a minimum wet density of at least 65 pcf is required, per the direction of the Engineer.
8. Cellular Concrete shall have a minimum 28-day compressive strength of 250 psi and shall be tested in accordance with ASTM C 495.
- H. Synthetic rubber, conical shape, pull-on or wrap-around style with Type 304 stainless steel bands.
 1. End Seals/Bulkheads at the ends of the pipe shall prevent spillout of the Cellular Concrete and not damage or degrade the Initial Support or Carrier Pipes during installation. Materials used to seal the annular spaces shall be free of materials that shall corrode or damage the Carrier Pipes in any way.
 2. Manufacturers:
 - a. Pipeline Seal and Insulator, Inc. (PSI), Houston, TX
 - b. Advance Products and Systems, Inc., Lafayette, LA
 - c. Cascade Waterworks Mfg. Co., Yorkville, IL
- I. Modular Wall Seals (if required by Owner or Engineer):
 1. Link-Seal Modular pipe penetration seal
 2. Or equal, on approval of the engineer.

PART 3 - EXECUTION

3.01 SURVEYS:

- A. Be performed by a Professional Land Surveyor licensed in the State of Colorado.
- B. Surveys shall be at intervals not exceeding 20 ft and shall be for both line and grade to an accuracy of 0.01 ft or better.
- C. Conduct the following surveys:
 1. Completed Initial Support at an identifiable location in the Initial Support cross section prior to installation of the Carrier Pipes.
 2. Carrier Pipe invert prior to annulus backfilling.
 3. Carrier Pipe invert following annulus backfilling.
 4. Monitoring of surface movement:
 - a. Before construction of access pits or bored casing, contractor shall perform a preconstruction survey of waterway.
 - b. Contractor shall record horizontal coordinates and elevations. Mark location where measurements are taken.
 - c. Monitor movement of ground surface on a daily basis and provide results to Engineer.
 - d. Stop operations if movement exceeds ¼ inch and immediately notify the Engineer.

SECTION 33 05 07.23 – UTILITY BORING AND JACKING: continued

3.02 INSTALLATION:

A. General:

1. All Work shall, as a minimum, meet the requirements of API RP1102 and the highway, railroad, or utility having jurisdiction, and shall be subject to their inspection and approval.
2. Install undercrossing to meet requirements of authority or agency having jurisdiction over undercrossing.
3. Observe work requirements stipulated in any permit condition.
4. Consult Contract Drawings for limitation of construction work limits.
5. Confirm location of all known existing utilities prior to start of shaft/pit excavation and casing pipe installation.
6. The Carrier Pipes shall have internal bracing as necessary to protect the pipe and control deflections including out-of-round distortions during handling, installation, annulus backfilling and service life.
7. The Carrier Pipes shall be ballasted or firmly anchored or blocked in-place to prevent flotation and movement during annulus backfilling.
8. Introduce Backfill Grout into the annulus outside the Carrier Pipe using grout lines (slick lines) secured to the Carrier Pipe or Initial Support or directly from the shafts. Grout Ports through the Carrier Pipe are not allowed.
9. Introduce Backfill Grout in tunnels at a spacing of not greater than 100 feet through the use of slick lines or other approved method.
10. Pipe installation and backfilling shall be conducted under the direct supervision of the Installation and Backfill Expert.

B. Jack & Boring:

1. Shaft/Pit Installation

- a. A Jack & Bore Plan shall be submitted to the Engineer for approval 15 working days prior to pit excavation activities. No excavation work shall be performed without approval of the Engineer. The plan shall include at least the following items:
 - (1) Location (layout) of the entry and exit pits.
 - (2) Distances to existing structures.
 - (3) Spoil management plan indicating if trucks or pits will be used.
 - (4) Information on pre-welded sections such as length of pipe and size of machine.
 - (5) Utility conflicts and plan for coordination with utility owners for temporary pipe supports or conduit relocation, if needed.
- b. Notify Engineer not less than 15 working days before beginning shaft excavation.
- c. Methods of construction for shafts/pits shall be such as to ensure the safety of the Work, Contractor's employees, the public, existing utilities, and adjacent property and improvements, whether public or private.
- d. Before beginning construction of shaft/pit, adequately protect existing structure, utilities, trees, shrubs, and other existing facilities.
- e. Provide complete groundwater control for excavation at all times.
- f. Perform shaft/pit excavations using appropriate excavation or large hole drilling methods, as required.

SECTION 33 05 07.23 – UTILITY BORING AND JACKING: continued

- g. Place fencing, gates, lights, and signs, as necessary around shafts and staging areas to provide for public safety.
 - h. Inspect shaft/pit excavations daily to check safety of excavation and structural integrity of support system.
- 2. Equipment Selection:
 - a. Select necessary equipment and methods to install casing and carrier pipe as shown on Drawings. Selected equipment shall be capable of accurate alignment and grade control, and shall protect against subsidence or other disturbance of ground, existing utilities, and existing road surface.
 - (1) Installation methods:
 - (a) Tunnel Boring Maching (TBM)
 - (b) Microtunnel Boring Machine (MTBM)
 - (c) Hand Tunneling
 - (d) Approved alternative as recommended by Contractor
- 3. Lubrication of Casing Exterior:

SECTION 33 05 07.23 – UTILITY BORING AND JACKING: continued

- a. Bentonite slurry may be used to lubricate exterior of casing during installation.
- 4. Casing Installation – Bore and Jack Method:
 - a. The Contractor shall install the Carrier Pipes into the Initial Support by sliding an assembled pipe into the tunnels by jacking or pulling, or both. Complete each joint including mating and welding or fusing outside the tunnel prior to pushing or pulling into the tunnel. Complete all exterior pipe treatments on the pipe prior to pushing or pulling into the tunnel.
 - (1) Use Casing Spacers attached to the Carrier Pipes as skids. Adjust the position of the Carrier Pipes within the spacers as necessary to achieve proper line and grade when the pipe is at the final position. Distance between spacers shall be determined by the spacer manufacturer. At a minimum, spacers shall be located at 5-ft intervals. For erected support, modify the initial support invert as needed to accommodate skids.
 - b. Ensure that each pipe segment is firmly secured to prevent flotation, settlement, lateral and axial movement, and pipe deflection during the design life of the Carrier Pipe.
 - c. Pipe joints shall be mated and welded or fused in accordance with the pipe manufacturer's specifications and the Contract Documents.
 - d. Casing installation shall not commence until the tunnel is prepared for pipe installation in accordance with the following requirements:
 - (1) The tunnel excavation has been stabilized.
 - (2) The line and grade of the initial support has been surveyed and has been verified to allow for the installation of the Carrier Pipes to the specified tolerances and clearances.
 - (3) The initial support has been cleaned as specified herein.
 - e. Verify casing pipe minimum wall thickness is adequate for anticipated jacking loads.
 - f. Hole diameter shall not exceed outside diameter of casing pipe by more than 1 inch.
 - g. Where unstable soil conditions are found to exist, conduct boring operations in a manner that will not be detrimental to facility being crossed.
 - h. Tolerance shall be as follows:
 - (1) For casing pipe less than 24-inch
 - (a) Line and grade tolerance of 0.5%
 - (2) For casing pipe equal to or greater than 24-inches
 - (a) Line and grade tolerance of 3 inches over the length of casing
- 5. Provide means of checking line and grade at least once a day to confirm allowable tolerances can be achieved.
- 6. If necessary to abandon a bored hole, remedial measures shall be taken by Contractor, subject to review by Engineer and approval of Owner of facility being crossed at the Contractor's expense.

SECTION 33 05 07.23 – UTILITY BORING AND JACKING: continued

C. Steel Pipe Casing Welded Joints:

1. Welds shall be continuous, complete joint penetration (CJP) butt joint welds as required for rigid and watertight connections.

D. Correction of Grade:

1. If required grade tolerance has not been achieved, use one of the following methods to correct grade (if possible):
 - a. Place concrete or grout in invert of casing as required to achieve proper grade.
 - b. Use casing spacers of varying height.
 - c. Install rails inside casing that allows complete grout or sand encasement. All casts for correction of grade shall be the responsibility of the Contractor.

E. Carrier Pipe Installation:

1. Entire length of casing shall be installed complete before any carrier pipe is placed therein. Repair defects in casing pipe or leakage at joints.
2. Install casing spacers to each length of carrier pipe in such a manner that electrical continuity will not occur between casing pipe and carrier pipe. Spans between spacers shall be no more than 10 feet or the casing spacer manufacturer's recommendations, whichever is shorter.
3. Check each joint makeup and pipe segment prior to pushing carrier pipe segments into casing.

F. Removal of Shaft Support System:

1. Remove support elements, except those required by Engineer to remain in place, from excavation in upper 5 feet below ground surface. In addition, remove support elements as needed to install pipeline.
2. Removal of support system shall be performed in a manner that will not disturb or harm adjacent construction or facilities.
3. Fill voids created by removal of support system with clean sand as approved by Engineer.

G. Backfilling of Shafts/Pits:

1. Seal shaft/pit opening and backfill at shafts when no longer required.
2. Backfill shall be as specified in Section 31 21 33.13; Trenching and Backfilling for Utilities.

3.03 CASING INSULATORS:

A. Furnish insulators for pipe alignment guides as indicated for all carrier pipe to be installed in casing.

1. Pipe skids shall be positioned on the pipe as shown on the drawings.
2. On both ends of casing place first casing insulator within 12 inches of the casing end.
3. On both ends of casing place second casing insulator within 12-inches of the first casing insulator (24 inches from the casing end).
4. Place third casing insulator within 5-feet of the second casing insulator.
5. Place remaining casing insulators at a spacing of :
 - a. 10-feet for carrier pipes 10-inches or smaller
 - b. 7.5-feet for carrier pipes 12-inches to 34-inchs and
 - c. 5.0 feet for carrier pipes 36-inches and larger

SECTION 33 05 07.23 – UTILITY BORING AND JACKING: continued

6. Place additional casing insulators for bell and spigot or mechanical joint piping 12-inches on each side of a joint.
7. Size to fit outside diameter of carrier pipe and inside diameter of casing pipe.
8. Insulators to be sized slightly larger than carrier pipe's outside joint diameter.

3.04 SEALING AND BACKFILLING METHODS:

- A. Entire annulus between casing pipe and carrier pipe shall be filled.
- B. Do not install annulus grouting until after electrical isolation has been verified.
- C. Before placement of cellular concrete in the tunnel, demonstrate, using trial mixes of the same design as those proposed for use and the same equipment proposed for placement, the ability to produce Cellular Concrete of the required density and strength. Demonstrate the ability to pump the Cellular Concrete mix the distances proposed without loss of Cellular Concrete quality. This requirement may be satisfied by providing records from previous projects in which the same mix, water and cement sources, materials and equipment were successfully used.
- D. Completely backfill the annulus between the Carrier Pipe and the Initial Support with Cellular Concrete. Placement methods shall completely fill the spaces below the Carrier Pipe and around the Carrier Pipe support system components.
- E. The method of backfilling shall ensure that the annulus is filled between injection points and from the tunnel invert to the tunnel crown. Verification of satisfactory backfilling shall be determined as the difference between the calculated annulus volume and the actual volume of backfill placed being within 1%.
- F. Place Cellular Concrete backfill in multiple lifts to prevent pipe flotation unless stiffeners or pipe supports, and closely spaced blocking of sufficient structural rigidity are provided to prevent pipe flotation, movement, or damage to the pipe. Lift thickness required to prevent flotation and damage to the pipe shall be determined by the Contractor.
- G. Cellular Concrete shall not be subject to free fall greater than 10 ft. Piston or plunger pumps shall not be used for pumping of Cellular Concrete. The pressure of the Cellular Concrete against the Carrier Pipe shall be determined by the Contractor and based on recommendations from the Carrier Pipe manufacturer.
- H. The injection points for Cellular Concrete shall be at intervals not greater than every 100 ft or more frequently. Closer spacing of discharge points shall be used as necessary to assure continuity between discharge points.
- I. Cellular Concrete shall be injected from the top of the shafts or pumped from the base of the shaft. Vertical drop holes shall not be allowed.
- J. Maintain a supply of water in the tunnel at the location of the Cellular Concrete backfilling operations or the Bulkhead as appropriate to facilitate flushing of injection lines or outlets.
- K. Prior to backfilling, ensure the annulus is cleaned of debris, soil, water, and other materials that may be deleterious to the Casing and Carrier Pipes.

3.05 MODULAR WALL SEAL:

- A. Construct modular wall seal as indicated and as follows:
 1. After inside of casing has been thoroughly cleaned and approved by Owners Representative.

SECTION 33 05 07.23 – UTILITY BORING AND JACKING: continued

2. After carrier pipe has been permanently placed inside casing, tested, and approved. Pipe shall be centered and restrained, where called for in casing.
 3. Place on both ends of the casing pipe.
- 3.06 END SEALS:
- A. Construct end seals as indicated and as follows:
 1. After inside of casing has been thoroughly cleaned and approved by Owners Representative.
 2. After carrier pipe has been permanently placed inside casing, tested, and approved. Pipe shall be centered and restrained, where called for in casing.
 3. Place on both ends of the casing pipe
- 3.07 TOLERANCES AND CLEARANCES:
- A. The Carrier Pipe shall be installed to the line and grade shown on the Contract Drawings.
 - B. At all locations, the invert of the Carrier Pipe shall be within 2 in. of the elevation shown on the Contract Drawings. No reverse grades are allowed. No low spots or bellies are allowed.
 - C. At all locations, the Carrier Pipe shall be within 6 in. of the horizontal alignment shown on the Contract Drawings.
 - D. Changes in Carrier Pipe alignment and grade shall be made gradually such that pipe joints are mated within the pipe manufacturer's specifications, fully functional and not compromised in any way.
 - E. The Carrier Pipe shall have a minimum clearance of three inches between the outside of the pipe and the closest point of the Initial Support in all directions.
 - F. If a skid system is used to guide and support the Carrier Pipe during installation and backfill it can remain in contact with the Carrier Pipe; however, such a support system shall be designed for the free flow of backfill behind the system and under the pipe between the support rails, guides and skids.
 - G. Make changes in Carrier Pipe alignment and grade gradually such that pipe joints are mated as specified and as shown on the Drawings, fully functional and not compromised in any way.
 - H. If the Carrier Pipe is off line and/or grade by more than the specified tolerances, the Contractor or Subcontractor shall adjust, repairs and changes as necessary to achieve the specified tolerances.
 - I. If the Carrier Pipe is off line and/or grade by an amount that requires, in the opinion of the Engineer, re-design of any structure, the Contractor shall be responsible for all redesign costs.
- 3.08 MAINTENANCE:
- A. Keep the site clean and orderly. Site improvements shall be protected from damage or becoming soiled through suitable temporary covering.
 - B. Upon completion of the Work, remove waste from the site and the site restored to as near its original condition as possible. Remnants of drilling fluid or grout that may have splattered on improvements shall be completely removed.
 - C. Maintain and repair Work as required.

SECTION 33 05 07.23 – UTILITY BORING AND JACKING: continued

- D. Where measurements and observations indicate possibility of failure or excessive movement of Carrier Pipe, take appropriate action immediately and provide a plan and calculations for immediate repair and reinforcing of the Work that is prepared, stamped, and signed by a Professional Engineer registered in the State of Colorado.

END OF SECTION 33 05 07.23

SECTION 33 05 16 - UTILITY STRUCTURES

PART 1 - GENERAL

1.01 SUMMARY:

- A. This Section includes the following structures and related appurtenances:
 - 1. Valve Manholes.
 - 2. Combination air release/vacuum valve vaults.
 - 3. Manway access vaults.
 - 4. Blowoff vaults.
- B. Furnish all labor, materials, equipment, and incidentals required to install the vaults, frames, rings and covers, manhole rungs (steps), vent piping, vent pipes, and appurtenances as shown on the Drawings and as specified herein. Specific attention should be made to details for dimensions, reinforcement requirements, etc.
- C. Related Work Specified Elsewhere:
 - 1. Concrete: DIVISION 3.
 - 2. Trenching and Backfilling for Utilities: SECTION 31 23 33.13.
- D. Applicable Standards:
 - 1. American Society for Testing and Materials (ASTM):
 - a. A48 - Gray Iron Castings.
 - b. C478 - Precast Reinforced Concrete Manhole Sections.
 - c. C857 - Standard Practice for Minimum Structural Design Loading for Underground Precast Concrete Utility Structures.
 - d. C858 - Standard Specification for Underground Precast Concrete Utility Structures.
 - e. C890 - Standard Practice for Minimum Structural Design Loading for Monolithic or Sectional Precast Concrete Water and Wastewater Structures.
 - f. C913 - Standard Specifications for Precast Concrete Water and Wastewater Structures.

1.02 QUALITY CONTROL:

- A. The quality of all materials, the process of manufacturer, and the finished sections of all precast vaults shall be subject to inspection and approval by the Owner. Such inspection may be made at the place of manufacturer, or on the work site after delivery, or at both places, and the materials shall be subject to rejection at any time on account of failure to meet any of the Specification requirements; even through samples may have been accepted as satisfactory at the place of manufacturer. Material rejected after delivery to the job shall be marked for identification and shall be removed from the job at once. All materials which have been damaged will be rejected, and if already installed, shall be acceptably repaired, if permitted by the Owner, or removed and replaced, entirely at the Contractor's expense.
- B. All precast sections shall be supported by structural design calculations and stamped shop drawings provided by a licensed structural engineer in the State of Colorado.

SECTION 33 05 16 – UTILITY STRUCTURES: continued

- C. At the time of inspection, the materials will be carefully examined for compliance with the latest ASTM designation and these specifications, and with the approved manufacturer's drawings. All vault sections shall be inspected for general appearance, dimension, "scratch-strength", blisters, cracks, roughness, soundness, etc. The surface shall be dense and close-textured.
- D. Imperfections in vault sections may be repaired, subject to the approval of the Owner, after demonstration by the manufacturer that strong and permanent repairs result. Repairs shall be carefully inspected before final approval. Cement mortar used for repairs shall have a minimum compressive strength of 4,000 psi at 7 days and 5,000 psi at 28 days, when tested in 3"x6" cylinders stored in the standard manner. Epoxy mortar may be utilized for repairs subject to the approval of the Owner.

1.03 SUBMITTALS:

- A. Submittals shall be made as required in the General and Special Conditions. In addition, the following specific information shall be provided:
 - 1. Structural Design Certification:
 - a. Properly identified with project name, location, and date, provide written certification of the precast manufacturer's compliance with the requirements specified herein.
 - b. The certification shall state that the precast units have been designed by a Professional engineer registered in the State of Colorado. The Engineer's seal shall appear on the certification.
 - c. The Engineer reserves the right to review, upon request, calculations specifically for this project for compliance with the requirements of these specifications. This review in no way relieves the Contractor or his engineer of complete responsibility for the design of the precast concrete as referred to on the drawings and these specifications.
 - d. Calculations shall identify all loading and stress analysis of precast units as installed.
 - e. Submit information for reinforcing, joints, connection to structures, manhole rungs (steps), interior coating system, exterior damp proofing system, joint wrap, joint sealant, manhole frame, manhole cover, and/or access hatch.

PART 2 - PRODUCTS

2.01 MATERIALS:

- A. Concrete: Reinforced, 4500 psi. Conform to DIVISION 3.
- B. Mortar:
 - 1. Conform to ASTM C270 Type M.
 - 2. Type I/II/III portland cement.
 - 3. Proportion 1 part portland cement to 1/4 part lime to not less than 2-1/4 nor more than 3 times the sum of the cement and lime used of loose damp sand.
- C. Precast Concrete Vault/Manhole Sections:
 - 1. Acceptable Manufacturers:

SECTION 33 05 16 – UTILITY STRUCTURES: continued

- a. Rinker Materials
 - b. Colorado Precast Concrete
 - c. Amcor Concrete Products
 - d. Adams City Manufacturing
 - e. Copeland Precast
 - f. Oldcastle Precast
 - g. Arco Concrete
1. Precast concrete barrel sections, transition sections, and top sections.
- a. Precast concrete sections and barrels shall conform to Specifications for Precast Reinforced Concrete Manhole Sections, ASTM C478 and/or ASTM C858 and meet the following requirements:
 - b. The wall thickness shall not be less than that shown on the drawings or 5 inches for 48-inch or 54-inch diameter reinforced barrel sections, 6-inch for 60-inch diameter reinforced barrel sections, and 7-inch for 72-inch diameter reinforced barrel sections, whichever is greatest.
 - (1) Wall corners shall have added reinforcement
 - (2) If base slab is integral with the wall sections, walls must be doweled into the floor.
 - c. Top sections shall be eccentric where called for in details.
 - (1) Only concrete collars will be allowed to bring to final grade.
 - d. Removable vault lids shall be cast such that their individual weight does not exceed 7,500 pounds.
 - (1) Provide lids with 3-inch diameter holes in the sections for lifting. The holes shall be perpendicular to the face of the lid surface. Holes shall not displace any of the required reinforcement nor should they protrude from either face of the roof. Holes shall be placed in such a manner that when lifting cables are being used there is equal weight distribution on all cables.
 - e. Barrel and vault sections shall have tongue and groove joints.
 - f. All sections shall be cured by an approved method and shall not be shipped nor subjected to loading until the concrete compressive strength has attained 3,000 psi and not before 5 days after fabrication and/or repair, whichever is longer.
 - g. Precast concrete barrel and vault sections with precast top slabs and precast concrete transition sections shall be designed for a minimum of H-20 loading plus the weight of the soil above.
 - h. The date of manufacture and the name and trademark of the manufacturer shall be clearly marked on the inside of each precast section.
 - i. All materials shall conform to Drawings.

SECTION 33 05 16 – UTILITY STRUCTURES: continued

2. Concrete Bases:
 - a. Precast concrete bases shall be constructed and installed as shown on the Drawings. The thickness of the bottom slab of the precast bases shall not be less than the manhole barrel sections or that called for specifically on Drawings.
 - b. See project details sheets for specific design requirements including reinforcement requirements for each structure to be installed under this project.
- D. Jointing Precast Vault Sections:
 1. All precast joints shall be tongue and groove (or similar with a locking edge) and shall be sealed to be made water-tight by using a two (2) system technique. The seal shall be composed of BOTH a preformed flexible butyl joint sealant (Ramnek® or similar) AND an external joint seam wrap.
 - a. Tongue and groove joint sealing using a preformed flexible SS-S-00210 butyl rubber joint sealant combined with an external 6-inch joint seam wrap.
 - (1) Preformed flexible butyl rubber joint sealant:
 - (a) Acceptable manufacturers:
 - 1) Concrete Sealants, Conseal – CS-102
 - 2) Kent Seal No. 2, as manufactured by Hamilton-Kent
 - 3) Rubber-Nek, as manufactured by K. T. Snyder company
 - 4) Or equal, on approval of the Engineer.
 - (2) External joint seam wrap:
 - (a) Acceptable manufacturers:
 - 1) Conseal Conwrap - CS-212
 - 2) Or equal, on approval of the Engineer.
 2. Install in a manner that will result in watertight joints.
 3. All vaults except for blowoff manholes shall be completely watertight both to external water table wanting to enter the vault and/or water in the vault entering the environment.
 4. Pre-cast vault walls shall be connected together by a plate and bolt type arrangement. Pre-cast walls shall be appropriately secured to the floor slab if not integral.
 - E. Pipe penetration thru vault wall:
 1. Pipe penetrations for each structure shall be closed per the vault detail.
 2. Generally, penetrations are closed in the following ways:
 - a. "Link-Seal"
 - (1) Acceptable Manufacturers:
 - (a) Link-Seal Modular pipe penetration seal
 - (b) Or equal, on approval of the engineer.
 - (2) Provide seals on both the inside and outside wall penetration, as shown on the construction drawings
 - (3) The "Link Seal" shall be installed between the pipe and precast structure, after the insertion is acceptable. The bolts should be tightened in proper sequence and to the manufacturers torque

SECTION 33 05 16 – UTILITY STRUCTURES: continued

requirements. The formed gasket shall be tight fitting and waterproof.

b. "Rubber Boot" (where specified at Blow-Off Assemblies)

- (1) "A-Lok" shall be a rubber-like gasket cast in the precast vault. The rubber gasket shall be cast into a formed opening in the vault wall.
- (2) "KOR-N-SEAL" joint shall be installed as recommended by the manufacturer. Stainless-steel clamps shall be protected from corrosion with a bituminous coat.

F. Vault or Manway Steps:

1. ½-inch minimum diameter steel reinforced polypropylene plastic or rubber.
2. Acceptable Manufacturers:
 - a. M.A. Industries Model PS2-PF,
 - b. American Step Company Model ML,
 - c. Or equal as approved by Engineer.
3. Steps shall be approximately 14-inches wide.
4. Copolymer polypropylene shall be Type II, grade 16906 meeting ASTM specification D2146.
5. Steel reinforcing shall be 3/8-inch diameter, grade 60 conforming to ASTM Specification A615 and shall be continuous throughout the step. The portion of the legs to be embedded in the precast section shall have fins and be tapered to insure a secure bond.

G. Vault Frames and Covers:

1. Acceptable Manufacturers:
 - a. East Jordan Iron Works
 - b. Neenah
 - c. D&L Foundry
 - d. Engineer approved equal.
2. Minimum opening diameter of 36-inches. Additional reinforcement shall be added around the opening at 45-degree angles to the edges. This shall extend a minimum of 2 feet beyond the opening or the ends of the reinforcing bars shall be standard 180 degree hooks.
3. Heavy duty with machined bearing surfaces to provide even seating.
4. Both the inner and outer covers shall be bolt-down style.
5. Entire assembly shall be H-20 load rated
 - a. Submit proof that lid has been certified to meet AASHTO M306 proof load of 40,000 lb for iron castings.
6. Include the Owner's Logo and indicate the word "Water" on the inner (24") cover.
7. Assembly shall be watertight.
8. Height of entire frame shall be 10-inches.
9. Cast iron shall conform ASTM A48 with minimum tensile strength of 30,000 psi.
10. Frames and covers shall be of good quality, strong, tough, even-grained cast iron smooth, free from scales, lumps, blisters, sand holes and defects of any kind which render them unfit for the service for which they are intended.

SECTION 33 05 16 – UTILITY STRUCTURES: continued

11. Covers and frame seats shall be machined to a true surface to provide even seating.
 12. Castings shall be thoroughly cleaned and subject to hammer inspection.
 13. Before shipment from the foundry, castings shall be given one coat of coal tar pitch varnish which shall present a casting that is smooth and tough, but not brittle.
 14. Interchangeable within same pattern.
 15. Conform to Drawings in all essentials of design.
 16. Weight shall be within 10% of that listed for pattern.
- H. Exterior Vault Waterproofing:
1. Waterproofing shall be installed on all exterior buried concrete structure walls.
 - a. Exterior structure wall waterproofing shall be:
 - (1) Carbolite – Bitumastic 300 M
 - (2) International – Interturf 100
 - (3) Tnemec – HB Tnemecol 45-464
 - (4) Or equal, on approval of the Engineer.
 - b. Apply coating in two coats to minimum 12-mil dry-film thickness per coat.
- I. Valve operator access thru vault lid:
1. All valve operators, wither indicated on the construction drawings or not, shall be accessible with a valve key (T-handled wrench) from the finished grade surface.
 - a. Provide core drills thru vault top (lid) as required in the field.
 - (1) Do not provide precast or factory applied penetrations so that adjustment can be made to align directly over valve operators.
- J. Frost Dampening Devices (on Vent Pipe):
1. The vent piping penetration leaving the vault shall be equipped with a wafer-style two-way hinge-less damper to prevent cold air from entering the vault but still allow the vent to perform its function of admitting and expelling air under normal operating conditions.
 2. Design:
 - a. The device shall contain no hinges or seats.
 - b. The device shall not be subject to freezing.
 - c. Body and disc shall be corrosion resistant capable of operating in temperature range of -40F to 150F.
 3. Acceptable Manufacturers:
 - a. FrostSafe® series #1500 as manufactured by Val-Matic.
 - b. Engineer approved equal.
- K. Warning Signs:
1. Warning signs shall be installed in every unventilated manhole or vault. A plastic warning sign will be permanently affixed on the inside wall between the top to steps. The sign will be inscribed with the words: "CAUTION – VENTILATE BEFORE ENTERING" in clear, large lettering. Attach the sign to the concrete with four plastic and type 316 stainless steel screws.
- L. Active Infiltration Stopping Materials:
1. Active water shall be stopped by using a polyurethane resin injection system.

SECTION 33 05 16 – UTILITY STRUCTURES: continued

2. Chemical grouting and water stop materials utilized shall be compatible with the specified repair/resurfacing materials and epoxy coating/lining system.
3. The polyurethane resin system for injection into concrete shall be a two-part system composed of 100 percent hydrophobic polymer resin of the isocyanate type.
4. The urethane resin, when reacted with water, shall be capable of forming either a flexible closed-cell foam or a cured gel dependent upon the resin-to-activator ratio.
5. The polyurethane resin shall be such that the cured material meets the following physical properties:
 - a. Minimum tensile strength - 150 pounds per square inch.
 - b. Bond to concrete (wet) - greater than 150 pounds per square inch.
 - c. Minimum elongation - 250 percent.
6. Acceptable Manufacturers:
 - a. DeNeef Construction Chemicals, Inc: Hydroactive Flex LV.
 - b. Quadex, LLC (Vortex Companies): I+I Guard.
 - c. Sika Corporation: SikaFix HH LV.
 - d. Owner-approved equal.

PART 3 - EXECUTION

3.01 BUTTERFLY VALVE VAULT:

A. Design:

1. Construct as follows:
 - a. Precast manhole with precast barrel sections, precast top section, and precast base.
 - (1) Precast vault sections shall conform to ASTM C478, C858, and C913.
 - (2) Conform to Drawings.
 - (a) Drawings indicate minimum vault dimensions.
 - 1) Vault dimensions may be produced at slightly larger dimensions in order to take advantage of production or manufacture efficiency.
 - 2) Thinner walled sections (different than those indicated in the drawings) may be approved by the Engineer.
 - a) Manufacturer to supply structural calculations and Professional Engineer's stamp certifying the capacity of the structure and indicating the structure's ability to resist all loads.
 - (3) Base shall be placed on compacted granular fill.
 - (4) Set to be vertical and with section in true alignment with 1/4-inch maximum tolerance allowed.
 - (5) Inside of joint to be filled with non-shrink mortar and finished flush with the adjoining surface.

SECTION 33 05 16 – UTILITY STRUCTURES: continued

- (6) Holes in the concrete barrel sections required for handling or other purposes shall be plugged with a non-shrink grout in combination with concrete plugs and finished flush on the inside.
- (7) Where holes must be cut in the precast sections to accommodate pipes, cutting shall be done prior to setting manhole sections in place to prevent any subsequent jarring which may loosen the mortar joints.
- b. Provide Submittal for precast and cast-in-place reinforced concrete vaults and manholes prior to installation.
- c. Modify, repair, use polyurethane grouting, or remove entire structure and rebuild to stop any leaks to obtain watertight construction.
- d. Protect against flooding or flotation.
- e. Backfilling shall be done in a careful manner, bringing the fill up evenly on all sides. If any leaks appear in the manholes, the inside joints shall be sealed to the satisfaction of the Engineer.

3.02 CONCRETE ANCHOR AND THRUST BLOCKS:

- A. Construct of concrete as indicated.
- B. Waterlines and waterline accessories (stubs, blowoff assemblies, etc.) less than 16-inch:
 - 1. Install at tees, elbows, bends, blowoffs, and dead ends where indicated.
- C. Place against undisturbed earth or rock.
- D. Of design indicated or specified:
 - 1. Bearing surface areas based on soil bearing capacity of 2000 lbs./square foot.
 - 2. Bearing surface area may be adjusted should field conditions be in variance with design assumption:
 - 3. Removable thrust blocks shall be constructed by using a sheet of 3/8-inch plywood to prevent concrete adherence to pipe, fittings, or accessories.
 - 4. Apply two coats of epoxy coating to minimum 20-mil dry-film thickness on anchor bars, straps, and hardware.

3.03 STRUCTURE STEPS:

- A. Steps shall be driven into tapered holes in the precast riser and cone sections during manufacturing of the sections.
- B. All steps shall be installed at intervals of 12-inches on center and 18-inches maximum from the of the ring to the first step.
- C. Holes for steps shall be performed during the casting of the sections and shall not be drilled out after casting.
- D. The preformed holes shall be a minimum of 3-1/2-inches deep and shall taper from 1-1/8-inch to 1-3/8-inch diameter.

3.04 VENT PIPES:

- A. Above-ground vent pipe and screen shall be in accordance with the Drawings
- B. Vent Pipe Piping:

SECTION 33 05 16 – UTILITY STRUCTURES: continued

1. Below-ground vent piping shall be 6-inch diameter, Schedule 40 PVC with glued joints beginning no sooner than 5-feet horizontally from the 90-bend as indicated on the Drawings.
2. Above-ground vent pipe shall be 3-feet tall and 8-inch nominal outside diameter galvanized steel pipe, schedule 40 with threaded joints per the Drawings, or 8" O.D. Seamless Aluminum or Composite Plastic Pipe.

3.05 WATER INFILTRATION STOPPAGE WITH POLYURETHANE RESIN:

A. Surface Preparation:

1. Surface must be clean and sound. Remove grease, dust, laitance, efflorescence, loose concrete, or any other contaminants.
2. Cracks in the substrate to be repaired must be less than ¼" wide. Cracks to be injected shall be as indicated and approved by Engineer or Owner.

B. Injection of Polyurethane Resin:

1. Polyurethane injection shall be used on cracks or precast joints that are actively leaking water.
2. The pump used to inject the polyurethane resin system shall be a two-component positive-displacement type pump with static mixing head. The equipment will be subject to approval by the Engineer and manufacturer.
3. Vacuum out all drilled holes prior to installing injection ports and flushing with water.
4. Install injection ports, zerks, or packer by drilling holes designed to intersect the crack at one-half the thickness of the concrete section. The holes shall be drilled roughly at a 45-degree angle if possible.
5. All injection holes shall be flushed with clean water to remove drilling dust and loose debris and to clean the intersected crack line. Each drill hole shall be water tested at the resin injection pressure to determine if the crack intersection is open. Polyurethane resin shall not be pumped into a drill hole that refuses to take water at the resin injection pressure.
6. Inject polyurethane resin system into cracks at the minimum pressure required to obtain the desired travel, filling, and sealing and as recommended by the manufacturer. The Contractor should anticipate the necessity to provide a surface seal for the crack or joint to contain the injection resin if necessary. It may also be necessary to inject the crack or joint in an intermittent manner to achieve filling and sealing. Injection shall be by the method of split spacing unless otherwise approved by the Engineer.
7. Primary holes shall be drilled and injected on centers not exceeding 2 feet. Secondary holes, halfway between the primary holes, will then be drilled and injected. If resin take occurs in the secondary holes, a series of tertiary holes, halfway between the secondary and primary holes, shall then be drilled and injected. All holes shall be injected to absolute refusal.
8. To finish the injection process, re-inject each installed injection port with a small amount of water. Allow the urethane to completely cure before removal of the port.

C. Cleaning:

SECTION 33 05 16 – UTILITY STRUCTURES: continued

1. Polyurethane resin spillage shall be immediately and thoroughly cleaned up. Spilled polyurethane resin can be removed and disposed as recommended by manufacturer.
2. Clean off excess epoxy or urethane from the surface of the concrete.
3. Remove all injection ports, zerks, or packers.
4. After repair of port holes and proper curing come back to area and grind down surface irregularities to match surrounding concrete surface and blend in patched areas.
5. Cleanup and disposal of injection resin. - All materials, tools, and containers contaminated with injection shall be removed from the site for disposal in accordance with appropriate local or Federal regulations.

3.06 CLEANING OF STRUCTURES:

- A. Prior to substantial completion, remove all accumulated construction debris, rocks, gravel, sand silt and other foreign material from the vaults.

END OF SECTION 33 05 16

SECTION 33 05 97 - UTILITY IDENTIFICATION

PART 1 - GENERAL

1.01 SUMMARY:

- A. This Section includes identification devices for utilities.
- B. Related Work Specified Elsewhere:
 - 1. Passive Cathodic Protection for Underground and Submerged Piping: SECTION 26 42 13.
 - 2. Water Utility Transmission Piping: SECTION 33 14 11.
 - 3. Waterline Accessories: SECTION 33 14 26.

1.02 REFERENCES:

- A. Applicable Standards:
 - 1. American Society of Mechanical Engineers (ASME):
 - a. A13.1, Scheme for the Identification of Piping Systems.
 - 2. American Society for Testing and Materials (ASTM):
 - a. B869 – Specification for 21% Conductivity, Hard Drawn, Copper-Clad Steel Wire.
 - b. B170 – Specification for Oxygen-Free Electrolytic Copper.
 - c. D1248 – Standard Specification for Polyethylene Plastics Extrusion Materials for Wire and Cable.
 - d. D2103 – Standard Specification for Polyethylene Film and Sheeting.
 - 3. Occupational Safety and Health Administration (OSHA):
 - a. 29 CFR 1910.145, Specification for Accident Prevention Signs and Tags

1.03 SUBMITTALS:

- A. Submit as specified in the General and Special Conditions.
- B. Include, but not limited to, the following:
 - 1. Catalog information for all identification systems.
 - 2. Acknowledgment that products submitted meet requirements of the standards referenced.
- C. Identification register, listing all items in Part 3 to be identified, type of identification system to be used, lettering, location and color.

PART 2 - PRODUCTS

2.01 TRACER WIRE:

- A. Design:
 - 1. 12-gauge HDPE or High Molecular Weight Density Ethylene (HMWDE) insulated high strength solid copper suitable for direct bury.
 - 2. Insulation shall be minimum 30 mil.
- B. Color:
 - 1. Wire insulation shall be blue in color.

2.02 TRACER WIRE SECURING TAPE:

- A. 2-inch wide vinyl plastic electrical tape.
- B. Seven (7) mil in thickness.

SECTION 33 05 97 - UTILITY IDENTIFICATION: continued

2.03 TRACER WIRE SPLICE KITS:

- A. Where connections to existing tracer wire are required or where connections to newly installed tracer wire (tees, end of rolls, etc.) are required, tracer wire shall be spliced with:
- B. Acceptable Manufacturers:
 - 1. 3M DBY-6 Low Voltage Direct Bury Splice Kit capable of handling three (3) #12 wires.
 - 2. Engineer approved equal.

2.04 TRACER WIRE TEST STATION TERMINAL BOARDS:

- A. Design:
 - 1. Insulated terminal board made of PVC.
 - 2. Terminal board hardware shall be stainless steel or nickel-plated brass and consist of a minimum of five 1/4-inch diameter by 1-1/4 inch long studs with double nuts, flat washers, and lock washers.

2.05 UNDERGROUND LOCATION AND WARNING TAPE:

- A. Design
 - 1. Size:
 - a. Minimum three (3) inches in width for pipe equal to or less than 24-inches in diameter.
 - b. Minimum six (6) inches in width for pipe greater than 24-inches in diameter.
 - c. Minimum overall thickness of five (5) mils.
 - d. Preprinted and permanently embedded.
 - e. Message continuous printed.
 - f. Minimum tensile strength: 3500 psi
 - g. Color/Legend:
 - (1) Potable water mains:
 - (a) Color: Blue with black letters
 - (b) Legend:
 - 1) "CAUTION BURIED WATERLINE BELOW"
 - 2. Impervious to all known alkalis, chemical reagents, and solvents found in soil
 - 3. Color coding shall be in conformance with the APWA/ULCC Color Code
 - 4. Maximum imprint length of thirty-six inches (36").
 - 5. Provide for all waterlines.
 - 6. Acceptable Manufacturer:
 - a. Empire Custom Tape
 - (1) Magnatectm
 - (2) Engineer approved equal.

2.06 UTILITY MARKER POST / MARKER POST TEST STATION:

- A. General:
 - 1. Where called out on the drawings and at all locations, Utility Marker Posts shall always mean a combination Utility Marker Post and Test Station.

SECTION 33 05 97 - UTILITY IDENTIFICATION: continued

- a. Marker posts provided without the ability to connect tracer wire with permanent leads are not an acceptable substitute.
 - b. Provide marker posts with test points for monitoring electric currents and potentials.
- B. Acceptable Manufacturers:
 - 1. Gerome Electric, Model 100
 - 2. Engineer approved equal.
- C. Design:
 - 1. 4" Galvanized Rigid Steel Post
 - 2. Five (5) terminal board minimum.
 - 3. Stainless steel continuity shunt.
 - 4. Coated in accordance with Section 09 90 00.
 - 5. See Drawings for marker post detail.
- D. Marker posts shall contain the following information:
 - 1. Utility owner's name – City of Thornton
 - 2. Utility owner's address – 12450 Washington St, Thornton, Colorado
 - 3. Utility owner's telephone number – 720-977-6500
 - 4. Emergency number – 303-255-7760
 - 5. Size of utility – varies
 - 6. Call 811 prior to digging

PART 3 - EXECUTION

3.01 INSTALLATION:

- A. Install identification devices at specified locations.
- B. All identification devices to be printed by mechanical process, hand printing is not acceptable.

3.02 TRACER WIRE:

- A. All water main installations shall include the installation of a single tracing wire taped to the top of the pipe.
- B. Tracer wire shall be secured at no less than four (4) locations per every twenty (20) feet of pipe and at every fitting and/or change in direction.
- C. The tracing wire shall be installed in a continuous run and the ends of the tracer wire shall be brought to the surface in marker post test stations.
- D. Tracer wire shall be routed around manholes/vaults and brought up into test stations/tracer wire boxes located adjacent to the manhole/vault.
- E. Wire splices shall be accomplished using a mechanical connector as specified. The use of electrical tape for splicing is not permitting.

3.03 WARNING TAPE:

- A. During the backfilling operation, continuously place pipe locating tape along centerline of buried pipe. Place 1-foot above top of piping with the printed side up for visual identification.
 - 1. Detectable Marking Tape: Install with nonmetallic piping and waterlines.
 - 2. Non-detectable Marking Tape: Install with metallic piping.

SECTION 33 05 97 - UTILITY IDENTIFICATION: continued

3.04 TRACER WIRE TESTING:

- A. The Contractor is responsible for all tracer wire continuity testing including: providing equipment, qualified personnel, and record keeping.
- B. All new tracer wire installations shall be located and verified by the Contractor using typical low frequency (512Hz) line tracing equipment, witnessed by the Contractor, Engineer, and Owner as applicable, prior to acceptance of ownership.
- C. This verification shall be performed upon completion of rough grading and again prior to final acceptance of the project.
- D. Continuity testing in lieu of actual line tracing shall not be accepted.

3.05 MARKER POST TEST STATIONS:

- A. Marker posts shall be installed per manufacturers recommendations.
- B. Marker post (whether specifically indicated on the Drawings or not) shall be installed in all locations at the following minimum locations:
 - 1. Vaults (Butterfly Valves, Air/Vacuum Valves, Blowoffs, Manways, etc.),
 - 2. Direct bury valves,
 - 3. Manholes,
 - 4. Taps and turnouts,
 - 5. At all bends greater than 15-degrees,
 - 6. At ends of steel casing pipe,
 - 7. At distances not exceeding 500-feet,
 - 8. At all fence crossings,
 - 9. At both sides of all road and right-of-way crossings,
 - 10. At all other locations indicated in the Drawings.

END OF SECTION 33 05 97

SECTION 33 11 20 – HYDRODYNAMIC MIXING SYSTEM

PART 1 - GENERAL

1.01 SUMMARY:

- A. The Hydrodynamic Mixing System (HMS) is a supplemental system installed within a potable water storage reservoir which passively utilizes the energy provided by the inlet water supply and generates sufficient inlet momentum to achieve a complete homogeneous blending of the water volume within the reservoir with the inlet supply flow. Determination of complete homogeneous blending shall be defined by the modeling requirements and supporting hydraulic analysis as conducted by each individual manufacturer for their specific system configuration as defined within these specifications. System submittals not providing this validation shall not be considered as a viable HMS and shall not be accepted as an equivalent to this system specification.
- B. The specifications in this section include all components of the reservoir HMS consisting of an inlet flow manifold equipped with variable orifice duckbill inlet nozzles that are NSF61 certified. The HMS manufacturer shall be responsible for designing the system in accordance with the hydrodynamic criteria defined within these specifications and submit design calculations verifying compliance in accordance with the submittal requirements.
- C. The complete HMS shall be supplied by the variable orifice nozzle manufacturer to maintain single source responsibility for the system. The complete system shall be defined as all piping and appurtenances within the tank downstream of the tank penetration. Appurtenances include pipe, fittings, expansion joints, variable orifice duckbill check valves, and any other equipment specified within this section of the specifications.

1.02 RELATED WORK SPECIFIED ELSEWHERE:

- A. General Requirements: General and Special Conditions.
- B. Water Utility Transmission Piping: SECTION 33 14 11

1.03 REFERENCES:

- A. Applicable Standards:
 - 1. American Water Works Association (AWWA):
 - a. C906 – Polyethylene (PE) Pressure Pipe and Fittings, 4 in through 63 in for Water Distribution
 - b. M55 – PE Pipe – Design and Installation
 - 2. American National Standards Institute (ANSI):
 - a. B16.21 - Nonmetallic Flat Gaskets for Pipe Flanges.
 - 3. American Society for Testing and Materials (ASTM):
 - a. A351 – Standard Specification for Castings, Austenitic, for Pressure-Containing Parts
 - b. D471-98 - Standard Test Method for Rubber Property – Effect of Liquids
 - c. D638 – Standard Test Method for Tensile Properties of Plastics
 - d. D790 – Standard Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials

SECTION 33 11 20 – HYDRODYNAMIC MIXING SYSTEM: continued

- e. D1238 – Standard Test Method for Melt Flow Rates of Thermoplastics by Extrusion Plastometer
- f. D1505 – Standard Test Method for Density of Plastics by the Density-Gradient Technique
- g. D2240 – Standard Test Method for Rubber Property – Durometer Hardness
- h. D2837 – Standard Test Method for Obtaining Hydrostatic Design Basis for Thermoplastic Pipe Materials or Pressure Design Basis for Thermoplastic Pipe Products
- i. D3261 – Standard Specification for Butt Heat Fusion Polyethylene (PE) Plastic Fittings for Polyethylene (PE) Plastic Pipe and Tubing
- j. D3350 – Standard Specification for Polyethylene Plastics Pipe and Fittings Materials
- k. F714 – Standard Specification for Polyethylene (PE) Plastic Pipe (DR-PR) Based on Outside Diameter
- l. F1473 – Standard Test Method for Notch Tensile Test to Measure the Resistance to Slow Crack Growth of Polyethylene Pipes and Resins
- 4. National Sanitation Foundation (NSF):
 - a. 61 - Drinking Water System Components - Health Effects.

1.04 SUBMITTALS:

- A. Submit as specified in the General and Special Conditions.
- B. Independent Computational Fluid Dynamics (CFD) Modeling Validation: The mixing system designer/supplier must supply data or report from at least one project of similar size and configuration where an independent company conducted CFD modeling on their mixing system design and the modeling results verified the design achieved complete mixing.
- C. Full Scale Tracer Study Validation: The mixing system designer/supplier must supply data or report from at least one project where a full-scale tracer study was conducted on a circular reservoir and the tracer study results verified the mixing system design achieved complete mixing.
- D. Inlet Nozzle Testing and Validation: Verification of independent hydraulic testing to determine headloss and jet velocity characteristics on size of valves used for the project under free discharge and submerged conditions.
- E. Verification of independent hydraulic testing to determine headloss characteristics on valve sizes used for this project.
- F. Verification of Finite Element Analysis (FEA) modeling on a perforated disc/elastomeric membrane check valve to determine stress and deflection characteristics under reverse differential pressure.
- G. Validation of Long-term performance: The mixing system designer/supplier must supply at least one inspection report showing proper operation of, and no deterioration of, the duckbill valves after being in service in a water tank mixing application for a minimum of 10 years.
- H. NSF61 Certification.
 - 1. Copy of the NSF61 Certified listing for the valves used in the HMS.

SECTION 33 11 20 – HYDRODYNAMIC MIXING SYSTEM: continued

- I. Test Report on Elastomer Exposure to Chlorine and Chloramine: Test report from an accredited independent laboratory that confirmed there is no degradation in the elastomer when exposed to chlorine and chloramine per ASTM D471-98.
- J. System Installation Drawings: The duckbill valve manufacturer shall be responsible for providing engineering installation drawings of the complete manifold piping system as supplied by the manufacturer. These drawings shall include plan view piping arrangement, sections and elevations as required, support bracket installation details, duckbill nozzle orientation details, and all dimensions required for locating the system within the specified dimensions of the tank.
- K. Design Calculations.
 - 1. All Design Calculations, curves, and reference information listed below must be submitted by HMS system supplier.
 - 2. Calculations showing the fill time required, under isothermal conditions, for the HMS system to achieve complete mix of the reservoir volume at minimum, average and peak fill rates. Complete mixing defined as 95% homogenous solution. The theory and equations used in calculating the mixing times must be from a published AWWA reference manual or paper. The reference document(s) must be submitted with the equations and calculations.
 - 3. Calculations showing the water level drawdown required to achieve complete mixing on the fill cycles at minimum, average, and peak flow rates.
 - 4. Calculations of average storage tank water age for fill-then-draw scenarios. Theory used in calculating water age must be submitted with the calculations.
 - 5. A representative CFD model evaluation of the proposed HMS system configuration applied within the reservoir geometry. Model output documentation shall include all design variables applied for the simulation, plot of the 3-D geometry showing the mesh definition, velocity magnitude vector and contour plots at different cross-sections throughout the water volume, simulated tracer animations showing the spatial and temporal distribution of inlet water in real time during the fill cycle. CFD modeling shall be performed for minimum, average, and peak flow rates.
 - 6. Hydraulic calculations showing the resulting jet velocities of each inlet nozzle at minimum, average, and peak fill rates.
 - 7. Hydraulic calculations showing the flow distribution among all inlet ports at minimum, average, and peak fill rates.
 - 8. Manifold hydraulic calculations showing the total headloss of the HMS at minimum, average, and peak fill and draw rates. Headloss shall include all minor losses and headloss of nozzles.
 - 9. Hydraulic curves showing thrust vs. flow for the inlet nozzles.
 - 10. Hydraulic curves for each outlet check valves showing head loss vs. flow.
 - 11. Calculations showing the terminal rise height of the jets that discharge at an angle above horizontal. The terminal rise height shall be calculated assuming 10°F and 20°F colder inlet water and calculated at minimum, average and peak fill rates. The theory and equations used to calculate the terminal rise height shall be included.
 - 12. Hydraulic curves for each inlet nozzle of Densimetric Froude number vs. flow

SECTION 33 11 20 – HYDRODYNAMIC MIXING SYSTEM: continued

- L. Installation, Operation and Maintenance Manuals as required in the General and Special Conditions and below.
 - 1. Copy of design calculations for the manifold system as defined in the previous section.
 - 2. Copy of complete set of the installation plans.
 - 3. Copy of NSF61 Certified Listing for the valves.
 - 4. Parts and equipment list with specification numbers for ordering of replacement parts.
 - 5. Product specification sheets for nozzles, expansion joints, concrete anchors, and any other specialized items supplied with the system.
 - 6. Installation guidelines for the HMS manifold system.
 - 7. Operational procedures for the HMS manifold system.
 - 8. Guidelines for repair and/or replacement of system components.
 - 9. Schedule for suggested periodic maintenance of the manifold system.
 - M. Submit the following for acceptance prior to fabrication of the pipe:
 - 1. Pipe and joint details.
 - 2. Special, fitting, and coupling details.
 - 3. Laying and installation schedule.
 - 4. Specifications, data sheets, and affidavits of compliance for protective shop coatings and linings.
 - N. Certificates and Affidavits: Furnish the Following Prior to Shipment:
 - 1. Affidavit of compliance or Certificate of Conformance with applicable standard.
- 1.05 QUALITY CONTROL:
- A. Manufacturers shall be experienced in the design and manufacture HMS, including all valves and appurtenances for a minimum period of 5 years.
- 1.06 WARRANTY
- A. The HMS Manufacturer shall warrant that all equipment shall be free from defects caused by faulty material or workmanship for a minimum period of one (1) year from the date of Construction Acceptance.
 - B. Multiple warranties for individual components will not be acceptable.
- 1.07 DELIVERY, STORAGE AND HANDLING:
- A. Ship all material to the Site and store in assigned laydown areas or as directed by Engineer.
 - B. Handling and storage shall be in accordance with the manufacturer's recommendations.
 - C. Individual nozzles shall be packaged separately from the piping equipment.
 - D. All flanges shall be protected by using plastic inserts or plank wood, pipe sections are to be fully supported to prevent pipe deflection or damage to fittings or connections.
 - E. All equipment shall be shipped on pallets capable of fully supporting the pipe sections across their entire length. Pallets should be accessible for fork lift

SECTION 33 11 20 – HYDRODYNAMIC MIXING SYSTEM: continued

- transport or strap and hoist means without causing any load to the pipe equipment.
- F. All stainless steel components shall be stored separately away from any carbon steel components or other materials that could stain or deface the stainless steel finish from run-off of oxidized ferrous materials.
 - G. All pipe equipment should be covered and stored in areas free from contact with construction site sediment erosion to prevent accumulation of materials within the pipe and fittings.
 - H. Duckbill nozzles should be protected from contact with rigid objects during handling and storage. The contractor shall be responsible for replacing any duckbill nozzles or elastomeric components that are damaged after arrival on the site through installation and start-up of the system.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS:

- A. Acceptable manufacturers include those regularly engaged in passive mixing tank mixing systems with a history of successful installations in the United States.
 - 1. Tideflex Technologies, Carnegie, PA.
 - 2. Engineer Approved Equal.
- B. Manufacturer's submitting as an approved equal shall be responsible for obtaining any and all proprietary rights, license fees, royalties, technology licenses, and/or and permissions required to provide such a system. The Manufacturer shall indemnify and hold harmless Owner and Engineer against all claims, damages, losses, and expenses arising out of any infringement of patent rights or copyrights incident relating to this system.

2.02 DESIGN CRITERIA:

- A. Fill Rate: 3400 gpm
- B. Draw Rates: 3400 gpm
- C. Required Pipe Header Size: 36"
- D. System Headloss: less than or equal to 2.0 feet

2.03 PIPE REQUIREMENTS:

- A. All piping required for the HMS shall be provided by the HMS manufacturer.
- B. Pipe material shall be selected by the HMS manufacturer. If metallic pipe is selected cathodic protection is required.
- C. Materials and Manufacturer:
 - 1. All piping system components shall be the products of one manufacturer.
- D. All HMS metallic components, including nuts and bolts, to be 316L Stainless Steel.
- E. Pipe-Flange Gaskets shall conform to ANSI B16.21, 1/8-inch thick Garlock Blue Gylon Style 3505 gasket, or engineer approved equal. Provide full-face gaskets for all pump and equipment connections.
- F. Pipe Marking: All pipe and fittings shall be marked conforming to the applicable standard specification under which the pipe is manufactured and as otherwise specified.

SECTION 33 11 20 – HYDRODYNAMIC MIXING SYSTEM: continued

2.04 VARIABLE ORIFICE DUCKBILL INLET NOZZLES:

- A. Inlet ports/nozzles shall be duckbill-style check valves that allow fluid to enter the reservoir during fill cycles and prevent flow in the reverse direction through the nozzle during draw periods. Inlet ports/nozzles may not be fixed-diameter ports or pipes.
- B. The duckbill valves shall be NSF61 Certified. NSF61 approved/Certified materials will not be accepted in lieu of valve certification.
- C. Inlet ports/nozzles shall have a variable diameter vs. flow hydraulic profile that provides a non-linear jet velocity vs. flow characteristic and a linear headloss vs. flow characteristic. The hydraulic characteristics of the duckbill valves shall be defined by "Hydraulic Code".
- D. The inlet ports/nozzles shall discharge an elliptically shaped jet.
- E. Manufacturer must have representative inspection videos showing the duckbill valves discharging water into the reservoir during an initial fill (unsubmerged). Manufacturer must also have representative underwater inspection videos showing the operation of the valves when submerged.
- F. The duckbill style nozzles shall be one-piece elastomer matrix with internal fabric reinforcing designed to produce the required discharge velocity and minimum headloss requirements as stipulated in the Submittals section. The flange portion shall be an integral portion of the nozzle with fabric reinforcing spanning across the joint between the flange and nozzle body.
- G. The elastomer used in construction of the duckbill valves must have been tested by an accredited independent laboratory that confirmed there is no degradation in the elastomer when exposed to chlorine and chloramine per the ASTM D471-98 "Standard Test Method for Rubber Property – Effect of Liquids."
- H. The manufacturer's name, plant location, serial number and product part number which designates nozzle size, material and construction specifications shall be bonded onto the surface of the nozzle.

PART 3 - EXECUTION

3.01 INSTALLATION:

- A. Installation of the manifold system shall be in accordance with the installation plans and guidelines provided by the manufacturer.
- B. Additional installation guidelines as specified herein.

3.02 CLEANING:

- A. HMS manufacturer shall be responsible for cleaning all materials and equipment and removal of construction debris prior to tank filling, disinfection, and testing.

3.03 INSTALLATION INSPECTION AND START-UP TESTING PROCEDURES

- A. The HMS manufacturer's authorized representative shall provide one (1) day inspection to verify that the system has been installed in accordance with the design specifications and installation drawings.
- B. Start-Up Flow Testing:
 - 1. Coordinate start-up flow testing with Owner and Engineer.
 - 2. Refer to the General Conditions for temporary water available for testing.

SECTION 33 11 20 – HYDRODYNAMIC MIXING SYSTEM: continued

3. Following installation of the complete manifold piping system, the contractor shall open the upstream isolation valve to allow flow into the tank through the manifold system. The isolation valve must be opened slowly to prevent surge or over-pressurization of the manifold system. The isolation valve must be fully opened to inspect the flow characteristics of the manifold system.
4. The contractor and factory representative shall visually inspect the entire piping system for leakage.
5. The contractor and factory representative shall visually inspect all of the inlet nozzles to ensure flow is being discharged into the tank through all nozzles.

END OF SECTION 33 11 20

SECTION 33 12 16 – ELECTRIC MOTOR ACTUATORS:

PART 1 - GENERAL

1.01 SUMMARY:

- A. This Section includes all valve actuators and accessories.
- B. Related Work Specified Elsewhere:
 - 1. DIVISION 01.
 - 2. Process Valves and Operators: SECTION 40 27 02.

1.02 REFERENCES:

- A. Applicable Standards:
 - 1. 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.
 - 2. American Water Works Association (AWWA):
 - a. C540 - Power-Actuating Devices for Valves and Sluice Gates.
 - 3. Institute of Electrical and Electronics Engineers (IEEE):
 - a. 43 – Testing Insulation Resistance of Rotating Machinery.
 - b. 112 – Test Procedure for Polyphase Induction Motors and Generators.
 - 4. National Electrical Manufacturers Association (NEMA):
 - a. MG1 – Motors and Generators.
 - b. MG2 – Safety Standard for Construction, and Guide for Selection, Installation, and Use of Electric Motors and Generators.
 - c. MG13 – Frame Assignments for Alternating-Current Integral-Horsepower Induction Motors.
 - 5. National Fire Protection Association (NFPA):
 - a. 70 – National Electric Code (NEC).
 - 6. Underwriters Laboratories (UL) Listed.

1.03 SUBMITTALS:

- A. Submit as specified in the General and Special Conditions.
- B. Include, but not limited to, the following:
 - 1. Catalog data or illustrations showing principal dimensions, parts, and materials.
 - 2. Spare parts list referenced to illustration of parts.
 - 3. Assembly and disassembly or repair instructions.
 - 4. Detailed Equipment installation drawings, showing mounting flange sizes, bolting patterns and locations, location of existing connections, and all clearances required for installation, operation, and disassembly for maintenance.
 - 5. Schematic diagrams for electrical items, showing external connections, terminal block numbers, internal wiring diagrams, power consumption data, and one-line diagrams.
 - 6. Sizing calculations showing that the required safety factor has been met.
- C. Certificates and Affidavits: Furnish prior to shipment. Include the following:
 - 1. Test certificates.
 - 2. Affidavit of compliance with applicable AWWA Standard.

SECTION 33 12 16 – ELECTRIC MOTOR ACTUATORS: continued

1.04 DELIVERY, STORAGE, AND HANDLING:

- A. Valve actuators shall be shipped installed on valve from the valve manufacturer. Separate shipment of valves and actuators to the Project Site will not be permitted.
- B. Provide covers, enclosures, and other means to prevent moisture damage, mechanical and electrical injury, and accumulation of dirt, dust, and other foreign matter.
- C. Provide suitable rust-preventive compound for outdoor storage on exposed machined surfaces and unpainted iron and steel.
- D. Provide grease packing or oil lubrication in all bearings and similar items.

PART 2 - PRODUCTS

2.01 ACTUATORS:

- A. General:
 - 1. Design, fabricate, and test motor operators in accordance with the codes and standards listed in PART 1, this Section.
 - 2. Design to function with 24-inch and 36-inch butterfly valves.
 - a. For open/close service
 - 3. Actuators shall be designed with a safety factor of 1.40 for open/close duty.
 - 4. Actuators shall be supplied with standard factory applied paint.
 - 5. Contractor shall submit a copy of Valve Data to the motor operator manufacturer with the purchase order.
 - 6. Contractor shall bear all costs associated with the replacement or field modification of incorrect operators due to failure to comply with the above requirement.

2.02 ELECTRIC MOTOR OPERATOR:

- A. Acceptable Manufacturers:
 - 1. Beck
 - 2. Rotork
 - 3. Auma SIPOS
 - 4. Approved Equal
- B. General:
 - 1. Constructed to NEMA 4, IP68 weatherproof class as a minimum for all enclosures including motors.
 - a. Equipped with 120Vac, single-phase, 60-Hertz space heater in both limit switch and motor compartments.
 - 2. Provide integral-reversing starter complete with control-power transformer. Transformer shall be sized to operate starter, two local indicating lights, motor space heater, and limit switch compartment heater.
 - 3. Actuators shall have two integral or close-coupled indicating lights. One green light shall indicate valve is open, and one red light shall indicate valve is closed. Both lights shall be on, in mid-travel.
 - a. Provide dry contacts for the remote indication of these lights.
 - 4. Provide opening and closing torque switches wired to trip motor if excessive torque is generated in either direction of travel. Closing torque switch shall be wired to trip motor when a predetermined torque is reached which

SECTION 33 12 16 – ELECTRIC MOTOR ACTUATORS: continued

corresponds to required seating thrusts as determined by the valve manufacturer.

5. Provide a permanently mounted manual operating wheel that is automatically disengaged whenever motor is energized. Operator shall be capable of complete manual valve actuation whenever motor drive is not energized even if motor is fused or otherwise fails. However, simultaneous manual and motor operation shall not be possible.
 6. Actuators shall have self-locking wormset gearing.
 7. Actuators shall be equipped with a direct position readout at the valve by means of a mechanical dial-position indicator showing percent of valve opening.
 8. Motor operators shall have complete internal wiring to terminals and have motor leads brought into the limit switch compartment directly to the terminal board without use of external conduit.
 9. Actuators shall be oil or grease lubricated.
 10. Actuators shall be provided with a lost-motion hammer blow mechanism for unseating valves in both motor drive and manual operation modes.
 11. Equipped with thrust compensator or Belleville-spring mechanism as required and as recommended by the actuator manufacturer for the specified service in high-speed or high-temperature applications.
 12. Limit switch makeup sequences shall be subject to Engineer approval.
- C. Motors: Electric motors for valve motor operators shall be as follows:
1. Sized to function with the butterfly valves. Minimum open/closing time (5 minutes).
 2. Designed to operate on 120/240Vac, 1-phase, 60-hertz supply.
 3. Designed with totally enclosed nonventilated (TENV).
 4. High-starting-torque type, specifically designed for valve actuator service.
 5. Sized to actuate valve against full specified operating pressure with motor terminal voltage variations of $\pm 10\%$ unless otherwise specified.
 6. Provided with Class B insulation with a maximum continuous temperature rating of 120°C for 40°C environment.
 7. Designed with a 15-minute duty rating or three successive open/close cycles, whichever is greater.
 8. Designed to move disc from fully-open (full flow) to fully-closed position, or reverse, in a minimum of five (5) minutes.
 9. Furnished with Add-on Pak 1.
 10. Provided with the following switch functions for each direction of travel:
 - a. Position limit switch (single).
 - b. Twin end of travel auxiliary switches.
 - c. Three switches can be adjusted to operate at any point between full open and full closed.
 11. Provided with the capability of bypassing opening torque switch to prevent nuisance tripping due to high transient torque requirements during beginning of unseating. Where backseating of the valve is recommended by the valve manufacturer, provide similar closing torque switch bypass.
- D. Accessories

SECTION 33 12 16 – ELECTRIC MOTOR ACTUATORS: continued

1. Four contacts must be provided which can be selected to indicate any position of the valve.
2. Provision must be made for the selection of a normally closed or open contact form.
3. Contacts shall maintain and update position indication during handwheel operation when all external power to the actuator is isolated.
4. Remote Hand Station
 - a. Provide a NEMA 4X Remote hand station that replicates the functionality of the actuator interface which shall include the following at the minimum:
 - (1) Local/Remote/Stop switch
 - (2) Open/Close Switch
 - (3) Display Window
 - (4) Sun Shade
 - b. The hand station should be pole/wall mountable with vandal proof cover.
 - c. Provide manufacturer cable between the hand station and the actuator.

PART 3 - EXECUTION

3.01 COORDINATION REQUIREMENTS:

- A. Design the actuators, controls, and accessories including sizing, assembly, certification, field testing, and calibration necessary for proper operation of valves.

3.02 INSTALLATION:

- A. Comply with provisions of AWWA C600 and as specified.
- B. Comply with the Manufacturer's instructions and recommendations.
- C. Thoroughly clean and remove all shipping materials prior to setting. Operate all valves from fully opened to totally closed.
- D. Equip with anchorage where indicated.

3.03 FIELD TESTING:

- A. Manufacturer's Field Service Representative shall be onsite to calibrate the motor operated actuators, including:
 1. A minimum of one day onsite for:
 - a. Setting valve open and close limit switches
 - b. Verifying valve open and close times, for normal and emergency operation
 - c. Verifying valve leakage at closed position using a stethoscope earphone, or similar equipment
 2. Provide minimum four (4) hour field training course for designated operating and maintenance staff members. Training shall be provided during normal working time and shall start after the system is functionally complete but prior to full start-up. Field training shall cover all the items contained in the operating and maintenance manuals. Provide video recording, with audible sound, of training session to Trust.

SECTION 33 12 16 – ELECTRIC MOTOR ACTUATORS: continued

3. Coordinate with Trust to determine that the system transients are acceptable during startup and stopping. Adjust opening and closing speed until Trust is satisfied with operation of actuator.

END OF SECTION 33 12 16

SECTION 33 14 11 – WATER UTILITY TRANSMISSION PIPING

PART 1 - GENERAL

1.01 SUMMARY:

- A. This Section includes all pressure pipe, fittings, specials, and appurtenances.
- B. Related Work Specified Elsewhere:
 - 1. Steel Pipe Polyurethane Coating: SECTION 09 90 05.
 - 2. Cathodic Protection for Underground and Submerged Piping: SECTION 26 42 13.
 - 3. Trenching and Backfilling for Utilities: SECTION 31 23 33.13.
 - 4. Utility Identification: SECTION 33 05 97.
 - 5. Utility Valves and Accessories: SECTION 33 14 26.

1.02 REFERENCES:

- A. Applicable Standards:
 - 1. American Association of State Highway and Transportation Officials (AASHTO).
 - 2. American Water Works Association (AWWA):
 - a. C104 - Cement-Mortar Lining for Ductile-Iron Pipe and Fittings for Water.
 - b. C105 - Polyethylene Encasement for Ductile-Iron Pipe Systems.
 - c. C110 - Ductile-Iron and Gray-Iron Fittings, 3 Inches Through 48 Inches, for Water and Other Liquids.
 - d. C111 - Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings.
 - e. C115 - Flanged Ductile-Iron Pipe with Ductile-Iron or Gray-Iron Threaded Flanges.
 - f. C150 - Thickness Design of Ductile-Iron Pipe.
 - g. C151 - Ductile-Iron Pipe, Centrifugally Cast, for Water or Other Liquids.
 - h. C153 - Ductile-Iron Compact Fittings, 3 In. Through 24 In. and 54 In. Through 64 In., for Water Service.
 - i. C200 - Steel Water Pipe 6 Inches and Larger.
 - j. C205 - Cement-Mortar Protective Lining and Coating for Steel Water Pipe - 4 Inch and Larger - Shop Applied.
 - k. C207 - Steel Pipe Flanges for Waterworks Service, Sizes 4 Inch Through 144 Inch.
 - l. C208 - Dimensions for Fabricated Steel Water Pipe Fittings.
 - m. C209 - Cold-Applied Tape Coatings for the Exterior of Special Sections, Connections, and Fittings for Steel Water Pipelines.
 - n. C210 - Liquid Epoxy Coating Systems for the Interior and Exterior of Steel Water Pipelines.
 - o. C213 - Fusion-Bonded Epoxy Coating for the Interior and Exterior of Steel Water Pipelines.
 - p. C214 - Tape Coating Systems for the Exterior of Steel Water Pipelines.
 - q. C215 - Extruded Polyolefin Coatings for the Exterior of Steel Water Pipelines.

SECTION 33 14 11 – WATER UTILITY TRANSMISSION PIPING: continued

- r. C218 - Coating the Exterior of Aboveground Steel Water Pipelines and Fittings.
 - s. C219 - Bolted, Sleeve-Type Couplings for Plain-End Pipe.
 - t. C300 - Reinforced Concrete Pressure Pipe, Steel Cylinder Type, for Water and Other Liquids.
 - u. C301 - Prestressed Concrete Pressure Pipe, Steel Cylinder Type, for Water and Other Liquids.
 - v. C303 - Concrete Pressure Pipe, Bar-Wrapped Steel Cylinder Type.
 - w. C304 - Design of Prestressed Concrete Cylinder Pipe.
 - x. C600 - Installation of Ductile Iron Water Mains and Their Appurtenances.
 - y. C605 - Underground Installation of PVC and PVCO Pressure Pipe and Fitting.
 - z. C606 - Grooved and Shouldered Joints.
 - aa. C651 - Standard for Disinfecting Water Mains.
 - bb. C900 - Polyvinyl Chloride (PVC) Pressure Pipe, 4 Inch through 12 Inch, for Water Distribution.
 - cc. C905 - Polyvinyl Chloride (PVC) Water Transmission Pipe, Nominal Diameters 14 Inch Through 36 Inch.
 - dd. M11 - Steel Pipe - A Guide for Design and Installation.
 - ee. M23 - PVC Pipe-Design and Installation.
 - ff. M41 - Ductile-Iron Pipe and Fittings.
 - 3. American National Standards Institute (ANSI):
 - a. B16.1 - Cast-Iron Pipe Flanges and Flanged Fittings, Class 25, 125, 250 and 800.
 - b. B16.21 - Nonmetallic Flat Gaskets for Pipe Flanges.
 - 4. American Society for Testing and Materials (ASTM):
 - a. A307 - Carbon Steel Bolts and Studs, 60,000 psi Tensile.
 - b. D1248 - Polyethylene Plastics Molding and Extrusion Materials.
 - c. F477 - Elastomeric Seals (Gaskets) for Joining Plastic Pipe.
 - d. G62 - Test Methods for Holiday Detection in Pipeline Coatings.
 - 5. American Welding Society (AWS):
 - a. D1.1 – Structural Welding Code – Steel.
 - 6. National Sanitation Foundation (NSF):
 - a. 61 - Drinking Water System Components - Health Effects.
 - 7. Society for Protective Coatings (SSPC):
 - a. SP1 - Solvent Cleaning.
 - b. SP3 - Power Tool Cleaning.
 - c. SP5 - White Metal Blast Cleaning.
 - d. SP7 - Brush-Off Blast Cleaning.
 - e. SP10 - Near-White Blast Cleaning.
- 1.03 STEEL PIPE 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:

SECTION 33 14 11 – WATER UTILITY TRANSMISSION PIPING: continued

1. Design in accordance with AWWA M11:
 - a. General:
 - (1) Base stationing and elevation convention as shown on Drawings.
 - (2) Maximum Laying Lengths:
 - (a) Not limited, unless specifically shown on 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 Owner's Project Representative and 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 or ASME BPVC SEC IX 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

SECTION 33 14 11 – WATER UTILITY TRANSMISSION PIPING: continued

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):
 - 1. 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. Submit as specified in General and Special Conditions.
- B. Submit existing utility information (potholes) identifying location and elevation prior to submission of pipe submittals. Existing utility shall be verified as noted in the General and Special Conditions of the Contract.
- C. Submit the following for acceptance prior to fabrication:
 - 1. Pipe and joint details.
 - a. Size
 - b. Dimensionality
 - c. Pressure Class
 - d. Color
 - e. Manufacturer's Calculations and Recommendation for Minimum Bending Radius
 - 2. Special, fitting, and coupling details.
 - 3. Laying and installation schedule.
 - 4. Specifications, data sheets, and affidavits of compliance for protective shop coatings and linings.
 - 5. Manufacturer's design calculations including, but not limited to, wall thickness and deflection under specified live and dead loads.
- D. Certificates and Affidavits: Furnish the Following Prior to Shipment:
 - 1. Affidavit of compliance with applicable standard.
 - 2. Certificate of origin for all steel flanges. Flanges shall be manufactured in the U.S.A.
 - 3. Test certificates.

1.05 QUALITY CONTROL:

- A. Manufacturers shall be experienced in the design and manufacture of pipe, fittings, specials, or appurtenances for a minimum period of 5 years.
- B. All pipe, of same material, and fittings shall be from a single manufacturer.
- C. All pipe manufactured to AWWA C-200 series specifications shall be furnished by a manufacturer certified by the Steel Plate Fabricators Association (SPAA) for steel pipe fabrication.
- D. Observation of the pipe shall be made by the Owner's Project Representative or other representatives of the Owner after delivery. The pipe shall be subject to rejection at any time on account of failure to meet any of the Specification requirements, even though pipes may have been accepted as satisfactory at the

SECTION 33 14 11 – WATER UTILITY TRANSMISSION PIPING: continued

place of manufacture. Pipe rejected after delivery shall be marked for identification and shall immediately be removed from the job.

1.06 DELIVERY, STORAGE AND HANDLING:

- A. Ship all material to the Site and store in assigned laydown areas or as directed by Engineer.
- B. Handle in a manner to ensure installation in sound and undamaged condition.
 - 1. Do not drop or bump.
 - 2. Use slings, lifting lugs, hooks, and other devices designed to protect pipe, joint elements, linings, and coatings.
- C. Ship, move, and store with provisions to prevent movement or shock contact with adjacent units.
- D. Handle with equipment capable of work with adequate factor of safety against overturning or other unsafe procedures.
- E. Ship spare material separately packaged and tagged as spare parts. Spare part tags shall identify type, size, material, and other related information.

PART 2 - PRODUCTS

2.01 PIPE REQUIREMENTS:

- A. Furnish pipe of materials, joint types, and sizes as indicated or specified.
- B. Pipe shall be designed to withstand all stresses resulting from external loads and internal pressures listed in the following table plus applicable allowance for surge unless otherwise specified:

Location	Nominal Pipe Size	Design Cover Depth	Live Load	Design Internal Working Pressure (PSI)	Required Pipe Material
Tank Drain	12"	45' max	H-20	25	DIP or PVC
Overflow Line	16"	40' max 4.5' min	H-20	5	DIP or PVC
Tank Combined Inlet/Outlet Line	36"	40' max 4.5' min	H-20	25	Steel

- C. Pipe Marking: All pipe and fittings shall be marked conforming to the applicable standard specification under which the pipe is manufactured and as otherwise specified.

2.02 STEEL PIPE:

- A. Design and Manufacture of Pipe:
 - 1. Pipe and fabricated fittings shall be responsibility of one main Supplier.
 - 2. Design shall conform to AWWA C200, AWWA M11, or as otherwise specified below.

SECTION 33 14 11 – WATER UTILITY TRANSMISSION PIPING: continued

3. Materials furnished shall be NSF 61 approved for use with potable water.
- 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.
 - a. Pipe size shall be nominal outside diameter for 14-inch diameter pipe and larger.
 - b. Pipe size shall be nominal inside diameter for 12-inch diameter pipe and smaller.
- C. Materials:
 1. Steel: Provide fully-killed, fine grained steel coils for spiral welded steel pipe or steel plate for straight seam welded steel pipe per AWWA C200 and as follows:
 - a. Specified Minimum Yield Strength: 42,000 psi.
 - b. Minimum Elongation in 2-inch Gauge Length: 21 percent.
 - c. Steel Quality as follows:
 - (1) Toughness:
 - (a) Charpy V-notch Acceptance Criteria: Transverse specimen orientation, full size specimens, 25 foot-pounds energy at test temperature of 30 degrees F.
 - (b) Frequency: See Paragraph Steel Toughness Testing for Thickness Equal to or Greater than 1/2 Inches
 - d. Minimum wall thickness as shown herein:

Location	Finished Inside Diameter	Minimum Thickness
Combined Inlet/Outlet Line	36"	0.188"
Altitude Valve Bypass Line	24"	0.188"
Zone 3A Bypass Line	24"	0.188"

- (1) Maximum allowable thickness variation for plate, sheet, or coil shall be 0.010 inch less than ordered thickness.
- D. Pipe shall be designed to withstand all stresses resulting from external loads and internal pressures listed in the following table plus applicable allowance for surge unless otherwise specified:
 1. External Loading:
 - a. Earth dead load cover at 125 pcf plus AASHTO H-20 live loads.
 - b. Use 100% of earth prism above the pipe.
 - c. Deflection Lag Factor 1.0
 - d. Bedding condition as indicated.
 - (1) For granular embedment material, use E' of 700 and bedding angle of 90°.

SECTION 33 14 11 – WATER UTILITY TRANSMISSION PIPING: continued

- (2) For CLSM embedment material, use E' of 2,000 and bedding angle of 90°.
 2. Allowable design stresses for steel shall be as follows:
 - a. 50% of minimum yield stress when subjected to working pressure.
 - b. 70% of minimum yield stress when subjected to working pressure plus surge.
 3. Design shall limit allowable deflection from external loads to 3% for flexible coating systems including tape coating systems and polyurethane systems (with cement mortar lining) per the recommendation of M11.
 4. Deflection lag factor shall be 1.25 for the dead load and 1.0 for live loads.
- E. Joints:
 1. Shop Welded:
 - a. Fabricate in accordance with AWWA C200 as modified herein.
 - b. Complete joint penetration (CJP) butt joints shall be used for longitudinal, girth, and spiral welds, unless otherwise indicated.
 - c. Lengths of pipe shall not be shop-joined using lap joints.
 2. Preparation of Joints for Field Welding:
 - a. Unless specifically indicated otherwise on the drawings, all joints and fittings shall be single lap welded. Double lap welds and butt welds are required at special installations.
 - b. Butt Joint Welded:
 - (1) Plain ends beveled as required by AWWA C200 and Contractor's field WPS.
 - (2) Provide protection for factory beveled pipe ends so ends are not damaged during transport.
 1. Lap Joint Welded:
 - a. Double fillet and single fillet lap joints in preparation for field welding shall be in accordance with AWWA C200.
 - b. For pipe 30 inches in diameter and larger, provide one of the following:
 - (1) Tack weld four metal tabs at equal intervals around inside circumference of bell ends to indicate location at which spigot end has reached maximum penetration into bell. Remove stops after welding of joint.
 - (2) Train field crews and provide supplies to field paint (or draw) a 3/4-inch wide white stripe (or stripes) on outside circumference of spigot end of pipe. Side of stripe furthest from pipe end shall indicate location at which spigot end has reached maximum penetration into bell. Side of stripe closest to end of pipe will indicate limit of maximum joint pull.
 - c. Double welded lap joints and butt-strap joints shall be tapped and drilled for testing in accordance with AWWA C206.
 3. Miter-End Cuts:
 - a. Lap Joints:
 - (1) As shown on Drawings.

SECTION 33 14 11 – WATER UTILITY TRANSMISSION PIPING: continued

- (2) Moderate deflections and long radius curves may be made using miter-end cuts.
 - (3) Use only with lap welded joints, unless specifically approved in writing by Engineer.
 - (4) Maximum Total Allowable Angle: lesser of manufacturer's actual limit or 5 degrees per pipe joint
 - (5) Provide miter-cut that is cold expanded square with face of miter-cut on bell ends only.
 - (6) Mitering of spigot ends will not be permitted.
- b. Welded Butt Joints:
 - (1) Maximum Total Allowable Angle: 2.5 degrees per pipe joint.
 - (2) Minimum Pipe Wall Thickness: 3/8 inch.
 - (3) Welded Butt joints shall be CJP.
- 4. Special Temperature Control Joint:
 - a. Provide a special longer bell end (Special Temperature Control Joint) at a maximum spacing in accordance with AWWA C206 and M11 to account for movement on installed pipe as a result of temperature changes.
 - b. Pipe manufacturer shall determine length required for the longer bell, or may determine whether temperature control is required based on the method of installation (e.g. weld after backfill).
 - c. Minimum Special Temperature Control Joint length is as recommended by steel pipe manufacturer and indicated in the approved steel pipe laying schedule.
- 5. Acceptable joint types for each method of installation summarized below:

Steel Pipe Joint Requirements		
Joint Type	Minimum Requirement	Acceptable Alternative
Open-cut (Restrained)	Single Lap Weld	None
Trenchless Installations	Double Lap Weld	None

- F. Flanges:
 - 1. In accordance with AWWA C207
- G. Fittings and Specials:
 - 1. Fabrication:
 - a. Shop fabricate: No field fabrication will be allowed, unless approved by Owner's Project Representative or Engineer.
 - b. Fabricate from materials or straight tested pipe to conform to AWWA C208 except where otherwise indicated or specified.
 - 2. Bends, Unless Otherwise Indicated:
 - a. Minimum Radius: 2.5 times pipe diameter or as indicated on Drawings.

SECTION 33 14 11 – WATER UTILITY TRANSMISSION PIPING: continued

- b. 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.
 - c. 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.
 - d. 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.
 - e. Complete joint penetration (CJP) welds on miter welds.
 - 3. Outlets:
 - a. 24 Inches and Smaller: Fabricate from ASTM A53/A53M, Type E or S, Grade B, standard weight steel pipe.
 - b. Larger than 24 Inches: Fabricate from ASTM A106/A106M, Grade B, standard weight pipe.
 - c. Fabricate collar or wrapper reinforcement using same steel as specified for main pipe barrel.
 - 4. Steel Butt-Weld Fittings:
 - a. 24 Inches and Smaller: In accordance with ASME B16.9 conforming to ASTM A234/A234M.
 - b. Standard weight.
 - c. Taper pipe wall at welds at 4:1 for connection to pipe of different wall thickness.
 - d. Coordinate difference in diameter convention between fittings and AWWA C200 and AWWA C208 pipe and fittings to provide complete piping system as shown.
- H. Gaskets:
 - 1. See Section 33 14 26.
- I. Test Dished Head Plugs:
 - 1. Provide pressure test plugs where required to test the installation prior to connection to tank and existing water distribution system.
 - 2. Design test plugs to withstand the internal and external loading.
 - 3. Join test plug to pipe and tie as required to sustain internal and external loading.
- J. Lining:
 - 1. Cement Mortar Lining:
 - 2. General:
 - a. Notify Engineer at least seven (7) days prior to application of lining products.
 - b. Holdback of lining from field-welded joints shall be as follows:
 - (1) For lap-welded joints, hold back lining 2 inches on weld spigot and 6 inches on weld bell, minimum, or as recommended by the pipe manufacturer, whichever is greater.
 - (2) For butt-welded joints, holdback lining from field weld 3 inches (per side) or as recommended by the pipe manufacturer, whichever is greater.

SECTION 33 14 11 – WATER UTILITY TRANSMISSION PIPING: continued

3. Shop-Applied:
 - a. Applied centrifugally in conformance with AWWA C205. Thickness shall be in accordance with AWWA C205.
 - b. Lining machine type that has been used successfully for similar work and approved by Engineer.
 - c. Maintain pipe in round condition during lining operation and thereafter by suitable bracing or strutting.
 - d. 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.
 - e. Pipe shall be left bare where field joints occur.
 - f. Ends of lining shall be left square and uniform. Feathered or uneven edges will not be permitted.
4. Field-Applied:
 - a. Materials conforming to AWWA C602.
 - b. Do not use pozzolanic material in mortar mix.
 - c. Admixtures shall contain no calcium chloride.
 - d. Water shall be of potable quality.
 - e. Wire mesh conforming to AWWA C205.
5. Liquid Epoxy Lining (outlets and connections smaller than 6"):
 - a. The interior of all outlets and connections smaller than 6" shall be painted with liquid epoxy in accordance with AWWA C210, Liquid Epoxy Coating Systems for the Interior and Exterior of Steel Water Pipes.
- K. Coating:
 1. All steel pipe for buried service, exposed interior installation, and submerged service shall be polyurethane coated per AWWA C222. See Section 09 90 05 – Steel pipe Polyurethane Coating.
 2. Color:
 - a. Finish coating shall be blue.
 3. Holdback of any coating from field-welded shall be as shown in the Drawings or as recommended by the coating manufacturer for coating system selected.
 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.
- L. Bolting Materials:
 1. All bolting materials for interior piping shall be low alloy carbon steel.
- M. Cathodic Protection:
 1. See Section 26 42 13.
- N. Marking Pipe: In addition to the marking specified in paragraph "Pipe Marking," the following information shall be on all pipe, fittings, and specials:
 1. Design pressure in feet.
 2. Point of installation on all fittings and specials.
 3. Length of any short pipe.
 4. specified hydrostatic test pressure and time requirements were met with no leakage.

SECTION 33 14 11 – WATER UTILITY TRANSMISSION PIPING: continued

- O. Welding And Fabrication Quality Control Inspection Program:
 - 1. Welding and Fabrication Quality Control Supervision Qualifications: All welding and fabrication quality control inspections shall be performed by or under the direction of a Certified Welding Inspector (CWI) with a minimum of three (3) years' experience.
- P. Stulling (Strutting):
 - 1. Materials:
 - a. Shop-Lined Pipe: Wood stulls and wedges.
 - b. Unlined Pipe: Steel or wood.
 - 2. 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.
 - 3. Install stulling in manner that will not harm lining.
- Q. Source Quality Control:
 - 1. Steel Toughness Testing for Thickness Equal to or Greater than 7/16 Inches:
 - a. Include three impact specimens; conduct test in direction transverse to final direction of the coil rolling.
 - b. Coils:
 - (1) Conduct Charpy Testing per ASTM A370 on an initial coil of each heat to establish uniformity of steel.
 - (2) Take test coupons from an initial coil of each heat at locations of outer and inner wrap of coil.
 - (3) For each coil that fails to meet acceptance criteria, conduct Charpy Testing on next two coils in that heat.
 - (4) Do not use coils that do not qualify in production of pipe.
 - c. Plate:
 - (1) Conduct Charpy Tests on each plate in accordance with ASTM A20/A20M.
 - (2) Conduct on full-size (10 mm by 10 mm) specimens from each plate in accordance with ASTM A20/A20M.
 - (3) Do not use plates that do not qualify in production of pipe.
 - d. 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.
 - e. Shop Hydrostatic Pressure Test: In accordance with AWWA C200 Section 5.2, except as follows:
 - (1) General: Unless specified otherwise, testing of pipe and fittings shall be performed before lining and coating is applied.
 - (2) Pipe: Maintain test pressure for minimum of 2 minutes and conduct thorough inspection of entire weld length of pipe. Repair or reject pipe revealing leaks or cracks.

SECTION 33 14 11 – WATER UTILITY TRANSMISSION PIPING: continued

- (3) Fittings:
 - (a) Except as otherwise specified herein, no additional shop hydrostatic test will be required on fittings fabricated from successfully hydrostatically tested straight pipe.
 - (b) Test Pressure: Design Pressure of fitting.
 - (c) Maintain test pressure for a length of time as required to perform a visual inspection of welds.
 - (d) No leakage is allowed.
 - f. Joints, Gasketed:
 - (1) Fit test minimum of 2 joints, selected by Engineer, of each pipe sized 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.
- R. Shop Nondestructive Testing:
 - 1. Welds: 100 percent visually examined by Contractor's Shop Inspector to criteria in ASME BPVC SEC VIII, Division 1.
 - 2. CJP Welds: Spot radiographically or radioscopically examine pipe in accordance with ASME BPVC SEC VIII, Div. 1, Paragraph UW-52 or 100 percent ultrasonically examine in accordance with API 5L, Annex. E. or ASME BPVC SEC VIII, Div. 1 paragraph UW-53.
 - a. Except as otherwise specified herein, no shop CJP weld nondestructive testing will be required on straight pipe which has successfully been hydrostatically tested in accordance with this Section.
 - 3. Fillet Welds: 100 percent examine using magnetic particle inspection method in accordance with ASME BPVC SEC VIII, Division 1, Appendix 6.
 - 4. Air test collars and wrappers in accordance with AWWA C206.

2.03 DUCTILE-IRON PIPE:

- A. Design and Manufacture of Pipe:
 - 1. Ductile-iron pipe shall conform to AWWA C115, C150 and C151 except as otherwise specified.
 - a. Ductile Iron Pipe must be centrifugally cast, lined, and coated in the USA.
 - 2. With laying condition Type 4 for ductile iron for load requirements tabulated herein.
 - a. Use E' of 700 and bedding angle of 90°.
 - b. 2.5% deflection limit.
 - c. Add service allowance and standard casting tolerances of AWWA C150 and AWWA C151.
 - d. Select standard pressure class thickness next above total calculated thickness.

SECTION 33 14 11 – WATER UTILITY TRANSMISSION PIPING: continued

- B. Dimensions: The minimum thickness as defined by pressure class for mechanical or push-on-type joint ductile-iron pipe shall be as follows:

Location	Nominal Pipe Size	Minimum Pressure Class
Tank Drain Line	12"	350
Tank Overflow Line	16"	250

1. Minimum thickness for ductile-iron pipe threaded for screw-on flanges shall be in accordance with AWWA C115.
 2. Pipe with grooved barrel for any type of restrained joint shall have wall thickness increased to provide a minimum wall thickness conforming to AWWA C606.
- C. Joints:
1. Mechanical and Push-On Type:
 - a. Provide mechanical or push-on-type joints for all buried pipe less than 36-inches in diameter unless otherwise specified or indicated.
 - b. Joints shall conform to AWWA C111.
 2. Flanged:
 - a. Provide flanged joints for all interior tank and interior vault and exposed exterior pipe except where otherwise specified or indicated.
 - b. Flanges shall have a pressure rating not less than that for pipe.
 - c. Flanges for pipe shall be ductile iron and conform to the applicable provisions of AWWA C110 and C115 and shall be drilled ANSI B16.1 Class 125.
 - d. Contractor is responsible for matching all flange drilling patterns.
 3. Sleeved or Coupled:
 - a. Provide for sleeves or couplings where indicated.
 - b. Furnish pipe ends suitable for receiving style of sleeve or coupling indicated or specified.
 - c. Provide anchored couplings where restraint is required to withstand specified operating or hydrostatic test pressure and where indicated.
 4. Restrained:
 - a. All pipe and fittings shall be fully restrained.
 - b. Furnish for all fittings and where joint restraint is required to offset internal pipeline forces as indicated on the drawings.
 - c. Provide restrained joints of following approved types:
 - (1) Restrained mechanical joint.
 - (2) Restrained push-on joint.
 - (3) Anchored couplings.
- D. Fittings:
1. Fittings shall conform to AWWA C110 or C153 and shall have a pressure rating of not less than that specified for pipe.
 2. Fittings shall be ductile iron.
 3. Fittings for pipe with mechanical joint shall have mechanical joints.

SECTION 33 14 11 – WATER UTILITY TRANSMISSION PIPING: continued

4. Fittings for pipe with push-on joints shall be mechanical joint or push-on-type joint.
 5. Include all specials, taps, plugs, flanges, and wall fittings as required.
 - E. Gaskets and bolting materials:
 1. Provide all gaskets, bolts, lubricant, and other accessories required to install pipe, fittings, and specials complete and ready for service.
 2. For gaskets, see SECTION 33 14 26.
 3. Gaskets for ductile iron flanged pipe and fittings 12 inches and smaller shall have "nominal" inside diameters, not the larger inside diameters per ANSI B16.21.
 4. Gaskets and bolts for other than flanged joints shall be as otherwise specified for pipe and pipe joints.
 5. All bolting materials for interior piping shall be Type 316 stainless steel conforming to ANSI/ASME B18.2.1 and ANSI/ASME B18.2.2.
 6. Plastic insulating sleeve/washers shall be utilized to isolate dissimilar bolt and flange metals where required.
 - F. Lining:
 1. Pipe:
 - a. All pipe shall be cement-mortar lined in accordance with AWWA C104.
 2. Fittings:
 - a. All fittings shall be fusion bonded epoxy lined per AWWA C116.
 - G. Coating:
 1. All ductile iron pipe and fittings for interior exposed and/or submerged installation shall be fusion bonded epoxy lined and coated to AWWA C116 and NSF-61 specifications. Finish coating will be blue.
 2. All fittings shall be fusion bonded epoxy coated per AWWA C116.
 3. Fully buried ductile iron pipe shall be coated with manufacturer's standard bituminous paint coating.
 4. Flange faces shall be coated in accordance with AWWA C115.
 - H. Protective Sleeve (Polyethylene Wrap):
 1. All buried iron pipe and fittings shall be wrapped with polyethylene sleeve in accordance with AWWA C105.
 2. Material as specified.
 - I. Corrosion Protection:
 1. Corrosion Control Systems: As specified.
- 2.04 PVC PIPE:
- A. Design and Manufacture of Pipe:
 1. Materials shall conform to AWWA C900.
 2. Gaskets shall conform to ASTM F477 and be synthetic rubber.
 - B. Design of Pipe: Design shall conform to AWWA C900 and as specified:
 1. Internal Loading:
 - a. Internal pressure specified plus allowance for surge pressure conforming to AWWA C900
 - b. Hydrostatic test pressure as specified.
 2. External Loading:
 - a. Earth dead load cover at 125 pcf plus AASHTO H-20 live loads

SECTION 33 14 11 – WATER UTILITY TRANSMISSION PIPING: continued

- b. 5% deflection limit
- c. Bedding condition as indicated.
- d. Use E' of 700 and bedding angle of 90°.
- 3. Dimensions: The minimum pressure class for PVC pipe shall be as follows:

Location	Nominal Pipe Size	Minimum Pressure Class
Tank Drain Line	12"	DR-18
Tank Overflow Line	16"	DR-18

- C. Diameters: PVC pressure pipe shall have Cast-Iron-Pipe-Equivalent (CI) outside diameters.
- D. Joints: Pipe shall be furnished with integral bell-type pipe ends designed for joint assembly using elastomeric gaskets.
 - 1. Restrained:
 - a. All pipe and fittings shall be fully restrained.
 - b. See later in this specification for joint restraint devices.
- E. Fittings:
 - 1. Fittings shall conform to AWWA C110 or C153 and be ductile iron and have a pressure rating of not less than that specified for pipe.
 - 2. Fittings shall have mechanical joints.
 - 3. All buried ductile iron fittings shall be fusion bonded epoxy lined and coated per AWWA C116.
- F. Marking: Identification markings on pipe shall conform to AWWA C900.
- G. Color:
 - 1. The color for PVC overflow pipe shall indicate the contents within the pipe and shall be as follows:

Location	Contents	Pipe Color
All PVC installations	Overflow Potable Water	Blue

- H. All PVC pipe shall be installed with tracing wire taped securely to the top of the pipe and shall extend along the entire length of the pipe installed. The tracing wire shall be a minimum 14 AWG direct bury solid copper wire. The tracing wire shall be tested prior to and as a condition of construction acceptance.

2.05 PIPE LABELS:

- 1. Provide preprinted, color-coded labels with lettering indicating service and arrows showing flow direction.
- 2. Label colors shall conform to ASME A13.1.
- 3. Labels shall be one of the following types:
 - a. Printed plastic with contact-type, permanent-adhesive backing.

SECTION 33 14 11 – WATER UTILITY TRANSMISSION PIPING: continued

- b. Pretensioned labels with precoiled, semirigid plastic formed to cover full circumference of pipe and to attached to piping without fasteners or adhesive.

2.06 GASKETS AND BOLTING MATERIALS:

- A. See section 33 14 26.

2.07 SLEEVES AND COUPLINGS:

- A. See section 33 14 26.

2.08 MECHANICAL JOINT WEDGE ACTION RETAINER GLANDS:

- A. See section 33 14 26.

2.09 TRACING WIRE:

- A. See section 33 05 97.

2.10 WARNING TAPE:

- A. See section 33 05 97.

2.11 POLYETHYLENE ENCASEMENT:

- A. See section 33 14 26.

PART 3 - EXECUTION

3.01 INSTALLATION:

- A. General:
 - 1. Use equipment, methods, and materials ensuring installation to lines and grades shown on the Drawings.
 - 2. Inspect pipe and fittings before installation. Reject defective, damaged, or unsound pipe and fittings and remove them from the site. Clean ends thoroughly, remove foreign matter and dirt from inside.
 - 3. Maintain within tolerances specified or acceptable laying schedule.
 - a. Alignment: +/- 1 inch per 100 feet in open cut or tunnel.
 - b. Grade: +/-1 inch per 100 feet.
 - 4. Do not lay on blocks unless pipe is to receive total concrete encasement.
 - 5. Accomplish horizontal and vertical curve alignments with bends, bevels, and joint deflections.
 - a. Limit joint deflection with ductile-iron pipe to conform to AWWA C600 and with PVC pipe to conform to AWWA C605. Deflection may, with approval, exceed standard deflections by using machined bells.
 - b. Limit joint deflection in DIP pipe to:
 - (1) 5% with mechanical joint.
 - (2) 3% with bell and spigot-rubber gasket joint.
 - c. Limit joint deflection in PVC pipe to:
 - (1) 3% with mechanical joint.
 - (2) 3% with fused joints.

SECTION 33 14 11 – WATER UTILITY TRANSMISSION PIPING: continued

- (3) 1% with bell and spigot-rubber gasket joint.
- d. Limit joint deflection in Steel pipe to:
 - (1) Maximum Allowable Angle: Manufacturer's recommendation.
 - (2) Maximum Allowable Gap: 1/8 inch between bell and spigot at weld location.
- e. Use short specials preceding curves as required.
- 6. Obtain acceptance of method proposed for transfer of line and grade from control to the Work.
- B. Install pipe of size, materials, strength class, and joint type with embedment indicated for plan location.
- C. Insofar as possible, commence laying at downstream end of line and install pipe with bell ends in direction of laying. Obtain Engineer approval for deviations therefrom.
- D. Clean interior of all pipe, fittings, and joints prior to installation. Exclude entrance of foreign matter during installation and at discontinuance of installation.
 - 1. Close open ends of pipe with snug-fitting closures.
 - 2. Do not let water fill trench. Include provisions to prevent flotation should water control measures prove inadequate.
 - 3. Remove water, sand, mud, and other undesirable materials from trench before removal of end cap.
- E. Brace or anchor as required to prevent displacement after establishing final position.
- F. Perform only when weather and trench conditions are suitable. Do not lay in water.
- G. Observe extra precaution when hazardous atmospheres might be encountered.
- H. Personnel Protection: Contractor is also responsible for furnishing all personal protection equipment, hazard communication and worker training necessary for the necessary pipe installation including coatings and linings, chlorination, and other materials.
- I. Confined Space Entry: CONTRACTOR shall satisfy OSHA confined space entry requirements for their personnel, and the ENGINEER and OWNER to enter the pipe and other confined spaces. This shall include furnishing and operating air quality testing equipment, furnishing and operating air movement equipment, and furnishing and operating other equipment and manpower to satisfy confined space entry requirements.
- J. Necessary firefighting equipment and fire extinguishers shall be provided for all crews. During dry summer months when fire danger is high, where cutting and welding or other field operations are being conducted that cause sparks or ignition sources, the Contractor shall provide a water truck or other fire containment equipment at that work area.
- K. Ignition sources, the Contractor shall provide a water truck or other fire containment equipment at that work area.

3.02 INSTALLATION OF STEEL PIPE:

SECTION 33 14 11 – WATER UTILITY TRANSMISSION PIPING: continued

- A. In addition to the installation requirements above, the following shall be followed:
1. 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.
 2. 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.
 3. Control of Temperature Stresses:
 - a. In accordance with AWWA M11, AWWA C206, approved Temperature Stress Control Plan submittal, and this specification.
 - b. To control temperature stresses, shade un-backfilled 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.
 - c. Locate special temperature control (thermal expansion) joints at maximum intervals recommended by the steel pipe manufacturer and not exceeding recommendations in AWWA M11 (latest edition) and AWWA C206 (latest edition) considering type of installation (for instance weld after backfill vs. open trench welding).
 - d. Install special temperature control joints as indicated on Shop Drawings.
 - e. 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. Hand held 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.
 - f. Temperature Control Requirements:
 - (1) 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.
 - (2) Place pipe backfill from a single heading starting at one special temperature control joint and proceed toward next special temperature control joint.

SECTION 33 14 11 – WATER UTILITY TRANSMISSION PIPING: continued

- (3) 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.
 - (4) Prior to welding special temperature control joints, pipeline extending 300 feet (or as recommended by steel manufacturer) each direction from joint shall be maintained at or below 85 degrees F. Additionally, pipeline extending 300 feet (or as recommended by steel manufacturer) 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.
- 4. 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.
 - e. Remove surface rust prior to performing the weld.
- 5. 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.
 - c. All damaged linings and coatings shall be repaired prior to backfill.
- 6. Coating of Field-Welded Joints:
 - a. Provide coating repair as required for coating system specified and selected.
 - b. Coat as recommended by the steel pipe manufacturer with the selected coating system provided.
 - c. Weld after backfill (WAB) using heat shrink sleeves:
 - (1) Welding from the inside of the pipe after backfilling shall only

SECTION 33 14 11 – WATER UTILITY TRANSMISSION PIPING: continued

- be used on single-lap welded joints.
 - (2) Apply heat shrink sleeves prior to internal welding of pipe using approved procedure compatible with coating system.
 - (3) Install heat shrink joint system in accordance with manufacturer's recommendation
 - (a) Install heat resistant underlay, if required by manufacturer, as shown in Drawings
 - (4) Provide services of technical representative or manufacturer available on site at beginning of pipe laying operations.
 - (a) Representative to advise contractor regarding installation, repairs, and general construction methods.
 - (b) Installations using this method shall be quality controlled by verification.
 - 1) At least three (3) randomly selected joints within the first twenty (2) joints shall be buried, welded, and then subsequently excavated/exposed to verify that the pipe coating system has performed as specified. This process shall be repeated should the field welding procedure change.
 - 2) The heat shrink sleeve representative and Owner's Project Representative shall witness excavation to verify that the coating system is performing appropriately. The heat shrink representative shall be coordinated and paid for by the Contractor at no additional cost to the Owner.
7. 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 pipe embedment and backfill have been placed, begin cleaning and lining operation with approval of Owner's Project Representative.
 - (a) Access for cleaning and lining operations shall be at pipe access manways 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

SECTION 33 14 11 – WATER UTILITY TRANSMISSION PIPING: continued

already been lined.

(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.

8. 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, latest edition.

3.03 DELIVERY AND OFF-LOADING:

- A. All pipe shall be bundled or packaged in such a manner as to provide adequate protection of the coating system and ends during transportation to the site. Any pipe damaged in shipment shall be replaced as directed by the Owner's Project Representative, Owner, or Engineer.
- B. Each pipe shipment should be inspected prior to unloading to see if the load has shifted or otherwise been damaged. Notify Owner or Engineer immediately if more than immaterial damage is found. Each pipe shipment should be checked for quantity and proper pipe size, color, and type.
- C. Pipe should be loaded, off-loaded, and otherwise handled in accordance with AWWA M11, M23, M41, and all of the pipe supplier's guidelines shall be followed.
- D. Off-loading devices such as chains, wire rope, chokers, or other pipe handling implements that may scratch, nick, cut, or gouge the pipe are strictly prohibited.
- E. During removal and handling, be sure that the pipe does not strike anything. Significant impact could cause damage, particularly during cold weather.
- F. If appropriate unloading equipment is not available, pipe may be unloaded by removing individual pieces. Care should be taken to insure that pipe is not dropped or damaged.
- G. Pipe should be carefully lowered, not dropped, from trucks.

3.04 HANDLING AND STORAGE

- A. Any length of pipe showing a crack or which has received a blow that may have caused an incident fracture, even though no such fracture can be seen, shall be marked as rejected and removed at once from the work. Damaged areas, or possible areas of damage may be removed by cutting out and removing the suspected incident fracture area. Limits of the acceptable length of pipe shall be determined by the Owner or Engineer.
- B. Any scratch or gouge in non-metallic pipe greater than 10% of the wall thickness will be considered significant and can be rejected unless determined acceptable by the Owner or Engineer.
- C. Pipe lengths should be stored and placed on level ground. Pipe should be stored at the job site in the unit packaging provided by the manufacturer. Caution should be exercised to avoid compression, damage, or deformation to the ends of the pipe. The interior of the pipe, as well as all end surfaces, should be kept free from dirt and foreign matter.

SECTION 33 14 11 – WATER UTILITY TRANSMISSION PIPING: continued

- D. Pipe shall be handled and supported with the use of woven fiber pipe slings or approved equal. Care shall be exercised when handling the pipe to not cut, gouge, scratch or otherwise abrade the piping in any way.
- E. ge, scratch or otherwise abrade the piping in any way.
- F. If pipe is to be stored for periods of 1 year or longer, the pipe should be shaded or otherwise shielded from direct sunlight. Covering of the pipe which allows for temperature build-up is strictly prohibited. Pipe should be covered with an opaque material while permitting adequate air circulation above and around the pipe as required to prevent excess heat accumulation.
- G. Pipe shall be stored and stacked per the pipe supplier's guidelines.
- H. Steel Pipe:
 - 1. Shop coated materials shall be handled, transported, stored, and shipped in a manner that will prevent damage to the coating and lining. Adequate bracing (stulls) shall be provided. Coating or lining damaged in handling or other operations shall be repaired to the approval of and at no additional cost to the Owner. Damage to the coating shall be repaired in accordance with these Specifications.
 - 2. Pipe stored along the trench side shall be suitably supported off the ground to avoid damage to the coating. At all times during construction of the pipeline, the Contractor shall use every precaution to prevent damage to protective coating on the pipe.
 - 3. No metal tools or heavy objects shall be permitted to come into contact unnecessarily with the finished coating. Workmen shall not be permitted to walk upon the coating except when absolutely necessary.
 - 4. Any damage to the pipe or the protective coating from any cause during the installation of the pipeline and before final acceptance shall be repaired in accordance with these Specifications and at no additional cost to the Owner.
 - 5. Pipe shall be hoisted from the trench side to the trench by means of wide belt slings. Pick all pipe 40-feet or longer with a minimum of two pick points. Utilize belts minimum ten-inch (10") or wider in accordance with pipe manufacturer's recommendations depending on pipe diameter and weight.
 - 6. Metal chains, cables, tongs or other equipment likely to cause damage to the coating shall not be permitted. The Contractor shall allow inspection of the coating on the underside of the pipe while the pipe is suspended from the slings. Coated pipe shall be handled with nylon sling choker belts or equivalent. Caliper clamps shall not be used. Sufficient shoring of dunnage, padding and bonding shall be used when stacking and shipping pipe to adequately protect the pipe and its coating. Hoisting multiple pieces of pipe with an overall length greater than 50 feet shall not be permitted without prior written approval from the Pipe Manufacturer and Engineer.
 - 7. nded from the slings. Coated pipe shall be handled with nylon sling choker belts or equivalent. Caliper clamps shall not be used. Sufficient shoring of dunnage, padding and bonding shall be used when stacking and shipping pipe to adequately protect the pipe and its coating. Hoisting multiple pieces of pipe with an overall length greater than 50 feet shall not be permitted without prior written approval from the Pipe Manufacturer and Engineer.

SECTION 33 14 11 – WATER UTILITY TRANSMISSION PIPING: continued

8. pieces of pipe with an overall length greater than 50 feet shall not be permitted without prior written approval from the Pipe Manufacturer and Engineer.
 9. Welding of multiple pieces of pipe on the bank with an overall length greater than 50 feet prior to lowering into the trench shall not be permitted without prior written approval from the Pipe Manufacturer and Engineer.
- 3.05 JOINTING:
- A. General Requirements:
 1. Locate joint to provide for differential movement at changes in type of pipe embedment, impervious trench checks, and structures.
 - a. Not more than 36 inches from structure wall, or
 - b. Support pipe from wall to first joint with concrete cradle structurally continuous with base slab or footing.
 - c. As indicated.
 2. Perform conforming to manufacturer's recommendations.
 3. Clean and lubricate all joint and gasket surfaces with lubricant recommended.
 4. Store gasket material so as to maintain temperatures within 50° F and 100° F range up to and through pipe installation in accordance with the gasket manufacturer's recommendations. In cold weather pre-heat gasket as required and in hot weather shade or cool as recommended by gasket manufacturer so as to aid in gasket conforming to joint type.
 5. Relieve tension on gasket during joint assembly in accordance with the gasket manufacturer's recommendations.
 6. Do not over or under-engage pipe joints. Provide blocking or pipe engagement markings so as to ensure that pipe and fittings are seated correctly per the pipe or fitting.
 7. Utilize feeler gauges as recommended by pipe manufacturer to confirm correct engagement.
 8. Use methods and equipment capable of fully seating or making up joints without damage.
 9. Check joint opening and deflection for specification limits.
 - B. Special Provisions for Jointing Ductile-Iron Pipe:
 1. Conform to AWWA C600.
 2. Visually examine while suspended and before lowering into trench.
 - a. Paint bell, spigot, or other suspected portions with turpentine and dust with cement to check for cracks invisible to the eye.
 - b. Remove turpentine and cement by washing when test is satisfactorily completed.
 3. Never exceed the pipe manufacturer's recommendations regarding maximum allowable joint deflection or minimum/maximum engagement.
 - C. Field Welding And Nondestructive Testing of Steel Pipe Welds:
 1. Welding Procedures Specification (WPS).
 - a. All welds shall be completed with a minimum of two passes or more.
 - b. The CONTRACTOR shall submit all field welding procedures required for the installation of welded steel pipe, specials and fittings. Welding

SECTION 33 14 11 – WATER UTILITY TRANSMISSION PIPING: continued

- procedure specifications and supporting welding procedure qualification records (for both manual and automated welding) shall be submitted to the ENGINEER for review prior to any welding. Welding documentation shall be submitted on appropriate forms found in the appendix to ASME BPV Code Section IX, Part A as indicated in AWWA C200.
- c. rt A as indicated in AWWA C200.
 - d. Alternately, Appendix E to ASNI/AWS d1.1 (most current edition), which contains sample welding forms, may be used, or forms A.7.1 and A.7.2 in Appendix A to AWS B2.1 (most current edition), "Standard for Welding Procedure and Performance Qualification" may be substituted.
2. Welder/Welding Operator Performance Qualifications (WPQ): The CONTRACTOR shall submit all field welder or welding operator performance qualification records to the ENGINEER for review prior to any welding. Welding documentation shall be submitted on the appropriate form found in the appendix to the referenced welding code indicated above.
 3. submitted on the appropriate form found in the appendix to the referenced welding code indicated above.
 4. Nondestructive Examination Personnel: The CONTRACTOR shall retain a certified testing organization employing experienced nondestructive testing personnel. The testing organization shall be independent from CONTRACTOR and not an affiliate company. The testing organization shall perform the magnetic particle, liquid penetrant, and other testing methods as specified herein. The testing organization shall be certified in accordance with the current American Society of Nondestructive Testing (4153 Arlingate
 5. I be certified in accordance with the current American Society of Nondestructive Testing (4153 Arlingate Plaza, Columbus, OH 43228) recommended Practice N. SNT-TC-1A and all supplements, NDT Level II. The CONTRACTOR shall submit the credentials of the testing organization to the ENGINEER for review prior to any field welding.
 6. Plaza, Columbus, OH 43228) recommended Practice N. SNT-TC-1A and all supplements, NDT Level II. The CONTRACTOR shall submit the credentials of the testing organization to the ENGINEER for review prior to any field welding.
 7. to the ENGINEER for review prior to any field welding.
 8. Nondestructive Testing Requirements (NDT): The CONTRACTOR shall submit nondestructive testing procedure specifications to the ENGINEER prior to any field welding. All nondestructive testing shall be performed in accordance with Chapter 6 of ANSI/AWS D1.1 (most current edition). The standards of acceptance for dye penetrant, magnetic particle and visual inspection methods shall be in accordance with ANSI/AWS D1.1 (most current edition), Visual Inspection, Paragraph 10.17.1. Nondestructive testing procedure specifications shall be prepared for the following categories:
 9. tion, Paragraph 10.17.1. Nondestructive testing procedure specifications shall be prepared for the following categories:
 10. re specifications shall be prepared for the following categories:
 - a. Fillet and Butt Welds: 100 percent examine using either dye penetrant or magnetic particle inspection methods.

SECTION 33 14 11 – WATER UTILITY TRANSMISSION PIPING: continued

- b. All Welds: In addition, all welds shall be visually inspected.
- c. II Visual Weld Inspections shall be performed by a current/non-expired CWI. All CWI's shall be certified welding inspectors in accordance with the provisions of AWS QC1.
- D. Special Provisions for Jointing Steel Pressure Pipe:
 - 1. Conform to AWWA M11.
 - 2. Welding:
 - a. Weld pipe and fittings to conform to AWWA C206 and AWS D1.1.
 - b. Welding shall be performed by certified welders as determined in AWS D1.1. The Contractor shall be responsible for protecting all welding materials and welded products from adverse weather in order to obtain the specified final product.
 - c. Completed field welds shall be 100 percent examined using magnetic particle methods.
 - (1) Testing of welds shall be accomplished in the presence of the Engineer.
 - d. An 18-inch wide strip of heat resistant material shall be draped over the top half of the pipe on each side of the coating and holdback during welding to avoid damage to the coating by hot weld splatter. No welding ground shall be attached to a coated portion of the pipe.
 - e. All welds that are defective shall be repaired by the Contractor to meet the requirements of sections 5 and 6 of AWWA C206 at no additional cost to the Owner.
 - f. Defects in welds or defective welds shall be removed, and that section of the joint shall then be re-welded. Only sufficient removal of defective material that is necessary to correct the defect is required. After the repair is made, the joint shall be checked by repeating the original test procedure.
 - g. Welds deficient in size shall be repaired by adding weld metal.
 - 3. Check for holidays in coating and make repairs as required per Division 09.
 - 4. Grout inside joints of steel pipe and fittings mortar lined conforming to AWWA C205.
 - a. All joints shall be assembled to the proper engagement depth as recommended by the pipe manufacturer so as to leave a sufficient space on the inside of the pipe to allow proper pointing of the internal joint with cement mortar. Typically a minimum of ¼-inch to allow sufficient room for joint grout material to be placed to the full thickness of the mortar lining.
 - b. Apply epoxy bonding agent to inside of welded joints or areas that are wider than 3-inches.
 - 5. Provide external coatings to buried exterior connections, special sections, fittings, couplings, joints and bare pipe in accordance with SECTION 09 90 05.
 - 6. Never exceed the pipe manufacturer's recommendations regarding maximum allowable joint deflection or minimum/maximum engagement.
 - 7. After backfill and compaction, inspect a cement mortar lining and conduct testing of pipe roundness (deflection) in accordance with the pipe

SECTION 33 14 11 – WATER UTILITY TRANSMISSION PIPING: continued

manufacturer's recommendations. Repair as required to meet project specifications.

3.06 ELECTRICAL BONDING AND INSULATION:

- A. Electrically bond adjacent lengths of pipe and fittings as indicated.
- B. Use materials specified in SECTION 26 42 13 applied to conform to manufacturer's instructions.
- C. Install insulated joints of dielectric materials.
 - 1. Where indicated – first flange after connection to PCCP.
 - 2. Between dissimilar materials which could cause galvanic action.
 - 3. Conform to manufacturer's instructions.

3.07 CUTTING:

- A. Cut in neat manner without damage to pipe.
- B. Observe Specifications regarding joint locations.
- C. Cut cast-iron, ductile-iron, and steel pipe with carborundum saw or other acceptable method per manufacturer's instructions.
 - 1. Smooth cut by power grinding to remove burrs and sharp edges.
 - 2. Repair lining as required and approved.

3.08 CLOSURE PIECES:

- A. Connect two segments of pipeline or a pipeline segment and existing structure with short sections of pipe fabricated for the purpose.
- B. Observe Specifications regarding location of joints, type of joints, and pipe materials and strength classifications.
- C. May be accomplished with sleeve coupling:
 - 1. Of length such that gaskets are not less than 3 inches from pipe ends.
 - 2. Wrap exterior of buried steel couplings with polyethylene encasement conforming to AWWA C105.
 - 3. Include spacer ring identical to pipe end such that clear space in closure does not exceed ¼-inch.

3.09 TEMPORARY PLUGS:

- A. Furnish and install temporary plugs at each end of Work for removal by others where indicated on the Construction Drawings.
- B. Remove from pipe laid under adjacent contract in order to complete pipe connection when connecting to existing stub out or fitting..
- C. Plugs:
 - 1. Secured in place in a manner to facilitate removal when future work is required to connect to pipe.

3.10 CONNECTION TO EXISTING SYSTEM:

- A. At locations where connections to existing waterlines are to be installed, the Contractor shall locate the existing lines both vertically and horizontally and verify their exact size and material in advance of the time scheduled for making the connections.

SECTION 33 14 11 – WATER UTILITY TRANSMISSION PIPING: continued

- B. Prior to connecting to existing water mains, the Contractor shall measure the existing pipe for 'roundness'. If the pipe is determined to be 'out of round', Contractor to coordinate construction with Engineer before connecting.
- C. Prior to connecting to existing piping, the Contractor shall have all personnel, materials, and equipment ready to connect the fitting to the existing pipe system, so as to keep the shutoff time to a minimum. As soon as possible after making the connections, the Contractor shall flush the connection as needed so as to prevent debris from entering pump station. The Contractor shall take every precaution necessary to prevent dirt or debris from entering the pipe system.
- D. Flush the connection as needed so as to prevent debris from entering pump station. The Contractor shall take every precaution necessary to prevent dirt or debris from entering the pipe system.
- E. Connections to the existing water system shall be completed in a neat and workmanlike manner. The Owner shall be notified at least seventy two (72) hours in advance and be present at all times during the Construction of the connection. The connection is subject to approval by the Owner or Resident Inspector. Water mains and appurtenances must be completely installed, flushed, disinfected, and satisfactory bacteriological samples results received prior to a permanent connection being made to the active distribution system.
- F. The City does not guarantee the water tightness of its valves on existing facilities. If existing valves leak, the Contractor must use methods at his own disposal, to dewater the trench and complete any required testing or disinfection of the waterline.
- G. All connections shall be valved to separate new construction from the existing system. Valves shall be kept closed until acceptance of the new system.

3.11 FIELD WELD 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

SECTION 33 14 11 – WATER UTILITY TRANSMISSION PIPING: continued

- 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 Owner's Project Representative.
 - 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: Engineer 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.
- 3.12 FIELD TESTING:
- A. Contractor shall submit testing plan for water pipeline to Owner and Engineer for approval.
 - 1. Flushing, hydrostatic testing, and tie-in plan shall be subject to Owner and Engineer approval and shall be submitted at least 48 hours in advance of testing.
 - 2. Testing and flushing discharge shall be in conformance with all local and State requirements.
 - B. Acceptance Tests for Pressure Pipelines:
 - 1. Perform disinfection process and high chlorine testing
 - 2. Perform hydrostatic pressure and leakage testing
 - 3. Perform flushing and pass bacteriological and turbidity "clear water" testing.
 - C. Perform after backfilling.
 - D. Test separately in segments between sectionalizing valves, between a sectionalizing valve and a test plug, or between test plugs.
 - 1. Select test segments such that adjustable seated valves are isolated for individual checking.
 - 2. Contractor shall furnish and install test plugs.
 - a. Including all anchors, braces, and other devices to withstand hydrostatic pressure on plugs.
 - b. Be responsible for any damage to public or private property caused by failure of plugs.

SECTION 33 14 11 – WATER UTILITY TRANSMISSION PIPING: continued

- E. Limit fill rate of line to available venting capacity. Fill rate shall be regulated to limit velocity in lines when flowing full to not more than 0.25 fps.
- F. Owner shall make water for testing available to Contractor at nearest source.

3.13 DISINFECTION OF WATERLINES:

- A. Disinfection of Pipelines for Conveying Potable Water:
 - 1. Contractor shall provide all equipment and materials and perform conforming to AWWA C651.
 - a. As modified herein.
 - b. At no additional cost to Owner
 - c. Include preliminary flushing, chlorination, and high chlorine slug flushing.
 - 2. Obtain approval of materials and acceptance of methods proposed for use.
 - 3. May be conducted in conjunction with acceptance tests.
 - 4. Owner will provide sampling and laboratory testing.
 - 5. At minimum initial dosage of 25 mg/L (ppm) in all portions of the line.
 - a. Allow to stand for a minimum of 24 hours.
 - b. Minimum residual after required contact time shall be at least 5 mg/L (ppm) at all tested locations.
 - 6. Flush pipeline before use for potable water supply purposes. Dispose of final flushing water without damage to public or private property.
 - 7. Repeat disinfection procedure should initial treatment fail to yield satisfactory results.
 - a. At no additional cost to Owner.
 - b. Owner will provide water under terms stipulated for acceptance tests.

3.14 HYDROSTATIC PRESSURE AND LEAKAGE TEST:

- A. 100% of the newly installed waterlines shall be hydrostatically tested in accordance with the recommendations of AWWA M11, Chapter 12, AWWA M23, and AWWA M41.
 - a. As modified herein.
 - b. At no additional cost to Owner.
- B. General:
 - 1. Notify Engineer in writing seven (7) days prior to testing. Perform testing in presence of Owner's Project Representative.
 - 2. Test 100% of newly installed pipelines.
 - 3. Using clear, clean, oil free, and alkali free water as test medium, pipes shall successfully pass a leakage test prior to acceptance.
 - a. Pressure testing with air as a medium is not acceptable.
 - 4. Contractor shall furnish all 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.
 - 5. Isolate new pipelines that are connected to existing pipelines.
 - 6. Isolate separate waterline test segments from other test segments per the test pressure requirements detailed in this specification

SECTION 33 14 11 – WATER UTILITY TRANSMISSION PIPING: continued

- section.
7. Contractor is responsible for providing valving, bulkheads, and/or plugs as required to separate test segments.
 8. Contractor shall provide an over-pressurization valve (pressure safety valve) near the test pump correctly calibrated to open and expel water in the event of over pressurization.
 9. Conduct field hydrostatic test on buried piping after trench has been completely backfilled and compacted. Testing may, as approved by Engineer, be done prior to placement of asphaltic concrete or roadway structural section.
 10. 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.
 11. 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 valves or through corporation stop installed at high points and other strategic points.
 3. Test Pressure:
 - a. Hydrostatic test pressures shall be per the table herein.
 - b. Gage pressure (psi) at point of application must be calculated based upon the vertical elevation of the test equipment.
 - c. Over pressurization device (pressure safety valve) must be included in the test section and calibrated to release water safely to the atmosphere at pressures greater than 15 psi over the calculated test pressure at the pressure safety valve location.
 - d. It is NOT acceptable to test the pipeline in alternative segments or at pressures greater than or less than those indicated. This may result in internal pressures above those used for the pipeline design.

SECTION 33 14 11 – WATER UTILITY TRANSMISSION PIPING: continued

Location	Nominal Pipe Size	Test Hydraulic Pressure (psi)	Notes	Required Pipe Material
Tank Drain	12"	50	Coordinate test locations and respective test pressures with Engineer	DIP or PVC
Overflow Line	16"	5		DIP or PVC
Tank Combined Inlet/Outlet Line	36"	50		Steel

* Coordinate test locations and respective test pressures with Engineer

4. Maintain hydrostatic test pressure continuously for 2 hours minimum. Maintain pressure throughout test +/- 1 psi of required test pressure.
 5. Allowable Make-up Water:
 - a. Leakage test shall be conducted concurrently with the pressure test on push-on gasketed waterlines.
 - (1) Acceptable when leakage does not exceed that determined by the following formula:

$$L = \frac{S \cdot D \cdot \sqrt{P}}{148,000}$$

L = Allowable Leakage in gallons per hour
 S = Length of pipe tested, in feet
 D = Nominal diameter of pipe, in inches
 P = Average test pressure during the hydrostatic test, in PSI
 - (2) When testing against existing closed valves, an additional leakage per closed valve of 0.0078 gal/hr/in of nominal valve size shall be allowed.
 - b. For pipe with fully welded joints, no make-up water is allowed.
- 3.15 FLUSHING:
- A. The entire line shall be flushed after the specified disinfection contact time, and after passing the disinfection test.
 1. The entire line, including bypass lines, and outlets/dead end mains shall be flushed.
 - B. Such flushing shall continue until the water is clear and meets the chlorine content of the existing line.

SECTION 33 14 11 – WATER UTILITY TRANSMISSION PIPING: continued

- C. Minimum preliminary flushing rates to produce 2.5 fps velocity in main shall be as follows:

Pipe Size (in)	Flow Rate (gpm)	Hydrant Outlets	
		No. of 2-1/2- inch	No. of 4-1/2- inch
12	885	1	-
36	7,930	8	4

- D. Valve hydrant outlet to control flow. With a 40 psi pressure in the main with the hydrant flowing to atmosphere, a 2-1/2-inch hydrant outlet will discharge approximately 1,000 gpm and a 4-1/2-inch hydrant outlet will discharge approximately 2,500 gpm.
- E. Dispose of preliminary flushing water without damage to public or private property.
1. The discharge of flushed water shall be accomplished such that no erosion will occur and with no harm to fish, animals, or plants. Procedures for discharge will be subject to the review by the Owner and Engineer.
 2. Water Discharge to the Environment:
 - a. Water Quality:
 - (1) Contractor is responsible for meeting the requirement of the State of Colorado Hydrostatic Discharge Water Permit and Dewatering Permit.
 - (2) Discharge water so that no damage will be done to the environment.
 - (3) Contractor shall adjust the water pH and chlorine levels to conform to permit discharge requirements.
 - (a) This may include the use of chemical and chemical delivery systems as required to meet discharge permit limits.
 - (b) It's common on steel and ductile waterline projects that discharge test water has a low pH. This is due to the test water being in contact with the cement mortar pipe lining system. Low pH water must be adjusted to a more neutral level before discharging to the environment.

3.16 BACTERIOLOGICAL AND TURBIDITY TESTING (CLEARWATER TESTING):

- A. Before placing into service, water from new tank and pipeline must successfully pass a bacteriological and turbidity test in accordance with the requirements of the Owner before the project is placed in service.
1. Owner will provide sampling and laboratory testing.
 - a. A minimum 24 hours is required to receive bacteriological test results and may take as long as 72 hours.
 2. When unsatisfactory results are obtained from bacteriological tests, the Owner may direct the contractor to rechlorinate the main.
 - a. When rechlorination is deemed necessary, it will be done by the contractor, at his expense.

SECTION 33 14 11 – WATER UTILITY TRANSMISSION PIPING: continued

- b. After rechlorination, the bacteriological test shall be performed again and the procedure repeated until the test passes.
- 3. Repeat pipeline acceptance testing as necessary.
 - a. Until satisfactory performance of test.

3.17 FIELD PROTECTIVE COATING:

- A. Specified in SECTION 09 90 00.

END OF SECTION 33 14 11

SECTION 33 14 26 - WATERLINE ACCESSORIES

PART 1 - GENERAL

1.01 SUMMARY:

- A. This Section includes waterline accessories and appurtenances.
- B. Related Work Specified Elsewhere:
 - 1. Protective Coatings: SECTION 09 90 00.
 - 2. Cathodic Protection: SECTION 26 42 13.
 - 3. Welded Steel Pipe and Fittings: SECTION 33 05 01.01.
 - 4. Utility Structures: SECTION 33 05 16.
 - 5. Ductile Iron Utility Pipe and Fittings: SECTION 33 05 19.
 - 6. Utility Identification: SECTION 33 05 97.
 - 7. Process Valves and Operators: SECTION 40 27 02.

1.02 REFERENCES:

- A. Applicable Standards:
 - 1. American National Standards Institute (ANSI):
 - a. B16.1 - Cast-Iron Pipe Flanges and Flanged Fittings, Class 25, 125, 250 and 800.
 - 2. American Society for Testing and Materials (ASTM):
 - a. A48 – Standard specification for Gray Iron Castings
 - b. A126 - Gray Iron Castings for Valves, Flanges and Pipe Fittings.
 - c. A242 – Standard Specification for High-Strength Low-Alloy Structural Steel
 - d. A276 - Stainless and Heat Resisting Steel Bars and Shapes.
 - e. A536 - Ductile Iron Castings.
 - f. A564 - Hot-Rolled and Cold-Finished Age-Hardening Stainless and Heat Resisting Steel Bars and Shapes.
 - 3. American Water Works Association (AWWA):
 - a. C111 - Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings.
 - b. C207 - Steel Pipe Flanges for Waterworks Service - Sizes 4 Inch through 144 Inch.
 - c. C500 - Metal-Seated Gate Valves for Water Supply Service.
 - d. C502 - Dry-Barrel Fire Hydrants.
 - e. C504 - Rubber-Seated Butterfly Valves.
 - f. C507 - Ball Valves, 6 Inch through 48 Inch.
 - g. C509 - Resilient-Seated Gate Valves for Water Supply Service.
 - h. C512 - Air-Release, Air/Vacuum, and Combination Air Valves for Waterworks Service.
 - i. C550 - Protective Epoxy Interior Coatings for Valves and Hydrants.
 - j. C600 - Installation of Ductile-Iron Water Mains and Their Appurtenances.
 - 4. National Fire Protection Association (NFPA):
 - a. 1963 - Screw Threads and Gaskets, Fire Hose Connections.

1.03 SUBMITTALS:

- A. Submit as specified in the General and Special Conditions.

SECTION 33 14 26 – WATERLINE ACCESSORIES: continued

- B. Include, but not limited to, the following:
 - 1. Catalog data or illustrations showing principal dimensions, parts, and materials.
 - 2. Spare parts list referenced to illustration of parts.
 - 3. Assembly and disassembly or repair instructions.
 - 4. Accessory coating information including performance tests of adhesion, hardness and abrasion resistance.
- C. Certificates and Affidavits: Furnish prior to shipment. Include the following:
 - 1. Test certificates.
 - 2. Affidavit of compliance with applicable AWWA Standard.

1.04 QUALITY CONTROL:

- A. Manufacturers shall be experienced in the design and manufacture of specific accessories for a minimum period of 5 years.

1.05 DELIVERY, STORAGE, AND HANDLING:

- A. Ship all valves with suitable end covers to prevent entrance of foreign material into valve body.
- B. Protect valve threads, flanges, stems, and operators from damage.
- C. Ship valves 4-inch and larger to the Project Site tagged with the station number shown on the Drawings. Tag smaller valves to show the piping system in which it is to be used.

1.06 RESPONSIBILITY:

- A. Actuators, their controls, and accessories shall be the responsibility of the valve manufacturer for sizing, assembly, certification, field testing, and any adjustments necessary to operate the valve as specified.

PART 2 - PRODUCTS

2.01 GENERAL

- A. All products and components in contact with potable water shall be certified to comply with NSF/ANSI 61. Components shall also be suitable for exposure to chloraminated water.

2.02 RESILIENT-SEATED GATE VALVES:

- A. See section 40 27 02.

2.03 BUTTERFLY VALVES:

- A. See section 40 27 02.

2.04 BALL VALVES:

- A. See section 40 27 02.

2.05 BOLTED SLEEVE-TYPE COUPLING:

- A. Acceptable Manufacturers: Match existing couplings in pump station, if possible.
 - 1. World Wide Metric, Inc. (Dresser)
 - 2. Ford Meter Box Company, Inc
 - 3. Smith-Blair, Inc.

SECTION 33 14 26 – WATERLINE ACCESSORIES: continued

4. Engineer approved equal.
- B. Design
 1. All couplings shall conform to AWWA C219 and be designed in accordance with AWWA Manual M11.
 2. Manufactured from either cast iron or ductile iron and shall conform to ASTM A48 or ASTM A126, Class B for Cast Iron, or ASTM A536 for Ductile Iron.
 3. Consist of one center sleeve, two end rings, two rubber compound wedge section gaskets, and sufficient bolts to compress the gaskets.
 4. Couplings shall be constructed without pipe stop.
 5. Provide certification from manufacturer that the coupling is sufficient for the types of pipe being joined.
 6. Pressure Rating:
 - a. Provide sleeves with a minimum working pressure of 150 psi.
 7. Sleeve length:
 - a. Provide a minimum sleeve length of 5 or 7-inches for pipe diameters up to and including 30-inch and 10 inches long for pipe diameters greater than 30-inch. For long sleeve couplings, the coupling shall be 16 inches long for all pipe diameters.
 8. Coating and Lining:
 - a. Fusion bonded epoxy lined and coated.
 9. Nuts and bolts:
 - a. Shall be as a minimum ASTM A193/A193M Grade B7 with ASTM A194/A194M Grade 2H heavy hex nuts or ASTM A563 heavy hex nuts for 1 inch and smaller Retaining rods and nuts.
 10. Middle rings and followers:
 - a. Center rings formed of carbon steel with minimum yield of 30,000 psi.
 - b. Heavy rolled steel follower.
 - c. Middle ring shall be at least the same wall thickness as the pipe to which the coupling is connected and not less than ¼-inch thick
 - d. If the strength of the middle ring material is less than the strength of the pipe material, the thickness of the middle ring shall be increased to have the same strength as the pipe.
 - e. Followers shall be single-piece contoured mill sections welded and cold-expanded as required for the middle rings and of sufficient strength to accommodate the number of bolts necessary to obtain adequate gasket pressures without excessive rolling.
 11. Gaskets:
 - a. Nitrile Butadiene Rubber (NBR) for potable water service.
 - b. AWWA C219 and ASTM D 2000.

2.06 DISMANTLING JOINT:

- A. Acceptable Manufacturers:
 1. Smith Blair
 2. Dresser
 3. JCM
 4. Engineer approved equal.
- B. Design
 1. Consists of a mechanical joint fitting located between two pipe flanges with restraining rods (or wedge restrainers) across the mechanical joint section,

SECTION 33 14 26 – WATERLINE ACCESSORIES: continued

- providing a restrained system with integral space for removal of adjacent equipment.
 - 2. Body:
 - a. Fabricated from steel, ASTM A512 or 513
 - b. Body shall be at least the same wall thickness as the pipe to which the coupling is connected, but not less than ¼ inch thick.
 - c. If the strength of the body material is less than the strength of the pipe material, the thickness of the middle ring shall be increased to have the same strength as the pipe.
 - 3. 150 psi minimum working pressure
 - 4. Fusion bonded epoxy coated and lined.
 - 5. Fully restrained.
 - 6. Nuts, bolts, and rods shall be as a minimum ASTM A193/A193M Grade B7 with ASTM A194/A194M Grade 2H heavy hex nuts or ASTM A563 heavy hex nuts for 1 inch and smaller
 - 7. Dismantling Joint shall have a pressure rating not less than that of the connecting pipe.
 - 8. Shall conform to AWWA C-219.
 - 9. The follower flange shall be fabricated from steel, ASTM A576
 - 10. Install insulating flange kit when required to prevent corrosion due to dissimilar metals per SECTION 26 42 13.
 - 11. Ends
 - a. Flanged
 - (1) Provide flanges in conformance with AWWA C207
 - (2) Flange dimensions and drilling shall match that of the connecting appurtenances.
 - (3) Contractor is responsible for verifying and matching all flanged ends.
- 2.07 TAPPING SLEEVE:
- A. Design
 - 1. Stainless Steel
 - 2. Full bodied
 - 3. Insulated, as required.
 - 4. Must meet the pressure requirements of the host pipe being tapped.
 - B. Acceptable Manufacturers:
 - 1. Romac Industries, Inc.
 - a. SST III.
 - b. STS 420.
 - c. FTS420T with Fusion Bonded Epoxy for ¾" Taps
 - 2. Ford Style FTSS.
 - 3. Mueller H-304 all Stainless.
 - 4. Engineer approved equal.
- 2.08 PRESSURE GAUGES:
- A. Design:
 - 1. Case: 304 SS case, 4.5-inch diameter, with laminated shatter-resistant glass window. Glycerin liquid filled.

SECTION 33 14 26 – WATERLINE ACCESSORIES: continued

2. Burdon Tube: 316SS.
 3. Pressure Connection: ½" NPT bottom connection
 4. Dial: White-coated aluminum with black lettering.
 5. Pointer: Aluminum alloy, black painted.
 6. Movement: 304SS
 7. Accuracy: Grade 1A, plus or minus 1 percent of full scale.
 8. Range: Comply with the following:
 - a. Pressure: 0 – 300 psi.
 - B. Acceptable Manufacturers:
 1. Ashcroft, Inc.
 2. AMETEK, Inc, U.S, Gauge Div.
 3. Ernst Gage Co
 4. Weiss Instruments, Inc.
 5. Winters Instruments
 6. Engineer approved equal
- 2.09 COPPER WATER SERVICE LINE AT 2" BLOW OFF ASSEMBLIES:
- A. Design:
 1. Type "K" soft copper.
 2. Completely lead free.
 - B. Connections shall be made with compression fittings.
- 2.10 FASTENERS (BOLTS, NUTS, STUDS, AND WASHERS):
- A. Bolts shall not be used. Use studs and nuts (all-thread and nuts) in lieu of bolts.
 - B. All fasteners (studs, nuts, rods, and washers) installed below-grade (either buried, submerged, or immersed in vaults) shall be as a minimum ASTM A193/A193M Grade B7 with ASTM A194/A194M Grade 2H heavy hex nuts or ASTM A563 heavy hex nuts for 1 inch and smaller and be polytetrafluoroethylene (PTFE, Teflon®) coated.
 - C. Bolting shall have a product marking in accordance with ASTM A193/A193M and ASTM A962/A962M.
 - D. Studs and nuts shall be coated with an anti-galling lubricating compound or coat with a 1-mil fluoropolymer or equal fastener coating system to aid in preventing galling.
 - E. All studs and nuts shall be accompanied by hardened steel flat washers on both sides of the flange.
 - F. All fasteners (studs, nuts, rods, and washers) type, size, and strength shall be as designed for the application. All nuts shall be fully seated. Nuts shall be compatible with the studs and have a proof stress equal or greater than the tensile strength of the studs. Minimum stud size, lengths, and tensile shall be as designed for the application.
 - G. Nut heads shall be hexagonal.
 - H. Rods and nuts shall be adequately labeled to provide traceability of the material and producer.
 1. The identification mark shall be cast, forged or stamped on the bolt and nut. Painted markings are not acceptable.
 2. The rod and nut manufacturer shall provide information on the type of material provided and corresponding identification mark, and country of origin.

SECTION 33 14 26 – WATERLINE ACCESSORIES: continued

- 3. Markings and traceability requirements shall be in accordance with The Industrial Fasteners Institute and AWWA guidelines.
 - I. All bolts and nuts shall be installed according to manufacturer's requirements including the use of anti-galling lubricant compound or use of a thermosetting fluoropolymer type coating for stainless steel materials.
 - J. If galling or seizing of the nut and bolt occurs, they shall be cut off and replaced with a new nut and bolt.
 - K. Exercise care to assure tightening of the nut is against the flange or gland and not due to galling or seizing.
 - L. Fastener manufacturer shall provide the "K Factor" for use in calculating appropriate torque values for hardware at each flange.
- 2.11 TIE RODS (RESTRAINING RODS):
- A. All tie rods installed below-grade (either buried, submerged, or immersed in vaults) shall be as a minimum ASTM A193/A193M Grade B7 with ASTM A194/A194M Grade 2H heavy hex nuts or ASTM A563 heavy hex nuts for 1 inch and smaller.
 - B. All tie rods type, size, and strength shall be as designed for the application. All nuts shall be fully seated. Nuts shall be compatible with the tie rods and have a proof stress equal or greater than the tensile strength of the all-thread. Minimum bolt size, lengths, and tensile shall be as designed for the application per M11.
- 2.12 FLANGE GASKET MATERIAL (STANDARD):
- A. Provide all gaskets required to install pipe, fittings, and specials complete and ready for service.
 - B. Design:
 - 1. For flanges 30" and greater, provide full face gasket, 3/32" thick.
 - 2. For flanges 24" and below, provide full face gasket, 3/32" thick.
 - 3. Conform to ANSI B16.21.
 - 4. Gaskets shall be NSF 61 approved.
 - 5. PTFE with aluminosilicate microspheres
 - 6. No lamination
 - 7. Color shall be blue.
 - 8. Minimum pressure capability of 800 psi.
 - C. Acceptable Manufacturers:
 - 1. Garlock Sealing Technologies:
 - a. Gylon Style 3505 EPIX (Blue)
 - 2. Engineer approved equal.
- 2.13 FLANGE GASKET MATERIAL (INSULATING/ISOLATION):
- A. See Section 26 42 13.
- 2.14 POLYETHYLENE ENCASEMENT/WRAP:
- A. Encase ductile iron pipe, fittings, valves, restraining harnesses, and other appurtenances with polyethylene film as indicated or specified.
 - B. Materials:
 - 1. Polyethylene material shall be as follows
 - a. High-Density Cross-Laminated (HDCL) Polyethylene Encasement.

SECTION 33 14 26 – WATERLINE ACCESSORIES: continued

- (1) Provide minimum 4-mil high-density, cross-laminated polyethylene film manufactured of virgin high density polyethylene material per ASTM D4976 and AWWA C105.
- (2) Conform to AWWA C105.
- (3) Final film shall be produced by molecularly orienting film in one direction by stretching and then two layers of film be laminated together at a (90 degree) right angle to the other layer's molecular orientation.
- (4) Acceptable Manufacturers:
 - (a) Corr Flex, Inc, Odenville, AL
 - (b) Northtown Company, Huntington Beach
 - (c) Sigma (formerly Fulton Enterprises), Birmingham, AL
 - (d) Engineer approved equal.

2.15 POLYETHYLENE ADHESIVE TAPE:

- A. Approximately 2 inches wide and plastic backed.
- B. Capable of bonding securely to metal surfaces and/or polyethylene material.
- C. Acceptable Manufacturers:
 1. Polyken No. 900.
 2. Scotchrap No. 50 (polyvinyl).
 3. Engineer approved equal.

2.16 MECHANICAL JOINT WEDGE ACTION RETAINER GLANDS:

- A. General:
 1. Manufactured of ductile iron conforming to ASTM A536
 2. Dimensioned such that the gland can be used with the standardized mechanical joint bell and tee-head bolts conforming to AWWA C111 and C153.
 3. Mechanism shall consist of numerous individually activated gripping surfaces to maximize restraint capability. The gripping surfaces shall be wedges designed to spread the bearing surfaces on the pipe.
 4. Twist-off nuts shall be sized the same as tee-head bolts and shall be used to insure proper actuating of restraining devices. When the nut is sheared off, a standard hex nut shall remain.
- B. Coating:
 1. Retainer glands shall have a premium epoxy coating per AWWA C213.
 2. Mega-Bond, Flexi-Coat, or Engineer approved equivalent.
- C. Bolting Material:
 1. Low-alloy carbon steel nuts and bolts with Teflon coating
- D. Acceptable Manufacturers:
 1. MEGALUG® 1100 manufactured by EBAA Iron, Inc.
 2. Romac Roma Grip RG
 3. Uni-Flange 1400
 4. Star Grip 3000
 5. Engineer Approved Equal.

2.17 BOLTS AND NUTS:

- A. Tee-head bolts and hexagon nuts shall be high strength, low-alloy steel with Teflon coating.

SECTION 33 14 26 – WATERLINE ACCESSORIES: continued

2.18 CONCRETE THRUST BLOCKS:

- A. Concrete Materials:
 - 1. Conform to ASTM C150. Portland Cement Type I/II
 - 2. Water: Clean and free from injurious amounts of oil, acid, alkaline, or other deleterious substances. Any potable drinking water will be acceptable.
 - 3. Fine Aggregates: Clean natural sand. Manufactured sand may be used upon written approval of Engineer. Conform to ASTM C33.
 - 4. Coarse Aggregates: Clean crushed stone or processed gravel, not containing organic materials. Conform to ASTM C33, size No. 67.
 - 5. Air-entraining admixtures shall conform to ASTM C260.
 - 6. Water-Reducing Admixture: Conform to ASTM C494, Type A.
 - 7. Admixtures shall not contain chloride ions.
- B. Concrete Mix:
 - 1. Ready-mix concrete shall conform to ASTM C94.
 - a. Ready-mixed concrete plant shall be subject to approval of Engineer.
 - 2. Pre-mixed, packaged concrete may be used with approval from Engineer.
 - a. Pre-mixed, packaged concrete shall conform to ASTM C387.
 - 3. 3,000 psi - thrust blocks
 - a. Minimum compressive strength: 3,000 psi at 28 days.
 - 4. Water/Cement Ratio: 0.45.
 - 5. Slump: 5 inches, +/- 1 inch.
 - 6. Air Content: 6% +1.5%.
- C. Forms:
 - 1. Use as necessary to construct thrust block per Drawings
 - 2. Material:
 - a. Exterior Grade Plywood: 5/8-inch-thick.
 - b. Steel.
 - c. Approved wood fiberboard.
 - d. Dressed lumber free of loose knots.

2.19 VALVE BOXES:

- A. Acceptable Manufacturers:
 - 1. For Valve Box assemblies over 8 feet in depth, use Castings, Inc. Series 500 and 501, or engineer approved equal.
 - 2. Tyler, Series 6860 (with No. 160 base)
 - 3. Olympic Foundry Inc., Model No. 450VB
 - 4. Castings Inc., Series 6850
 - 5. East Jordan Iron Works, Series 8560
 - 6. Engineer approved equal.
- B. Provide for all direct buried valves.
- C. Design:
 - 1. Conforming to ASTM A48 Class 35
 - 2. Gray cast-iron, buffalo-type
 - 3. Boxes shall be two-piece 6" nominal cast-iron screw type with the following components and their minimum weights:
 - a. 16-inch top section – 34 lbs
 - b. 18-inch extension – 29 lbs
 - c. 24-inch stem – 35 lbs

SECTION 33 14 26 – WATERLINE ACCESSORIES: continued

- d. 30-inch bottom – 38 lbs
 - e. Base – 68 lbs
 - 4. Use wide base with valve box adapter to valve, as specified.
 - 5. Provide extension stem to bring operating nut within 2 feet of valve box top.
 - D. Covers (Lids)
 - 1. Drop cover shall be marked "WATER", or similar approved label.
 - 2. Minimum 13 lbs
 - 3. Lids shall have a lip or flange extending into the valve box shaft.
 - a. No slip-type boxes will be allowed.
 - E. Coating
 - 1. Components shall be deburred and machined so that final dimensions are within plus or minus 0.0625 inches of the specified dimensions. Components shall be provided with the manufacturer's standard rust preventative coating.
- 2.20 VALVE BOX ADAPTOR:
- A. Design:
 - 1. Designed to work with all types and sizes of gate valve 2" through 16".
 - 2. Made to be used with a 5.25" cast iron valve box.
 - 3. Adapter must center box around red 2" AWWA operations nut.
 - B. Acceptable Manufacturers:
 - 1. Valve Box Adaptor II as manufactured by Adaptor Inc.
 - 2. Engineer approved equal.
- 2.21 FLOOR STANDS:
- A. Acceptable Manufacturers:
 - 1. Cooper B-Line
 - 2. Engineer approved equal.
 - B. Provide steel or cast-iron floor stands where indicated.
 - 1. Base shall be suitable for bolting to supporting structure.
 - 2. Equip with bronze shaft bearing.
 - 3. Nonrising stem design with PVC stem cover.
 - C. Provide extension shafts where required.
 - 1. Include bronze-bushed, cast-iron shaft guides adjustable in two directions.
 - D. Locate guides to limit unsupported extension shaft length to 5 feet.
- 2.22 FLEXIBLE COUPLINGS
- A. Acceptable Manufacturers:
 - 1. EBAA Iron, FLEXTEND
 - B. General
 - 1. Flexible expansion joints shall be installed in the locations indicated on the drawings and shall be manufactured of ductile iron conforming to the material requirements of ASTM A536 and ANSI/AWWA C153/A21.53. Foundry certification of material shall be readily available upon request.
 - 2. Each flexible expansion joint shall be pressure tested prior to shipment against its own restraint to a minimum of 350 PSI for 3 inch through 16 inch and 250 PSI for 18 inch and greater. A minimum 2:1 safety factor, determined from the published pressure rating, shall apply.
 - 3. Each flexible expansion joint shall consist of an expansion joint designed and cast as an integral part of a ball and socket type flexible joint, having a

SECTION 33 14 26 – WATERLINE ACCESSORIES: continued

minimum per ball deflection of: 20° for sizes 4-inch through 12-inch; 15° for sizes 14-inch through 36-inch and 12° for size 48-inch. The flexible expansion fitting shall not expand or exert an axial imparting thrust under internal water pressure. The flexible expansion fitting shall not increase or decrease the internal water volume as the unit expands or contracts. The minimum total linear travel shall be 8-inches.

4. All internal surfaces (wetted parts) shall be lined with a minimum of 15 mils of fusion bonded epoxy conforming to the applicable requirements of ANSI/AWWA C213. Sealing gaskets shall be constructed of EPDM. The coating shall meet ANSI/NSF-61.
5. Exterior surfaces shall be coated with a minimum of 6 mils of fusion bonded epoxy conforming to the applicable requirements of ANSI/AWWA C116/A21.16.
6. Polyethylene sleeves, meeting ANSI/AWWA C105/A21.5, shall be included for direct buried applications.
7. Manufacturer's certification of compliance to the above standards and requirements shall be readily available upon request. The purchaser (or owner) shall reserve the right to inspect the manufacturer's facility for compliance. All flexible expansion joints shall be The Force Balanced FLEX-TEND as manufactured by EBAA Iron, Inc. Eastland, TX., U.S.A.

2.23 SHOP PAINTING:

- A. Prepare surfaces and paint or coat all valves, floor stands, valve boxes, corporation stops, and all related accessories standard of the manufacturer unless otherwise specified herein.
- B. Paint and coatings shall be suitable for the service intended.
- C. Submit type of paint or coating proposed with drawings and data for approval prior to fabrication.

PART 3 - EXECUTION

3.01 INSTALLATION:

- A. Comply with provisions of AWWA C600 and as specified.
- B. Thoroughly clean and remove all shipping materials prior to setting. Operate all valves from fully opened to totally closed.
- C. Equip with anchorage where indicated.
- D. Set fire hydrants with bottom of traffic break-away flange 2 inches above finished grade. Check and fill stem bonnet lubricant reservoir.

3.02 FIELD FLANGE ASSEMBLY:

- A. Provide hardened steel flat washers on both sides of the flange.
- B. All studs and nuts shall be torqued with a torque wrench.
- C. Tighten in a star pattern per flange manufacturer recommendations.
- D. Do not over-tighten studs and nuts.

3.03 BOLTED SLEEVE-TYPE COUPLING:

- A. Bolted sleeve-type couplings shall be installed in accordance with AWWA C219.

SECTION 33 14 26 – WATERLINE ACCESSORIES: continued

- B. Split sleeve mechanical-type couplings shall be installed in accordance with AWWA C227.
- C. All bolts shall be tightened in accordance with the coupling manufacturer's written requirements.
- D. Install restraint rings on pipe in accordance with the coupling manufacturer's written instructions.
- E. Install joint harnesses in accordance with AWWA M11.

3.04 PRESSURE GAUGES:

- A. Install pressure gauges on piping with pressure-gauge located at most readable position.

3.05 POLYETHELENE WRAP:

- A. Suggested installation procedure for polyethylene tube wrapping is as follows:
 - 1. Pick up the pipe with a sling or pipe tongs. Slip a polyethylene tube that is approximately two feet (2') longer than the pipe over the plain end and leave it bunched up accordion style.
 - 2. Lower the pipe into the trench and line up the joint with the preceding pipe. Shallow bell holes are required to allow overlap of the tube at the joints. Remove the sling or tong from the center of the pipe, raise the bell a few inches and slip the polyethylene tube along the pipe barrel, leaving approximately one foot (1') of the tube bunched up at each end of the pipe for wrapping the joints.
 - 3. Overlap each joint by first pulling one bunched-up tube over the bell, folding it around the adjacent plain end, and securing it in place with two or three wraps of the polyethylene adhesive tape. Complete the overlap by repeating the same procedure with the bunched-up tube on the adjacent pipe.
 - 4. Take up the slack tube along the pipe barrel by folding it over the top of the pipe holding the fold in place with polyethylene adhesive tape.
 - 5. Repair any rips, punctures, or other damage to the polyethylene with tape or by cutting open a short length of tube, wrapping it around the pipe and securing with tape.
- B. Use adhesive tape to fasten polyethylene film in place at maximum two-foot increments.
- C. Minimize exposure of polyethylene film to sunlight.
- D. Wrap valve boxes and curb stop boxes per AWWA C105 installation standards.

3.06 FIELD PAINTING: Surface preparation and finish painting are specified in SECTION 09 90 00.

3.07 FIELD TESTING:

- A. Perform on piping and valves as specified in SECTION 40 27 02 and for the following:
 - 1. Combination Air/Vacuum Valves.
 - 2. Gate valves.
 - 3. Butterfly valves.
 - 4. Ball valves

END OF SECTION 33 14 26

DIVISION 40 – PROCESS INTEGRATION

SECTION 40 27 02 - PROCESS VALVES AND OPERATORS

PART 1 - GENERAL

1.01 SUMMARY:

- A. This Section includes all valves including manual valves, automatic valves, and air/vacuum valves.
- B. Related Work Specified Elsewhere:
 - 1. Protective Coatings: SECTION 09 90 00.
 - 2. Welded Steel Pipe and Fittings: SECTION 33 05 01.01.
 - 3. Waterline Accessories: SECTION 33 14 26.
 - 4. Electric Motor Actuators: SECTION 33 12 16

1.02 REFERENCES:

- A. The following is a list of standards which may be referenced in this SECTION:
 - 1. American Society of Mechanical Engineers (ASME):
 - a. B16.1, Gray Iron Pipe Flanges and Flanged Fittings: Classes 25, 125, and 250.
 - 2. American Society of Sanitary Engineers (ASSE): 1011, Performance Requirements for Hose Connection Vacuum Breakers.
 - 3. American Water Works Association (AWWA):
 - a. C111/A21.11, Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings.
 - b. C504, Rubber-Seated Butterfly Valves, 3 In. Through 72 In.
 - c. C508, Swing-Check Valves for Waterworks Service, 2-in. through 24-in. NPS
 - d. C509, Resilient-Seated Gate Valves for Water Supply Service.
 - e. C515, Reduced-Wall, Resilient-Seated Gate Valves for Water Supply Service.
 - f. C550, Protective Interior Coatings for Valves and Hydrants.
 - g. C606, Grooved and Shouldered Joints.
 - h. C800, Underground Service Line Valves and Fittings.
 - 4. ASTM International (ASTM):
 - a. A126, Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings
 - b. A276, Standard Specification for Stainless Steel Bars and Shapes.
 - c. A351/A351M, Standard Specification for Castings, Austenitic, for Pressure-Containing Parts.
 - d. A380, Standard Practice for Cleaning, Descaling, and Passivation of Stainless-Steel Parts, Equipment, and Systems.
 - e. A564/A564M, Standard Specification for Hot-Rolled and Cold-Finished Age-Hardening Stainless-Steel Bars and Shapes.
 - f. B61, Standard Specification for Steam or Valve Bronze Castings.
 - g. B62, Standard Specification for Composition Bronze or Ounce Metal Castings.
 - h. B98/B98M, Standard Specification for Copper-Silicon Alloy Rod, Bar, and Shapes.
 - i. B127, Standard Specification for Nickel-Copper Alloy (UNS

SECTION 40 27 02 - PROCESS VALVES AND OPERATORS: continued

- N04400) Plate, Sheet, and Strip.
- j. B139/B139, Standard Specification for Phosphor Bronze Rod, Bar and Shapes.
- k. B164, Standard Specification for Nickel-Copper Alloy Rod, Bar, and Wire.
- l. B194, Standard Specification for Copper-Beryllium Alloy Plate, Sheet, Strip, and Rolled Bar.
- m. B584, Standard Specification for Copper Alloy Sand Castings for General Applications.
- n. B763, Standard Specification for Copper Alloy Sand Castings for Valve Applications
- o. D429, Standard Test Methods for Rubber Property-Adhesion to Rigid Substrates.
- p. D1784, Standard Specification for Rigid Poly (Vinyl Chloride) (PVC) Compounds and Chlorinated Poly (Vinyl Chloride) (CPVC) Compounds.
- 5. ASME:
 - a. B16.1 – Cast Iron Pipe Flanges and Flanged Fittings
 - b. B16.42 – Ductile Iron Pipe Flanges and Flanged Fittings
 - c. B16.24 – Cast Copper Alloy Pipe
- 6. National Electrical Manufacturers Association (NEMA): 250, Enclosures for Electrical Equipment (1000 Volts Maximum).
- 7. NSF International (NSF):
 - a. NSF/ANSI 61, Drinking Water System Components - Health Effects.
 - b. NSF/ANSI 372, Drinking Water System Components - Lead Content.
- 8. Underwriters Laboratories (UL).
- 9. USC Foundation for Cross-Connection Control and Hydraulic Research.

1.03 SUBMITTALS:

A. Action Submittals:

- 1. Shop Drawings:
 - a. Product data sheets for each make and model. Indicate valve Type, Number, applicable, Tag Number, and service where used.
 - b. Complete catalog information, descriptive literature, specifications, and identification of materials of construction.
 - c. Certification for compliance to NSF/ANSI 61 for valves used for drinking water service.
 - d. Power and control wiring diagrams, including terminals and numbers.
 - e. For each power actuator provided, manufacturer's standard data sheet, with application specific features and options clearly identified.
 - f. Sizing calculations for open-close/throttle and modulating valves.
 - g. Anchorage and bracing drawings and cut sheets, as required by applicable specification.

B. Informational Submittals:

- 1. Manufacturer's Certificate of Compliance, in accordance with SECTION, for:
 - a. Electric actuators: full compliance with C542.
 - b. Butterfly valves; full compliance with AWWA C504.
 - c. Gate valves, full compliance with AWWA C509.

SECTION 40 27 02 PROCESS VALVES AND OPERATORS: continued

2. Tests and inspection data.
3. Operation and Maintenance Data as specified in application specification.
4. Manufacturer's Certificate of Proper Installation, in accordance with applicable specification.

1.04 QUALITY CONTROL:

- A. Manufacturers shall be experienced in the design and manufacture of specific valves and accessories for a minimum period of 5 years.

1.05 DELIVERY, STORAGE, AND HANDLING:

- A. Ship all valves with suitable end covers to prevent entrance of foreign material into valve body.
- B. Protect valve threads, flanges, stems, and operators from damage.
- C. Ship valves 4-inch and larger to the Project Site tagged with the station number shown on the Drawings. Tag smaller valves to show the piping system in which it is to be used.

1.06 RESPONSIBILITY:

- A. Actuators, their controls, and accessories shall be the responsibility of the valve manufacturer for sizing, assembly, certification, field testing, and any adjustments necessary to operate the valve as specified.

PART 2 - PRODUCTS

2.01 GENERAL:

- A. Valves shall include operator, actuator, handwheel, chain wheel, extension stem, floor stand, operating nut, chain, wrench, and accessories to allow a complete operation from the intended operating level.
- B. Valve to be suitable for intended service. Renewable parts not to be of a lower quality than specified.
- C. Valve shall be the same size as adjoining pipe, unless otherwise called out on Drawings or in Supplements.
- D. Valve ends shall suit adjacent piping.
- E. Resilient seated valves shall have no leakage (drip-tight) in either direction at valve rated design pressure. All other valves shall have no leakage (drip-tight) in either direction at valve rated design pressure, unless otherwise allowed for in this section or in stated valve standard.
- F. Size operators and actuators to operate valve for full range of pressures and velocities.
- G. Valve to open by turning counterclockwise (open left), unless otherwise specified.
- H. Factory mount operator, actuator, and accessories.
- I. Components and Materials in Contact with Water for Human Consumption: Comply with the requirements of the Safe Drinking Water Act and other applicable federal, state, and local requirements. Provide certification by manufacturer or an accredited certification organization recognized by the Authority Having Jurisdiction that components and materials comply with the maximum lead content standard in accordance with NSF/ANSI 61 and NSF/ANSI 372.

SECTION 40 27 02 - PROCESS VALVES AND OPERATORS: continued

1. Use or reuse of components and materials without a traceable certification is prohibited.

2.02 SCHEDULE:

- A. See drawings for valve types and locations.

2.03 MATERIALS:

- A. Bronze and brass valve components and accessories that have surfaces in contact with water to be alloys containing less than 16 percent zinc and 2 percent aluminum.
 1. Approved alloys are of the following ASTM designations: B61, B62, B98/B98M (Alloy UNS No. C65100, C65500, or C66100), B139/B139M (Alloy UNS No. C51000), B584 (Alloy UNS No. C90300 or C94700), B164, B194, and B127.
 2. Stainless steel Alloy 18-8 may be substituted for bronze.
- B. Valve materials in contact with or intended for drinking water service to meet the following requirements:
 1. Materials shall comply with the requirements of the Safe Drinking Water Act and other applicable federal, state, and local requirements.
 2. Coatings materials shall be formulated from materials deemed acceptable to NSF/ANSI 61.
 3. Supply certification product is certified as suitable for contact with drinking water by an accredited certification organization in accordance with NSF/ANSI 61. Provide certification for each valve type used for drinking water service.

2.04 FACTORY FINISHING:

- A. General:
 1. Interior coatings for valves and hydrants shall be in accordance with AWWA C550, unless otherwise specified.
 2. Exterior coating for valves and hydrants shall be in accordance with applicable specification.
 3. Material in contact with potable water shall conform to NSF/ANSI 61.
 4. Exposed safety isolation valves and lockout valves with handles, handwheels, or chain wheels shall be "safety yellow."
- B. Where epoxy lining and coating are specified, factory finishing shall be as follows:
 1. In accordance with AWWA C550.
 2. Either two-part liquid material or heat-activated (fusion) material except only heat-activated material if specified as "fusion" or "fusion bonded" epoxy.
 3. Minimum 7-mil dry film thickness except where limited by valve operating tolerances.

2.05 VALVES:

- A. Resilient-Seated Gate Valves:
 1. General:
 - a. AWWA gate valves to be in full compliance with stated AWWA

SECTION 40 27 02 PROCESS VALVES AND OPERATORS: continued

standard and the following requirements:

- (1) Provide Affidavit of Compliance per AWWA C509 standard for gate valves.
 - (2) Mark AWWA gate valves with manufacturer's name or mark, year of valve casting, valve size, and working water pressure.
 - (3) Repaired AWWA gate valves shall not be submitted or supplied.
 - (4) Supply AWWA gate valves with stainless steel bolting.
 - (5) Gate Valves furnished under this SECTION shall be of the Resilient Wedge type conforming to the American Water Works Association Standard C509 or C515, latest edition.
- b. Suitable for exposure to chlorinated and chloraminated water.
 - c. Each valve, after shop assembly, shall be given the operation and hydrostatic tests in accordance with AWWA C500/C509 or C515.
2. Buried gate valves shall be mechanical joint conforming to AWWA C111.
 - a. Tee-head bolts and hexagon nuts shall be fabricated from a high-strength, low alloy steel.
 3. Resilient seated gate valves shall have flanged ends in vaults and conform to the following:
 - a. Shop coated with a rust preventive compound
 - b. ANSI B16.1, Class 125.
 - c. Contractor shall verify all flanges before ordering for compatibility with adjoining fittings and pipe.
 4. Design:
 - a. Non-directional, standard-wall resilient seated (AWWA C509), or reduced-wall resilient seated gate valves (AWWA C515), 250 psig pressure rating, bronze mounting.
 - b. Valve shall be drip tight with a pressure of 250 psi against the valve seat.
 - c. Fully encapsulated rubber wedge or rubber seat ring mechanically attached with minimum 304 stainless-steel fasteners or screws, threaded connection isolated from water by compressed rubber around opening.
 - d. Valve components in waterway to contain not more than 15 percent zinc and not more than 2 percent aluminum.
 - e. Non-rising stem:
 - (1) ASTM B763 Bronze, Copper Alloy No. C99500 or ASTM A276 Stainless Steel
 - (2) Sem nut independently or integrally cast
 - (3) Minimum yield strength of 40,000 psi
 - (4) Minimum elongation in 2 inches of 12%
 - (5) All stem seals shall be O-ring type:
 - (a) Section 2.2.6 and 4.8.2 AWWA C509
 - (b) Section 4.2.2.5 AWWA C515
 - (c) Consist of three O-rings, two above and one below thrust collar with anti-friction washer located above thrust collar for operating torque

SECTION 40 27 02 - PROCESS VALVES AND OPERATORS: continued

- f. Resilient wedge shall be molded, synthetic rubber, vulcanized and bonded to cast or ductile iron wedge or attached with 304 stainless steel screws tested to meet or exceed ASTM D 429 Method B, seat against epoxy-coated surface in valve body.
- g. Bolting Material:
 - (1) See SECTION 33 14 26 – Waterline Accessories.
- h. Interior and Exterior Coating:
 - (1) AWWA C550 non-toxic
 - (a) The coating and lining shall be fusion-bonded epoxy, min. 8-mils thick.
 - (2) Apply to all interior and exterior ferrous metal surfaces.
 - (3) Prior to assembly of valve, apply protective coating to interior and exterior surfaces of body.
- i. Actuators:
 - (1) All gate valves shall open counterclockwise (left).
 - (2) All direct bury valves shall have a red 2-inch square operation nut.
 - (3) All gate valves in vaults shall be provided with a hand wheel. The hand wheel shall be supplied with a 2" AWWA nut welded to the center of the hand wheel. Provide cast iron welding as required.
 - (4) Do not exceed 600 ft-lbs of torque on operator nut on gate valve.
- j. Testing:
 - (1) Testing shall be performed conforming to AWWA C509 or C515, latest edition.
 - (2) Furnish affidavit of compliance.
- 5. Acceptable Manufacturers and Products:
 - a. Mueller Co. (C500 and C509)
 - b. Clow (C500 and C509)
 - c. American AVK (C509 only)
 - d. Waterous Series 500
 - e. Engineer approved equal.
- B. Butterfly Valves:
 - 1. General:
 - a. Provide AWWA C504, latest edition, Class 150B valves, and as specified.
 - b. Suitable for service of 150 psi, drip tight through the seat.
 - c. Suitable for exposure to chlorinated and chloraminated water and potable service.
 - d. Suitable for bidirectional service.
 - e. Design velocity shall be 16 fps, maximum.
 - f. Shop tested in accordance with AWWA C504 and shipped fully assembled.
 - 2. All butterfly valves shall have flanged ends conforming to the following:
 - a. ANSI B16.1, Class 125.
 - b. Machined to a flat surface with a serrated finish in accordance with AWWA C207.
 - c. Flanges shall have full-sized bolt holes through the flanges, except that drilled and tapped holes will be acceptable only in the areas where the shaft passes through the body. Flanges with all holes tapped will not be allowed.
 - d. Contractor shall verify all flanges before ordering for compatibility with

SECTION 40 27 02 PROCESS VALVES AND OPERATORS: continued

adjoining fittings and pipe.

3. Valves with a stop or lug cast integrally or mechanically secured to the body for the purpose of limiting disc travel will not be acceptable.
4. Valves shall be designed for buried, exposed, or submerged service and shall comply with the whole of the AWWA C504 Standard, except as specified under these specifications and the options, stipulations or modifications as indicated.
5. Materials of Construction:
 - a. Materials and Construction:
 - (1) Body:
 - (a) Ductile iron, short body pattern.
 - (2) Disc:
 - (a) Ductile iron, having no hollow chambers that can entrap water.
 - (3) Shafts:
 - (a) Shafts shall be ASTM 564 Type 630 stainless steel and may be either through or stub type.
 - (b) Shaft seals for valves 24-inch diameter and smaller shall be designed for use of standard self-adjusting split-V-type packing or 6 O-ring type contained in a corrosion resistant cartridge.
 - (c) Retention of the above seals shall be designed to utilize the actuator case as a positioner of the seal. Replacement of seals shall be done without removal of the valve shaft.
 - (d) On buried valves, the shaft seal area and exposed valve shaft shall be totally enclosed to prevent infiltration of material around the shaft seal and valve shaft during backfilling. Adjustable packing gland shall be accessible either through the bonnet or by removing the enclosure around the packing gland.
 - (4) Seats:
 - (a) Seats shall be synthetic rubber and be body or disc mounted. Provide field replaceable and adjustable seat. Mating seat surface shall be stainless steel or sprayed in accordance with AWWA C504.
 - (b) Rubber seats shall be of new natural or synthetic rubber and may be reinforced by the manufacturer.
 - (c) Seats mounted on the disc shall be a continuous full circle 360-degree seal, clamped thereon with corrosion resistant restraining rings and threaded fasteners.
 - (d) Seats mounted in the groove of the valve body on valves 24-inch diameter and smaller may be bonded to the body. Bonded seats must withstand a 75-pound pull in accordance to the 90-degree stripping test procedure "Method B" of ASTM D 429
 - (e) Seats mounted in the valve body shall be full circle 360-degree and shall be retained in the valve body by mechanical means in such a manner that the seat can be adjusted to provide a tight shutoff. Valve shaft shall not penetrate the rubber seat.
 - (5) Bearings:
 - (a) Valves furnished with an externally adjustable thrust bearing shall have the external adjusting mechanism enclosed in a substantial watertight housing.
 - (6) Bonnet:

SECTION 40 27 02 - PROCESS VALVES AND OPERATORS: continued

- (a) Buried valves shall be furnished with a separate one piece cast iron or fabricate steel extension bonnet with (if applicable) access opening fitted with removable covers, located to permit access to the stuffing box for tightening the packing. The extension bonnet shall be 24-inches in length and shall be of a single diameter over its entire length. Minimum thickness of removable cover shall be 14 gauge (0.0747") and shall be attached to extension sleeve with a minimum of four ¼-inch diameter cap screws. Gasketing of the opening is not required.
- (7) Torque Tubes:
 - (a) Valves shall be supplied with torque tube type shaft extensions and actuator support stands. Each torque tube and actuator support stand shall be sized to operate under the maximum service conditions for the valve. The torque tube shall transmit the required torque to the valve without twisting or bending. The torque tube shall be connected to the valve shaft with a taper pin and nut or with a "keyed" fit.
- (8) Nameplates:
 - (a) Corrosion-resistant nameplates shall be provided. There shall be one valve nameplate attached to the valve body, or for "buried" or "submerged" valves, attached to the valve actuator. The valve nameplates shall include the normal valve data and the serial number.
- (9) Shafting, bolts, and fastening hardware shall be stainless steel.
- b. Bolting Material:
 - (1) See SECTION 33 14 26 – Waterline Accessories.
- c. Actuators:
 - (1) Electric Actuators:
 - (a) See Section 33 12 16 – Electric Motor Actuators
 - (2) Manual Actuators:
 - (a) Provide worm gear actuators designed and sized to develop output torques for the specified operating service and shall be sufficient to seat, unseat, and rigidly hold the disc in any intermediate position for the above conditions.
 - (b) All butterfly valves shall open counterclockwise (left).
 - (c) Manual actuators shall be worm-gear or traveling nut type with a red 2" AWWA square operating nut, suitable for buried service or submerged service in vaults, as indicated on the Drawings.
 - (d) The actuator housing shall be fully sealed and constructed of ASTM A48 Class 40 gray iron or ASTM A536 Grade 65-45-12 ductile iron.
 - (e) All exposed, buried service shafting, bolts, and fasteners shall be stainless steel, Type 304 or 316.
 - (f) Actuators shall be at least 90% grease packed and completely sealed using gaskets. O-rings and similar means shall be droptight in water to a depth of twenty (20) feet.

SECTION 40 27 02 PROCESS VALVES AND OPERATORS: continued

- (g) Maximum input torque required to fully open or close the valve for the specified service conditions shall not exceed 150 foot-pounds when applied to the operating nut, or an 80-pound pull when applied to the hand wheel.
- (h) Actuators shall have a minimum safety factor of 1.5 of the actuator rated torque capacity to the maximum torque required by the valve.
- (i) Actuators shall be capable of withstanding 450 foot-pounds of torque against the stops, if applicable, without damage to any parts of the actuator or valve.
- (j) Actuator shall be self-locking at all variable open positions.
- (k) Provide sealed bonnet/stem extensions on direct bury installations where actuators are placed in a manhole or vault. Sealed bonnets/stem extensions shall be a minimum of 48" in length or as indicated on the drawings.
- (l) The diameter of the output shaft or spline of the actuator shall be sized equal to or greater than the turned-down section of the valve shaft.
- (m) Actuator housing shall be coated with an epoxy conforming to AWWA C550 with a minimum dry film thickness of 8 mils.
- (n) Worm-gear actuators shall be as manufactured by Rotork, EIM, Limitorque, or Engineer approved equal.
- (o) Actuators shall be mounted and installed by the valve manufacturer.
- (p) Provide indicators to show position of disc except on direct buried actuators.
- (q) Actuators shall be located in positions indicated or as otherwise determined when manufacturer's drawings are submitted.
- d. Testing.
 - (1) Furnish certified copies of results of performance, leakage, and hydrostatic tests performed in compliance with Section 5, AWWA C504.
- e. Valve Coating and Lining:
 - (1) All internal and external ferrous surfaces except machined or bearing surfaces shall be prepared for coating per SSPC-SP-10. These surfaces shall then be coated with a two-part thermosetting polyamide epoxy in two or more uniform coats, or with fusion bonded epoxy, to a minimum dry film thickness of 12 mils. Epoxy coating shall conform to AWWA C550 and shall be Ameron 400, Tnemec Series 140F Pota-Pox Plus, Corvel ECA-1626 or approved equal.
 - (2) After above painting is completed, a lubricant compatible with the rubber seal shall be applied to surface of this seal and the mating metal surface to prevent bonding of the two surfaces during shipment and storage. Following application of the seal lubricant, the valve disk shall be placed in a slightly open position for shipment.
 - (3) Flange faces shall be shop coated with a rust preventive compound, Houghton "Rust-Veto 344", or Rust-Oleum "R-9".

6. Acceptable Manufacturers:

SECTION 40 27 02 - PROCESS VALVES AND OPERATORS: continued

- a. Mueller
 - b. Henry Pratt
 - c. M&H Valve Company
 - d. DeZurik
 - e. Valmatic and Manufacturing Corporation
 - f. Engineer approved equal.
- C. Ball Valve 2 Inches and Smaller for General Water Service:
 - 1. Three-piece, full port, NPT threaded ends, bronze body and end pieces, hard chrome plated solid bronze or brass ball, RTFE seats and packing, blowout-proof stem, zinc-plated steel hand lever operator with vinyl grip, rated 600-pound WOG, 150 psi SWP, complies with MSS SP-110.
 - 2. Minimum pressure rating of 600 psig.
 - 3. Acceptable Manufacturers:
 - a. Threaded Ends:
 - (1) Apollo Valves; 82-100.
 - (2) Nibco; T-595-Y.
 - (3) Stockham; T-395 Series.
 - (4) Engineer approved equal.
- D. Flanged Duckbill Check Valves:
 - 1. Design:
 - a. As specified in the Contract Drawings.
 - 2. Acceptable Manufacturers:
 - a. Tideflex Series 35
 - b. Engineer Approved Equal.

2.06 OPERATORS AND ACTUATORS:

- A. Manual Operators:
 - 1. General:
 - a. For AWWA valves, operator force not to exceed requirements of applicable valve standard. Provide gear reduction operator when force exceeds requirements.
 - b. For non-AWWA valves, operator force not to exceed applicable industry standard or 80 pounds, whichever is less, under operating condition, including initial breakaway. Provide gear reduction operator when force exceeds requirements.
 - c. Operator self-locking type or equipped with self-locking device.
 - d. Position indicator on quarter-turn valves.
 - e. Worm and gear operators one-piece design, worm-gears of gear bronze material. Worm of hardened alloy steel with thread ground and polished. Traveling nut type operator's threaded steel reach rod with internally threaded bronze or ductile iron nut.
 - 2. Exposed Operator:
 - a. Galvanized and painted handwheel.
 - b. Cranks on gear type operator.
 - c. Chain wheel operator with tieback, extension stem, floor stand, and other accessories to permit operation from normal operation level.
 - d. Valve handles to take a padlock, and wheels a chain and padlock.
 - 3. Buried Operator:

SECTION 40 27 02 PROCESS VALVES AND OPERATORS: continued

- a. Buried service operators on valves larger than 2-1/2 inches shall have a red 2-inch AWWA operating nut. Buried operators on valves 2 inches and smaller shall have cross handle for operation by Forked Key. Enclose moving parts of valve and operator in housing to prevent contact with the soil.
- b. Buried service operators to be grease packed and gasketed to withstand submersion in water to 20 feet minimum.
- c. Buried valves shall have extension stems, bonnets, and valve boxes.

2.07 ACCESSORIES:

- A. Tagging: 1.5-inch diameter heavy brass or stainless-steel tag attached with No. 16 solid brass or stainless-steel jack chain for each valve 6-inch and larger, bearing valve tag number or stationing as shown on Drawings.
- B. T-Handled Operating Wrench:
 1. One (1) each galvanized operating wrenches, 6 feet long.
 2. Manufacturers and Products:
 - a. Mueller; No. A-24610.
 - b. Clow No.; F-2520.
 - c. Engineer approved equal.
- C. Cast-Iron Valve Box: See SECTION 33 14 26 – Waterline Accessories.

PART 3 - EXECUTION:

3.01 INSTALLATION:

- A. Flange Ends:
 1. Flanged valve bolt holes shall straddle vertical centerline of pipe.
 2. Clean flanged faces, insert gasket and bolts, and tighten nuts progressively and uniformly.
- B. Valve Installation and Orientation:
 1. General:
 - a. Install valves so handles operate from fully open to fully closed without encountering obstructions.
 - b. Install valves in location for easy access for routine operation and maintenance.
 - c. Install valves per manufacturer's recommendations.
 2. Gate and Ball Valves:
 - a. Install operating stem vertical in buried horizontal waterlines without gearing, bypasses, rollers, or tracks.
 - b. Direct buried gate valves shall have their operator fit with a valve box adapter prior to installation of the valve box. Valve box adapter shall center, align, and support the valve box. See SECTION: 33 14 26 for valve box adapter requirements.
 3. Butterfly Valves:
 - a. Unless otherwise restricted or shown on Drawings, install valve with shaft in horizontal position.
- C. Locate valve to provide accessibility for control and maintenance.
- D. Extension Stem for Operator: Where depth of valve operating nut is 3 feet or greater below finish grade, furnish operating extension stem with 2-inch operating nut to bring operating nut to a point within 6 inches of finish grade.

SECTION 40 27 02 - PROCESS VALVES AND OPERATORS: continued

- E. Torque Tube: Where operator for quarter-turn valve is located on floor stand, furnish extension stem torque tube of a type properly sized for maximum torque capacity of valve.
- F. Floor Box and Stem: Steel extension stem length shall locate operating nut in floor box.

3.02 TESTS AND INSPECTION:

- A. Valve may be either tested while testing pipelines, or as a separate step.
- B. Test that valves open and close smoothly under operating pressure conditions. Test that two-way valves open and close smoothly under operating pressure conditions from both directions.
- C. Inspect air and vacuum valves as pipe is being filled to verify venting and seating is fully functional.
- D. Count and record number of turns to open and close isolation valves; account for discrepancies with manufacturer's data.
- E. Automatic valves shall be tested in conjunction with control system testing. Set opening and closing speeds, limit switches, as required or recommended by manufacturer or Engineer.

3.03 MANUFACTURER'S SERVICES:

- A. Valve(s) as listed below require manufacturer's field services:
 - 1. Four function combination air/vacuum valves.
 - 2. Gate valves.
 - 3. Butterfly valves.
 - 4. Ball valves.
- B. Manufacturer's Representative: Present at Site for minimum person-days listed below, travel time excluded:
 - 1. 1 person-days installation assistance and inspection.
 - 2. 1 person-days for functional and performance testing and completion of Manufacturer's Certificate of Proper Installation.

END OF SECTION 40 27 02

SECTION 40 66 00 – PROCESS CONTROL NETWORKS

PART 1 - GENERAL

1.01 SUMMARY:

- A. This Section includes network infrastructure, and ancillaries for process control networks and Supervisory Control and Data Acquisition (SCADA) systems.
- B. Process control network shall not be connected to the internet and shall remain separate and unconnected from any Local Area Network (LAN) provided by the Owner.
- C. The Process control network shall be connected to the existing RTU located at the Hilltop Antenna Building.
- D. This Section includes, but not limited to the following:
 - 1. Fiber Optic Cabling, Termination and Accessories.
 - 2. Fiber Optic patch panels and cables.
 - 3. Network Cabling and Accessories.
 - 4. Ethernet Switches.
 - 5. Equipment Racks and Accessories.
 - 6. Ethernet switches.

1.02 RELATED REQUIREMENTS:

- A. Section 40 67 00 - Process Control Panels and Hardware

1.03 REFERENCE STANDARDS:

- A. Furnish equipment which conforms in all respects to applicable industry standards and sound engineer practice.
- B. Design, fabricate, assemble, and test equipment so as to conform with the latest revision of all applicable codes and standards including, but not necessarily limited to, the following.
- C. Electronic Components Industry Association (ECIA):
 - 1. EIA/ECA-310-E – Cabinets, Racks, Panels, and Associated Equipment.
- D. Institute of Electrical and Electronic Engineers (IEEE):
 - 1. IEEE 802.1 – Local and Metropolitan Area Networks.
 - 2. IEEE 802.3 – Ethernet.
 - 3. IEEE 1613 – Environmental and Testing Requirements for Communications Networking Devices in Electric Power Substations.
- E. National Electrical Manufacturer's Association (NEMA):
 - 1. NEMA 250 – Enclosures for Electrical Equipment (1000 Volts Maximum).
- F. National Fire Protection Association (NFPA):
 - 1. NFPA 70 – National Electrical Code.
 - 2. NFPA 262 – Standard Method of Test for Flame Travel and Smoke of Wires and Cables for Use in Air-Handling Spaces.
- G. Underwriter's Laboratories, Inc. (UL):
 - 1. UL 44 – Thermoset-Insulated Wires and Cables.
 - 2. UL 50 – Electrical Cabinets and Boxes.
 - 3. UL 444 – Communications Cables.
 - 4. UL 467 – Grounding and Bonding Equipment.
 - 5. UL 514C – Nonmetallic Outlet Boxes, Flush-Device Boxes, and Covers.
 - 6. UL 969 – Marking and Labeling Systems.

SECTION 40 66 00 – PROCESS CONTROL NETWORKS: continued

7. UL 1581 – Electrical Wires, Cables, and Flexible Cords.
8. UL 1863 – Communication Circuit Accessories.
9. UL 60950-1 – Information Technology Equipment - Safety - Part 1: General Requirements.

1.04 SUBMITTALS:

- A. Submit as specified in the General and Special Conditions.
- B. Product Data:
 1. Data sheets for each cable type and equipment type specified.
 2. Cable manufacturer's approval of pulling compounds.
 3. Cable manufacturer's installation requirements such as maximum pulling tensions, sidewall pressures, minimum bending radii, reel dimensions, etc.
 4. Other ancillary equipment and materials to be used.
 5. Description of cable identification tags and attachment methods which will be used.

1.05 QUALITY CONTROL:

- A. Materials and Equipment shall be the standard products of a manufacturer regularly engaged in the manufacture of such products and shall be the manufacturer's latest standard design that has been in satisfactory use for at least 1 year prior to Bid opening. Each major component of the equipment shall have the manufacturer's name and type identified on the equipment. All products supplied shall be specifically designed and manufactured for use with plant communications systems. All items of the same class of equipment shall be the products of a single manufacturer unless indicated otherwise.

1.06 SITE CONDITIONS:

- A. All Equipment provided as part of this system shall be rated for the temperature, seismic and elevations as specified.

PART 2 - PRODUCTS

2.01 MANUFACTURERS:

- A. Fiber-Optic Cable Connectors, Duplex Jumpers, Patch Panels and Accessories:
 1. AFL.
 2. Avaya Inc.
 3. Black Box Corporation.
 4. Corning Optical Communications.
 5. Ortronics, Legrand.
 6. Panduit.
- B. UTP Cables, Patch Panels, Connectors and Accessories:
 1. Belden.
 2. Berk-Tek, Nexans.
 3. Leviton.
 4. Mohawk, Belden.
 5. Ortronics, Legrand.
 6. Panduit.

SECTION 40 66 00 – PROCESS CONTROL NETWORKS: continued

- 7. Siemon.
 - C. Ethernet Switches:
 - 1. Manufacturer:
 - a. Shall be as required by control system Manufacturer specified in Section 40 67 00.
 - D. Cable Accessories:
 - 1. Tape:
 - a. Minnesota Mining and Manufacturing (3M).
 - 2. Cable Ties:
 - a. AMP, TE Connectivity Ltd.
 - b. IDEAL Industries, Inc.
 - c. Minnesota Mining and Manufacturing (3M).
 - d. Panduit.
 - e. Thomas and Betts Corporation, ABB Group.
 - 3. Cable Supports:
 - a. O-Z Gedney, Emerson Electric Co.
- 2.02 FIBER-OPTIC DUPLEX JUMPER/PATCH CORD:
- A. Two-fiber cable with zipcord cable design, riser - rated (UL listed type OFNR).
 - B. Fiber shall be 62.5 μ m, multimode, graded index.
 - C. Factory installed LC type connectors on each end of each fiber for patch through cables and connection to panel mounted Ethernet switches as required.
 - D. Factory installed LC type connectors on one end and LC type connectors on other end for connection to managed Ethernet switches as required.
 - E. Minimum length of 3 feet. Provide longer jumpers as required.
 - F. Provide patch cords as indicated plus 25% spare of each type.
- 2.03 FIBER-OPTIC PATCH PANELS:
- A. Provide 6 port (3 pair) LC type connectors Fiber Optic Patch Panels for connection to the network.
- 2.04 UTP JUMPER/PATCH CORD:
- A. Patch cords shall consist of factory assembled, 4 pair, 100 ohm UTP, Category 6 cables and equivalent eight-position, RJ-45 wiring connectors at each end.
 - B. Cables shall be wired with straight through pinning and shall be label verified.
 - C. Cable jacket shall be factory marked indicating organization and performance level.
 - D. Cable assemblies shall be designed with strain relief at each connector.
 - E. Cables shall be terminated according to type T568B configuration as defined by TIA-568-C.1.
 - F. Minimum length of 2 feet. Provide longer jumpers as required.
 - G. Provide patch cords as indicated plus 25% spare.
 - H. Cable shall comply with the applicable requirements of UL 444, UL 1685, UL 1863, and ANSI/TIA-568-C.2.
 - I. UTP patch cable specifications shall be as provided by the specification sheets at the end of this Section.

SECTION 40 66 00 – PROCESS CONTROL NETWORKS: continued

2.05 COMMUNICATIONS JACK/CONNECTOR ASSEMBLIES:

- A. Copper jack/connectors shall comply with FCC Part 68.5, and TIA-568-C.2.
- B. Shall be UL 1863 and UL 44 listed, non-keyed, 4 pair, constructed of high impact rated thermoplastic housing and shall be third party verified and shall comply with TIA-568-C.2 Category 6 requirements.
- C. Shall meet or exceed Category 6 requirements.
- D. Shall be terminated using a 110 style PC board connector, color coded for both T568A and T568B wiring.
- E. Shall be wired T568B.
- F. Shall comply with TIA-455-21A for 500 mating cycles.
- G. Cover plates shall comply with UL 514C, and TIA-568-C.2; flush design constructed of 302 stainless steel material.
- H. Stenciled lettering for voice and data circuits shall be provided using thermal ink transfer process.
- I. Cover plates shall accept 4 Category 6 data jacks, or 4 RJ-45 telephone jacks, or a combination thereof.
- J. Provide blank filler plates as required.

2.06 UTP PATCH PANELS:

- A. Shall be a complete system of components by a single manufacturer, and shall provide termination, cable fastening, storage, and cross connection.
- B. Utilize 110-style punch-down terminations on back of panel with individual retention caps. RJ-45 ports on front of unit.
- C. Rear of panel shall have incoming cable strain relief and routing guides.
- D. Shall meet or exceed TIA-568-C.2-1 Category 6 requirements. Each port shall be factory tested.
- E. Wired to T568B configuration.
- F. Shall be capable of terminating number of cables as indicated plus 25% spare capacity.
- G. Shall be provided with labeling space, panel directory and warning labels.
- H. Designed for installation within a 19-inch equipment rack.

2.07 ETHERNET SWITCHES:

- A. Ethernet switches provided for the network shall be DIN rail mount hardened industrial managed Ethernet switches, capable of 10/100/1000 Mbps with autosensing and operate using the Store and Forward Method.
- B. Capable of tree spanning protocol or manufacturers equivalent required for ring level topology in self-healing network.
- C. Unmanaged switches are not acceptable.
- D. Operating temperature 0°C to 60°C minimum.
- E. Provide with redundant fan module for switch chassis when required to meet industrial environment ratings.
- F. Ethernet switch shall be modular in design and accept Small form-factor pluggable (SFP) media modules.
- G. Provide with required 10/100/1000 Base-T RJ-45 ports.
- H. Shall provide half and full duplex operation.
- I. LED indicators for system status, each power supply status, fault.

SECTION 40 66 00 – PROCESS CONTROL NETWORKS: continued

- J. LED indicators for each port indicating link, activity, full/half duplex mode and speed.
- K. Provide with a basic set of I/O parameters available via the Ethernet/IP protocol for device management and remote monitoring.
- L. Comply with IEEE 802.1Q, 802.1D, 802.3, 802.3U, 802.3X, 802.3Z, and 802.3ab.
- M. Capable of operating in a mesh network with rapid spanning tree protocol.
- N. Shall support the following protocols or functions as minimum: SNMPv3, IGMP, DHCP, RMON, RSTP, HTTP, HTTPS, Telnet, and VLAN.
- O. Shall be UL listed and FCC approved. Unit shall be rated for continuous operation under the environmental temperature, humidity, and vibrating conditions encountered at the installed location.
- P. Provide all required management and monitoring software.
- Q. Provide with redundant 120Vac, 60-hertz power supplies and cord and plug connection.
- R. Provide with a minimum of two gigabit LC ports for connection to the fiber backbone.

PART 3 - EXECUTION

3.01 EXAMINATION:

- A. Verify site conditions are suitable for installation of equipment. The area for network equipment installation shall be fully enclosed, weather tight, and free of contaminants.
- 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 installation and shall be maintained for the remainder of the construction period.
- C. Verify that all labels and nameplates meet UL 969 standards.
- D. Any applicable equipment shall meet UL 60950-1.

3.02 INSTALLATION:

- A. General:
 - 1. Cabling, connector assemblies, and associated hardware shall be installed in accordance with TIA 568 C.1, TIA 568 C.2, TIA-568-C.3, TIA 569 C, NFPA 70, and UL standards as applicable.
- B. Cable:
 - 1. General Requirements:
 - a. Metal raceway bases, covers, and dividers shall be bonded and grounded in accordance with TIA-607-B and UL 467.
 - b. Install cable in raceway as indicated.
 - c. Do not subject cable to pulling tensions or sidewall pressures in excess of manufacturer's recommendations.
 - d. Subcontractor shall use a load rated swivel, rated to assure compliance with cable pulling tension as published by the cable manufacturer.
 - e. Attach pulling grips around the cable diameter. Sufficient slack should be provided to cut off several meters of cable after it is in place.

SECTION 40 66 00 – PROCESS CONTROL NETWORKS: continued

- f. Do not subject cable to bending radius less than those recommended by the cable manufacturer.
 - g. Support cables at connections or termination points such that any strain on cable will not be transmitted to the connection or termination.
 - h. Install cable supports in vertical runs of conduit, at boxes and at terminations in equipment, and as required to meet intermediate support requirements of National Electrical Code (NEC).
 - i. All pulling compounds shall be approved by cable manufacturer as being compatible with cable materials.
 - j. Follow the cable numbering scheme indicated and attach a cable identification tag to each cable at all termination or end points.
2. UTP Cable:
- a. Communications cabling and pathways with copper media shall be installed in accordance with the following criteria to avoid potential electromagnetic interference between power and communications equipment.
 - (1) The interference ceiling shall not exceed 3.0 volts per meter measured over the usable bandwidth of the communications cabling.
 - (2) Pathways shall be installed in accordance with the following minimum clearance distances of 4 feet from motors, generators, frequency converters, transformers, or uninterruptible power system, 12 inches from power conduits and cable systems, 5 inches from fluorescent or high frequency lighting system fixtures.
 - b. Screw terminals shall not be used.
 - c. Use an approved insulation displacement connection (IDC) tool kit for copper cable terminations.
 - d. Do not untwist Category 6 UTP cables more than 1/2 inch from the point of termination to maintain cable geometry.
 - e. Provide service loop on each end of the cable, 10 feet at the equipment rack and 12 inches at the jack.
 - f. Do not exceed 25 pounds pull tension for four pair copper cables.
 - g. Do not chafe or damage outer jacket materials.
 - h. Do not over cinch cables, or crush cables with staples.
 - i. UTP cable bend radii shall not be less than four times the cable diameter.
3. Cable Connections and Terminations:
- a. Subcontractor shall provide a qualified technician to make all connections and terminations cable as specified.
 - b. All cable connections and terminations shall be made according to manufacturer's instructions.
 - c. Make only in terminal boxes, equipment or other accepted enclosures and not in conduit or cable tray.
 - d. Install all connectors with manufacturer's approved tooling.
 - e. Cable identification markers shall be installed at each connection.
- C. Fiber Optic Patch Panels:
- 1. Install patch panels as indicated and specified.

SECTION 40 66 00 – PROCESS CONTROL NETWORKS: continued

2. Install panel mounted enclosures in NEMA rated enclosure or control panels as specified and indicated. For panels installed in equipment manufacturer's control panels coordinate with supplier for required panel space and location.
3. Arrange with proper clearances from other equipment and material to obtain accessibility for operation and maintenance.
4. Install adaptor plates and connectors in accordance with manufacturer's recommendations.
5. Utilize panel spools for slack management of individual fibers.
6. Mount plumb and level.
7. Complete panel directory and labeling.
- D. UTP Patch Panels:
 1. Install in equipment racks.
 2. Punch down cables as specified.
 3. Install cable strain relief and routing guides.
 4. Wire to T568B configuration.
 5. Complete port labeling.
- E. Ethernet Switches:
 1. Install Ethernet switches in equipment rack or control panels and make connections as indicated.
 2. Arrange with proper clearances from other equipment and material to obtain accessibility for operation and maintenance.
 3. Program managed switches for proper operations.
 - a. Rapid spanning tree operation shall be implemented for redundancy in system.
 - b. Program switch fault contacts to alert operators of switch problems or errors.
 4. Manufacturer's management software shall be installed on the server, Workstation and laptop to allow the Owner to monitor and configure the Ethernet switches.

3.03 FIELD QUALITY CONTROL:

- A. System Tests:
 1. Perform communications cabling inspection, verification, and performance tests in accordance with TIA-568-C.0, TIA-568-C.1, TIA-568-B.2 and TIA-568-C.3.
 2. Inspect all cabling terminations to confirm color code for tip and ring pin assignments, and inspect cabling connections to confirm compliance with TIA-568-C.2.
 3. Perform optical fiber end to end attenuation tests using an optical light meter and manufacturer's recommended test procedures.
 - a. Perform tests in accordance with TIA-526-14-B, Method B for horizontal, multimode optical fiber.
 - b. Perform verification acceptance test on each fiber after installation of the cable.

SECTION 40 66 00 – PROCESS CONTROL NETWORKS: continued

- c. Any excessive losses due to installation, connectors, etc., shall be identified and corrected by the Subcontractor and tested with no additional charge.
 - 4. Category 6 Links: Perform UTP link tests in accordance with TIA-568-C.2.
 - a. Tests shall include wire map, length, attenuation, NEXT, and propagation delay.
 - 5. After acceptance of communication cable system, all additional components (including Ethernet switches and jumpers) shall be installed and operation of the complete system tested.
 - 6. Copies of the test shall be submitted to the Contractor for acceptance of the communication system.
- 3.04 ADJUSTING AND CLEANING:
- A. All network cables shall be adjusted and neatly secured with tie wraps, hook-and-loop straps, or the like.
 - B. Prior to final acceptance all network equipment shall be wiped clean and free from dust.
- 3.05 TRAINING:
- A. Provide a minimum of 4 hours of training at the customer's facility for operations, maintenance and service personnel of the installed network and SCADA radio system equipment.
 - 1. The training session shall include classroom discussion on the theory of operation of the equipment, as well as maintenance and service methods for the purchased equipment.
 - 2. Topics covered shall include hardware layout and functions, programming and configuration, diagnostic indicators, faults, diagnostic tools, troubleshooting, and preventive maintenance.
 - 3. Hands-on training shall be provided on equipment.
 - 4. Documentation shall be provided which shall include actual hard copies of manuals for the equipment supplied for this project.
 - B. Subcontractor shall record the training sessions and provide a final edited version to the Owner on a video DVD-ROM and electronic video file format.

END OF SECTION 40 66 00

SECTION 40 67 00 – PROCESS CONTROL PANELS AND HARDWARE

PART 1 - GENERAL

1.01 SUMMARY:

- A. This Section includes requirements for process control panels and internal components. Process control panels shall include:
 - 1. Process Control Panel Enclosure
 - 2. Nameplates
 - 3. Circuit Breakers
 - 4. Control Power Transformers
 - 5. Surge Protective Devices
 - 6. Terminal Blocks
 - 7. Switch Action Fuse Blocks
 - 8. Push Buttons and Selector Switches
 - 9. Pilot Lights
 - 10. Control Relays
 - 11. Time Delay Relays
 - 12. Power Supplies
 - 13. Uninterruptable Power Supply (UPS)
 - 14. Convenience Receptacles
 - 15. Interior Illumination
 - 16. Ethernet Switches
 - 17. Programmable Logic Controllers (PLC)
 - 18. Operator Interface Terminal (OIT)

1.02 RELATED REQUIREMENTS:

- A. Section 40 66 00 - Process Control Networks.

1.03 REFERENCE STANDARDS:

- A. Publication Dates: Comply with standards in effect as of date of the Contract Documents unless otherwise indicated.
- B. Institute of Electrical and Electronic Engineers (IEEE):
 - 1. IEEE 802.1 – Local and Metropolitan Area Networks.
 - 2. IEEE 802.3 – Ethernet.
- C. National Fire Protection Association (NFPA):
 - 1. NFPA 70 – National Electrical Code (NEC).
 - 2. NFPA 79 – Electrical Standard for Industrial Machinery.
- D. National Electrical Manufacturers Association (NEMA):
 - 1. NEMA 250 – Enclosures for Electrical Equipment (1,000V maximum).
 - 2. NEMA ICS 1 – Industrial Control and Systems - General Requirements.
 - 3. NEMA ICS 2 – Industrial Control and Systems - Controllers, Contactors, and Overload Relays Rated 600 Volts.
 - 4. NEMA ICS 4 – Application Guideline for Terminal Blocks.
 - 5. NEMA ICS 5 – Industrial Control and Systems - Control Circuit and Pilot Devices.
 - 6. NEMA ICS 6 – Industrial Control and Systems - Enclosures.
- E. Underwriters Laboratories (UL):

SECTION 40 67 00 – PROCESS CONTROL PANELS AND HARDWARE: continued

1. UL 50 – Enclosures for Electrical Equipment.
2. UL 489 – Molded-Case Circuit Breakers, Molded-Case Switches and Circuit Breaker Enclosures.
3. UL 508 – Industrial Control Equipment.
4. UL 508A – Industrial Control Panels.
5. UL 698A – Industrial Control Panels Relating to Hazardous (Classified) Locations.
6. UL 869A – Service Equipment.
7. UL 1449 – Surge Protective Devices.
8. UL 1778 – Uninterruptible Power Systems.

1.04 SUBMITTALS:

- A. Product Data: Submit the following for each type of product specified:
 1. Specification data sheets.
 2. Catalog cut sheets.
 3. Fabricator's qualifications.
- B. Shop Drawings: Provide the following as minimum:
 1. Fabrication drawings, front elevation, wiring diagrams, and bills of material for control panels.
 2. Electrical connection diagrams showing termination locations for all field wiring. External connection diagrams shall indicate cable number and wire color for field cables terminated at the panel.
 3. Engraving schedule and physical dimensions for nameplates.
 4. Provide heat dissipation calculations for all panels containing programmable logic controllers. Include calculation for ventilation fans if required.
- C. Shop Test Plan:
 1. Provide a complete and detailed test plan for the supplied control panels.
 2. Include procedures for certification, validation, and testing.
- D. Test and Evaluation Reports:
 1. Factory test reports.
 2. Field test reports.
- E. Closeout Submittals: Final documentation shall include the following as minimum:
 1. Operation and Maintenance Manuals including the following:
 - a. Operation and maintenance manuals for all components furnished.
 - b. Certified "As-Built"/"As-Installed" drawings.
 - c. Copies of all approved Product Data.
 - d. Copies of all approved Test Reports.
 - e. Spare parts and supply list.
 - f. Warranty Information.
 - g. Subcontractor Information.
 2. Training Materials.

1.05 QUALITY CONTROL:

- A. Materials and Equipment shall be the standard products of a manufacturer regularly engaged in the manufacture of such products and shall be the manufacturer's latest standard design that has been in satisfactory use for at least 1 year prior to Bid opening.

SECTION 40 67 00 – PROCESS CONTROL PANELS AND HARDWARE: continued

- B. Fabricator Qualifications:
 - 1. Prior to assembly and installation, submit data of fabricator's experience and qualifications.
 - 2. Fabrication shall be by a manufacturer or a particular division of a manufacturing firm specializing in control panel construction.
 - 3. Shall have a minimum of 10 years' experience in control panel fabrication.
 - 4. Panel shall be fabricated in a UL listed panel shop.
- C. Factory Tests:
 - 1. The manufacturer shall conduct tests according to industry standard requirements.
 - 2. Perform factory tests on all control panels and components and subassemblies to assure that all devices and systems are in proper working order before delivery to jobsite.
 - 3. Test all power, control and communication systems for proper operation.
 - 4. Simulate actual system operation.
 - 5. Submit test reports as specified in Division 01.
- D. All control panels and associated equipment shall conform to the requirements of NEMA ICS and UL 508A standards.

1.06 DELIVERY, STORAGE, AND HANDLING:

- A. Control panels and associate equipment shall be packaged and shipped to the project site in such a manner as to avoid damage.
- B. All control panels shall be stored according to the manufacturer's instructions and in a conditioned space to avoid condensation, dust, and other environmental contaminants.

1.07 SITE CONDITIONS:

- A. All Equipment provided as part of this system shall be rated for the temperature, seismic and elevations as specified in the Site Conditions in Section 01 11 04.

PART 2 - PRODUCTS

2.01 MANUFACTURERS:

- A. Enclosures:
 - 1. B-Line, Eaton.
 - 2. Hoffman, Pentair PLC.
 - 3. Wiegmann, Hubbell, Inc.
 - 4. Milbank Manufacturing Company.
 - 5. Saginaw Control & Engineering.
- B. Thermal Management Components:
 - 1. Hoffman, Pentair PLC.
 - 2. Noren Products, Inc.
 - 3. Pfannenberg.
 - 4. Saginaw Control & Engineering.
- C. Surge Protective Devices:
 - 1. Advanced Protection Technologies, Inc.

SECTION 40 67 00 – PROCESS CONTROL PANELS AND HARDWARE: continued

2. Citel, Inc.
3. ASCO/EDCO, Vertiv Co.
4. Ferraz Shawmut, Mersen.
5. MCG Surge Protection, Inc.
6. MTL Instruments, Eaton.
7. Phoenix Contact.
8. Square-D, Schneider Electric.
- D. Terminal Blocks:
 1. Allen-Bradley, Rockwell Automation, Inc.
 2. Buchanan, Tyco Electronics Corporation.
 3. Phoenix Contact.
 4. Square-D, Schneider Electric.
 5. Weidmuller.
- E. Push Buttons, Selector Switches and Pilot Lights:
 1. Allen-Bradley, Rockwell Automation, Inc.
 2. Appleton, Emerson Electric Company.
 3. Eaton.
 4. IDEC Corporation.
 5. Killark, Hubbell, Inc.
 6. Square-D, Schneider Electric.
- F. Control and Timing Relays:
 1. Allen-Bradley, Rockwell Automation, Inc.
 2. Eaton.
 3. IDEC Corporation.
 4. Phoenix Contact.
 5. Potter & Brumfield, Tyco Electronics Corporation.
 6. Square-D, Schneider Electric.
 7. Turck, Inc.
- G. Intrinsically Safe Barriers:
 1. MTL Instruments, Eaton.
 2. Pepperl+Fuchs.
 3. Square-D, Schneider Electric.
 4. Turck, Inc.
- H. DC Power Supplies:
 1. Allen-Bradley, Rockwell Automation, Inc.
 2. IDEC Corporation.
 3. Phoenix Contact.
 4. PULS.
 5. SolaHD, Emerson Electric Company.
- I. Uninterruptible Power Supplies (UPS):
 1. Refer to Section 26 33 53 - Static Uninterruptible Power Supply
- J. Convenience and UPS Receptacles:
 1. Cooper Industries, Eaton.
 2. Hubbell, Inc.
 3. Leviton Manufacturing Co., Inc.
 4. Phoenix Contact.
- K. Interior Illumination:

SECTION 40 67 00 – PROCESS CONTROL PANELS AND HARDWARE: continued

1. Acuity Brands, Inc.
2. Hoffman, Pentair Inc.
3. Hubbell, Inc.
4. Stego, Inc.
- L. Wiring Duct:
 1. Panduit Corporation, H-Type.
 2. Thomas and Betts Corporation, ABB Group.
- M. Wire Markers:
 1. Brady Worldwide, Inc.
 2. Panduit Corporation.
 3. Thomas and Betts Corporation, ABB Group.
- N. Programmable Logic Controllers (PLC):
 1. As specified for the Control System below.
- O. Operator Interface Terminal (OIT):
 1. As specified for the Control System below.
- P. Ethernet Switches:
 1. As specified for the Control System below.
- Q. Variable Frequency Drives:
 1. As specified for the Control System below.

2.02 PROCESS CONTROL PANEL ENCLOSURE:

- A. Totally enclosed panel with gasketed doors, continuous hinge, and three point latching mechanism with lockable handle.
- B. Sized to house all equipment and devices required, provide sufficient space for conduit entry, and provide sufficient heat dissipation for the installed components.
- C. Unless specified or indicated otherwise provide the following NEMA 250 approved enclosure type(s):
 1. For the following areas:
 - a. Outdoor process areas: NEMA Type 4X stainless steel.
- D. Unless specified or indicated otherwise provide the following enclosure design:
 1. Wall Mount Design:
 - a. Provide for enclosures with a vertical dimension less than 50-inches.
 - b. Formed and welded construction, minimum 14-gauge.
 - c. Interior 12-gauge minimum steel mounting panel(s).
 - d. Provide mounting tabs and required hardware for installation of enclosures.
 2. Free Standing and Floor Mount Design:
 - a. Provide for enclosures with vertical dimensions of 50-inches or greater.
 - b. Formed and welded construction, minimum 12-gauge for single door enclosures. For multi-door enclosures provide a 10-gauge back.
 - c. Interior 10 or 12-gauge steel mounting panel(s).
 - d. Provide door mounted folding shelf for support of instruments and test equipment. Shelf shall be mounted on the interior of the door. For multi-door enclosures provide a shelf for each pair of doors.
 - e. Provide with lifting eyes.
- E. Provide lockable design.
- F. Provide convenience receptacle as specified this Section.

SECTION 40 67 00 – PROCESS CONTROL PANELS AND HARDWARE: continued

- G. Provide Thermal management as specified this Section.
- H. Provide LED light with door switch as specified this Section.
- I. Accessories:
 - 1. Provide data pocket mounted on the interior of the panel for storage of wiring diagrams.
 - 2. Provide a door stop kit designed to secure the door in the 90 degree open position.
- J. Shall comply with UL 50, UL 508A, and NEMA ICS 6 standards.

2.03 NAMEPLATES:

- A. Fabricate from laminated phenolic sheeting with black core and satin finish melamine overlay.
- B. Colors shall white with black letters.
- C. Thickness: 1/16 inch nominal.
- D. Bevel edges to expose black core on perimeter.
- E. Engraved legend through overlay to expose core.
- F. Attach to panels with industrial grade double-faced tape.
- G. Refer to Section 26 05 53 – Electrical Identification for additional labeling requirements.

2.04 CIRCUIT BREAKERS:

- A. Provide for main disconnecting means for panel and for power distribution within the panel for all voltages.
 - 1. 480Vac:
 - a. Protective devices shall be molded case circuit breakers with thermal-magnetic trip units and inverse time and instantaneous tripping characteristics.
 - b. Circuit breakers shall be operated by a toggle-type handle and shall have a quick-make, quick-break over-center switching mechanism that is mechanically trip-free. Automatic tripping of the breaker shall be clearly indicated by the handle position.
 - c. Circuit breakers shall have a symmetrical interrupting capacity AIC rating matching the power panel supplying power, refer to Power Panel Schedules, and a minimum rating of 18,000 AIC or available fault current whichever is greater.
 - d. Main circuit breakers shall be provided with a door interlocked remote operator kit suitable for installation in provided enclosure. The main disconnect shall be lockable in the off position.
 - e. Number of poles and ampere rating as required.
 - 2. 120/240Vac and 24Vdc:
 - (1) Rated for 120/240Vac and 24Vdc as indicated.
 - b. Thermal-magnetic trip units.
 - c. Trip rating and curve as recommended by manufacturer of equipment being protected.
 - d. DIN rail mounted on the inside of the control panel in a readily accessible location.

SECTION 40 67 00 – PROCESS CONTROL PANELS AND HARDWARE: continued

- e. Toggle-type handle with a quick-make, quick-break over-center switching mechanism that is mechanically trip-free.
 - 3. Minimum symmetrical interrupting capacity of 10,000 AIC or available fault current which ever is greater.
 - B. All circuit breakers must be UL 489 listed.
- 2.05 CONTROL POWER TRANSFORMERS:
- A. Control Panels shall be provided with control power transformers. Refer to Section 26 22 13 – Low Voltage Distribution Transformers for requirements.
- 2.06 SURGE PROTECTIVE DEVICES (SPD):
- A. Control Panels shall be provided with an integral Surge Protective Device (SPD). Refer to Section 26 43 13 – Surge Protection Devices for Low-Voltage Electrical Power Equipment for requirements.
- 2.07 TERMINAL BLOCKS:
- A. 600V, sectional type polyamide blocks.
 - B. Rated a minimum of 24A. Provide higher Amp rated blocks as required.
 - C. Screw connection type.
 - D. Finger safe.
 - E. Slide in vinyl marking strip for terminal identification.
 - F. DIN rail mounted.
 - G. Terminal blocks shall comply with NEMA ICS 4.
- 2.08 SWITCH ACTION FUSE BLOCKS:
- A. Rated 600V.
 - B. Screw connection type.
 - C. Finger safe.
 - D. DIN Rail mounted.
- 2.09 PUSH BUTTONS AND SELECTOR SWITCHES:
- A. Heavy duty, 30 mm units with contacts rated 10A continuous at 120Vac.
 - B. NEMA 4X rated when installed in 4X enclosures.
 - C. Provide the number of contacts and contact development as indicated.
 - D. Operator colors shall comply with UL 508A and NFPA 79.
 - 1. Start or On push buttons shall have green operators.
 - 2. Stop or Off push buttons shall have red operators.
 - E. Emergency Stop push buttons shall have red mushroom head operators with a yellow base.
 - F. Provide hermetically sealed units when installed within a classified area.
 - 1. Suitable for installation in a Class I, Division 1 and 2, Group D area.
 - G. Push Buttons and Selector Switches shall conform to NEMA ICS 5.
- 2.10 PILOT LIGHTS:
- A. Heavy duty, 30 mm units.
 - B. NEMA 4X rated when installed in 4X enclosures.
 - C. 120Vac or 24Vdc cluster LED type.

SECTION 40 67 00 – PROCESS CONTROL PANELS AND HARDWARE: continued

- D. Green lights shall indicate “Equipment On”, “Running”, or “Valve Open”.
- E. Red lights shall indicate “Equipment Off”, “Stopped”, or “Valve Closed”.
- F. Amber lights shall indicate “Equipment Failure” or “Alarm”.
- G. Blue lights shall indicate “Equipment in Auto”.
- H. Push-to-test type.
- I. Pilot lights shall conform to NEMA ICS 5.

2.11 CONTROL RELAYS:

- A. Plug-in type relay with neon coil energization indicator.
- B. Coil voltage: 120Vac or 24Vdc as required.
- C. Contacts rated 10 Amps at 120Vac.
- D. Number of contacts as required.
 - 1. Provide one spare N.O. and one spare N.C. contact (minimum).
 - 2. Spare contacts shall be as indicated.
- E. Provide DIN rail mounted relay socket with screw type terminations.
- F. Control relays shall conform to NEMA ICS 5.

2.12 TIME DELAY RELAYS:

- A. Plug-in type digital based electronic timing relay with coil energization indicator.
- B. Coil voltage: 120Vac or 24Vdc as required.
- C. Contacts rated 10 Amps at 120Vac.
- D. Timing range as indicated with a minimum setting accuracy of $\pm 2\%$ and repeat accuracy of $\pm 0.1\%$.
- E. The selection of timing range settings via DIP switches. The time delay within the range shall be set utilizing an adjustment dial.
- F. Number of contacts as required.
 - 1. Provide one spare N.O. and one spare N.C. contact (minimum).
- G. Provide DIN rail mounted relay socket with screw type terminations.
- H. Time delay relays shall conform to NEMA ICS 5.

2.13 DC POWER SUPPLIES:

- A. Provide industrial rated primary switched 24Vdc power supplies as specified and indicated.
- B. Enclosed design with finger safe input and output terminal blocks.
- C. Designed for DIN rail or back panel mounting.
- D. DC power supply rated as follows:
 - 1. Input voltage: 95 to 130Vac.
 - 2. Output voltage: 24Vdc $\pm 1\%$.
 - 3. Output current: 10A minimum with a minimum 25% spare capacity.
 - 4. Line regulation: $\pm 0.2\%$ maximum.
 - 5. Load regulation: $\pm 1.5\%$ maximum.
 - 6. Ripple: <50 mV pk-pk.
 - 7. No overshoot for turn on, turn off, or power failure.
 - 8. Operating temperature: -25°C to +60°C.
 - 9. Overload and short circuit protection.
 - 10. Indicating lights for status.
- E. Redundancy Module.

SECTION 40 67 00 – PROCESS CONTROL PANELS AND HARDWARE: continued

1. Provide DIN rail mounted redundancy module that provides complete isolation between two 24Vdc power supplies.
 2. Unit shall accept two 24Vdc inputs and provide one redundant 24Vdc output.
 3. Rated for a minimum of two []A inputs and one []A output.
 4. Operating temperature: -25°C to +60°C.
 5. Provide status light and dry output contact that opens when either of the 24Vdc inputs is lost. Output contact shall be rated a minimum of 2 Amps at 30Vdc.
- 2.14 UPS (LINE INTERACTIVE):
- A. Network grade, uninterruptible power system completely self-contained module with an inverter, batteries and control system as specified in Section 26 33 53.
 - B. Shall be provided for PLC Cabinets and other control panels containing micro-processor based controllers.
 - C. Electrical Capacity: 1500VA minimum.
 - D. Provide all required mounting hardware to mount the panel on a shelf within the PLC panel.
 - E. Provide three ½ amp fused terminals for 120 VAC UPS power to be wired by others to field devices.
- 2.15 CONVENIENCE RECEPTACLES:
- A. Interior Mounted Receptacle:
 1. DIN rail mounted, 15-A duplex three-wire grounding GFCI type receptacle with enclosure.
 2. Equipped with terminal blocks for power connection.
 3. Outlet shall be protected with a 5 Amp circuit breaker.
 4. One mounted inside control panel for use in powering laptops and test equipment for service of the panel.
 - B. Door Mounted Receptacle:
 1. Interior PLC Control Panels shall include a door mounted combination power receptacle and data port to allow access to devices inside without opening the enclosure door.
 2. The receptacle shall be a 15-A duplex three-wire grounding GFCI type. The receptacle shall be equipped with terminal blocks for power connection. The receptacle shall be protected with a 5 Amp circuit breaker.
 - a. The receptacle shall be sourced from the control panel 120Vac UPS unit.
- 2.16 INTERIOR ILLUMINATION:
- A. Provide LED type panel lights.
 - B. Minimum 50,000 hour life.
 - C. Size and quantity designed to provide a minimum 50 foot-candles at the base of the panel.
 - D. Powered from 120Vac. Provide required power supply.
 - E. Panel light shall be controlled by a door interlock switch.

SECTION 40 67 00 – PROCESS CONTROL PANELS AND HARDWARE: continued

2.17 POWER DISTRIBUTION:

- A. Wiring:
 - 1. UL style 1015 (AWM), or UL style 1063 machine tool wire (MTW), 600V, 90°C.
 - 2. No. 14 AWG (minimum), 41 strand, for all control wiring.
 - 3. No. 18 AWG (minimum), shielded twisted pairs and triads as applicable for all instrumentation wiring.
 - a. Color code shall be black/red pair (black/red/white triad) with black PVC jacket.
 - 4. Wire Colors (UL508A):
 - a. Black: 240V or 480V AC wiring.
 - b. Red: 120V AC wiring.
 - c. White: AC neutral.
 - d. Green: Ground.
 - e. Blue: DC(+).
 - f. White w/ Blue Tracer: DC(-) grounded.
 - g. From alternate power source that remains energized when main disconnect is open:
 - (1) Yellow: Un-switched power.
 - (2) White w/Yellow Tracer: Un-switched neutral.
- B. Wire Markers:
 - 1. Heat shrinkable, tube-type sleeve markers, constructed of polyolefin material.
 - 2. White sleeves with black thermal printed text.
 - 3. Identify both ends of wire with the same unique wire number.
 - 4. Assign wire numbers where specific designations are not indicated.
 - 5. Markers sized for snug fit for wire size.
- C. Wiring Duct:
 - 1. Provide wide slot wiring duct in panel for routing of panel wiring. Slots shall be a minimum of 0.25-inches.
 - 2. Provide with dual hinge, push-on cover that opens a minimum of 100 degrees to either side.
 - 3. Wiring ducts shall be sized to accommodate all installed wire plus a minimum of 25% spare capacity.
- D. Ground Bus:
 - 1. Provide copper ground bus for power circuits.
 - 2. Provide isolated copper ground bus for instrument shields.

2.18 ARC FLASH LABEL:

- A. Provide a 6 x 4 inch (minimum), plastic arc flash label for each control panel.
- B. Label shall be orange and white.
- C. Label shall read as follows: WARNING – Arc Flash and Shock Hazard. Appropriate PPE and Tools Required When Working on this Equipment.

2.19 SPARE PARTS:

- A. Two spare LED indicating lamps for each type and color used.
- B. Two spare indicating light assemblies.
- C. Ten spare control fuses of each voltage and current rating used.

SECTION 40 67 00 – PROCESS CONTROL PANELS AND HARDWARE: continued

- D. One aerosol cans of manufacturer's touch-up paint for each color used. Color shall match the original factory applied color.
- E. Provide ten (10) spare fuses of each type used including those used in power supplies, processor and all I/O cards.

2.20 PROGRAMMABLE LOGIC CONTROLLERS (PLC):

- A. Provide SPD in process control panels on main power feed for all PLCs installations.
- B. All analog inputs and outputs shall be individually fused.
- C. All digital inputs and outputs shall be individually fused.
- D. Provide PLC hardware.
 - 1. General:
 - a. The programmable controller shall receive status intelligence, perform logic functions, issue control commands, and provide alarms and status information for the systems described in these Specifications.
 - b. The programmable controller Equipment shall consist of a solid-state control system which has user programmable memory for storage of instructions to implement specific functions.
 - c. The PLC Equipment shall be purposely designed as an industrial control system which can perform functions equivalent to a relay panel or a wired solid-state logic system.
 - d. Maximum scan time of 25 ms for all channels.
 - e. All PLC Equipment provided shall be capable of operation in ambient temperatures of 0°C to 60°C, and 5 to 95% relative humidity (non-condensing), without fans or other cooling equipment.
 - f. All external connection points shall be capable withstanding the IEEE surge withstand capability (SWC) test as defined in IEEE C37.90.1.
 - g. The PLC's shall be capable of being configured as a redundant controller.
 - 2. Chassis:
 - a. Provide PLC chassis as required to accommodate the I/O and communications modules required and indicated.
 - b. Provide slot fillers for all unused chassis spaces.
 - 3. Power Supplies:
 - a. Provide power supplies for the processor chassis and expansion chassis as required.
 - b. Power supply shall be sized to supply required power for all installed modules and any spare spaces within the chassis.
 - c. Input voltage shall be 120Vac as indicated.
 - 4. Processor:
 - a. The processor shall be of solid-state design on modular printed circuit boards.
 - b. The processor shall be equipped with an additional communications port for programming.
 - c. The processor shall have user-programmable memory with provisions to prevent unauthorized changes.

SECTION 40 67 00 – PROCESS CONTROL PANELS AND HARDWARE: continued

- d. The processor shall continuously perform diagnostics analysis with a predetermined failure mode in the event of a fault.
- e. All I/O including analog shall be scanned and updated at a rate not to exceed 0.3 milliseconds per scan.
- f. The processor shall allow the logic to be modified, while the processor is in the Run mode without affecting the operation of those portions of the logic not being modified.
- g. The processor shall provide selectable timed interrupt capabilities for the user to incorporate into the running code.
- h. The processor shall provide user defined fault routine capabilities.
- i. The processor shall automatically clear all output and update all input on power-up and prior to scanning and solving any logic.
- j. The processor shall provide the user with a status bit for use in the logic for initialization purposes. This status bit shall be set/reset based on the indicating the first program scan.
- k. The processor shall provide a comprehensive instruction set including:
 - (1) Relay Contact Input:
 - (a) Normally open.
 - (b) Normally closed.
 - (c) Transitional.
 - (2) Relay Coil Output:
 - (a) Standard.
 - (b) Retentive.
 - (3) Timers:
 - (a) On delay.
 - (b) Off delay.
 - (c) Duration.
 - (d) Retentive
 - (e) Time bases of 1.0 sec, 0.1 sec, and 0.01 sec.
 - (4) Counters:
 - (a) Count up.
 - (b) Count down.
 - (5) Arithmetic:
 - (a) Single-precision.
 - (b) Double-precision.
 - (c) Integer.
 - (d) Add.
 - (e) Subtract.
 - (f) Multiply.
 - (g) Divide.
 - (h) Square root.
 - (i) Less than.
 - (j) Greater than.
 - (k) Equal.
 - (6) Logical:
 - (a) And.
 - (b) Or.

SECTION 40 67 00 – PROCESS CONTROL PANELS AND HARDWARE: continued

- (c) Exclusive or.
 - (d) Compare.
 - (7) PID.
 - 5. Communications Hardware:
 - a. Provide communication modules for communications via the communications network.
 - (1) All data within a PLC shall be accessible to any operator workstation, PLC or OIT.
 - (a) Programming functions shall be possible over the network.
 - (b) Unloading and downloading of programs shall be possible over the network.
 - (c) The operating mode of the PLC shall be changeable via the network.
 - b. Provide all required communication cables, connectors, and terminating resistors.
 - 6. PLC Input and Output Modules:
 - a. Digital Input Modules:
 - (1) 120Vac nominal input voltage with an on state voltage of 79 to 132Vac and an off state voltage less than 20Vac.
 - (2) Maximum hardware input delay time of 10 ms.
 - (3) Maximum inrush current of 0.25 Amps.
 - b. Relay Output Modules:
 - (1) Rated 2.0 Amps nominal at 120Vac.
 - (2) Maximum output delay time of 13 ms.
 - (3) Make rating of 15 Amps and a break rating of 1.5 Amps at 120Vac.
 - (4) Provide individual surge suppressors for each output to protect module from surges caused by inductive load switching.
 - c. Analog Input Modules:
 - (1) Individually isolated, 4-20 mA current inputs.
 - (2) Each input shall have a minimum 16-bit resolution.
 - (3) Programmable input filter.
 - d. Analog Output Modules:
 - (1) Individually isolated, 4-20 mA current outputs.
 - (2) Each output shall have a minimum 16-bit current resolution.
 - (3) Provide 1700Vdc channel to channel isolation and channel to backplane isolation.
 - e. Provide screw clamp removable terminal block connectors for each module.
- 2.21 OPERATOR INTERFACE TERMINAL (OIT):
- A. Provide for process control panels and Manufacturer supplied control panels.
 - B. Provide a 15.6" capacitive touch flat panel color TFT display (18-bit color, minimum). Resolution shall be 1920x1080 (16:9 aspect ratio), minimum.
 - C. Luminance shall be a minimum of 400 cd/m2 (Nits) LED backlight.
 - D. Operating systems shall be Microsoft Windows 10 IoT or newer.
 - E. CPU shall be dual-core 2.4 GHz clock speed, minimum.
 - F. Drive storage

SECTION 40 67 00 – PROCESS CONTROL PANELS AND HARDWARE: continued

- G. 1 x bootable up to 128 GB CFast SATA III slot onboard with external front access
- H. 1 x onboard connector for direct insertion of mSATA up to 1 TB SSD SATA III
- I. 1 x onboard connector for 2.5" SSD SATA III up to 1 TB
- J. Storage amount provided to be determined by equipment supplier or system integrator with a minimum of 100% spare storage capacity
- K. OIT unit shall have a minimum of 4GB or DDR4-2400 RAM. Size to be determined based on operating requirements for smooth operation.
- L. Environmental operating temperature range shall be 0 to 55°C, at 5 to 95% non-condensing relative humidity.
- M. Shall be panel mounted with a NEMA rating to match the associated enclosure rating.
- N. Provide the following external ports and interfaces as minimum:
- O. One SD Card (SDHC).
- P. A minimum of 2 USB-3.0, and 2 USB-2.0 host ports for peripheral connections.
- Q. 1 RS-232 port
- R. 1 DVI-D video port
- S. 1 PCIe x4 expansion port
- T. Communication interfaces shall include the following:
- U. One RJ-45 Ethernet (10/100/1000 Mb Autosensing).
- V. Shall accept input power from 24VDC. Provide DIN-rail 120Vac AC-to-DC power supply as required.
- W. Shall be capable of communicating over the Control system network as indicated.

2.22 ETHERNET SWITCHES:

- A. Provide MOXA EDS-4008-2GT-2GS-LV.
- B. Provide smart industrial ethernet managed switches with built-in network security, hardened, VLAN segmentation and Network Address Translation (NAT).
- C. Provide a network switch and all options and accessories to connect the System to the Owners Plant Control System (PCS). As specified in Section 40 66 00.
- D. Provided with all process control panels or cabinets.
- E. Capable of 10/100/1000 Mbps with autosensing and operate using the Store and Forward Method.
- F. Compact Industrial DIN rail mounted design.
- G. Convection cooled with no fans and designed for an industrial environment.
- H. Operating temperature 0°C to 60°C minimum.
- I. Ethernet switch shall be modular in design and accept Small form-factor pluggable (SFP) media modules. Provide with 2 SFP modules.
- J. Provide with eight 10/100/1000 Base-T RJ-45 ports.
- K. Provide half and full duplex operation.
- L. LED indicators for system status, each power supply status, fault.
- M. LED indicators for each port indicating link, activity, full/half duplex mode and speed.
- N. Provide with a basic set of I/O parameters available via the Ethernet/IP protocol for device management and remote monitoring.
- O. Provide an alarm output contact rated a minimum of 0.5 Amp at 30Vac (60Vdc). Contact shall close when a fault condition is detected.
- P. Comply with IEEE 802.1Q, 802.1D, 802.3, 802.3U, 802.3X, 802.3Z, and 802.3ab.

SECTION 40 67 00 – PROCESS CONTROL PANELS AND HARDWARE: continued

- Q. Capable of operating in a mesh network with rapid spanning tree protocol or manufacturers equivalent.
- R. Shall support the following protocols or functions as minimum: SNMPv3, IGMP, DHCP, RMON, RSTP, HTTP, HTTPS, Telnet, and VLAN.
- S. Shall be UL listed and FCC approved. Unit shall be rated for continuous operation under the environmental temperature, humidity, and vibrating conditions encountered at the installed location.
- T. Provide all required management and monitoring software.
- U. Provide UPS power to all Ethernet Switches 120Vac, 60-hertz power supplies and cord and plug connection.
- V. Provide with a minimum of two gigabit LC ports for connection to the fiber backbone.

PART 3 - EXECUTION

3.01 EXAMINATION:

- A. Verify site conditions are suitable for installation of equipment.
- B. For indoor control panels 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 panel and shall be maintained for the remainder of the construction period.

3.02 PANEL FABRICATION:

- A. Install all components in the panel as required and recommended by the manufacturer.
- B. Provide master nameplate and nameplates for all operator interfaces. Interior nameplates shall be provided for individual component identification including, but not limited to, power supplies, PLCs, control relays, terminal blocks, Ethernet switches, circuit breakers, etc.
- C. Provide interior illumination for all panels.
- D. Power Distribution:
 - 1. Provide circuit breakers for protection of equipment in the panel and distribution of power to equipment powered from the control panel.
 - 2. Provide main power disconnect operable from the exterior of the panel for all panels supplied with 480-volts. For panel supplied with 480-volt power provide properly sized control power transformer and required circuit breakers for distribution of power within the panel. Provide dedicated circuit breakers for all 480-volt equipment powered from the panel.
 - 1. Control panels shall include provisions for connection of a 120Vac, 20Amp supply.
 - a. Control panels served by a panel mounted UPS shall include provisions for connection of two (2) 120Vac, 20Amp supply circuits. One circuit shall be used as "House" power for lights, fans, receptacles, etc. The second circuit shall power the panel mounted UPS and shall power all PLC, network, and control system related loads.

SECTION 40 67 00 – PROCESS CONTROL PANELS AND HARDWARE: continued

2. Provide 120Vac circuit breakers to distribute power within the control panel. Circuit breakers shall be sized based upon connected load. As a minimum, a dedicated circuit breaker shall be provided for the each of the following:
 - a. Incoming power sources.
 - b. UPS power source.
 - c. Each device such as lights, fans, heaters, receptacles installed within the panel.
 - d. 24Vdc power supplies.
 - e. Each 120Vac digital input or output module.
 - f. Each 120Vac instrument or device powered from the panel.
 3. Provide 24Vdc circuit breakers to distribute power within the control panel. Circuit breakers shall be sized based upon connected load. As a minimum, a dedicated circuit breaker shall be provided for each of the following:
 - a. Output of 24Vdc power supply.
 - b. PLC power supply (24Vdc).
 - c. Each 24Vdc digital input or output module.
 - d. Each loop powered instrument.
 - e. Each analog input module, if required.
 - f. Each analog output module, if required.
 - g. Each 24Vdc instrument or device powered from the panel.
 4. Provide signage on panel to clearly indicate that the panel is powered from multiple sources if applicable.
- E. Surge Protection:
1. Provide surge protection on the [incoming 480Vac supply and] 120Vac distribution systems within the panel to protect electronic components from transient voltage surges.
 2. Provide surge protection on all power circuits to instruments installed outside of the building envelope in which the control panel is installed. The terminal block type surge suppressor shall be the termination point for the field cabling.
 3. Provide surge protection on all inputs and outputs that are connected to equipment outside of the building envelope in which the control panel is installed. The terminal block type surge suppressor shall be the termination point for the field cabling.
- F. Component Mounting:
1. Operator interfaces and indicating lights shall be installed in the door of the panel at a convenient height for operator interaction.
 2. Components shall be mounted to provide complete accessibility to all terminals, relay sockets, and other devices without dismantling of panel equipment.
 3. Provide sufficient space around and layout components to allow for proper heat dissipation.
 4. Provide sufficient space at the [top] [and] [bottom] of the panel for conduits and cable entry. Conduit entry locations shall be coordinated with the Subcontractor.

SECTION 40 67 00 – PROCESS CONTROL PANELS AND HARDWARE: continued

- G. PLC I/O:
 - 1. Provide interposing relays for all discrete outputs from the PLC including spare points.
 - 2. Provide interposing relays for all relay outputs from the PLC driving loads that exceed 1.5A and when indicated.
 - 3. Wire all inputs and outputs from the PLC to terminal blocks.
 - H. Wiring Methods:
 - 1. Route main groups of wires in plastic nonflammable wiring duct.
 - 2. Smaller groups of wire shall be cabled and secured with nylon cable clamps and ties or plastic spiral wraps.
 - 3. Maintain physical separation of power, control and instrumentation cables within the panel.
 - 4. Provide dedicated wiring ducts for management of field cables within the panel. Wiring ducts shall be sized to accommodate multi-conductor control cables. Assume a minimum of 25% spare conductors and provide a minimum of 25% spare capacity when sizing wiring ducts.
 - I. Terminal Blocks and Connections:
 - 1. Provide terminal blocks for all external connections.
 - 2. Make all connections on terminal blocks.
 - 3. Follow manufacturer's recommendations for terminal block installation.
 - 4. Connect terminal blocks for instrumentation cable shields to isolated ground bus.
 - 5. Provide required grounding type terminal blocks.
 - J. Spare Capacity:
 - 1. Provide a minimum of 40 percent or 4 circuit breakers, whichever is greater, for each power source (Vac and Vdc) present within the panel. All spare circuit breakers shall be mounted, wired, and include provisions to terminate associated neutral or negative conductors.
 - 2. Provide a minimum of 4 spare slots in each PLC chassis. Provide blank filler modules for all empty slots.
 - 3. Provide a minimum of 20 percent or 4 points, whichever is greater, spare PLC inputs and outputs for each type in each panel. All spare points shall be wired to field terminal blocks. Fifty percent of spare analog inputs shall be configured to provide loop power.
 - 4. Provide a minimum of 20 percent spare terminal blocks of each type mounted in the panel.
 - 5. Provide spare DIN rail space for the installation of terminal blocks for all spare slots in the PLC chassis.
 - K. Provide labeling on all terminal blocks, wiring and relays to match panel drawings.
- 3.03 UNINTERRUPTIBLE POWER SUPPLY INSTALLATION:
- A. Install UPS systems in control panel as specified.
 - B. Startup and initial charging shall be as required by the UPS manufacturer.
 - C. Install the Maintenance Bypass Switch and make the required connections to UPS and loads served.

SECTION 40 67 00 – PROCESS CONTROL PANELS AND HARDWARE: continued

3.04 ETHERNET SWITCH INSTALLATION:

- A. Install Ethernet switches in control panels and make connections as indicated.
- B. Arrange with proper clearances from other equipment and material to obtain accessibility for operation and maintenance.
- C. Shall provide adequate ports for connection to the plant control system, PLC, OIT, door mounted RJ-45 port, and provide a minimum of one spare programming port.

3.05 PLC PROGRAMMING:

- A. Coordinate with City.

3.06 OIT PROGRAMMING:

- A. Coordinate with City.

3.07 INSTALLATION:

- A. Control Panels:
 - 1. Conform to manufacturer's written instructions.
 - 2. Surface-mount wall mount enclosures on structural supports or wall approximately 4 feet to center line above the floor when possible.
 - 3. Install floor mounted enclosures where indicated and bolt to floor using expansion type concrete anchors.
 - 4. Install all necessary openings in panels.
 - 5. Arrange with proper clearances from other equipment and material to obtain accessibility for operation and maintenance.
 - 6. Mount plumb and level.
- B. Electrical Connections:
 - 1. Install wire and cable as specified in Division 26.
 - 2. Conform to manufacturer's wiring diagrams.
 - 3. Install circuits to field-mounted equipment as indicated and required.
 - 4. Installation shall conform to NFPA 70 (NEC).
- C. Place arc flash label on equipment.

3.08 FIELD QUALITY CONTROL:

- A. Manufacturer's Field Services:
 - 1. The panel supplier shall provide the field services of a trained technician for the amount of time required to commission, test and start-up all equipment provided.
 - 2. All travel and living expenses shall be included for all trips to the site. All equipment required for testing, start-up and performance verification shall be provided by the start-up technician.
- B. Check all internal and external connections and tighten as required.
- C. Perform I/O checkout on all points and verify proper operation.
- D. Verify proper connection of communication cabling and proper communication system configuration.
- E. Field verify proper operation of all inputs and outputs.
- F. Record results of I/O checkout and submit test reports as specified in Division 01.

SECTION 40 67 00 – PROCESS CONTROL PANELS AND HARDWARE: continued

3.09 FINISHES:

- A. Control panel coatings shall be free from scratches, rust, or other defects.
- B. All damaged or defective coatings shall be repaired prior to final acceptance.
- C. Field Painting:
 - 1. Touch Up:
 - a. Subcontractor shall prepare surfaces and touch up manufacturer applied coatings as required for any damage during shipment and installation.
 - b. Field painting shall be performed based on manufacturer's recommended procedures.
 - c. Subcontractor shall provide the necessary quantity of Manufacturer's touch-up paint to match the factory applied finish.

3.10 ADJUSTING AND CLEANING:

- A. After field installation and final wiring terminations are completed the 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.
- C. Prior to final acceptance control panel interior and exterior shall be wiped clean and free from dust and debris.

3.11 TRAINING:

- A. Provide a minimum of 4 hours of training for each panel provided at the customer's facility for operations, maintenance and service personnel.
 - 1. The training session shall include classroom discussion on the theory of operation of the equipment, as well as maintenance and service methods for the purchased equipment.
 - 2. Topics covered shall include safety, hardware layout and functions, power and control wiring, diagnostic indicators, keypad/display interface, faults, diagnostic tools, troubleshooting, and preventive maintenance.
 - 3. Hands-on training shall be provided on equipment.
 - 4. Documentation shall be provided which shall include actual manuals for the equipment and drawings and schematics of equipment supplied for this project.
- B. Subcontractor shall record the training sessions and provide a final edited version to the Owner on a video DVD-ROM and electronic video file format.

END OF SECTION 40 67 00

SECTION 40 70 00 – INSTRUMENTATION FOR PROCESS SYSTEMS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS:

- A. Drawings and conditions of the Contract, including General and Special Conditions, apply to this SECTION.

1.02 SUMMARY:

- A. This Section includes the requirements for measuring and controlling instruments.

1.03 RELATED REQUIREMENTS:

- A. SECTION 40 60 00 – Process Control Panels and Hardware.

1.04 REFERENCE STANDARDS:

- A. Publication Dates: Comply with standards in effect as of date of the Contract Documents unless otherwise indicated.
- B. American Society of Mechanical Engineers (ASME):
 - 1. ASME B16.5 – Pipe Flanges and Flanged Fittings.
- C. International Society of Automation (ISA).
 - 1. ISA S20 – Specification Forms for Process Measurement and Control Instruments, Primary Elements and Control Valves.
- D. National Electrical Manufacturers Association (NEMA).
- E. NSF International:
 - 1. NSF 61 - Drinking Water System Components - Health Effects.

1.05 SUBMITTALS:

- A. Submit as in the General and Special Conditions.
- B. Manufacturer with prime responsibility shall assume responsibility for all Compliance Submittals.
- C. Product Data: Submit for each type of product specified and included the following as minimum:
 - 1. Individual specifications and technical data for instruments and similar major system components to conform to ISA S20.
 - 2. Electrical and mechanical connection diagrams for all instruments.
 - 3. Physical dimensions for each instrument.
- D. Special Procedure Submittals:
 - 1. Test Plan:
 - a. Provide a complete and detailed calibration and test plan for the supplied instrumentation.
 - b. Include procedures for certification, validation, and testing.
 - 2. Syllabus for Owner training.
- E. Test and Evaluation Reports:
 - 1. Factory test and calibration reports.
 - 2. Field test and calibration reports.
- F. Closeout Submittals: Final documentation shall include the following as minimum:
 - 1. Operation and Maintenance Manuals including the following:
 - a. Operation and maintenance manuals for all instruments furnished.
 - b. Copies of all approved Product Data.

SECTION 40 70 00 – INSTRUMENTATION FOR PROCESS SYSTEMS: continued

- c. Copies of all approved Test and Calibration Reports.
 - d. Spare parts and supply list.
 - e. Warranty Information.
 - f. Contractor Information.
 - g. Training Materials.
 - G. Maintenance Material Submittals:
 - 1. Spare Parts:
 - a. Provide five (5) spare fuses of each type used.
 - b. Provide any cabling and serial to USB converters necessary to setup and calibrate supplied instrumentation from a laptop computer.
 - 2. Software:
 - a. Manufacturer supplied software required for setup and calibration of instrumentation shall be provided.
 - b. Assemble and submit all device type manager (DTM) software modules required for HART enabled instrumentation.
 - c. Organize and submit all software copies in a 3-ring binder.
- 1.06 QUALITY CONTROL:
- A. Factory Tests:
 - 1. As a minimum, the manufacturer's standard tests and calibration procedures shall be conducted on all instruments.
- 1.07 DELIVERY, STORAGE, AND HANDLING:
- A. Instrumentation and associated equipment shall be packaged and shipped to the project site to avoid damage.
 - B. All instrumentation shall be stored according to the manufacturer's instructions.
- 1.08 WARRANTY:
- A. Instruments shall be provided with a minimum 1-year manufacturer's warranty after construction acceptance.
 - B. In the event a component or instrument fails to perform as specified or is proven defective during the warranty period, the manufacturer shall promptly repair or replace the defective part at no cost to the Owner.

PART 2 - PRODUCTS

- 2.01 MANUFACTURERS:
- A. Radar Level Transmitters:
 - 1. Endress+Hauser, Inc., FMR series
 - B. Point Level Switches:
 - 1. Endress+Hauser, Inc.
 - 2. Fluid Components International LLC.
 - 3. Magnetrol International, Inc.
 - 4. Rosemount, Emerson Electric Co.
 - C. Float Switches (Optical):
 - 1. Cox Research.
 - 2. Float Switches.

SECTION 40 70 00 – INSTRUMENTATION FOR PROCESS SYSTEMS: continued

3. Anchor Scientific, Inc.
4. Siemens.

2.02 INSTRUMENTS:

- A. Refer to the instrument list at the end of the contract documents for a list of instruments specified to be provided by this Division.

2.03 GENERAL:

- A. All applicable analog level devices and pressure devices shall communicate over analog (4-20mA).
 1. Bluetooth capability shall be incorporated as well in these instruments.
- B. All analog indicating and recording receivers shall have evenly graduated scales.
- C. Provide all mounting brackets, pipe stands, and accessories required to install all field mounted instruments. All mounting brackets and hardware for instruments installed in exterior locations or within process areas shall be stainless steel.
- D. Furnish and install all accessories required for complete and working systems as specified and indicated.
- E. Provide sun shades for all exterior mounted transmitters.
- F. All flanged instruments shall comply with ASME B16.5.
- G. All instruments or instrument wetted parts contacting the process stream directly shall comply with NSF 61 for contact with potable water.

2.04 RADAR LEVEL TRANSMITTERS:

- A. Provide loop powered radar level transmitter for continuous level detection of liquids.
- B. Provide 316 stainless steel 4-inch horn antenna minimum with a maximum beam angle of 8 degrees for liquid applications.
- C. Provide with Hart communication capability. Provide device type manager (DTM) software module for use in Hart device setup and monitoring software if required.
- D. Provide with Bluetooth communication capability.
- E. System accuracy shall be within ± 0.25 -inch.
- F. Unit shall be capable of mapping out unwanted obstructions via user friendly interface software. Provide required software and cable to connect to the unit.
- G. Provide waveguide extension for proper mounting as required.
- H. Provide sunshield for outdoor mounted units.
- I. Provide stainless steel mounting bracket for units indicated to be wall mounted.

PART 3 - EXECUTION

3.01 EXAMINATION:

- A. Verify site conditions are suitable for installation of instrumentation and associated equipment.

3.02 INSTALLATION:

- A. Field Mounted Devices:
 1. Install as follows:
 - a. Mount on floor or wall as required.

SECTION 40 70 00 – INSTRUMENTATION FOR PROCESS SYSTEMS: continued

- b. Mount plumb and level.
 - c. Mount on walls with bottom of box or instrument four feet above floor unless indicated otherwise and instrument case spaced at least 1/2-inch away from wall.
 - d. Install supports as specified this Division.
 - e. Install floor-mounted instruments on strut support racks or pipe stands.
 - f. Install measuring and controlling instruments in accordance with manufacturer's written instructions.
 - g. Calibrate and setup instruments to specified ranges. Install DTM files in Hart software library if required.
 - h. Install identification tags on all instruments.
 - 2. Connect inputs and outputs as indicated on the manufacturer's shop drawings and as follows:
 - a. Transmitters requiring electric power shall be supplied from their associated control panels.
- 3.03 FIELD QUALITY CONTROL:
 - A. Manufacturer's field services:
 - 1. Manufacturer's field services shall be provided as specified in this Section and in the General and Special Conditions.
 - 2. Provide a minimum of 2 hours for each instrument to supervise/inspect installation, commission, test and start-up all equipment provided.
 - 3. All equipment required for testing, start-up and performance verification shall be provided by the start-up technician.
 - 4. All travel and living expenses shall be included.
 - B. Field Testing:
 - 1. Test and start-up supervision shall continue until the system is in proper operating condition as determined by Engineer.
 - 2. Provide manufacturer's supervision during Work to correct deficiencies in Equipment manufactured by them and to correct deficiencies in the installation and wiring of Equipment. Corrections shall be at no increase in the Contract Price.
 - 3. Functional Testing of Controls:
 - a. Perform before equipment is placed in service.
 - b. Include operating control system from each control point.
 - c. Completely check each annunciator point and equipment alarm.
 - d. Operate by hand all relays, pressure switches, limit switches and other system components that cannot be operated in normal manner with plant not in service.
 - e. Repeat with plant in operation.
 - 4. Instrument Tests and Adjustments:
 - a. Calibrate and startup measuring and controlling instruments in accordance with manufacturers recommendations.
 - b. With each system variable transmitter disconnected from its normal source of input signal, apply an input with manometer, instrument potentiometer, or other device and adjust span and zero on all instruments transmitting, receiving, or retransmitting the resulting

SECTION 40 70 00 – INSTRUMENTATION FOR PROCESS SYSTEMS: continued

variable current, voltage, time duration or pneumatic signal and on all final control devices. Check instruments and final control devices at several points over the instrument measuring or control device span.

- c. Apply manually adjustable time duration or current signals directly to receivers where required to adjust zero and span and to check operation of the instrument over the measuring span.
- d. Accurately measure variable current, voltage, time duration and pneumatic signals as required to adjust all receivers, transmitters, transducers, and final control devices.
- e. Check operation of controller with various set points and system variable inputs; adjust controller proportional band, reset, and rate to conform to instructions from manufacturer's representative and Engineer.
- f. Check operation of each instrument with system in actual operation.
- g. Readjust controller settings as required to obtain desired control of the associated system variables.

3.04 TRAINING:

- A. Provide a minimum of 4 hours of training at the customer's facility for operations, maintenance and service personnel for each type of instrument provided.
 - 1. The training session shall include classroom discussion on the theory of operation of the equipment, as well as maintenance and service methods for the purchased equipment.
 - 2. Topics covered shall include safety, hardware layout and functions, power and control wiring, diagnostic indicators, keypad/display interface, faults, diagnostic tools, troubleshooting, and preventive maintenance.
 - 3. Hands-on training shall be provided on equipment.
 - 4. Documentation shall be provided which shall include actual manuals for the equipment and drawings and schematics of equipment supplied for this project.
- B. The Owner at their option shall be allowed to video record all training sessions for future reference.

END OF SECTION 40 70 00