Dundee State Fish Hatchery
Water Reuse – Effluent Pump Back

Technical Specifications

BGE, Inc.
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December 2020
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INFORMATION AVAILABLE TO BIDDERS
Geotechnical Information
BGE, Inc.

TBPE Firm No. 1046

December 2020

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PROJECT MANAGER

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December 2020
STRUCTURAL ENGINEER

John D. Mischkot
JQ Infrastructure, LLC
TBPE Firm No. 7986

December 2020

Division 3, Division 5
Dundee State Fish Hatchery
Pump Back System
Technical Specifications

ELECTRICAL ENGINEER
George B. Luke, PE
Gupta & Associates, Inc.
TBPE Firm No. F-2593

20 December 2020

13310, 13312, Division 16
SECTION 01561
TRENCH SAFETY SYSTEM

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Trench safety system for the construction of trench excavations.
B. Trench safety system for structural excavations, which fall under provisions of state and federal trench safety laws.

1.02 MEASUREMENT AND PAYMENT

A. Measurement for trench safety systems used on trench excavations shall be lump sum.
B. No payment will be made for trench safety systems for structural excavations under this section. Include payment for trench safety system in applicable structure installation sections.

1.03 DEFINITIONS

A. A trench shall be defined as a narrow excavation (in relation to its depth) made below the surface of the ground. In general, the depth is greater than the width, but the width of a trench (measured at the bottom) is not greater than 15 feet.
B. The trench safety system requirements will apply to larger open excavations if the erection of structures or other installations limits the space between the excavation slope and the installation to dimensions equivalent of a trench as defined.
C. Trench safety systems include but are not limited to sloping, sheeting, trench boxes or trench shields, sheet piling, cribbing, bracing, shoring, dewatering or diversion of water to provide adequate drainage.

1.04 SUBMITTALS – Not Used

1.05 REGULATORY REQUIREMENTS

A. Install and maintain trench safety systems in accordance with the detail specifications set out in the provision of Excavations, Trenching, and Shoring, Federal Occupation Safety and Health Administration (OSHA) Standards, 29CFR, Part 1926, Subpart P, as amended, including Final Rule, published in the Federal Register Vol. 54, No. 209 on Tuesday, October 31, 1989. The sections that are incorporated into these specifications by reference include Sections 1926-650 through 1926-652.
B. OSHA standards included in "Subpart P - Excavations" from the Federal Register Vol. 54, No. 209 is available in the Federal Register.

C. Legislation that has been enacted by the Texas Legislature with regard to trench safety systems is hereby incorporated, by reference, into these specifications. Refer to Texas Health and Safety Code Ann., §756.021 (Vernon 1991).

PART 2 - PRODUCTS

2.01 GEOTECHNICAL METHODS

A. The Contractor is responsible for obtaining borings and soil analysis as required for the system design.

2.02 PLAN DESCRIPTION

A. The trench safety plan shall identify the project for which it was prepared in BOLD CAPITAL letters on the cover page.

B. The Trench Safety Plan shall be prepared by a licensed Civil Engineer in the State of Texas. The engineer who prepared the Plan shall affix his seal on the cover page of the Plan with a signature and date. Under no circumstances shall the date when the Plan is submitted to the Engineer for record purposes be greater than 14 days.

C. The Trench Safety Plan shall reference the types of soil conditions on-site for which it was prepared. Any and all OSHA guidelines shall be adhered to during the preparation of the Trench Safety Plan.

D. Contractor shall be solely responsible for ensuring the Trench Safety Plan is adequate to complete the project.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install and maintain trench safety systems in accordance with provisions of OSHA 29CFR.

B. Install specially designed trench safety systems in accordance with the Contractor's trench excavation safety program for the locations and conditions identified in the program.

C. A competent person, as identified in the Contractor's Trench Safety Program, shall verify that trench boxes and other pre-manufactured systems are certified for the actual installation conditions.
3.02 INSPECTION

A. Contractor, or Contractor's independently retained consultant, shall make daily inspections of the trench safety systems to ensure that the installed systems and operations meet OSHA 29CFR and other personnel protection regulations requirements.

B. If evidence of possible cave-ins or slides is apparent, Contractor shall immediately stop work in the trench and move personnel to safe locations until Contractor has taken the necessary precautions to safeguard personnel entering the trench.

C. Maintain a permanent record of daily inspections.

D. Contractor shall post and have available on-site a copy of the trench safety plan for review by the Engineer, Owner, or public agency, as deemed necessary. Contractor shall hold weekly meetings with employees and any subcontractors regarding the trench safety plan to ensure compliance with the intent of the plan. Contractor shall notify Engineer prior to the meeting.

3.03 FIELD QUALITY CONTROL

A. Contractor shall verify specific applicability of the selected or specially designed trench safety systems to each field condition encountered on the project.

END OF SECTION
PART 1 - GENERAL

1.01 SECTION INCLUDES

A. This Section describes the required documentation to be prepared and signed by the Contractor before conducting construction operations, in accordance with the terms and conditions of the Texas National Pollutant Discharge Elimination System (TNPDES) General Permit No TXR150000, pursuant to Section 26.040 of the Texas Water Code and Section 402 of the Clean Water Act, issued by the Texas Commission on Environmental Quality effective March 5, 2013.

B. The Contractor shall be responsible for implementation, maintenance, and inspection of storm water pollution prevention control measures including, but not limited to, erosion and sediment controls, storm water management plans, waste collection and disposal, off-site vehicle tracking, and other practices outlined in the Storm Water Pollution Prevention Plan (SWPPP attached as an Appendix to these Contract Documents and Specifications) and as shown on the PLANS or specified elsewhere in this or other specifications.

C. Contractor shall review implementation of the SWPPP with the Engineer prior to start of construction.

1.02 MEASUREMENT AND PAYMENT

A. Unless indicated in the BID FORM as a pay item, no separate payment will be made for work performed under this section. Include cost of work performed under this section in pay items of which this work is a component.

PART 2 - PRODUCTS - Not Used

PART 3 - EXECUTION

3.01 NOTICE OF INTENT

A. The Contractor shall submit Contractor’s Notice of Intent (NOI) as required by the TNPDES General Permit.

3.02 CERTIFICATION REQUIREMENTS

A. The Contractor is to complete the Contractor’s/Subcontractor’s Certification form and provide copies to the Engineer at the Pre-Construction Meeting.

B. The persons or firms responsible for maintenance and inspection of erosion and sediment control measures shall complete the reports as required in the SWPPP.
3.03 RETENTION OF RECORDS

A. The Contractor shall keep a copy of the Storm Water Pollution Prevention Plan at the construction site or at the Contractor’s office from the date that it became effective to the date of project completion.

B. At project closeout, the Contractor shall submit to the Owner all TNPDES forms and certifications, as well as a copy of the SWPPP. Storm water pollution prevention records and data will be retained by Owner for a period of 3 years from the date of project completion.

3.04 REQUIRED NOTICES

A. The following notices shall be posted from the date that this SWPPP goes into effect until the date of final site stabilization:

1. Copies of the Notices of Intent submitted by the Contractor and a brief project description, as given in Paragraph 1.1 of the SWPPP, shall be posted at the construction site or at Contractor’s office in a prominent place for public viewing.

2. Notice to drivers of equipment and vehicles, instructing them to stop, check, and clean tires of debris and mud before driving onto traffic lanes. Post such notices at every stabilized construction exit area.

3. In an easily visible location on site, post a notice of waste disposal procedures.

4. Notice of hazardous material handling and emergency procedures shall be posted with the NOI on site. Keep copies of Material Safety Data Sheets at a location on site that is known to all personnel.

5. Keep a copy of each signed certification at the construction site or at Contractor’s office.

END OF SECTION
SECTION 01572
SOURCE CONTROLS FOR EROSION AND SEDIMENTATION

PART 1 - GENERAL

1.01 SECTION INCLUDES
A. Description of erosion and sediment control and other control-related practices that shall be utilized during construction activities.

1.02 MEASUREMENT AND PAYMENT
A. Unless indicated in the BID FORM as a pay item, no separate payment will be made for work performed under this section. Include cost of work performed under this section in pay items of which this work is a component.

PART 2 - PRODUCTS - Not Used

PART 3 - EXECUTION

3.01 PREPARATION AND INSTALLATION
A. No clearing and grubbing or rough cutting shall be permitted until erosion and sediment control systems are in place, other than site work specifically directed by the Engineer to allow soil testing and surveying.

B. Equipment and vehicles shall be prohibited by the Contractor from maneuvering on areas outside of dedicated rights-of-way and easements for construction. Damage caused by construction traffic to erosion and sediment control systems shall be repaired immediately by the Contractor.

C. The Contractor shall be responsible for collecting, storing, hauling, and disposing of spoil, silt, and waste materials as specified in this or other sections and in compliance with applicable federal, state, and local rules and regulations.

D. Contractor shall conduct all construction operations under this Contract in conformance with the erosion control practices described in the PLANS and this section.

E. The Contractor shall install, maintain, and inspect erosion and sediment control measures and practices as specified in the PLANS and in this or other sections.

3.02 TOPSOIL PLACEMENT FOR EROSION AND SEDIMENT CONTROL SYSTEMS
A. When topsoil is specified as a component of another section, the Contractor shall conduct erosion control practices described in this section during topsoil placement operations.
1. When placing topsoil, maintain erosion and sediment control systems, such as swales, grade stabilization structures, berms, dikes, waterways, and sediment basins.

2. Maintain grades, which have been previously established on areas to receive topsoil.

3. After the areas to receive topsoil have been brought to grade, and immediately prior to dumping and spreading the topsoil, loosen the subgrade by disk or by scarifying to a depth of at least 2 inches to permit bonding of the topsoil to the subsoil.

4. No sod or seed shall be placed on soil that has been treated with soil sterilant until enough time has elapsed to permit dissipation of toxic materials.

3.03 PROTECTION OF TREES IN CONSTRUCTION AREAS

A. Heavy equipment, vehicular traffic, and stockpiles of construction materials, including topsoil, are not permitted within the dripline of any tree to be retained. Contractor shall avoid all contact with trees to be retained unless otherwise directed by the Owner or required by the work under this Contract.

B. Specimen trees shown on the PLANS shall be boxed or fenced. When called for in the PLANS, tunnel under the root system for the installation of utility lines.

C. Contractor shall water those trees indicated to be preserved, as required, to maintain their healthy growth during construction operations. Contractor shall protect tree root systems from damage due to noxious materials in solution caused by runoff or spillage during mixing and placement of construction materials or drainage from stored materials.

D. Tree trunks, exposed roots, and limbs of the trees designated to be retained which are damaged during construction operations will be cared for as prescribed by a forester or licensed tree expert at the expense of the Contractor.

3.04 DUST CONTROL

A. Implement dust control methods to control dust creation and movement on construction sites and roads and to prevent airborne sediment from reaching receiving streams or storm water conveyance systems, to reduce on-site and off-site damage, to prevent health hazards, and to improve traffic safety.

B. Control blowing dust by using one or more of the following methods:

1. Mulches bound with chemical binders, such as Curasol, Terratak, or Engineer approved equal.

2. Temporary vegetative cover.

3. Spray-on adhesives on mineral soils when not used by traffic.

4. Tillage to roughen surface and bring clods to the surface.

5. Irrigation by water sprinkling.
6. Barriers using solid board fences, snow fences, burlap fences, crate walls, bales of hay, or similar materials.

C. Implement dust control methods immediately whenever dust can be observed blowing on the project site.

3.05 KEEPING STREETS CLEAN

A. Keep streets clean of construction debris and mud carried by construction vehicles and equipment. If to keep the streets clean, install stabilized construction exits at construction, staging, storage, and disposal areas. A vehicle/equipment wash area (stabilized with coarse aggregate) may be installed adjacent to the stabilized construction exit, as needed. Release wash water into a drainage swale or inlet protected by erosion and sediment control measures. Construction exit and wash areas are specified in Section 01575 - Stabilized Construction Exit.

B. In lieu of or in addition to stabilized construction exits, shovel or sweep the pavement to the extent necessary to keep the street clean. Water hosing or sweeping of debris and mud off of the street into adjacent areas is not allowed.

3.06 EQUIPMENT MAINTENANCE AND REPAIR

A. Confine maintenance and repair of construction machinery and equipment to areas specifically designated for that purpose. Locate such areas so that oils, gasoline, grease, solvents, and other potential pollutants cannot be washed directly into receiving streams or storm water conveyance systems. Provide these areas with adequate waste disposal receptacles for liquid as well as solid waste. Clean and inspect maintenance areas daily.

B. On a construction site where designated equipment maintenance areas are not feasible, take precautions during each individual repair or maintenance operation to prevent potential pollutants from washing into streams or conveyance systems. Provide temporary waste disposal receptacles.

3.07 WASTE COLLECTION AND DISPOSAL

A. Contractor shall formulate and implement a plan for the collection and disposal of waste materials on the construction site. In plan, designate locations for trash and waste receptacles and establish a collection schedule. Methods for ultimate disposal of waste shall be specified and carried out in accordance with applicable local, state, and federal health and safety regulations. Make special provisions for the collection and disposal of liquid wastes and toxic or hazardous materials.

B. Keep receptacles and waste collection areas neat and orderly to the extent possible. Waste shall not be allowed to overflow its container or accumulate from day-to-day. Locate trash collection points where they will least likely be affected by concentrated storm water runoff.
3.08 WASHING AREAS

A. Construction equipment and vehicles such as concrete trucks shall be washed in designated areas only, as approved by the Engineer. These designated wash areas shall be designed and maintained such as to prevent runoff from leaving the site, as well as preventing the runoff from entering a storm sewer system or into a watercourse. The designated areas shall be located where the wash water will evaporate or infiltrate directly into the ground and where runoff can be collected in a temporary holding or seepage basin. Wash areas shall not be located immediately adjacent to a storm sewer system or other watercourse or near a designated jurisdictional wetland.

B. Concrete waste shall be permitted to dry in an impervious pit, sump, or other collection basin, and the waste shall be removed from the project site.

3.09 STORAGE OF CONSTRUCTION MATERIALS AND CHEMICALS

A. Isolate sites where chemicals, cements, solvents, paints, or other potential water pollutants are stored in areas where they will not cause runoff pollution.

B. Store toxic chemicals and materials, such as pesticides, paints, and acids in accordance with manufacturers’ guidelines. Protect groundwater resources from leaching by placing a plastic mat, packed clay, tarpaper, or other impervious materials on any areas where toxic liquids are to be opened and stored.

3.10 DEMOLITION AREAS

A. Demolition activities that create large amounts of dust with significant concentrations of heavy metals or other toxic pollutants shall use dust control techniques to limit transport of airborne pollutants. However, water or slurry used to control dust contaminated with heavy metals or toxic pollutants shall be retained on the site and shall not be allowed to run directly into watercourses or storm water conveyance systems. Methods of ultimate disposal of these materials shall be carried out in accordance with applicable local, state, and federal health and safety regulations.

3.11 SANITARY FACILITIES

A. All construction sites must be provided with adequate sanitary facilities for workers in accordance with applicable health regulations.
3.12 PESTICIDES

A. Use and store pesticides during construction in accordance with manufacturers’ guidelines and with local, state, and federal regulations. Avoid overuse of pesticides, which could produce contaminated runoff. Take great care to prevent accidental spillage. Never wash pesticide containers in or near flowing streams or storm water conveyance systems.

END OF SECTION
SECTION 01573
FILTER FABRIC FENCE

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Installation of erosion and sedimentation control filter fabric fences utilized during construction and prior to the final development of the site. The purpose of filter fabric fences is to contain pollutants from overland flow. Filter fabric fences are not for use in channelized flow areas.

1.02 MEASUREMENT AND PAYMENT

A. Unless indicated in the BID FORM as a pay item, no separate payment for work performed under this section. Include cost of work performed under this section in Contract prices bid for items of which this work is a component.

B. Payment for filter fabric fence will include and be full compensation for all labor, equipment, materials, supervision, and all incidental expenses for installation, complete in place, including, but not limited to, protection of trees, maintenance requirements, repair and replacement of damaged sections, removal of sediment deposits, and removal of erosion and sedimentation control systems at the end of construction.

1.03 SUBMITTALS

A. Manufacturer's catalogue sheets and other pertinent information on geotextile fabric.

1.04 REFERENCES


PART 2 - PRODUCTS

2.01 FILTER FABRIC

A. Provide geotextile filter fabric made of either polypropylene or polyethylene material. Geotextile fabric shall have a grab strength of 90lbs. in any principal direction (ASTM D4632), and the apparent opening size between 50 and 140 for soils with more than 15 percent by weight passing a No. 200 sieve; and permittivity of 0.05 sec⁻¹ (ASTM D4491). Filter fabric material shall contain ultraviolet ray inhibitors and stabilizers to provide an expected usable life.
comparable to the anticipated construction period. Ultraviolet stability shall exceed 70% after 500 hours of exposure (ASTM D4355).

PART 3 - EXECUTION

3.01 GENERAL

A. Provide erosion and sedimentation control systems at the locations shown on PLANS. Such systems shall be of the type indicated and shall be constructed in accordance with the requirements shown on the PLANS and set out in this section.

B. No clearing and grubbing or rough cutting, other than as specifically directed by the Owner to allow soil testing and surveying, shall be permitted until erosion and sedimentation control systems are in place.

C. Maintain existing erosion and sedimentation control systems located within the project site installed by others prior to start of construction under this contract until acceptance of the project or until directed by the Owner to remove and discard the existing system.

D. Regularly inspect and repair or replace components of filter fabric fences as specified in this section. Unless otherwise directed, maintain the filter fabric fence until the project is accepted by the Owner. Remove filter fabric fence promptly when directed by the Owner. Discard removed materials offsite.

E. Remove and dispose of sediment deposits at the project spoil site. If a project spoil site is not designated on the PLANS, dispose of sediment offsite at location not in or adjacent to stream or floodplain. Off-site disposal will be the responsibility of the Contractor. Sediment to be placed at the project site should be spread, compacted and stabilized in accordance with the Owner's directions. Sediment shall not be allowed to flush into stream or drainage way. If sediment has been contaminated, it needs to be disposed of in accordance with existing federal, state and local regulations.

F. Unless otherwise indicated, compact embankments, excavations, and trenches by mechanically blading, tamping, and rolling soil in a maximum of 8-inch layers. Compaction density shall be at a minimum of 90 percent Standard Proctor ASTM D-698. Make at least one test per 500 cubic yards of embankment.

G. When installed in vehicular traffic areas, adjacent to such areas, or where vehicular traffic hazards exist (e.g. parking lots, roadways, etc.) orange filter fabric material (or another high-visibility color) shall be used.

H. Equipment and vehicles shall be prohibited by the Contractor from maneuvering on areas outside of dedicated rights-of-way and easements for construction. Damages caused by construction traffic to erosion and sedimentation control systems shall be repaired immediately.
I. Contractor shall employ protective measures described in Section 01572 - Source Controls for Erosion and Sedimentation to avoid damage to existing trees to be retained on the project site. Conduct all construction operations under this Contract in conformance with those measures.

3.02 Construction Methods

A. Provide filter fabric fence systems at locations specified on the PLANS in accordance with the PLAN detail. Filter fabric fence systems shall be installed in such a manner that surface runoff will percolate through the system in sheet flow fashion and allow sediment to be retained and accumulated.

B. Attach the filter fabric to 2-inch-by-2-inch wooden stakes spaced a maximum of 3 feet apart and embedded a minimum of 1 foot. The wooden stakes shall be installed at a slight angle toward the source of anticipated runoff.

C. Trench in the toe of the filter fabric fence with a spade or mechanical trencher so that the downward face of the trench is flat and perpendicular to the direction of flow or for V-trench configuration as shown on PLANS. Lay filter fabric along the edges and bottom of the trench. Backfill and compact trench.

D. The filter fabric should be provided in continuous rolls and cut to the length of the required to minimize the use of joints. When joints are necessary, the fabric should be spliced together only at a support post with a minimum 6-inch overlap and sealed securely.

E. Inspect sediment filter barrier systems at least once every 14 calendar days and within 24 hours of the end of a storm event of 0.5 inches or greater, or at a minimum of once every 7 calendar days. Repair or replace damaged section immediately to restore the requirements of this section. Remove sediment deposits when sediment reaches one-third of the height of the fence in depth.
FILTER FABRIC FENCE

1. SET POSTS AT REQUIRED UPSLOPE SPACING AND DEPTH

2. EXCAVATE A 6"x6" TRENCH ALONG THE LINE OF STAKES.

3. ATTACH FILTER MATERIAL TO STAKES AND INSTALL IT INTO SOIL. THE TRENCH.

4. BACKFILL THE TRENCH AND COMPACT THE EXCAVATED SOIL.

EXTENSION OF FABRIC INTO TRENCH.

ALTERNATE V-TRENCH EXTENSION OF FABRIC INTO TRENCH.

General Notes:
1. Posts to be set at 3-foot maximum spacing. If factory preassembled fence with support netting is used, spacing of post may be increased to 8 feet maximum.
2. When two sections of filter cloth adjoin each other they should be overlapped 6 inches at the posts, and folded.

FIGURE 4.2-1
BMP 4211
FILTER FABRIC FENCE
END OF SECTION
PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Installation of reinforced filter fabric barriers for erosion and sediment control used during construction and until the final development of the site. Reinforced filter fabric barriers are used to retain sedimentation in channelized flow areas.

1.02 MEASUREMENT AND PAYMENT

A. Unless indicated in the BID FORM as a pay item, no separate payment for work performed under this section. Include cost of work performed under this section in Contract prices bid for items of which this work is a component.

B. Payment for the reinforced filter fabric barrier will include and be full compensation for all labor, equipment, materials, supervision, and all incidental expenses for construction of these items, complete in place, including, but not limited to, protection of trees, maintenance requirements, repair and replacement of damaged sections, removal of sediment deposits, and removal of erosion and sedimentation control systems at the end of construction.

1.03 SUBMITTALS

A. Manufacturer’s catalog sheets and other product data on geotextile fabrics.

1.04 REFERENCES


PART 2 - PRODUCTS

2.01 FILTER FABRIC

A. Provide woven or non-woven geotextile filter fabric made of either polypropylene, polyethylene, ethylene, or polyamide material.

B. Geotextile fabric shall have a minimum grab strength of 100 psi in any principal direction (ASTM D-4632), Mullen burst strength exceeding 200 psi (ASTM D-3786), and the equivalent opening size between 50 and 140.
C. Filter fabric material shall contain ultraviolet inhibitors and stabilizers to provide a minimum of 6 months of expected usable construction life at a temperature range of 0 degrees F to 120 degrees F.

D. Representative Manufacturers: Mirafi, Inc., or equal.

2.02 FENCING

A. Provide woven galvanized steel wire fence with minimum thickness of 14 gauge and a maximum mesh spacing of 6 inches.

B. Woven wire shall be galvanized 2-inch by 4-inch welded wire fabric, 12-1/2 gauge.

PART 3 - EXECUTION

3.01 PREPARATION AND INSTALLATION

A. Provide erosion and sediment control systems at the locations shown on the PLANS. Such systems shall be of the type indicated and shall be constructed in accordance with the requirements shown on the PLANS and specified in this section.

B. No clearing and grubbing or rough cutting shall be permitted until erosion and sediment control systems are in place, other than as specifically directed by the Engineer to allow soil testing and surveying.

C. Maintain existing erosion and sediment control systems located within the project site until acceptance of the project or until directed by the Engineer to remove and discard the existing system.

D. Regularly inspect and repair or replace damaged components of the reinforced filter fabric barrier as specified in this section. Unless otherwise directed, maintain the erosion and sediment control systems until the project area stabilization is accepted by the Owner. Remove erosion and sediment control systems promptly when directed by the Engineer. Discard removed materials off site.

E. Remove sediment deposits and dispose of them at the designated spoil site for the project. If a project spoil site is not designated on the PLANS, dispose of sediment off site at a location not in or adjacent to a stream or floodplain. Off-site disposal is the responsibility of the Contractor. Sediment to be placed at the project site should be spread evenly throughout the site, compacted and stabilized. Sediment shall not be allowed to flush into a stream or drainage way. If sediment has been contaminated, it shall be disposed of in accordance with existing federal, state, and local rules and regulations.

F. Equipment and vehicles shall be prohibited by the Contractor from maneuvering on areas outside of dedicated rights-of-way and easements for construction.
Damage caused by construction traffic to erosion and sediment control systems shall be repaired immediately.

G. Conduct all construction operations under this Contract in conformance with the erosion control practices described in Section 01572 - Source Controls for Erosion and Sedimentation.

H. Unless otherwise indicated, compact embankments and sides and bottoms of excavations and trenches by mechanically blading, tamping, and rolling soils in a maximum of 8-inch layers. Compaction density shall be at a minimum of 90 percent Standard Proctor ASTM D-698 density. Make at least one test per 500 cubic yards of embankment.

I. When installed in vehicular traffic areas, adjacent to such areas, or where vehicular traffic hazards exist (e.g. parking lots, roadways, etc.) orange filter fabric material (or another high visibility color) should be used at the direction of the Owner.

3.02 CONSTRUCTION METHODS

A. Provide filter fabric barriers in accordance with the PLAN detail for Reinforced Filter Fabric Barrier. Filter Fabric barrier systems shall be installed in such a manner that surface runoff will percolate through the system in sheet flow fashion and allow sediment to be retained and accumulated.

B. Attach the woven wire support to 2-inch by 2-inch wooden stakes or steel fence posts (min of 1.25 lbs. per linear foot & Brinell Hardness greater than 140) spaced a maximum of 6 feet apart and embedded a minimum of 1 foot. Maximum spacing of 8 feet is allowed if posts are made of hot rolled steel, at least 4 feet long with Tee of Y-bar sections with the surface painted or galvanized. Provide safety caps on tops of metal posts. Install wooden stakes at a slight angle toward the source of the anticipated runoff.

C. Trench in the toe of the filter fabric barrier with a spade or mechanical trencher so that the downward face of the trench is flat and perpendicular to the direction of flow as shown on the PLANS. Lay filter fabric along the edges of the trench. Trench shall be a minimum of 6-inch by 6-inch, Backfill and compact trench.

D. Woven wire shall be galvanized 2" by 4" welded wire fabric, 14 gauge. Securely fasten the filter fabric material to the woven wire with tie wires.

E. Provide the filter fabric in continuous rolls and cut to the length of the fence to minimize the use of joints. When joints are necessary, splice the fabric together only at a support post with a minimum 6-inch overlap and seal securely.

F. Inspect the reinforced filter fabric barrier systems within 24 hours of the end of a storm event of 0.5 inches or greater daily during periods of prolonged rainfall, and at a minimum once each week. Repair or replace damaged sections.
immediately. Remove sediment deposits when silt reaches a depth one-third the height of the barrier or 6 inches, whichever is less.

G. When used in swales, ditches, or diversions, the elevation of the barrier at the top of the filter fabric at the flow line location in the channel shall be lower than the bottom elevation of the filter fabric at the ends of the barrier or the top of bank, whichever is less, in order to keep storm water discharge in the channel form overtopping the bank.
REINFORCED FILTER FABRIC BARRIER

1. SET POSTS AND EXCAVATE 8" x 6" TRENCH UPSLOPE ALONG LINE OF POSTS.

2. SECURE WIRE FENCING TO POSTS 2" x 4" WELDED WIRE 4" x 4" WOOD POST OR EQUIVALENT.

3. ATTACH FILTER MATERIAL TO WIRE FENCE AND EXTEND INTO THE TRENCH.

4. BACKFILL AND COMPACT THE EXCAVATED SOIL.

5. PROPER PLACEMENT OF A FILTER BARRIER IN A DRAINAGE WAY.

FIGURE 4.3-1
BMP 4311
REINFORCED FILTER FABRIC BARRIER
END OF SECTION
STABILIZED CONSTRUCTION EXIT

SECTION 01575
STABILIZED CONSTRUCTION EXIT

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Installation of erosion and sediment control for stabilized construction exits used during construction and until final development of the site.

1.02 MEASUREMENT AND PAYMENT

B. Unless indicated in the BID FORM as a pay item, no separate payment will be made for work performed under this section. Include cost of work performed under this section in pay items for which this work is a component.

C. Payment for stabilized construction roads, parking areas, access, and truck washing areas will include and be full compensation for all labor, equipment, materials, supervision, and all incidental expenses for construction of these items, complete in place, including, but not limited to, embankment and excavation, protection of trees, maintenance requirements, repair and replacement of damaged sections, removal of sediment deposits, redressing of aggregates and stones, and removal of erosion and sedimentation control systems at the end of construction.

1.02 SUBMITTALS

A. Manufacturer’s catalog sheets and other product data on geotextile fabric.

B. Size analysis of aggregates conforming to requirements of this specification.

1.03 REFERENCES


PART 2 - PRODUCTS

2.01 GEOTEXTILE FABRIC

A. Provide geotextile fabric made of polypropylene or polyethylene material.

B. Geotextile fabric shall have minimum grab strength of 270 psi in any principal direction (ASTM D-4632), and the equivalent opening size between 50 and 140.

C. Both the geotextile and threads shall be resistant to chemical attack, mildew, and rot and shall contain ultraviolet ray inhibitors and stabilizers to provide a minimum of 6 months of expected usable life at a temperature range of 0 degrees F to 120 degrees F.
2.02 COARSE AGGREGATES

A. Coarse aggregate shall consist of crushed stone, gravel, crushed blast furnace slag, or a combination of these materials. Aggregate shall be composed of clean, hard, durable materials free from adherent coatings, salt, alkali, dirt, clay, loam, shale, soft or flaky materials, or organic and injurious matter.

B. Coarse aggregates to consist of open graded rock 3-inch to 8-inch in size.

C. Minimum average rock shall be 2-inch to 3-inch in size.

PART 3 - EXECUTION

3.01 PREPARATION AND INSTALLATION

A. Provide erosion and sedimentation control systems at the locations shown on the PLANS. Such systems shall be of the type indicated and shall be constructed in accordance with the requirements shown on the PLANS and set out in this section.

B. No clearing and grubbing or rough cutting shall be permitted until erosion and sediment control systems are in place, other than as specifically directed by the Engineer to allow soil testing and surveying.

C. Maintain existing erosion and sediment control systems located within the project site until acceptance of the project or until directed by the Engineer to remove and discard the existing system.

D. Inspect and repair or replace components of all erosion and sedimentation control systems as specified for each type of system. Unless otherwise directed, maintain the erosion and sedimentation control systems until the project is accepted by the Owner. Remove erosion and sedimentation control systems promptly when directed by the Owner. Discard removed materials off site.

E. Remove sediment deposits and dispose of them at the designated spoil site for the project. If a project spoil site is not designated on the PLANS, dispose of sediment off site at location not in or adjacent to a stream or floodplain. Off-site disposal is the responsibility of the Contractor. Sediment to be placed at the project site should be spread evenly throughout the site, compacted and stabilized. Sediment shall not be allowed to flush into a stream or drainage way. If sediment has been contaminated, it shall be disposed of in accordance with existing federal, state, and local rules and regulations.

F. Equipment and vehicles shall be prohibited by the Contractor from maneuvering on areas outside of dedicated rights-of-way and easements for construction. Damage caused by construction traffic to erosion and sediment control systems shall be repaired immediately.
G. Contractor shall employ protective measures described in Specification 01572 – Source Controls for Erosion and Sedimentation to avoid damage to existing trees to be retained on the project site. Conduct all construction operation under this Contract in conformance with the erosion control practices described in that section.

3.02 CONSTRUCTION METHODS

A. Provide stabilized access roads, subdivision roads, parking areas, and other on-site vehicle transportation routes where shown on PLANS.

B. Provide stabilized construction access, and truck washing areas when approved by Owner, of the sizes and locations shown on PLANS. Construction traffic shall not be allowed to leave construction site and move directly onto public roadway, alley, sidewalk, parking area, or other right-of-way in areas other than at locations of stabilized construction access.

C. Vehicles leaving construction areas shall have their tires cleaned to remove sediment prior to entrance onto public right-of-way. When washing is needed to remove sediment, Contractor shall construct a truck washing area. Truck washing shall be done on stabilized areas, which drain into a drainage system protected by erosion and sediment control measures.

D. Details for stabilized construction exit are shown on the PLANS. Construction of all other stabilized areas shall be to the same requirements. Roadway width shall be at least 14 feet for one-way traffic and 20 feet for two-way traffic and shall be sufficient for all ingress and egress. Furnish and place geotextile fabric as a permeable separator to prevent mixing of coarse aggregate with underlying soil. Exposure of geotextile fabric to the elements between laydown and cover shall be a maximum of 14 days to minimize damage potential.

E. Roads and parking areas shall be graded to provide sufficient drainage away from stabilized areas. Use sandbags, gravel, boards, or similar methods to prevent sediment from entering public right-of-way, receiving stream or storm water conveyance system.

F. The stabilized areas shall be inspected and maintained daily. Provide periodic top dressing with additional coarse aggregates to maintain the required depth. Repair and clean out damaged control measures used to trap sediment. All sediment spilled, dropped, washed, or tracked onto public right-of-way shall be removed immediately.

G. The length of the stabilized area shall be as shown on the PLANS, but not less than 50 feet. The thickness shall not be less than 8 inches. The width shall not be less than the full width of all points of ingress or egress.

H. Stabilization for other areas shall have the same coarse aggregate, thickness, and width requirements as the stabilized construction exit, except where shown otherwise on the PLANS.
I. Stabilized area may be widened or lengthened to accommodate truck-washing area when authorized by Engineer.

J. Alternative methods of construction may be utilized when shown on PLANS, or when approved by the Engineer. These methods include the following:

1. Cement-Stabilized Soil - Compacted cement-stabilized soil or other fill material in an application thickness of at least 8 inches.
2. Wood Mats/Mud Mats - Oak or other hardwood timbers placed edge-to-edge and across support wooden beams which are placed on top of existing soil in an application thickness of at least 6 inches.
3. Steel Mats - Perforated mats placed across perpendicular support members.
General Notes:
1. Length shall be as shown on the construction drawings, but not less than 50 feet.
2. Thickness shall not be less than 8 inches.
3. Width shall be not less than full width of all points of ingress or egress.
4. Stabilization for other areas shall have the same aggregate thickness and width requirements as the stabilized construction exit, unless otherwise shown on the construction drawings.
5. Stabilized area may be widened or lengthened to accommodate a truck washing area, when shown on the construction PLANS. An outlet sediment trap must be provided for the truck washing area.
SECTION 01578
CONTROL OF GROUND WATER AND SURFACE WATER

PART 1 - GENERAL

A. SECTION INCLUDES

1. Dewatering, depressurizing, draining, and maintaining trenches, shaft excavations, structural excavations, and foundation beds in a stable condition, and controlling ground water conditions for tunnel excavations.
2. Protecting work against surface runoff and rising floodwaters.
3. Disposing of removed water.

1.02 MEASUREMENT AND PAYMENT

A. No separate payment will be made for control of ground water and surface water. Include the cost to control ground water and surface water in unit price for work requiring such controls.

1.03 REFERENCES

A. ASTM D 698 - Test Methods for Moisture-Density Relations of Soils and Soil-Aggregate Mixtures, Using 5.5-lb (2.49 kg) Rammer and 12-inch (304.8 mm) Drop.


1.04 DEFINITIONS

A. Ground water control includes both dewatering and depressurization of water-bearing soil layers.

1. Dewatering includes lowering the water table and intercepting seepage, which would otherwise emerge from slopes or bottoms of excavations, or into tunnels and shafts, and disposing of removed water. The intent of dewatering is to increase stability of tunnel excavations and excavated slopes; prevent dislocation of material from slopes or bottoms of excavations; reduce lateral loads on sheeting and bracing; improve excavating and hauling characteristics of excavated material; prevent failure or heaving of the bottom of excavations; and to provide suitable conditions for placement of backfill materials and construction of structures and other installations.

2. Depressurization includes reduction in piezometric pressure within strata not controlled by dewatering alone, as required to prevent failure or heaving of excavation bottom or instability of tunnel excavations.
B. Excavation drainage includes keeping excavations free of surface and seepage water.

C. Surface drainage includes use of temporary drainage ditches and dikes and installation of temporary culverts and sump pumps with discharge lines as required to protect the Work from any source of surface water.

D. Equipment and instrumentation for monitoring and control of the ground water control system includes piezometers and monitoring wells, and devices, such as flow meters, for observing and recording flow rates.

1.05 PERFORMANCE REQUIREMENTS

A. Conduct subsurface investigations to identify groundwater conditions and to provide parameters for design, installation, and operation of groundwater control systems.

B. Design a ground water control system, compatible with requirements of Federal Regulations 29 CFR Part 1926 and Section 01561 - Trench Safety Systems, to produce the following results:

1. Effectively reduce the hydrostatic pressure affecting:
   a. Excavations.
   b. Tunnel excavation, face stability or seepage into tunnels.

2. Develop a substantially dry and stable subgrade for subsequent construction operations.

3. Preclude damage to adjacent properties, buildings, structures, utilities, installed facilities, and other work.

4. Prevent the loss of fines, seepage, boils, quick condition, or softening of the foundation strata.

5. Maintain stability of sides and bottom of excavations.

C. Provide ground water control systems may include single-stage or multiple-stage well point systems, eductor and ejector-type systems, deep wells, or combinations of these equipment types.

D. Provide drainage of seepage water and surface water, as well as water from any other source entering the excavation. Excavation drainage may include placement of drainage materials, such as crushed stone and filter fabric, together with sump pumping.

E. Provide ditches, berms, pumps and other methods necessary to divert and drain surface water from excavation and other work areas.

F. Locate ground water control and drainage systems so as not to interfere with utilities, construction operations, adjacent properties, or adjacent water wells.
G. Assume sole responsibility for ground water control systems and for any loss or damage resulting from partial or complete failure of protective measures and any settlement or resultant damage caused by the ground water control operations. Modify ground water control systems or operations if they cause or threaten to cause damage to new construction, existing site improvements, adjacent property, or adjacent water wells, or affect potentially contaminated areas. Repair damage caused by ground water control systems or resulting from failure of the system to protect property as required.

H. Provide an adequate number of piezometers installed at the proper locations and depths as required for meaningful observations of the conditions affecting the excavation, adjacent structures, and water wells.

I. Provide environmental monitoring wells installed at the proper locations and depths as required for adequate observations of hydrostatic conditions and possible contaminant transport from contamination sources into the work area or into the ground water control system.

J. Decommission piezometers and monitoring wells installed during design phase studies and left for Contractors monitoring and use.

1.06 SUBMITTALS

A. Submit a Ground Water and Surface Water Control Plan for review by the Engineer prior to start of any fieldwork. A Professional Engineer registered in the State of Texas shall sign the Plan. Submit a plan to include the following:

1. Results of subsurface investigation and description of the extent and characteristics of water bearing layers subject to ground water control.
2. Names of equipment suppliers and installation subcontractors.
3. A description of proposed ground water control systems indicating arrangement, location, depth and capacities of system components, installation details and criteria, and operation and maintenance procedures.
4. A description of proposed monitoring and control system indicating depths and locations of piezometers and monitoring wells, monitoring installation details and criteria, type of equipment and instrumentation with pertinent data and characteristics.
5. A description of proposed filters including types, sizes, capacities and manufacturer's application recommendations.
6. Design calculations demonstrating adequacy of proposed systems for intended applications. Define potential area of influence of ground water control operation near contaminated areas.
7. Operating requirements, including piezometric control elevations for dewatering and depressurization.
8. Excavation drainage methods including typical drainage layers, sump pump application and other necessary means.
9. Surface water control and drainage installations.
10. Proposed methods and locations for disposing of removed water.

B. Submit the following records upon completed initial installation:

1. Installation and development reports for well points, eductors, and deep wells.
2. Installation reports and baseline readings for piezometers and monitoring wells.
3. Baseline analytical test data of water from monitoring wells.
4. Initial flow rates.

C. Submit the following records on a weekly basis during operations:

1. Records of flow rates and piezometric elevations obtained during monitoring of dewatering and depressurization. Refer to Paragraph 3.02, Requirements for Eductor, Well Points, or Deep Wells.
2. Maintenance records for ground water control installations, piezometers, and monitoring wells.

D. Submit the following records at end of work. Decommissioning (abandonment) reports for monitoring wells and piezometers installed by other during the design phase and left for Contractor's monitoring and use.

1.07 ENVIRONMENTAL REQUIREMENTS

A. Comply with requirements of agencies having jurisdiction.

B. Comply with Texas Natural Resource Conservation Commission regulations and Texas Water Well Drillers Association for development, drilling, and abandonment of wells used in dewatering system.

C. Obtain permit from EPA under the National Pollutant Discharge Elimination System (NPDES), for storm water discharge from construction sites. Refer to Section 01571 - TNPDES Permit Requirements.

D. Obtain all necessary permits from agencies with control over the use of groundwater and matters affecting well installation, water discharge, and use of existing storm drains and natural water sources. Because the review and permitting process may be lengthy, take early action to pursue and submit for the required approvals.

E. Monitor ground water discharge for contamination while performing pumping in the vicinity of potentially contaminated sites.
PART 2 - PRODUCTS

2.01 EQUIPMENT AND MATERIALS

A. Equipment and materials are at the option of Contractor as necessary to achieve desired results for dewatering. Selected equipment and materials are subject to review of the Engineer through submittals required in Paragraph 1.06, Submittals.

B. Eductors, well points, or deep wells, where used, must be furnished, installed and operated by an experienced contractor regularly engaged in ground water control system design, installation, and operation.

C. All equipment must be in good repair and operating order.

D. Sufficient standby equipment and materials shall be kept available to ensure continuous operation, where required.

PART 3 - EXECUTION

3.01 GROUND WATER CONTROL

A. Perform a subsurface investigation by borings as necessary to identify water bearing layers, piezometric pressures, and soil parameters for design and installation of ground water control systems. Perform pump tests, if necessary, to determine the drawdown characteristics of the water bearing layers. The results shall be presented in the Ground Water and Surface Water Control Plan (See Paragraph 1.06B.1).

B. Provide labor, material, equipment, techniques and methods to lower, control and handle ground water in a manner compatible with construction methods and site conditions. Monitor effectiveness of the installed system and its effect on adjacent property.

C. Install, operate, and maintain ground water control systems in accordance with the Ground Water and Surface Water Control Plan. Notify Engineer in writing of any changes made to accommodate field conditions and changes to the Work. Provide revised drawings and calculations with such notification.

D. Provide for continuous system operation, including nights, weekends, and holidays. Arrange for appropriate backup if electrical power is primary energy source for dewatering system.

E. Monitor operations to verify that the system lowers ground water piezometric levels at a rate required to maintain a dry excavation resulting in a stable subgrade for prosecution of subsequent operations.

F. Where hydrostatic pressures in confined water bearing layers exist below excavation, depressurize those zones to eliminate risk of uplift or other instability...
of excavation or installed works. Allowable piezometric elevations shall be defined in the Ground Water and Surface Water Control Plan.

G. Remove ground water control installations.

1. Remove pumping system components and piping when ground water control is no longer required.
2. Remove piezometers, including piezometers installed during the design phase investigations and left for Contractors use, upon completion of testing, in accordance with Section 02533 - Acceptance Testing of Sanitary Sewers.
3. Remove monitoring wells when directed by the Engineer.
4. Grout abandoned well and piezometer holes. Fill piping that is not removed with cement-bentonite grout or cement-sand grout.

H. During backfilling, dewatering may be reduced to maintain water level a minimum of 5 feet below prevailing level of backfill. However, do not allow that water level to result in uplift pressures in excess of 80 percent of downward pressure produced by weight of structure or backfill in place. Do not allow water levels to rise into cement-stabilized sand until at least 48 hours after placement.

I. Provide a uniform diameter for each pipe drain run constructed for dewatering. Remove pipe drain when it has served its purpose. If removal of pipe is impractical, provide grout connections at 50-foot intervals and fill pipe with cement-bentonite grout or cement-sand grout when pipe is removed from service.

J. Extent of construction ground water control for structures with a permanent perforated underground drainage system may be reduced, such as for units designed to withstand hydrostatic uplift pressure. Provide a means of draining the affected portion of underground system, including standby equipment. Maintain drainage system during operations and remove it when no longer required.

K. Remove system upon completion of construction or when dewatering and control of surface or ground water is no longer required.

L. Compact backfill to not less than 95 percent of the maximum dry density in accordance with ASTM D 698.

3.02 REQUIREMENTS FOR EDUCTOR, WELL POINTS, OR DEEP WELLS

A. For aboveground piping in ground water control system, include a 12-inch minimum length of clear, transparent piping between every eductor well or well point and discharge header so that discharge from each installation can be visually monitored.

B. Install sufficient piezometers or monitoring wells to show that all trench or shaft excavations in water bearing materials are pre-drained prior to excavation.
Provide separate piezometers for monitoring of dewatering and for monitoring of depressurization. Install piezometers and monitoring wells for tunneling as appropriate for Contractor’s selected method of work.

C. Install piezometers or monitoring wells not less than one week in advance of beginning the associated excavation.

D. Dewatering may be omitted for portions of underdrains or other excavations, but only where auger borings and piezometers or monitoring wells shows that soil is pre-drained by an existing system such that the criteria of the ground water control plan are satisfied.

E. Replace installations that produce noticeable amounts of sediments after development.

F. Provide additional ground water control installations, or change the methods, in the event that the installations according to the ground water control plan does not provide satisfactory results based on the performance criteria defined by the plan and by the specification. Submit a revised plan according to Paragraph 1.06B.

3.03 EXCAVATION DRAINAGE

A. Contractor may use excavation drainage methods if necessary, to achieve well-drained conditions. The excavation drainage may consist of a layer of crushed stone and filter fabric, and sump pumping in combination with sufficient wells for ground water control to maintain stable excavation and backfill conditions.

3.04 MAINTENANCE AND OBSERVATION

A. Conduct daily maintenance and observation of piezometers or monitoring wells while the ground water control installations or excavation drainage are operating in an area or seepage into tunnel is occurring. Keep system in good condition.

B. Replace damaged and destroyed piezometers or monitoring wells with new piezometers or wells as necessary to meet observation schedule.

C. Cut off piezometers or monitoring wells in excavation areas where piping is exposed, only as necessary to perform observation as excavation proceeds. Continue to maintain and make observations, as specified.

D. Remove and grout piezometers inside or outside the excavation area when ground water control operations are complete. Remove and grout monitoring wells when directed by the Engineer.

3.05 MONITORING AND RECORDING

A. Monitor and record average flow rate of operation for each deep well, or for each WellPoint or eductor header used in dewatering system. Also monitor and record
water level and ground water recovery. These records shall be obtained daily until steady conditions are achieved and twice weekly thereafter.

B. Observe and record elevation of water level daily as long as ground water control system is in operation, and weekly thereafter until the Work is completed or piezometers or wells are removed, except when Engineer determines that more frequent monitoring and recording are required. Comply with Engineer's direction for increased monitoring and recording and take measures as necessary to ensure effective dewatering for intended purpose.

3.06 SURFACE WATER CONTROL

A. Intercept surface water and divert it away from excavations through use of dikes, ditches, curb walls, pipes, sumps or other approved means. The requirement includes temporary works required to protect adjoining properties from surface drainage caused by construction operations.

B. Divert surface water and seepage water into sumps and pump it into drainage channels or storm drains, when approved by agencies having jurisdiction. Provide settling basins when required by such agencies.

END OF SECTION
SECTION 02020
FILL PLACEMENT

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. The work covered by this section includes the placement of fill within the limits of construction.

1.02 Measurement and Payment

A. Unless indicated in the BID FORM as a pay item, no separate payment will be made for work performed under this section. Include cost of work performed under this section in pay items of which this work is a component.

1.03 Coordination

A. It shall be the responsibility of the Contractor to inspect the site and determine the amount of related work required to perform this work.

1.04 Sub-Surface Data

A. Investigation: A sub-surface investigation is available for review by prospective bidders. The report is furnished as a matter of convenience and courtesy and there is no implied or expressed warranty as to the correctness of the report as to existing condition. However, where a treatment is not covered in the section, the recommendations made in the report shall be considered binding.

B. Site Visit: Data shown are for general information for bidders. Contractors are expected to examine the site, make investigations, and decide for themselves the character of the materials to be encountered.

C. Responsibility: The Owner and Engineer do not assume responsibility for variations of sub-soil quality or conditions other than those places shown at the time investigations were made.

1.05 Grade Lines and Levels

A. Grades, lines, levels and benchmarks not established by Owner shall be established and maintained by the Grading Contractor at no additional cost to the Owner, unless specified otherwise.

B. Verify all grades, lines, levels and dimensions, as shown on the PLANS.

C. If existing grades are at variance with the PLANS, notify the Engineer and receive instructions prior to commencing work.
1.06 Protection

A. Protect benchmarks and monuments. If disturbed or destroyed, secure the services of a licensed surveyor and replace as directed by the Engineer or Owner's Representative.

B. Protect existing facilities and adjacent property from ponding or washing of water and from construction damage.

C. Erect barricades, fences, signs and other protective devices in accordance with the General Conditions and Special Conditions.

D. Provide and maintain protection for persons and property.

E. Restore to original grades and conditions all properties damaged by an activity related to work and take adequate precautions to avoid sediment, materials, trash, etc., entering sewers or adjacent properties, both public and private.

1.07 Testing

A. A registered soils laboratory will perform testing to determine compliance with the project specifications. The laboratory will be selected and paid for by the Owner.

PART 2 - PRODUCTS

2.01 Material for Filling

A. Shall be clean subsoil free from debris, roots, topsoil, and rock. Soils are considered suitable for fill material if they are free of organic matter, topsoil, roots larger than 0.50 inches in diameter and other undesirable debris.

2.02 Unsuitable Fill Material

A. Shall be defined as that which fails to conform to requirements of paragraph 2.01 above.

PART 3 - EXECUTION

3.01 Prior to starting the filling operations, the site shall be cleared, grubbed, and stripped to meet the requirements specified in Section 02050 – Site Preparation, Clearing and Grubbing.

3.02 Layout grade stakes and maintain as required for property lines.

3.03 Subgrade Preparation

A. Just prior to fill placement, the subgrade soils shall be scarified to a minimum depth of six inches (6”). The scarified subgrade should then be recompacted to 90% of the maximum dry density determined by ASTM D 698.
B. The exposed subgrade areas should be proof rolled to detect the any soft or wet soils. Any soft or wet areas shall be removed by undercutting to firm soil and replaced with soils similar to the surrounding soils. Proof-rolling should be performed in accordance with the Texas State Department of Highways and Public Transportation’s Standard Specifications (1982), Item 216, Proof-rolling. The proof-rolling operation should be observed and monitored by the geotechnical engineer.

3.04 Material

A. Use approved excess excavation or borrow material. Where necessary to borrow material, borrow from approved source, excavate and clean up area. Material excavated from site may be used for general site fill, provided such material is free of rubbish and other objectionable matter as described in paragraph 2.01 above.

3.05 Fill Under Structures and Roads

A. Place dirt fill in 8-inch maximum layers, measured loose, and compact, at or near optimum moisture, with tamping roller (sheepsfoot) pulled with crawler-mounted tractor to at least 95% AASHTO Standard T-99 density. Fill to be placed to subgrade elevation without addition of topsoil. Where fill to subgrade elevation is less than 6-inches, scarify to a depth of 6-inches and compact as specified before.

3.06 Site Fill

A. All fill material placed in the fill area shall be placed in 8” thick (loose measure) lifts and compacted to 90% of the maximum dry density (ASTM D 698).

B. Maintaining of proper densities and moisture contents during the filling operation is critical to the completion of the project in an acceptable manner.

3.07 Waste

A. Stripped materials not suitable for re-use to be removed from jobsite. Remove or spread other waste material as directed. If waste material is permitted to be spread on site, dress by blading and slope to provide drainage.

3.08 Final Cleanup

A. Remove from site of work temporary structures, rubbish, waste materials, and construction debris. On site burial of form lumber, concrete and concrete blocks, brick and other similar type of debris left from construction is not permitted. Dispose of excess excavated off site. Grade project site (including storage areas, access roads, and other areas disturbed by construction operations) to level all washes, ruts, depressions, and mounds.

END OF SECTION
PART 1 - GENERAL

1.01 SECTION INCLUDES

A. This section governs the Site Preparation, Clearing and Grubbing within the project site.

1.02 MEASUREMENT AND PAYMENT

A. Unless indicated in the BID FORM, no separate payment will be made for work required under this section. Contractor will include all costs of the requirements of this section in the appropriate bid item(s) on the BID FORM.

1.03 PROTECT MONUMENTS

A. Protect monuments and benchmarks. If damaged or destroyed, a Texas Registered Professional Land Surveyor shall replace them at the Contractor’s expense.

PART 2 - PRODUCTS – Not used

PART 3 - EXECUTION

3.01 CLEARING

A. All trees, brush, logs, vegetation, buildings, internal fences, and debris within the areas designated on the plans shall be cleared and removed and legally disposed of in a manner acceptable to the Owner and the Engineer.

3.02 GRUBBING

A. Grub out all vegetation, trees and shrubs, including their entire root system, which occur within areas designated on the plans. Excavations left from the removal of large tree root systems shall be undercut and properly backfilled.

3.03 STRIPPING

A. All areas within the site should be stripped of all topsoil and organic matter to a depth of at least three inches (3"), or such depth that will adequately remove all organic matter, topsoil, and undesirable materials.

3.04 PRESERVATION

A. Protect trees to be left against damage, and trim where necessary.
3.05 PROTECTION OF EXISTING WORK REMAINING

A. Clearing and Grubbing operations shall be conducted to prevent damage to adjoining property, to existing structures and installations, and construction, and to provide for the safety of employees and others.

3.06 SECURITY

A. Provide site security fencing to prevent unauthorized access and to deter removal of materials, equipment, and supplies.

3.07 MATERIAL HANDLING

A. All waste resulting from clearing and grubbing shall be legally disposed of offsite at the Contractor's expense, unless otherwise directed by the Engineer or Owner's representative.

B. The use of any debris, rubbish, or waste material for backfilling, or filling of erosion ditches, will not be permitted without the Engineer or Owner's representative's written permission.

C. The stripped soils shall be stockpiled in the proposed easements and other areas adjacent to the site as designated by the Owner or Engineer.

D. Burning shall not be allowed on this project.

E. Contractor shall be responsible for obtaining all required permits, including Texas Air Control and the county where the work is to be performed, and any other permits required for burning operations.

3.08 CLEAN-UP

A. The entire site shall be cleared of broken concrete, stones, bricks, other debris and any additional undesirable materials. All debris and undesirable materials shall be hauled away from the site unless directed otherwise by the Engineer or Owner's representative.

B. At the completion of the site work, the premises (including all areas within the limit of, or adjacent to, work boundaries) shall be cleaned of all debris and trash remaining and left in condition for fill placement and grading operations.

END OF SECTION
PART 1 - GENERAL

1.01 SECTION INCLUDES

A. This section covers all areas disturbed by construction and/or where the elevation of natural ground is to be altered.

B. After construction has been substantially completed, clear ground surface of all foreign materials. Make fill as necessary in order to bring site to uniform smooth finished grade as shown on the construction drawings.

1.02 MEASUREMENT AND PAYMENT

A. No separate payment will be made for work required under this section. Contractor will include all costs of the requirements of this section in the appropriate bid item(s) on the bid form.

PART 2 - PRODUCTS

2.01 MATERIAL

A. Use approved excess excavation or approved borrow material. Material excavated from site may be used for general site fill, provided such material is free of rubbish and other objectionable matter.

2.02 FILL UNDER STRUCTURES

A. Place dirt fill (see plans for material to be used) in 8-inch maximum lifts, measured loose, and compact, at or near optimum moisture, with tamping roller (sheepsfoot) pulled with crawler-mounted tractor to at least 95% AASHTO Standard T-99 density. Fill to be placed to subgrade elevation without addition of topsoil. Where fill to subgrade elevation is less than 6 inches, scarify to a depth of 6-inches or as shown on plans and compact as specified before.

2.03 SITE FILL

A. Place approved fill to within four inches of finish grade shown on all areas not covered by structures or roads in 8-inch maximum lifts, measured loose, and compact at or near optimum moisture to at least 90% AASHTO standard T-99 density. Place final four inches in one lift; disc if material contains large lumps.

2.04 WASTE

A. Stripped materials not suitable for reuse are to be removed from the jobsite. Remove or spread other waste material as directed. If waste material is permitted to be spread on site, dress by blading and slope to provide drainage.
PART 3 - EXECUTION

3.01 CLEANUP

A. Remove from site of work temporary structures, rubbish, waste materials, and construction debris. On-site burial of form lumber, concrete and concrete blocks, brick and other similar type of debris left from construction is not permitted. Dispose of excess excavated materials (beyond that needed to establish final grade indicated in the contract plans) offsite. Grade project site (including storage areas and other areas disturbed by construction operations) to level all washes, ruts, depressions, and mounds.

END OF SECTION
PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Cast-in-place sanitary and storm sewer manholes.

1.02 MEASUREMENT AND PAYMENT

A. No separate payment will be made for work required under this section. Contractor will include all costs of the requirements of this section in the appropriate bid item(s) on the bid form.

B. Payment for cast-in-place concrete manholes is on a unit price basis per manhole. Payment will be made for each manhole installed complete in place, including manhole, drop pipe, excavation, foundation, connection to sewer pipe, and backfill.

C. Each cast-in-place concrete manhole has a separate pay item identified by station, as shown on the Drawings.

D. Stipulated Price (Lump Sum). If the Contract is a Stipulated Price Contract, payment for work in this Section is included in the total Stipulated Price.

1.03 REFERENCES


B. ASTM A 307 - Specification for Carbon Steel Bolts and Studs, 60,000 psi Tensile.

C. ASTM C 270 - Specification for Mortar for Unit Masonry.


F. ASTM D 698 - Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lb/ft3).


H. ASTM D 2996 - Specification for Filament-wound Fiberglass (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe.

J. AWWA C 213 - Fusion Bonded Epoxy Coating for the Interior and Exterior of Steel Water Pipelines.

1.04 SUBMITTALS

A. Submit proposed design mix and test data for each type and strength of concrete.

B. Submit manufacturer's data and details of following items for approval:

1. Frames, grates, rings, and covers.
2. Materials to be used in fabricating drop connections.
3. Materials to be used for pipe connections at manhole walls.
4. Materials to be used for stubs and stub plugs.
5. Plugs to be used for pipeline hydrostatic testing.

PART 2 - PRODUCTS

2.01 CONCRETE

A. Conform to requirements of Section 03300 – Cast-in Place Concrete.

B. For extra-depth manholes, provide Class A concrete with minimum compressive strength of 4,000 psi unless otherwise indicated on Drawings.

C. Precast and cast in place reinforced concrete manhole sections shall conform to the requirements of ASTM designation C-478. The precast sections shall be certified as to compressive strength, impermeability, and chemical resistance. Certification shall document corrosion resistance of the design mix for precast and cast-in-place manholes to fluids with a pH of two (2) or less in accordance with the performance requirements of ASTM C-267. Design mix shall include catalysts which generate non-soluble crystalline formation utilizing "Zypex" or approved equal.

2.02 REINFORCING STEEL

A. Conform to requirements of Section 03200 – Concrete Reinforcing.

2.03 MORTAR

A. Conform to requirements of ASTM C 270, Type S using Portland cement.

2.04 MISCELLANEOUS METALS

A. Provide cast-iron frames, grates, rings, and covers conforming to requirements of Section 02084 - Frames, Grates, Rings, and Covers.
2.05 DROP CONNECTIONS AND STUBS
A. Drop connections and stubs shall conform to the same pipe material
requirements used in the main pipe, unless otherwise indicated on the Drawings.

2.06 PIPE CONNECTIONS
A. Provide resilient connectors conforming to requirements of ASTM C 923.
Metallic mechanical devices as defined in ASTM C 923 shall be made of the
following materials:
   1. External clamps: Type 304 stainless steel.
   2. Internal, expandable clamps on standard manholes: Type 304 stainless
      steel, 11-gauge minimum.
   3. Internal, expandable clamps on corrosion-resistant manholes:
      a. Type 316 stainless steel, 11-gauge minimum, or
      b. Type 304 stainless steel, 11-gauge minimum, coated with minimum
         16-mil fusion-bonded epoxy conforming to AWWA C 213.
B. Where rigid joints between pipe and a cast-in-place manhole base are specified
   or shown on the Drawings, provide polyethylene-isoprene water stop meeting the
   physical property requirements of ASTM C 923, such as Pres-Seal WS Series, or
   approved equal.
C. Storm sewer pipe connections to concrete manholes shall be grouted in place,
   unless otherwise shown on the Drawings. Grout pipe penetration in place on
   both inside and outside of manhole.

2.07 SEALANT MATERIALS
A. Provide sealing materials between precast concrete adjustment ring and
   manhole cover frame, such as Adeka Ultraseal P 201, or approved equal.

2.08 CORROSION-RESISTANT MANHOLE MATERIALS
A. Where corrosion-resistant manholes or PVC-lined manholes are indicated on the
   Drawings, provide one of the following:
   1. PVC liner for precast cylindrical manhole section, base sections, and
      cone sections.

2.09 BACKFILL MATERIALS
A. Backfill materials shall conform to the requirements of Section 02317 -
   Excavation and Backfill for Utilities.
2.10 NON-SHRINK GROUT

A. Provide prepackaged, inorganic, flowable, non-gas-liberating, non-metallic, cement-based non-shrink grout requiring only the addition of water.

B. Provide grout meeting requirements of ASTM C 1107 and having a minimum 28-day compressive strength of 7,000 psi.

2.11 VENT PIPES

A. Provide external vent pipes for manholes where indicated on the Drawings.

B. Buried Vent Pipes: Provide 3-inch or 4-inch PVC DWV pipe conforming to ASTM D 2665. Alternatively, provide FRP pipe as specified for the vent outlet assembly.

C. Vent Outlet Assembly: Provide a vent outlet assembly as shown on the Drawings, constructed of the following specified materials:

1. FRP Pipe: Provide filament-wound FRP conforming to ASTM D 2996 or centrifugally cast FRP conforming to ASTM D 2997. Seal cut ends in accordance with manufacturer’s recommendations.

2. Joints and Fittings: Provide epoxy-bodied fittings and join pipe to fittings with epoxy adhesive, according to the pipe manufacturer’s instructions.

3. Flanges: Provide socket-flange fittings for epoxy adhesive bonding to pipe ends where shown on the Drawings. Flanges shall meet bolt pattern and dimensions for ANSI B 16.1, 125-pound flanges. Flange bolts shall be Type 304 stainless steel or hot-dip zinc coated, conforming to ASTM A 307, Class A or B.

4. Coating: Provide a two component, aliphatic polyurethane coating, using a primer or tie coat recommended by the manufacturer. Provide two or more coats to yield a dry film thickness of at least 3 mils. Provide Amershield, Tnemec 74, or approved equal. The Owner from the manufacturer’s standard colors shall select color.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Verify lines and grades are correct.

B. Determine if the subgrade, when scarified and recompacted, can be compacted to 95 percent of maximum Standard Proctor Density according to ASTM D 698 prior to placement of foundation material and base section. If it cannot be compacted to that density, the subgrade shall be moisture conditioned until that density can be reached or shall be treated as an unstable subgrade.

C. Do not build manholes in ditches, swales, or drainage paths unless approved by the Owner.
3.02 MANHOLES

A. Construct manholes to dimensions shown on Drawings. Commence construction as soon as possible after pipes are laid. On monolithic sewers, construct manholes at same time sewer is being constructed.

B. Unstable Subgrade Treatment: When unstable subgrade is encountered, notify the Owner for examination of subgrade to determine if the subgrade has heaved upwards after being excavated. If heaving has not occurred, the subgrade shall be over-excavated to allow for a 24-inch-thick layer of crushed stone wrapped in filter fabric as the foundation material under the manhole base. If there is evidence of heaving, a pile-supported concrete foundation, as detailed on the Drawings, shall be provided under the manhole base.

C. Cast manhole foundations and walls monolithically. A cold joint with approved water stop will be allowed when the manhole flow line depth exceeds 12 feet. No other joints will be allowed unless shown on Drawings.

D. For concrete containing micro silica admixtures, place, finish, and cure concrete for manholes following the procedures given in Section 03300 – Cast-in-Place Concrete.

3.03 PIPE CONNECTIONS

A. Install approved resilient connectors at each pipe entering and exiting manholes in accordance with manufacturer’s instructions.

B. Ensure that no concrete, cement stabilized sand, fill, or other solid material can enter the space between the pipe and the edge of the wall opening at and around the resilient connector on either the interior or exterior of the manhole. Fill the space with compressible material to ensure the resilient connector will maintain full flexibility where evidence of reduced flexibility is encountered.

C. Where a new manhole is to be constructed on an existing sewer, a rigid joint pipe may be used. Install a water stop gasket around the existing pipe at the center of the cast-in-place wall. Join ends of split water stop material at the pipe spring line using an adhesive recommended and supplied by the water stop manufacturer.

D. Do not construct joints on pipe within wall sections of manholes. Use approved connection material.

E. Construct pipe stubs with resilient connectors for future connections at locations and with material indicated on Drawings. Install approved stub plugs at interior of manhole.

F. Test connection for watertight seal before backfilling.

G. Connect line pipe grouted in place with mortar.
H. Seal internal PVC liner at pipe penetrations using manufacturer’s recommended methods.

3.04 MANHOLE FRAME AND ADJUSTMENT RINGS

A. Combine precast concrete adjustment rings so that the elevation of the installed casting cover matches the pavement surface. Seal between adjustment ring and the precast top section with non-shrink grout; do not use mortar between adjustment rings. Apply a latex-based bonding agent to precast concrete surfaces to be joined with non-shrink grout. Set the cast iron frame on the adjustment ring in a bed of approved sealant. The sealant bed shall consist of two beads of sealant, each bead having minimum dimensions of ½-inch and ¾-inch wide.

B. For manholes in unpaved areas, top of frame shall be set a minimum of 6 inches above existing ground line unless otherwise indicated on Drawings. Encase the manhole frame in mortar or non-shrink grout placed flush with the face of the manhole ring and the top edge of the frame. Provide a rounded corner around the perimeter.

C. When indicated on the Drawings, install manhole chimney seals to prevent inflow between manhole frames and chimneys. Conform to Section 02084 - Frames, Grates, Rings, and Covers.

3.05 BACKFILL

A. After leakage testing, place and compact backfill materials in the area of excavation surrounding manholes in accordance with requirements of Section 02317 - Excavation and Backfill for Utilities. Use embedment zone backfill material for the adjacent utilities, as shown in the Construction Document Drawing Details over each pipe connected to the manhole. Provide trench zone backfill, as specified for the adjacent utilities, above the embedment zone backfill.

B. Where rigid joints are used for connecting existing sewers to the manhole, backfill under the existing sewer up to the spring line of the pipe with Class B concrete or flowable fill.

C. In unpaved areas, provide positive drainage away from manhole frame to natural grade. Provide a minimum of 4 inches of topsoil conforming to requirements of Section 02911 - Topsoil. Seed in accordance with Section 02921 – Hydro-mulch Seeding.

3.06 FIELD QUALITY CONTROL

A. Conduct leakage testing of manholes in accordance with requirements of Section 02533 - Acceptance Testing for Pipelines.
3.07 PROTECTION

A. Protect manholes from damage until subsequent work has been accepted. Repair or replace damaged elements of manholes at no additional cost to the Owner.

END OF SECTION
PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Precast concrete manholes for gravity pipelines, storm sewers, and water lines. Manhole bases maybe round or square.

B. Precast concrete manholes with PVC liner where corrosion resistant manholes are specifically indicated in Drawings.

C. Pile-supported concrete foundation used for unstable subgrade treatment for manhole base.

1.02 MEASUREMENT AND PAYMENT

A. Unit Prices

1. No separate payment will be made for work required under this section. Contractor will include all costs of the requirements of this section in the appropriate bid item(s) on the bid form.

2. Payment for shallow depth manholes is on a unit price basis for each manhole installed. Shallow manholes have a depth of 5 feet or less measured from top of Tilt cover to sewer invert.

3. Payment for extra depth manholes is on a unit price basis per vertical foot for each foot of depth greater than 8 feet. Sewer manhole depth is measured from top of cover to sewer invert. Air release manhole depth is measured from top of cover to inside base for air release or vacuum release manholes. Manholes for water lines are measured from top of cover to inside base of manhole.

4. Payment for normal depth corrosion resistant manholes is on a unit price basis for each manhole installed.

5. Payment for standard manhole drops is on a unit price basis for each drop installed. Standard manhole drops include both internal and external drops.

6. Payment for watertight manholes, including external vent pipe is on a unit price basis for each.

7. Payment for air-release manhole with valves and fittings installed is on a unit price basis for each manhole with air-release valves and fittings installed.

8. Payment for pile-supported concrete foundation used for unstable subgrade treatment for manhole base is on a unit price basis for each foundation installed.

9. Pay estimates for partial payments will be made as measured above according to the following schedule for manholes:
a. Estimate for 90 percent payment will be authorized when the manhole is completely installed, and surrounding soil backfilled
b. Estimate for 100 percent payment will be authorized when manhole has been tested as specified in Section 02533 - Acceptance Testing for Pipelines.

B. Stipulated Price (Lump Sum). If the Contract is a Stipulated Price Contract, payment for work in this Section is included in the total Stipulated Price.

1.03 REFERENCES

A. ANSI B 16.1 - Cast Iron Pipe Flanges and Flanged Fittings
B. ASTM A 307 - Specification for Carbon Steel Bolts and Studs, 60,000 psi Tensile.
C. ASTM A 615 - Standard Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement
D. ASTM C 270 - Standard Specification for Mortar for Unit Masonry
G. ASTM C 890 - Standard Practice for Minimum Structural Design Loading for Monolithic or Sectional Precast Concrete Water and Wastewater Structures.
N. ASTM D 2997 - Specification for Centrifugally Cast Fiberglass (Glass-Fiber-Reinforced Thermosetting Resin) Pipe.


Q. AWWA C 213 - Standard for Fusion Bonded Epoxy Coating for Interior and Exterior of Steel Water Pipelines.

R. American Association of State Highway and Transportation Officials (AASHTO)

1.04 SUBMITTALS

A. Submit manufacturer's data and details of following items for approval:

1. Shop drawings of manhole sections and base units and construction details, including reinforcement, jointing methods, materials, and dimensions.

2. Summary of criteria used in the manhole design including, as a minimum, material properties, loadings, load combinations, and dimensions assumed. Include certification from manufacturer that precast manhole design is in full accordance with ASTM C 478 and design criteria as established in Paragraph 2.01E of this Specification.

3. Frames, grates, rings, and covers.

4. Materials to be used in fabricating drop connections.

5. Materials to be used for pipe connections at manhole walls.

6. Materials to be used for stubs and stub plugs, if required.

7. Materials and procedures for corrosion-resistant liner and coatings, if required.

8. Plugs to be used for pipeline hydrostatic testing.

9. Manufacturer's data for pre-mix (bag) concrete, if used for channel inverts and benches.

B. Seal submittal drawings by Professional Engineer registered in State of Texas.

PART 2 - PRODUCTS

2.01 PRECAST CONCRETE MANHOLES

A. Provide manhole sections, base sections, and related components conforming to ASTM C478. Provide base riser section with integral floors, unless shown otherwise. Provide adjustment rings which are standard components of manufacturer of manhole sections. Mark date of manufacture and name or trademark of manufacturer on inside of barrel.

B. Construct barrels for precast manholes from standard reinforced concrete manhole sections of diameter indicated on Drawings. Use various lengths of manhole sections in combination to provide correct height with fewest joints.
Design wall sections for depth and loading conditions in Paragraph 2.01 E, with minimum thickness of 5 inches. Base section shall have minimum thickness of 12 inches under invert.

C. Provide tops to support cast iron casting meeting AASHTO M-306 Section 5 loading, and receive manhole frame & covers, as indicated on Drawings.

D. Where manholes larger than 48-inch diameter are indicated on Drawings, provide precast base sections with flat slab top precast sections used to transition to 48-inch diameter manhole access riser sections. Transition can be concentric or eccentric unless otherwise shown on Drawings. Locate transition to provide minimum of 7-foot head clearance from base to underside of transition unless otherwise approved by Project Manager.

E. Design Loading Criteria: Manhole walls, transition slabs, cone tops, and manhole base slab shall be designed, by manufacturer, to requirements of ASTM C 478, ASTM C 890 and/or ASTM C 913 for depth as shown on Drawings and to resist following loads.

1. AASHTO M-306 H-20 / HS-20 design live loading loads as referred to in AASHTO M-306 applied to manhole cover and transmitted down to transition and base slabs.
2. Unit soil weight of 120 pcf located above all portions of the manhole, including base slab projections.
3. Lateral soil pressure based on saturated soil conditions producing an at-rest equivalent fluid pressure of 100 pcf.
4. Internal liquid pressure based on a unit weight of 63 pcf.
5. Dead load of manhole sections fully supported by the transition and base slabs.

F. Design: Manhole walls, transition slabs, cone tops, and manhole base slab shall be designed according to requirements of ASTM C 478, ASTM C 890 and/or ASTM C 913 and following:

1. Design additional reinforcing steel to transfer stresses at openings. Area of steel to be no less than shown on Drawings.
2. Wall loading conditions:
   a. Saturated soil pressure acting on an empty manhole.
   b. Manhole filled with liquid to mid-height from invert to cover, with no balancing external soil pressure.
3. The minimum clear distance between any two-wall penetrations shall be 12 inches or half the diameter of the smaller penetration, whichever is greater.

G. Provide joints between sections with gaskets conforming to ASTM C 443 and/or ASTM C- 990.
H. When base is cast monolithic with portion of vertical section, extend reinforcing in vertical section into base.

I. Precast Concrete Base: Suitable cutouts or holes to receive pipe and connections. Lowest edge of holes or cutouts: For water line manhole, no less than 6 inches above inside surface of floor of base

2.02 CONCRETE

A. Channel Inverts: Use 5 sack premix (bag) concrete or Class A concrete for inverts not integrally formed with manhole base, with minimum compressive strength of 4,000 psi.

B. Cement Stabilized Sand Foundation: Provide cement stabilized sand foundation under base section in lieu of foundation slab, as shown on Drawings, conforming to requirements of Section 02321 - Cement Stabilized Sand.

C. Concrete Foundation: Provide Class A concrete with minimum compressive strength of 4,000 psi for concrete foundation slab under manhole base section where indicated on Drawings.

2.03 REINFORCING STEEL – Not used

2.04 MORTAR – Not used

2.05 MISCELLANEOUS METALS

A. Provide cast-iron frames, rings, and covers conforming to requirements of Section 02084 - Frames, Grates, Rings and Covers.

2.06 DROP CONNECTIONS AND STUBS

A. Provide drop connections and stubs conforming to the same pipe material requirements used in the main pipe, unless otherwise indicated on the Drawings.

2.07 PIPE CONNECTIONS TO MANHOLE

A. Gravity Pipelines:

1. Provide resilient connectors conforming to requirements of ASTM C 923. Metallic mechanical devices as defined in ASTM C 923 shall be made of the following materials:

   a. External clamps: Type 304 stainless steel
   b. Internal, expandable clamps on standard manholes: Type 304 stainless steel, 11-gauge minimum.
   c. Internal, expandable clamps on corrosion-resistant manholes:
1) Type 316 stainless steel, 11-gauge minimum, or
2) Type 304 stainless steel, 11-gauge minimum, coated with minimum 16-mil fusion-bonded epoxy conforming to AWWA C 213.

2. Where rigid joints between pipe and a cast-in-place manhole base are specified or shown on the Drawings, provide polyethylene-isoprene water stop meeting the physical property requirements of ASTM C 923, such as Press-Seal WS Series, or approved equal.

B. Storm Sewer Connections:
1. Provide watertight connections in accordance with ASTM C 923 and ASTM F2510 as applicable for flexible (HDPE and CMP) pipe. Rigid (concrete) pipe to manhole connections do not have to comply with ASTM C 923 and may grouted instead.

C. Water Lines
1. Where smooth exterior pipes, i.e., steel, ductile iron, or PVC pipes are connected to manhole base or barrel, seal space between pi manhole wall with assembly consisting of rubber gasket or links mechanically compressed to form a watertight barrier. Assemblies: PressWedge, Res-Seal, Thunderline Link-Seal, or approved equal. See Drawings for placement of assembly in manhole sections.
2. When connecting concrete or cement mortar coated steel pipes, or as option for connecting smooth exterior pipes to manhole base or barrel, space between pipe and manhole wall may be sealed with an assembly consisting of a stainless-steel power sleeve, stainless steel -up clamp and a rubber gasket. Take-up clamp: Minimum of 9/16 inch wide. Provide PSX positive seal gasket system by Press-Seal Gasket Corporation or approved equal.

2.08 SEALANT MATERIALS

A. Sealing material between precast concrete adjustment ring and manhole, between each adjustment ring, and between adjustment ring and manhole cover frame shall be a hydrophilic elastic sealant, which adheres to both concrete and metal, or approved equal.

B. Provide approved external sealing material from Canusa Wrapid Seal manhole encapsulation system or approved equal.

C. Provide Butyl Sealant: Provide Press-Seal EZ Stick, or equal, for HDPE rings.

2.09 CORROSION RESISTANT MANHOLE MATERIALS

A. Where corrosion-resistant manholes are indicated on Drawings.
2.10 BACKFILL MATERIALS
A. Conform to requirements of Section 02317 - Excavation and Backfill for Utilities.

2.11 NON-SHRINK GROUT
A. Provide prepackaged, inorganic, flowable, non-gas-liberating, non-metallic, cement-based grout requiring only the addition of water.

B. Meet requirements of ASTM C 1107 and have minimum 28-day compressive strength of 7,000 psi.

2.12 VENT PIPES
A. Provide external vent pipes for manholes where indicated on the Drawings.

B. Buried Vent Pipes: Provide 3-inch or 4-inch PVC DWV pipe conforming to ASTM D2665. Alternatively, provide FRP pipe as specified for the vent outlet assembly.

C. Vent Outlet Assembly: Provide a vent outlet assembly as shown on the Drawings, constructed of the following specified materials:
   1. FRP Pipe: Provide filament wound FRP conforming to ASTM D 2996 or centrifugally cast FRP conforming to ASTM D 2997. Seal cut ends in accordance with manufacturer’s recommendations.
   2. Joints and Fittings: Provide epoxy-bodied fittings and join pipe to fittings with epoxy adhesive.
   3. Flanges: Provide socket-flange fittings for epoxy adhesive bonding to pipe ends where shown on the Drawings. Flanges shall meet bolt pattern and dimensions for ANSI B 16.1, 125-pound flanges. Flange bolts shall be Type 304 stainless steel or hot-dip zinc coated, conforming to ASTM A 307, Class A or B.
   4. Coating: Provide approved 2-component, aliphatic polyurethane coating using primer or tie coat recommended by manufacturer. Provide two or more coats to yield dry film thickness of at least 3 mils. Color shall be selected by Project Manager from manufacturer’s standard colors.

2.13 PROHIBITED MATERIALS
A. Do not use brick masonry for construction of manholes, including adjustment of manholes to grade. Use only specified materials listed above.

2.14 MANHOLE LADDER FOR WATERLINE MANHOLES
A. Manhole Ladder: Fiberglass with 300-lb rating at appropriate length; conform to requirements of Occupational Safety and Health Standards (OSHA), U.S. Department of Labor except where shown on Drawings:
   1. Use components, including rungs, made of fiberglass, fabricated with nylon or aluminum rivets and/or epoxy. Apply non-skid coating to ladder rungs. Mount ladder using manufacturer’s recommended hardware.
2. Provide ladder as manufactured by Saf-Rail or approved equal. Locate ladder as shown on Drawings.

3. Fiberglass: Premium type polyester resin, reinforced with fiberglass; constructed to provide complete wetting of glass by resin; resistant to rot, fungi, bacterial growth and adverse effects of acids, alkalis and residential and industrial waste; yellow in color.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Verify that lines and grades are correct.

B. Determine if subgrade, when scarified and recompacted, can be compacted to 95 percent of maximum Standard Proctor Density, at ±3% optimum moisture content according to ASTM D 698 prior to placement of foundation material and base section. If it does not meet the moisture-density requirement, condition the subgrade until the required moisture-density requirement is met or treat as an unstable subgrade.

C. Do not build manholes in ditches, swales, or drainage paths unless approved by Project Manager.

3.02 PLACEMENT

A. Install precast manholes to conform to locations and dimensions shown on Drawings.

B. Place sanitary and storm manholes at points of change in alignment, grade, size, pipe intersections, and end of sewer unless otherwise shown on Drawings.

3.03 MANHOLE BASE SECTIONS AND FOUNDATIONS

A. Place precast base on 12-inch-thick (minimum) foundation of crushed stone wrapped in filter fabric, cement stabilized sand, or a concrete foundation slab.

B. Unstable Subgrade Treatment: When unstable subgrade is encountered, notify Project Manager for examination of subgrade to determine if subgrade has heaved upwards after being excavated. When heaving has not occurred, over-excavate subgrade to allow for 24-inch-thick layer of crushed stone wrapped in filter fabric as foundation material under manhole base. When there is evidence of heaving, provide pile-supported concrete foundation, as detailed on Drawings, under manhole base.

C. For manholes located over large diameter water lines, place precast base on a foundation of cement stabilized sand extending from bottom of manhole to bottom of trench. Manhole base is to be a minimum of 12-inches above water line.
3.04 PRECAST MANHOLE SECTIONS

A. Install sections, joints, and gaskets in accordance with manufacturer’s printed recommendations.

B. Install precast adjustment rings above tops of cones or flat-top sections as required to adjust the finished elevation and to support the manhole frame.

C. Seal any lifting holes with non-shrink grout.

D. Where PVC liners are required, seal joints between sections in accordance with manufacturer’s recommendations.

E. Place at least two precast concrete grade rings with thickness of 12 inches or less, under casting.

3.05 PIPE CONNECTIONS AT MANHOLES

A. Install approved resilient connectors at each pipe entering and exiting manholes in accordance with manufacturer’s instructions.

1. Where smooth exterior pipes, i.e. steel, ductile iron or PVC pipes are connected to manhole base or barrel, space between pipe and manhole wall shall be sealed with an assembly consisting of rubber gaskets or links mechanically compressed to form watertight. Assemblies: “Press-Wedge,” “Res-Seal,” “Thunderline Link-Seals,” or approved equal. See Drawings for placement of assembly in manhole sections.

2. When connecting concrete or cement mortar coated steel pipes, or as an option for connecting smooth exterior pipes to manhole base or barrel, space between pipe and manhole wall may be sealed with an assembly consisting of stainless-steel power sleeve, stainless steel take-up clamp and rubber gasket. Take-up clamp: Minimum of 9/16 inch wide. Provide PSX positive seal gasket system by Press-Seal Gasket Corporation or approved equal.

B. Grout storm sewer connections to manhole when connecting a rigid (concrete) pipe to a concrete manhole unless otherwise shown on Drawings. Grout pipe penetration in place on both inside and outside of manhole.

C. Install approved resilient connectors at each flexible (hdpe or cmp) pipe connection as per ASTM C-923 and/or ASTM F 2510 to a concrete manhole.

D. Ensure no concrete, cement stabilized sand, fill, or other rigid material can enter space between pipe and edge of wall opening at and around resilient connector on either interior or exterior of manhole. If necessary, fill space with compressible material to ensure full flexibility provided by resilient connector.

E. Where new manhole is constructed on existing sewer, rigid joint pipe may be used. Install water stop gasket around existing pipe at center of cast-in-place wall. Join ends of split water stop material at pipe spring line using an adhesive recommended and supplied by water stop manufacturer.
F. Test connection for watertight seal before backfilling.

3.06 INVERTS FOR GRAVITY PIPELINES

A. Construct invert channels to provide a smooth flow transition waterway with no disruption of flow at pipe-manhole connections. Conform to following criteria:

1. Slope of invert bench: 1 inch per foot minimum; 1-1/2 inches per foot maximum
2. Depth of bench to invert shall be at least equal to the largest pipe diameter.
3. Invert slope through manhole: 0.10-foot drop across manhole with smooth transition of invert through manhole, unless otherwise indicated on Drawings.

B. Form invert channels with concrete if not integral with manhole base section. For direction changes of mains, construct channels tangent to mains with maximum possible radius of curvature. Provide curves for side inlets and smooth invert fillets for flow transition between pipe inverts.

3.07 DROP CONNECTIONS FOR GRAVITY PIPELINES

A. Backfill drop assembly with crushed stone wrapped in filter fabric, cement stabilized sand, or Class A concrete to form a solid mass. Extend cement-stabilized sand or concrete encasement a minimum of 4 inches outside of bells.

B. Install a drop connection when a sewer line enters a manhole higher than 24 inches above the invert of a manhole.

3.08 INVERTS FOR STORM SEWERS

A. When precast, square or rectangular structures are used for sewer manholes, construct invert channels to provide smooth flow transition waterway with no disruption of flow at pipe-manhole connections. Conform to following criteria:

1. Slope of invert bench: 1 inch per foot minimum; 1½ inches per foot maximum.
2. Depth of bench to invert: one half of largest pipe diameter.
3. Invert slope through manhole: 0.10-foot drop across manhole with smooth transition of invert through manhole, unless otherwise indicated on drawings.

B. Form invert channels with concrete, after all connections have been made.

1. Use 5 sack premix (bag) concrete or Class A concrete for inverts, with minimum compressive strength of 4,000 psi.

3.09 STUBS FOR FUTURE CONNECTIONS

A. In manholes, where future connections are indicated on Drawings, install resilient connectors and pipe stubs with approved watertight plugs.
3.10 MANHOLE FRAME AND ADJUSTMENT RINGS
A. Combine precast concrete or HDPE adjustment rings so elevation of installed casting cover matches pavement surface. Seal between concrete adjustment ring and precast top section with non-shrink grout; do not use mortar between adjustment rings. Apply latex-based bonding agent to precast concrete surfaces joined with non-shrink grout. Set cast iron frame on adjustment ring in bed of approved sealant material. Install sealant bed consisting of two beads of sealant, each bead having minimum dimensions of 1/2-inch and 1/2-inch wide.

B. Wrap manhole frame and adjustment rings with external sealing material, minimum 3 inches beyond joint between ring and frame and adjustment rings and precast section.

C. For manholes in unpaved areas, set top of frame minimum of 6 inches above existing ground line unless otherwise indicated on Drawings. In unpaved areas, encase manhole frame in mortar or non-shrink grout placed flush with face of manhole ring and top edge of frame. Provide rounded corner around perimeter.

3.11 BACKFILL
A. Place and compact backfill materials in area of excavation surrounding manholes in accordance with requirements of Section 02317 - Excavation and Backfill for Utilities. Provide embedment zone backfill material, as specified for adjacent utilities, from manhole foundation up to an elevation 12 inches over each pipe connected to manhole. Provide trench zone backfill, as specified for adjacent utilities, above embedment zone backfill.

B. Where rigid joints are used for connecting existing sewers to manhole, backfill under existing sewer up to spring line of pipe with Class B concrete or flowable fill.

C. In unpaved areas, provide positive drainage away from manhole frame to natural grade. Provide minimum of 4 inches of topsoil conforming to requirements of Section 02911 - Topsoil. Seed in accordance with Section 02921 – Hydro-mulch Seeding.

3.12 FIELD QUALITY CONTROL
A. Conduct leakage testing of manholes in accordance with requirements of Section 02533 - Acceptance Testing for Pipelines.

3.13 PROTECTION
A. Protect manholes from damage until work has been accepted. Repair damage to manholes at no additional cost to Owner.

END OF SECTION

02082 - 11 / 11
Dundee State Fish Hatchery Water Reuse – Effluent Pump Back
TPWD No. 1110061R
SECTION 02084
FRAMES, GRATES, RINGS AND COVERS

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Iron castings for manhole frames and covers, inlet frames and grates, catch basin frames and grates, meter vault frames and covers, adjustment rings, and extensions.

B. Ring grates.

1.02 MEASUREMENT AND PAYMENT

A. No separate payment will be made for work required under this section. Contractor will include all costs of the requirements of this section in the appropriate bid item(s) on the bid form.

1.03 REFERENCES


C. ASTM A 615 - Standard Specification for Deformed Billet-Steel Bars for Concrete Reinforcement.

D. AWS - D 12.1 Welding Reinforcing Steel.

1.04 SUBMITTALS

A. Submit copies of manufacturer's specifications, load tables, dimension diagrams, anchor details, and installation instructions.

B. Submit shop drawings for fabrication and installation of casting assemblies that are not included in Drawings or standard details. Include plans, elevations, sections and connection details. Show anchorage and accessory items. Include setting drawings for location and installation of castings and anchorage devices.

PART 2 - PRODUCTS

2.01 CASTINGS

A. Castings for frames, grates, rings and covers shall conform to ASTM A 48, Class 30. Provide locking covers if indicated on Drawings.
B. Castings shall be capable of withstanding the application of an AASHTO H-20 loading without permanent deformation.

C. Fabricate castings to conform to the shapes, dimensions, and with wording or logos shown on the Drawings. Standard dimensions for manhole covers are 32 inches in diameter.

D. Castings shall be clean, free from blowholes and other surface imperfections. Cast holes in covers shall be clean and symmetrical, free of plugs.

2.02 BEARING SURFACES

A. Machine bearing surfaces between covers or grates and their respective frames so that even bearing is provided for any position in which the casting may be seated in the frame.

2.03 SPECIAL FRAMES AND COVERS

A. Where indicated on the Drawings, provide watertight manhole frames and covers with a minimum of four bolts and a gasket designed to seal cover to frame. Supply watertight manhole covers and frames, Model R-1916H (32-inch cover diameter) manufactured by Neenah Foundry Company, Model V-7045 by Vulcan Foundry, or approval equal.

B. Where shown on the Drawing, provide manhole frames and covers with 48-inch-diameter clear opening, with inner cover for 22-inch diameter clear opening. Provide inner cover with pattern shown on Drawings, Vulcan Foundry V-7048-2, Neenah Foundry, Model R-1741-F, or approved equal.

2.04 FINISH

A. Unless otherwise specified, coat iron castings with the manufacturer's standard asphaltic paint.

2.05 FABRICATED RING GRATES

A. Ring grates shall be fabricated from reinforcing steel conforming to ASTM A 615.

B. Welds connecting the bars shall conform to AWS D 12.1.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install castings according to approved shop drawings, instructions given in related specifications, and applicable directions from the manufacturer's printed materials.

B. Set castings accurately at required locations to proper alignment and elevation. Keep castings plumb, level, true, and free of rack. Measure location accurately.
from established lines and grades. Brace or anchor frames temporarily in formwork until permanently set.

C. Ring grates shall be fabricated in accordance with the standard detail, Ring Grate for Open End of 18" to 72" Stubs to Ditch and shall be set in mortar in the mouth of the pipe bell.

END OF SECTION
PART 1 - GENERAL

1.01 SECTION INCLUDES
A. Removing existing structures facilities, and materials as shown on plans.
B. Turnover of salvageable materials and equipment to Owner.

1.02 Measurement and Payment
A. No separate payment will be made for work required under this Section. Contractor will include all costs of the requirements of this Section in the appropriate bid item(s) on the Bid Form.

1.03 SUBMITTALS
A. Submit proposed methods, equipment, materials and sequence of operations for demolition of equipment and materials. Plan operations to minimize temporary disruption of utilities to existing facilities or adjacent property.
B. Submit proposed demolition and removal schedule for approval. Notify Engineer in writing at least 48 hours before starting demolition.

1.04 OWNERSHIP OF MATERIAL AND EQUIPMENT
A. Materials and equipment designated for reuse or salvage are listed on the plans. Protect items designated for reuse or salvage from damage during demolition, handling and storage. Restore damaged items to satisfactory condition.
B. Materials and equipment not designated for reuse or salvage become the property of and the responsibility of the Contractor.

1.05 STORAGE AND HANDLING
A. Store and protect materials and equipment designated for reuse until time of installation.
B. Deliver items to be salvaged to Owner as directed by the Engineer.
C. Remove equipment and materials not designated for reuse or salvage and all waste and debris resulting from demolition from site. Remove material as work progresses to avoid clutter. Properly dispose of all waste material in accordance with applicable laws and regulations.
1.06 ENVIRONMENTAL CONTROLS

A. Minimize spread of dust and flying particles. Use temporary enclosures and other suitable methods to prevent the spread of dust, dirt and debris, or other methods conforming to requirements of Section 01572 – Source Controls for Erosion and Sedimentation.

B. Use appropriate controls to limit noise from demolition to levels designated in local ordinances.

C. Do not use water where it can create dangerous or objectionable conditions, such as localized flooding, erosion, or sedimentation of nearby ditches or streams.

D. Stop demolition and notify Engineer if underground fuel storage tanks, asbestos, PCBs, lead based paint, contaminated soils, or other hazardous materials are encountered.

E. Dispose of removed equipment, materials, waste and debris in a manner conforming to applicable laws and regulations.

PART 2 - PRODUCTS

2.01 EQUIPMENT AND MATERIALS FOR DEMOLITION

A. Fires are not permitted.

B. Do not use a "drop hammer" where the potential exists for damage to underground utilities, structures, or adjacent improvements.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Prior to demolition, inspect with Engineer to determine the condition of existing structures and features adjacent to items designated for demolition.

B. Engineer will mark or list existing equipment to remain the property of the Owner.

C. Do not proceed with demolition or removal operations until after the joint inspection and subsequent authorization by the Engineer.

3.02 PROTECTION OF PERSONS AND PROPERTY

A. Provide safe working conditions for employees throughout demolition and removal operations. Observe safety requirements for work below grade.

B. Maintain safe access to adjacent property and buildings. Do not obstruct roadways, sidewalks or passageways adjacent to the work.
C. Perform demolition in a manner to prevent damage to adjacent property. Repair
damage to the property or adjacent property and facilities.

D. The Contractor shall be responsible for safety and integrity of adjacent structures
and shall be liable for any damage due to movement or settlement. Provide
proper framing and shoring necessary for support. Cease operations if an
adjacent structure appears to be endangered. Resume demolition only after
proper protective measures have been taken.

E. Erect and maintain enclosures, barriers, warning lights, and other required
protective devices.

3.03 UTILITY SERVICES

A. Follow rules and regulations of authorities or companies having jurisdiction over
communications, pipelines, and electrical distribution services.

B. Notify and coordinate with utility company and adjacent building occupants when
temporary interruption of utility service is necessary.

3.04 DISPOSAL

A. Remove from the site all items contained in or upon the structure not designated
for reuse or salvage.

B. Follow method of disposal as required by regulatory agencies.

3.05 BACKFILL

A. Backfill holes in accordance with specification sections governing materials
indicated on Drawings. Where no material is indicated, backfill with approved
borrow and compact to a density of 90 percent standard Proctor.

B. Do not backfill with material from demolition unless approved by Engineer.

3.06 MECHANICAL WORK ITEMS

A. Mechanical removals consist of dismantling and removing existing piping,
pumps, motors, equipment and other appurtenances. It includes cutting,
capping, and plugging required to restore use of existing utilities.

END OF SECTION
SECTION 02305
TEMPORARY CRUSHED LIMESTONE ACCESS ROAD

PART 1 - GENERAL

1.01 SECTION INCLUDES
A. This item consists of surface course of crushed limestone and conforming to the dimensions, lines and grades as shown on the Plans.

1.02 MEASUREMENT AND PAYMENT
A. No separate payment will be made for work required under this Section. Contractor will include all costs of the requirements of this Section in the appropriate bid item(s) on the Bid Form.

PART 2 - PRODUCTS

2.01 SURFACE MATERIAL
A. The surface material shall be obtained from an approved source and be composed of crushed limestone. The processed material, when properly slaked and tested by standard procedure, shall meet the following requirements.

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<th>% Retained</th>
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<tr>
<td>Maximum Plasticity Index</td>
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<tr>
<td>Maximum Wet Ball Mill</td>
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</tr>
<tr>
<td>Maximum Los Angeles Wear</td>
<td>45</td>
</tr>
</tbody>
</table>

PART 3 - EXECUTION

3.01 GENERAL
A. Before any material is placed the grade shall be submitted to the Engineer for approval.

3.02 HAULING AND SPREADING
A. The crushed rock shall be spread and shaped to a thickness and cross section that will provide the required minimum thickness and section after compaction in accordance with plans.
3.03 PREPARATION OF SUB-GRADE

A. The sub-grade shall be prepared in conformity with the typical sections shown on the Plans. Compaction on ninety-five percent (95%) Standard Proctor density shall be obtained as per ASTM D-698 before the surface material is placed. Lime stabilized subgrade shall be 7% dry weight hydrated lime compacted at 1% to 3% wet optimum moisture content.

3.04 SURFACE COURSE

A. Flexible surface material deposited upon the sub-grade shall be spread, shaped and rolled the same day if possible, if not possible do this within the first 24 hours; the delay should be held to the minimum. This surface course shall be wetted, bladed and rolled until minimum of 95% Modified Proctor density has been attained and in conformity with the typical section shown in Plans.

3.05 COMPACTION

A. The roller used for compacting the material to the density previously indicated may be either sheep foot, steel or pneumatic rollers, or a combination of all, or as directed by the Engineer.

B. Rolling operations shall start as soon as possible after the material is spread over an area enough for efficient operation. The roller shall start at the side and work toward the center, overlapping on successive trips by one-half the width of each rear wheel. Rolling shall be done longitudinally with the sub-grade and, if directed by the Engineer, the roller shall be operated diagonally or crosswise to the direction of the first rolling.

C. At all times during the rolling operations the material shall be sprinkled, bladed and worked to maintain the shape of the required cross section and to the established grade.

D. Rolling shall continue until all material is firmly and uniformly compacted and does not yield or move when the roller is operated over the surface course.

END OF SECTION
PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Excavation, backfilling, and compaction of backfill for structures.

1.02 MEASUREMENT AND PAYMENT

A. No separate payment will be made for work required under this section. Contractor will include all costs of the requirements of this section in the appropriate bid item(s) on the bid form.

1.03 DEFINITIONS

A. Unsuitable Material: Unsuitable soil materials are the following:

1. Materials that are classified as ML, CL-ML, MH, PT, OH, and OL according to ASTM D 2487.
2. Materials that cannot be compacted to the required density due to either gradation, plasticity, or moisture content.
3. Materials that contain large clods, aggregates, stones greater than 4 inches in any dimension, debris, vegetation, waste or any other deleterious materials.
4. Materials that are contaminated with hydrocarbons or other chemical contaminants.

B. Suitable Material: Suitable soil materials are those meeting specification requirements. Unsuitable soils meeting specification requirements for suitable soils after treatment with lime or cement shall be considered suitable, unless otherwise indicated.

C. Select Material: Material as defined in Section 02320 - Utility Backfill Materials.

D. Backfill: Select material meeting specified quality requirements, placed and compacted under controlled conditions around structures.

E. Foundation Backfill Materials: Natural soil or manufactured aggregate meeting Class I requirements and geotextile filter fabrics as required, to control drainage and material separation. Foundation backfill material is placed and compacted as backfill where needed to provide stable support for the structure foundation base. Foundation backfill materials may include concrete fill and seal slabs.

F. Foundation Base: For foundation base material, use crushed stone aggregate with filter fabric as required, cement stabilized sand, or concrete seal slab. The foundation base provides a smooth, level-working surface for the construction of the concrete foundation.
G. Foundation Subgrade: Foundation subgrade is the surface of the natural soil which has been excavated and prepared to support the foundation base or foundation backfill, where needed.

H. Ground Water Control Systems: Installations external to the excavation such as well points, eductors, or deep wells. Ground water control includes dewatering to lower the ground water, intercepting seepage that would otherwise emerge from the side or bottom of the excavation, and depressurization to prevent failure or heaving of the excavation bottom.

I. Surface Water Control: Diversion and drainage of surface water runoff and rainwater away from the excavation. Remove rainwater and surface water that accidentally enters the excavation as a part of excavation drainage.

J. Excavation Drainage: Removal of surface and seepage water in the excavation by sump pumping and using French drains surrounding the foundation to intercept the water.

K. Over-Excavation and Backfill: Excavation of subgrade soils with unsatisfactory bearing capacity or composed of otherwise unsuitable materials below the foundation as shown on Drawings and backfilled with foundation backfill material.

L. Shoring System: A structure that supports the sides of an excavation to maintain stable soil conditions and prevent cave-ins.

1.04 REFERENCES

A. ASTM D 558 - Test Methods for Moisture-Density Relations of Soil Cement Mixtures.

B. ASTM D 698 - Test Methods for Moisture-Density Relations of Soils and Soil-Aggregate Mixtures, Using 5.5-lb (2.49-kg) Rammer and 12-in. (304.88-mm) Drop.

C. ASTM D 1556 - Density of Soil in Place by the Sand-Cone Method.

D. ASTM D 2487 - Classification of Soils for Engineering Purposes.

E. ASTM D 2922 - Test Methods for Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth).

F. ASTM D 3017 - Test Method for Moisture Content of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depths).


I. TxDOT Tex-110-E - Determination of Particle Size Analysis of Soils.

1.05 SUBMITTALS

A. Submit a work plan for excavation and backfill for each structure with complete written description that identifies details of the proposed method of construction and the sequence of operations for construction relative to excavation and backfill activities. The descriptions, with supporting illustrations, shall be sufficiently detailed to demonstrate to the Engineer that the procedures meet the requirements of the Specifications and Drawings.

B. Submit excavation safety system plan.

1. The excavation safety system plan shall be in accordance with applicable OSHA requirements for all excavations.
2. The excavation safety system plan shall be in accordance with the requirements of Section 01561 - Trench Safety System, for all excavations that fall under State and Federal trench safety laws.

C. Submit a ground and surface water control plan.

D. Submit backfill material sources and product quality information in accordance with requirements of Section 02320 - Utility Backfill Materials.

E. Record location of utilities, as installed, referenced to survey benchmarks. Include location of utilities encountered or rerouted. Give horizontal dimensions, elevations, inverts and gradients.

PART 2 - PRODUCTS

2.01 EQUIPMENT

A. Perform excavation with equipment suitable for achieving the requirements of this Specification.

B. Use equipment, which will produce the degree of compaction, specified. Backfill within 3 feet of walls shall be compacted with hand-operated equipment. Do not use equipment weighing more than 10,000 pounds closer to walls than a horizontal distance equal to the depth of the fill at that time. Use hand operated power compaction equipment where use of heavier equipment is impractical or restricted due to weight limitations.

2.02 MATERIAL CLASSIFICATIONS

A. Backfill materials shall conform to the classifications and product descriptions of Section 02320 - Utility Backfill Materials. The classification or product description for backfill applications shall be as shown on the Drawings and as specified.
2.03 TESTS

A. Testing and analysis of backfill materials for soil classification and compaction during construction will be performed by an independent laboratory provided by the Contractor.

B. Contractor shall perform embedment and backfill material source qualification testing in accordance with requirements of Section 02320- Utility Backfill Materials.

PART 3 - EXECUTION

3.01 PREPARATION

A. Conduct an inspection to determine condition of existing structures and other permanent installations.

B. Set up necessary street detours and barricades in preparation for excavation if construction will affect traffic. Maintain barricades and warning devices at all times for streets and intersections where work is in progress, or where affected by the Work, and is considered hazardous to traffic movements.

C. Perform work in accordance with OSHA standards. Employ an excavation safety system as specified in Section 01561 - Trench Safety Systems.

D. Remove existing pavements and structures, including sidewalks and driveways.

E. Install and operate necessary dewatering and surface water control measures.

3.02 PROTECTION

A. Protect trees, shrubs, lawns, existing structures, and other permanent objects outside of grading limits and within the grading limits as designated on the Drawings.

B. Protect and support above-grade and below-grade utilities that are to remain.

C. Restore damaged permanent facilities to pre-construction conditions unless replacement or abandonment of facilities are indicated on the Drawings.

D. Prevent erosion of excavations and backfill. Do not allow water to pond in excavations.

E. Maintain excavation and backfill areas until start of subsequent work. Repair and recompact slides, washouts, settlements, or areas with loss of density at no additional cost to the Owner.
3.03 EXCAVATION

A. Perform excavation work so that the underground structure can be installed to depths and alignments shown on Drawings. Use caution during excavation work to avoid disturbing surrounding ground and existing facilities and improvements. Keep excavation to the absolute minimum necessary. No additional payment will be made for excess excavation not authorized by the Engineer.

B. Upon discovery of unknown utilities, badly deteriorated utilities not designated for removal, or concealed conditions, discontinue work at that location. Notify the Engineer and obtain instructions before proceeding in such areas.

C. Immediately notify the agency or company owning any line which is damaged, broken or disturbed. Obtain approval from the Engineer and agency for any repairs or relocations, either temporary or permanent.

D. Avoid settlement of surrounding soil due to equipment operations, excavation procedures, vibration, dewatering, or other construction methods.

E. Provide surface drainage during construction to protect work and to avoid nuisance to adjoining property. Where required, provide proper dewatering and piezometric pressure control during construction.

F. Conduct hauling operations so that trucks and other vehicles do not create a dirt nuisance in streets. Verify that truck beds are sufficiently tight and loaded in such a manner that objectionable material will not spill onto streets. Promptly clear away any dirt, mud, or other materials that spill onto streets or are deposited onto streets by vehicle tires.

G. Maintain permanent benchmarks, monumentation, and other reference points. Unless otherwise directed, replace those, which are damaged or destroyed by the Work. Replacement will be performed by a Texas RPLS at no cost to the Owner.

H. Provide sheeting, shoring, and bracing where required to safely complete the Work, to prevent excavation from extending beyond limits indicated on Drawings, and to protect the Work and adjacent structures or improvements. Sheeting, shoring, and bracing used to protect workmen and the public shall conform to requirements of Section 01561 - Trench Safety Systems.

I. Prevent voids from forming outside of sheeting. Immediately fill voids with grout, concrete fill, cement-stabilized sand, or other material approved by the Engineer.

J. After completion of the structure, remove sheeting, shoring, and bracing unless shown on Drawings to remain in place or directed by the Engineer in writing that such temporary structures may remain. Remove sheeting, shoring and bracing in such a manner as to maintain safety during backfilling operations and to prevent damage to the Work and adjacent structures or improvements.
K. Immediately fill and compact voids left or caused by removal of sheeting with cement stabilized sand or material approved by the Engineer.

3.04 HANDLING EXCAVATED MATERIALS

A. Classify excavated materials. Place material, which is suitable for use as backfill in orderly piles at a sufficient distance from excavation to prevent slides or cave-ins.

B. Provide additional backfill material, if adequate quantities of suitable material are not available from excavation and trenching operations at the site.

3.05 DEWATERING

A. Provide ground water control as required to perform excavation safely.

B. Keep ground water surface elevation a minimum of 2 feet below the bottom of the foundation base.

C. Maintain ground water control as required and until the structure is sufficiently complete to provide the required weight to resist hydrostatic uplift with a minimum safety factor of 1.2.

3.06 FOUNDATION EXCAVATION

A. Notify the Engineer at least 48 hours prior to planned completion of foundation excavations. Do not place the foundation base until the Engineer accepts the excavation.

B. Excavate to elevations shown on Drawings, as needed to provide space for the foundation base, forming a level undisturbed surface, free of mud or soft material. Remove pockets of soft or otherwise unstable soils and replace with foundation backfill material or a material as directed by the Engineer. Prior to placing material over it, recompact the subgrade where indicated on the Drawings, scarifying as needed, to 95 percent of the maximum Standard Dry Density according to ASTM D 698. If the specified level of compaction cannot be achieved, moisture condition the subgrade and recompact until 95 percent is achieved, over-excavate to provide a minimum layer of 24 inches of foundation backfill material, or other means acceptable to the Engineer.

C. Fill unauthorized excessive excavation with foundation backfill material or other material as directed by the Engineer.

D. Protect open excavations from rainfall, runoff, freezing groundwater, or excessive drying so as to maintain foundation subgrade in a satisfactory, undisturbed condition. Keep excavations free of standing water and completely free of water during concrete placement.

E. Soils that become unsuitable due to inadequate dewatering or other causes, after initial excavation to the required subgrade, shall be removed and replaced with
foundation backfill material, as directed by the Engineer, at no additional cost to the Owner.

F. Place foundation base, or foundation backfill material where needed, over the subgrade on same day that excavation is completed to final grade. Where base of excavations are left open for longer periods, protect them with a seal slab or cement-stabilized sand.

G. Crushed aggregate, and other free draining Class I materials, shall have a filter fabric separating it from native soils or select material backfill. The fabric shall overlap a minimum of 12 inches beyond where another material stops contact with the soil.

H. Crushed aggregate, and other Class I materials, shall be placed in uniform lifts of 8-inch maximum thickness. Compaction shall be by means of at least two passes of a vibratory compactor.

3.07 FOUNDATION BASE

A. After the subgrade is properly prepared, including the placement of foundation backfill where needed, the foundation base shall be placed. The foundation base shall consist of a 12-inch layer of crushed stone aggregate or cement stabilized sand. Alternately, a seal slab with a minimum thickness of 4 inches may be placed. The foundation base shall extend a minimum of 12 inches beyond the edge of the structure foundation, unless shown otherwise on the Drawings.

B. Where the foundation base and foundation backfill are of the same material, both can be placed in one operation.

3.08 BACKFILL

A. Complete backfill to surface of natural ground or to lines and grades shown on Drawings. Use existing material that qualifies as select material, unless indicated otherwise. Deposit backfill in uniform layers and compact each layer as specified.

B. Do not place backfill against concrete walls or similar structures until laboratory test breaks indicate that the concrete has reached a minimum of 85 percent of the specified compressive strength. Where walls are supported by slabs or intermediate walls, do not begin backfill operations until the slab or intermediate walls have been placed and concrete has attained sufficient strength.

C. Remove concrete forms before starting backfill and remove shoring and bracing as work progresses.

D. Maintain fill material at no less than 2 percent below nor more than 2 percent above optimum moisture content. Place fill material in uniform 8-inch maximum loose layers. Compaction of fill shall be at least 95 percent of the maximum
Standard Dry Density according to ASTM D 698 under paved areas. Compact to at least 90 percent around structures below unpaved areas.

E. Where backfill is placed against a sloped excavation surface, run compaction equipment across the boundary of the cut slope and backfill to form a compacted slope surface for placement of the next layer of backfill.

3.09 FIELD QUALITY CONTROL

A. Tests will be performed initially on minimum of one different sample of each material type for plasticity characteristics, in accordance with ASTM D 4318, and for gradation characteristics, in accordance with Tex-101-E and Tex-110-E. Additional classification tests will be performed whenever there is a noticeable change in material gradation or plasticity.

B. In-place density tests of compacted subgrade and backfill will be performed according to ASTM D 1556, or ASTM D 2922 and ASTM D 3017, and at the following frequencies and conditions:

1. A minimum of one test for every 100 cubic yards of compacted backfill material.
2. A minimum of three density tests for each full work shift.
3. Density tests will be performed in all placement areas.
4. The number of tests will be increased if inspection determines that soil types or moisture contents are not uniform or if compacting effort is variable and not considered sufficient to attain uniform density.

C. At least one test for moisture-density relationships will be initially performed for each type of backfill material in accordance with ASTM D 698. Additional moisture-density relationship tests will be performed whenever there is a noticeable change in material gradation or plasticity.

D. If tests indicate work does not meet specified compaction requirements, recondition, recompact, and retest at Contractor’s expense.

3.10 DISPOSAL OF EXCESS MATERIAL

A. Dispose of excess materials in accordance with all local and state requirements.

END OF SECTION
SECTION 02317
EXCAVATION, TRENCHING AND BACKFILLING FOR UTILITIES

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Excavation, trenching, foundation, embedment, and backfill for installation of utilities, including manholes and other pipeline structures.

1.02 MEASUREMENT AND PAYMENT

A. Unit Prices

1. No additional payment will be made for trench excavation, embedment and backfill under this Section. Include cost in unit price for installed underground piping, sewer, conduit, or duct work.

2. When Project Manager directs Contractor to over excavate trench bottom, Contractor will be paid by unit price bid per linear foot under bid item - 6" Over Excavation of Trench Bottom.

a. No payment will be paid if Project Manager does not direct Contractor to over excavate trench bottom.

b. No over excavation will be measured or paid when unsuitable conditions result from dewatering system not in conformance with Section 01578 - Control of Ground Water and Surface Water.

c. No additional payment will be made for performing Critical Location exploratory excavation. Include cost in unit price for installed underground piping, sewer, conduit, or duct work.

B. Stipulated Price (Lump Sum). If Contract is Stipulated Price Contract, payment for Work in this Section is included in total Stipulated Price.

1.03 DEFINITIONS

A. Pipe Foundation: Suitable and stable native soils that are exposed at trench subgrade after excavation to depth of bottom of bedding as shown on Drawings, or foundation backfill material placed and compacted in over-excavations.

B. Pipe Bedding: Portion of trench backfill that extends vertically from top of foundation up to level line at bottom of pipe, and horizontally from one trench sidewall to opposite sidewall.

C. Haunching: Material placed on either side of pipe from top of bedding up to spring line of pipe and horizontally from one trench sidewall to opposite sidewall.

D. Initial Backfill: Portion of trench backfill that extends vertically from spring line of pipe (top of haunching) up to level line 12 inches above top of pipe, and horizontally from one trench sidewall to opposite sidewall.
E. Pipe Embedment: Portion of trench backfill that consists of bedding, haunching and initial backfill.

F. Trench Zone: Portion of trench backfill that extends vertically from top of pipe embedment up to pavement subgrade or up to final grade when not beneath pavement.

G. Unsuitable Material: Unsuitable soil materials are the following:
   1. Materials that are classified as ML, CL-ML, MH, PT, OH, and OL according to ASTM D 2487.
   2. Materials that cannot be compacted to required density due to gradation, plasticity, or moisture content.
   3. Materials that contain large clods, aggregates, stones greater than 4 inches in any dimension, debris, vegetation, waste or any other deleterious materials.
   4. Materials that are contaminated with hydrocarbons or other chemical contaminants.

H. Suitable Material: Suitable soil materials are those meeting specification requirements. Materials mixed with lime, fly ash, or cement that can be compacted to require density and meeting requirements for suitable materials may be considered suitable materials, unless otherwise indicated.

I. Backfill: Suitable material meeting specified quality requirements placed and compacted under controlled conditions.

J. Ground Water Control Systems: Installations external to trench, such as well points, eductors, or deep wells. Ground water control includes dewatering to lower ground water, intercepting seepage which would otherwise emerge from side or bottom of trench excavation, and depressurization to prevent failure or heaving of excavation bottom. Refer to Section 01578 - Control of Ground Water and Surface Water.

K. Surface Water Control: Diversion and drainage of surface water runoff and rain waiter away from trench excavation. Rainwater and surface water accidentally entering trench shall be controlled and removed as part of excavation drainage.

L. Excavation Drainage: Removal of surface and seepage water in trench by sump pumping and using drainage layer, as defined in ASTM D 2321, placed on foundation beneath pipe bedding or thickened bedding layer of Class I material.

M. Trench Conditions are defined with regards to stability of trench bottom and trench walls of pipe embedment zone. Maintain trench conditions that provide for effective placement and compaction of embedment material directly on or against undisturbed soils or foundation backfill, except where structural trench support is necessary.
1. **Dry Stable Trench**: Stable and substantially dry trench conditions exist in pipe embedment zone as a result of typically dry soils or achieved by ground water control (dewatering or depressurization) for trenches extending below ground water level.

2. **Stable Trench with Seepage**: Stable trench in which ground water seepage is controlled by excavation drainage.
   a. No payment will be paid if Project Manager does not direct Contractor to over Stable Trench with Seepage in Clayey Soils: Excavation drainage is provided in lieu of or to supplement ground water control systems to control seepage and provide stable trench subgrade in predominately clayey soils prior to bedding placement.
   b. Stable Wet Trench in Sandy Soils: Excavation drainage is provided in embedment zone in combination with ground water control in predominately sandy or silty soils.

3. **Unstable Trench**: Unstable trench conditions exist in pipe embedment zone if ground water inflow or high-water content causes soil disturbances, such as sloughing, sliding, boiling, heaving, or loss of density.

N. **Sub-trench**: Sub-trench is special case of benched excavation. Sub-trench excavation below trench shields or shoring installations may be used to allow placement and compaction of foundation or embedment materials directly against undisturbed soils. Depth of sub-trench depends upon trench stability and safety as determined by Contractor.

O. **Trench Dam**: Placement of low permeability material in pipe embedment zone or foundation to prohibit ground water flow along trench.

P. **Over-excavation and Backfill**: Excavation of subgrade soils with unsatisfactory bearing capacity or composed of otherwise unsuitable materials below top of foundation as shown on Drawings and backfilled with foundation bedding.

Q. **Foundation Bedding**: Natural soil or manufactured aggregate of controlled gradation, and geotextile filter fabrics as required, to control drainage and material separation. Foundation bedding is placed and compacted as backfill to provide stable support for bedding. Foundation bedding materials may include concrete seal slabs.

R. **Trench Safety Systems** include both protective systems and shoring systems as defined in Section 01561- Trench Safety Systems.

S. **Trench Shield (Trench Box)**: Portable worker safety structure moved along trench as work proceeds, used as protective system and designed to withstand forces imposed on it by cave in, thereby protecting persons within trench. Trench shields may be stacked if so designed or placed in series depending on depth and length of excavation to be protected.
T. Shoring System: Structure that supports sides of an excavation to maintain stable soil conditions and prevent cave-ins, or to prevent movement of ground affecting adjacent installations or improvements.

U. Special Shoring: Shoring system meeting special shoring as specified in Paragraph 1.08, Special Shoring Design Requirements, for locations identified on Drawings.

V. Vacuum Excavation: An excavation technique performed by an experienced subcontractor in which water or air jetting is used to slough off and vacuum away soil.

W. Large Diameter Water Line (LDWL): Water line that is 24-inches in diameter or larger.

X. Emergency Action Plan (EAP): The EAP document should include a discussion of procedures for timely and reliable detection, classification (level of emergency) and response procedure to a potential emergency condition associated with a large diameter water line.

Y. Subsurface Utility Exploration (SUE): Non-destructive excavation, unless otherwise approved by project manager.

1.04 REFERENCES


D. ASTM D 1556 - Standard Test Method for Density and Unit Weight of Soil in Place by Sand-Cone Method.


F. ASTM D 2487 - Standard Classification of Soils for Engineering Purposes.


H. ASTM D 3017 - Standard Test Method for Water Content of Soil and Rock in Place by Nuclear Methods (Shallow Depth).

1.05 SCHEDULING

A. Schedule work so that pipe embedment can be completed on same day that acceptable foundation has been achieved for each section of pipe installation, manhole, or other structures.

1.06 SUBMITTALS

A. Submit planned typical method of excavation, backfill placement and compaction including:
   1. Trench widths.
   2. Procedures for foundation and pipe zone bedding placement, and trench backfill compaction.
   3. Procedures for assuring compaction against undisturbed soil when pre-manufactured trench safety systems are proposed.

B. Submit backfill material sources and product quality information in accordance with requirements of Section 02320 - Utility Backfill Materials.

C. Submit trench excavation safety program in accordance with requirements of Section 01561 - Trench Safety System. Include designs for special shoring meeting requirements defined in Paragraph 1.08, Special Shoring Design Requirements contained herein.

D. Submit record of location of utilities as installed, referenced to survey control points. Include locations of utilities encountered or rerouted. Give stations, horizontal dimensions, elevations, inverts, and gradients.

E. Submit 11-inch by 17-inch or 12-inch by 18-inch copy of Drawing with plotted utility or obstruction location titled "Critical Location Report" to Project Manager.

1.07 TEST

A. Testing and analysis of backfill materials for soil classification and compaction during construction will be performed by an independent laboratory provided by Owner.

B. Perform backfill material source qualification testing in accordance with requirements of Section 02320 – Utility Backfill Materials.
1.08 SPECIAL SHORING DESIGN REQUIREMENTS

A. Have special shoring designed or selected by Contractor’s Professional Engineer to provide support for sides of excavations, including soils and hydrostatic ground water pressures as applicable, and to prevent ground movements affecting adjacent installations or improvements such as structures, pavements, and utilities. Special shoring may be a premanufactured system selected by Contractor’s Professional Engineer to meet project site requirements based on manufacturer’s standard design.

PART 2 - PRODUCTS

2.01 EQUIPMENT

A. Perform excavation with hydraulic excavator or other equipment suitable for achieving requirements of this Section.

B. Use only hand-operated tamping equipment until minimum cover of 12 inches is obtained over pipes, conduits, and ducts. Do not use heavy compacting equipment until adequate cover is attained to prevent damage to pipes, conduits, or ducts.

C. Use trench shields or other protective systems or shoring systems which are designed and operated to achieve placement and compaction of backfill directly against undisturbed native soil.

D. Use special shoring systems where required which may consist of braced sheeting, braced soldier piles and lagging, slide rail systems, or other systems meeting requirements as specified in Paragraph 1.08, Special Shoring Design Requirements.

2.02 MATERIAL CLASSIFICATIONS

A. Embedment and Trench Zone Backfill Materials: Conform to classifications and product descriptions of Section 02320 - Utility Backfill Materials. Concrete for Trench Dams: Concrete backfill, or 3 sack premixed (bag) concrete.

PART 3 - EXECUTION

3.01 EXCAVATION

A. Provide adequate safety measures to prevent unauthorized persons or vehicles from entering or falling into any excavation, including but not limited to fences, gates, and barricades.

B. Excavate materials encountered to lines and grades indicated.
C. Excavate by open cut with trenching machine, backhoe or by hand operation. Do not use excavated material composed by large chunks or clods (greater than 6-inches in diameter) for backfill but dispose of such material offsite and provide other suitable material for backfill without additional expense.

D. During excavation, pile material suitable for backfilling in an orderly manner far enough from the bank of the trench to avoid overloading, slides or cave-ins.

E. Remove from site excavated waste material not required or unsuitable for backfill.

F. Grade as necessary to prevent surface water from flowing into trenches or other excavations.

3.02 TRENCH EXCAVATION

A. Cut banks of pipe trench as nearly vertical as practical. Remove stones as necessary to avoid point bearing. Over-excavate wet or unstable soil from the trench bottom to permit construction of a more stable bed for pipe.

B. Dig the trench the proper width as specified. If the trench width below the top of pipe is wider than specified in this section or shown on the plans, then install a higher class of pipe and/or improved bedding as determined by the Engineer.

C. Accurately grade the trench bottom to provide uniform bearing and support for each section of pipe on undisturbed soil at every point along its entire length, except where necessary to excavate for bell holes and for proper sealing of pipe joints. Dig bell holes and depressions for joint after the trench bottom has been graded. Make bell holes and depressions for joints no deeper, longer, or wider than needed to make the joint properly.

D. Do not over-excavate. If any excavation is carried beyond the lines and grades required or authorized, fill such space with cement stabilized sand or other suitable material as directed by the Engineer at no additional cost.

3.03 PIPE BEDDING

A. Bedding for water and sewer lines shall be per the specifications and the construction drawing details.

3.04 PROTECTION OR REMOVAL OF UTILITY LINES

A. Anticipate all underground obstructions such as, but not limited to, water mains, gas lines, gravity pipelines, force mains, sanitary sewers or storm sewers, telephone or electric light or power ducts, concrete, and debris. Any such lines or obstructions indicated on the drawings show only the approximate locations and shall be verified in the field by the Contractor. The Owner and Engineer will endeavor to familiarize the Contractor with all known utilities and obstructions,
but this will not relieve the Contractor from full responsibility in anticipating all underground obstructions whether they are shown on the drawings or not.

B. Maintain in proper working order and without interruption of service all existing utilities and services which may be encountered in the work, except that with the consent of the Engineer such service connections may be temporarily interrupted to permit the Contractor to remove designated lines or to make temporary changes in the location thereof as will aid in the completion of the work and at the same time maintain services to property so originally benefited. The cost of making any temporary changes shall be at the Contractor’s expense and shall be incidental to the price of the project.

C. Before starting construction, the Contractor shall notify all utility companies involved to have their utilities located and marked in the field.

D. Contractor shall uncover all underground utilities to verify location and elevation in advance of construction near them so that adjustments can be made if necessary. The Contractor shall obtain all necessary permits.

3.05 BACKFILLING

A. Criteria: Do not backfill trenches until all utility systems as installed conform to specified requirements of appropriate sections. Backfill trenches to ground surface with specified material. Reopen trenches improperly backfilled to depth required for proper compaction. Refill and recompact as specified or otherwise correct the condition in an approved manner.

B. Open Areas Not Under Pavement or Structures: Refer to Subsection 3.03 "Pipe Bedding" above for bedding requirements.

C. Pavement Sections:

1. Refer to Subsection 3.03 "Pipe Bedding" above for bedding requirements.
2. Above the pipe zone, deposit cement-stabilized sand backfill in 8-inch lifts to a point one foot below proposed pavement subgrade and compact each layer to 95 percent Standard Proctor Density. Place suitable earth backfill up to the bottom of pavement. Cure cement stabilized sand top layer at least three days before placing earth backfill layer on top of it.
PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Material Classifications.
B. Utility Backfill Materials:
   1. Concrete sand
   2. Gem sand
   3. Pea gravel
   4. Crushed stone
   5. Crushed concrete
   6. Bank run sand
   7. Select backfill
   8. Random backfill
C. Material Handling and Quality Control Requirements.

1.02 MEASUREMENT AND PAYMENT

A. No separate payment will be made for work required under this section. Contractor will include all costs of the requirements of this section in the appropriate bid item(s) on the bid form.

1.03 DEFINITIONS

A. Unsuitable Material: Unsuitable soil materials are the following:
   1. Materials that are classified as ML, CL-ML, MH, PT, OH, and OL according to ASTM D 2487.
   2. Materials that cannot be compacted to the required density due to gradation, plasticity, or moisture content.
   3. Materials that contain large clods, aggregate, and stones greater than 4 inches in any dimension; debris, vegetation, and waste; or any other deleterious materials.
   4. Materials that are contaminated with hydrocarbons or other chemical contaminants.

B. Suitable Material: Suitable soil materials are the following:
   1. Those meeting specification requirements.
   2. Unsuitable soils meeting specification requirements for suitable soils after treatment with lime or cement.
C. Foundation Backfill Materials: Natural soil or manufactured aggregate meeting Class I requirements and geotextile filter fabrics as required, to control drainage and material separation. Foundation backfill material is placed and compacted as backfill where needed to provide stable support for the structure foundation base. Foundation backfill materials may include concrete fill and seal slabs.

D. Foundation Base: rushed stone aggregate with filter fabric as required, cement stabilized sand, or concrete seal slab. The foundation base provides a smooth, level-working surface for the construction of the concrete foundation.

E. Backfill Material: Classified soil material meeting specified quality requirements for the designated application as embedment or trench zone backfill.

F. Embedment Material: Soil material placed under controlled conditions within the embedment zone extending vertically upward from top of foundation to an elevation 12 inches above top of pipe, and including pipe bedding, haunching, and initial backfill.

G. Trench Zone Backfill: Classified soil material meeting specified quality requirements and placed under controlled conditions in the trench zone from top of embedment zone to base course in paved areas or to the surface grading material in unpaved areas.

H. Foundation: Either suitable soil of the trench bottom or material placed as backfill of over-excavation for removal and replacement of unsuitable or otherwise unstable soils.

I. Source: A source selected by the Contractor for supply of embedment or trench zone backfill material. A selected source may be the project excavation, off-site borrow pits, commercial borrow pits, or sand and aggregate production or manufacturing plants.

J. Refer to Section 02317 – Excavation, Trenching and Backfilling for Utilities for other definitions regarding utility installation by trench construction.

1.04 REFERENCES

A. ASTM C 33 - Specification for Concrete Aggregate.

B. ASTM C 40 - Test Method for Organic Impurities in Fine Aggregates for Concrete.


H. ASTM D 2487 - Classification of Soils for Engineering Purposes (Unified Soil Classification System).


L. TxDOT Tex-101-E - Preparation of Soil and Flexible Base Materials for Testing.

M. TxDOT Tex-104-E - Test Method for Determination of Liquid Limit of Soils (Part 1)

N. TxDOT Tex-106-E - Test Method - Methods of Calculating Plasticity Index of Soils.

O. TxDOT Tex-110-E - Determination of Particle Size Analysis of Soils.

1.05 SUBMITTALS

A. Submit a description of source, material classification and product description, production method, and application of backfill materials.

B. Submit test results for samples of off-site backfill materials to comply with Paragraph 2.03, Material Testing.

C. Before stockpiling materials, submit a copy of temporary easement or approval from landowner for stockpiling backfill material on private property.

D. For each delivery of material, provide a delivery ticket that includes source location.

1.06 TESTS

A. Perform tests of sources for backfill material in accordance with Paragraph 2.03B.

B. Verification tests of backfill materials may be performed by the Owner in accordance with Paragraph 3.03 and the General Conditions.

C. Random fill obtained from the project excavation as source is exempt from pre-qualification requirements by Contractor but must be inspected by Owner’s testing lab for unacceptable materials based on ASTM D 2488.
PART 2 - PRODUCTS

2.01 MATERIAL CLASSIFICATIONS

A. Materials for backfill shall be classified for the purpose of quality control in accordance with the Unified Soil Classification Symbols as defined in ASTM D 2487. Material use and application is defined in utility installation specifications and Drawings either by class, as described in Paragraph 2.01B, or by product descriptions, as given in Paragraph 2.02.

B. Class Designations Based on Laboratory Testing:

1. Class I: Well-graded gravels and sands, gravel-sand mixtures, crushed well-graded rock, little or no fines (GW, SW):
   a. Plasticity index: non-plastic.
   b. Gradation: D60/D10 - greater than 4 percent; amount passing No. 200 sieve - less than or equal to 5 percent.

2. Class II: Poorly graded gravels and sands, silty gravels and sands, little to moderate fines:
   b. Gradations:
      1) Gradation (GP, SP): amount passing No. 200 sieve - less than 5 percent.
      2) Gradation (GM, SM): amount passing No. 200 sieve - between 12 percent and 50 percent.
      3) Borderline gradations with dual classifications (e.g., SP-SM): amount passing No. 200 sieve - between 5 percent and 12 percent.

3. Class III: Clayey gravels and sands, poorly graded mixtures of gravel, sand, silt, and clay (GC, SC, and dual classifications, e.g., SP-SC):
   a. Plasticity index: greater than 7.
   b. Gradation: amount passing No. 200 sieve - between 12 percent and 50 percent.

4. Class IVA: Lean clays (CL):
   a. Plasticity Indexes:
      1) Plasticity index: greater than 7, and above A line.
      2) Borderline plasticity with dual classifications (CL-ML): PI between 4 and 7.
   b. Liquid limit: less than 50.
   c. Gradation: amount passing No. 200 sieve - greater than 50 percent.
   d. Inorganic.
5. Class IVB: Fat clays (CH):
   a. Plasticity index: above A line.
   b. Liquid limit: 50 or greater.
   c. Gradation: amount passing No. 200 sieve - greater than 50 percent.
   d. Inorganic.

6. Use soils with dual class designation according to ASTM D 2487, and which are not defined above, according to the more restrictive class.

2.02 PRODUCT DESCRIPTIONS

A. Soils classified as silt (ML), elastic silt (MH), organic clay and organic silt (OL, OH), and organic matter (PT) are not acceptable as backfill materials. These soils may be used for site grading and restoration in unimproved areas as approved by the Engineer. Soils in Class IVB, fat clay (CH) may be used as backfill materials where allowed by the applicable backfill installation specification. Refer to Section 02317 – Excavation, Trenching and Backfilling for Utilities.

B. Provide backfill material that is free of stones greater than 3 inches, free of roots, waste, debris, trash, organic material, unstable material, non-soil matter, hydrocarbon or other contamination, conforming to the following limits for deleterious materials:
   1. Clay lumps: Less than 0.5 percent for Class I, and less than 2.0 percent for Class II, when tested in accordance with ASTM C 142.
   2. Lightweight pieces: Less than 5 percent when tested in accordance with ASTM C 123.
   3. Organic impurities: No color darker than standard color when tested in accordance with ASTM C 40.

C. Manufactured materials, such as crushed concrete, may be substituted for natural soil or rock products where indicated in the product specification, and approved by the Engineer, provided that the physical property criteria are determined to be satisfactory by testing.

D. Bank Run Sand: Durable bank run sand classified as SP, SW, or SM by the Unified Soil Classification System (ASTM D 2487) meeting the following requirements:
   1. Less than 15 percent passing the number 200 sieve when tested in accordance with ASTM D 1140. The amount of clay lumps or balls not exceeding 2 percent.
   2. Material passing the number 40 sieve shall meet the following requirements when tested in accordance with ASTM D 4318:
      a. Liquid limit: not exceeding 25 percent.
      b. Plasticity index: not exceeding 7.
E. Concrete Sand: Natural sand, manufactured sand, or a combination of natural and manufactured sand conforming to the requirements of ASTM C 33 and graded within the following limits when tested in accordance with ASTM C 136:

<table>
<thead>
<tr>
<th>Sieve</th>
<th>Percent Passing</th>
</tr>
</thead>
<tbody>
<tr>
<td>3/8&quot;</td>
<td>100</td>
</tr>
<tr>
<td>No. 4</td>
<td>95 to 100</td>
</tr>
<tr>
<td>No. 8</td>
<td>80 to 100</td>
</tr>
<tr>
<td>No. 16</td>
<td>50 to 85</td>
</tr>
<tr>
<td>No. 30</td>
<td>25 to 60</td>
</tr>
<tr>
<td>No. 50</td>
<td>10 to 30</td>
</tr>
<tr>
<td>No. 100</td>
<td>2 to 10</td>
</tr>
</tbody>
</table>

F. Gem Sand: Sand conforming to the requirements of ASTM C 33 for course aggregates specified for number 8 size and graded within the following limits when tested in accordance with ASTM C 136:

<table>
<thead>
<tr>
<th>Sieve</th>
<th>Percent Passing</th>
</tr>
</thead>
<tbody>
<tr>
<td>3/8&quot;</td>
<td>95 to 100</td>
</tr>
<tr>
<td>No. 4</td>
<td>60 to 80</td>
</tr>
<tr>
<td>No. 8</td>
<td>15 to 40</td>
</tr>
</tbody>
</table>

G. Pea Gravel: Durable particles composed of small, smooth, rounded stones or pebbles and graded within the following limits when tested in accordance with ASTM C 136:

<table>
<thead>
<tr>
<th>Sieve</th>
<th>Percent Passing</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/2&quot;</td>
<td>100</td>
</tr>
<tr>
<td>3/8&quot;</td>
<td>85 to 100</td>
</tr>
<tr>
<td>No. 4</td>
<td>10 to 30</td>
</tr>
<tr>
<td>No. 8</td>
<td>0 to 10</td>
</tr>
<tr>
<td>No. 16</td>
<td>0 to 5</td>
</tr>
</tbody>
</table>

H. Crushed Aggregates: Crushed aggregates consist of durable particles obtained from an approved source and meeting the following requirements:

1. Materials of one product delivered for the same construction activity from a single source.
2. Non-plastic fines.
3. Los Angeles abrasion test wear not exceeding 45 percent when tested in accordance with ASTM C 131.
4. Crushed aggregate shall have a minimum of 90 percent of the particles retained on the No. 4 sieve with 2 or more crushed faces as determined by Test Method Tex-460-A, Part I.
5. Crushed stone: Produced from oversize plant processed stone or gravel, sized by crushing to predominantly angular particles from a naturally occurring single source. Uncrushed gravel are not acceptable materials for embedment where crushed stone is shown on the applicable utility embedment drawing details.
6. Crushed Concrete: Crushed concrete is an acceptable substitute for crushed stone as utility backfill. Gradation and quality control test requirements are the same as crushed stone. Provide crushed concrete produced from normal weight concrete of uniform quality; containing particles of aggregate and cement material, free from other substances such as asphalt, reinforcing steel fragments, soil, waste gypsum (calcium sulfate), or debris.

7. Gradations, as determined in accordance with Tex-110-E.

<table>
<thead>
<tr>
<th>Sieve</th>
<th>Percent Passing by Weight for Pipe Embedment</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>&gt;15&quot;</td>
</tr>
<tr>
<td>1&quot;</td>
<td>95 - 100</td>
</tr>
<tr>
<td>3/4&quot;</td>
<td>60 - 90</td>
</tr>
<tr>
<td>1/2&quot;</td>
<td>25 - 60</td>
</tr>
<tr>
<td>3/8&quot;</td>
<td>0 - 55</td>
</tr>
<tr>
<td>No. 4</td>
<td>0 - 10</td>
</tr>
<tr>
<td>No. 8</td>
<td>-</td>
</tr>
</tbody>
</table>

I. Select Backfill: Class III clayey gravel or sand or Class IV lean clay with a plasticity index between 7 and 20 or clayey soils treated with lime to meet plasticity criteria.

J. Random Backfill: Any suitable soil or mixture of soils within Classes I, II, III and IV; or fat clay (CH) where allowed by the applicable backfill installation specification. Refer to Section 02317 – Excavation, Trenching and Backfilling for Utilities.

K. Concrete Backfill: Conform to Class B concrete as specified in Section 03300 – Cast-In-Place Concrete.

2.03 MATERIAL TESTING

A. Ensure that material selected, produced and delivered to the project meets applicable specifications and is of sufficient uniform properties to allow practical construction and quality control.

B. Source or Supplier Qualification. Perform testing, or obtain representative tests by suppliers, for selection of material sources and products. Provide test results for a minimum of three samples for each source and material type. Test samples of processed materials from current production representing material to be delivered. Tests shall verify that the materials meet specification requirements. Repeat qualification test procedures each time the source characteristic changes or there is a planned change in source location or supplier. Qualification tests shall include, as applicable:

1. Gradation: Complete sieve analyses shall be reported regardless of the specified control sieves. The range of sieves shall be from the largest particle through the No. 200 sieve.

2. Plasticity of material passing the No. 40 sieve.
3. Los Angeles abrasion wear of material retained on the No. 4 sieve.
5. Lightweight pieces
6. Organic impurities

C. Production Testing: Provide reports to the Engineer from an independent testing laboratory that backfill materials to be placed in the Work meet applicable specification requirements.

D. Assist the Engineer in obtaining material samples for verification testing at the source or at the production plant.

PART 3 - EXECUTION

3.01 SOURCES

A. Use of material encountered in the trench excavations is acceptable, provided applicable specification requirements are satisfied. If excavation material is not acceptable, provide from another approved source.

B. Identify off-site sources for backfill materials at least 14 days ahead of intended use so that the Engineer may obtain samples for verification testing.

C. Obtain approval for each material source by the Engineer before delivery is started. If sources previously approved do not produce uniform and satisfactory products, furnish materials from other approved sources. Materials may be subjected to inspection or additional verification testing after delivery. Materials, which do not meet the requirements of the specifications, will be rejected. Do not use material, which, after approval, has become unsuitable for use due to segregation, mixing with other materials, or by contamination. Once the Engineer approves a material, expense for sampling and testing required to change to a different material will be credited to the Owner through a change order.

D. Bank run sand, select backfill, and random backfill, if available in the project excavation, may be obtained by selective excavation and acceptance testing. Obtain additional quantities of these materials and other materials required to complete the work from off-site sources.

E. The Owner does not represent or guarantee that any soil found in the excavation work will be suitable and acceptable as backfill material.

3.02 MATERIAL HANDLING

A. When backfill material is obtained from either a commercial or non-commercial borrow pit, open the pit to expose the vertical faces of the various strata for identification and selection of approved material to be used. Excavate the
selected material by vertical cuts extending through the exposed strata to achieve uniformity in the product.

B. Establish temporary stockpile locations for practical material handling and control, and verification testing by the Engineer in advance of final placement. Obtain approval from landowner for storage of backfill material on adjacent private property.

C. When stockpiling backfill material near the project site, use appropriate covers to eliminate blowing of materials into adjacent areas and prevent runoff containing sediments from entering the drainage system.

D. Place stockpiles in layers to avoid segregation of processed materials. Load material by making successive vertical cuts through entire depth of stockpile.

3.03 FIELD QUALITY CONTROL

A. Quality Control:

1. The Engineer may sample, and test backfill at:
   a. Sources including borrow pits, production plants and Contractor's designated off-site stockpiles.
   b. On-site stockpiles.
   c. Materials placed in the Work.

2. The Engineer may resample material at any stage of work or location if changes in characteristics are apparent.

B. Production Verification Testing: The Owner’s testing laboratory will provide verification testing on backfill materials, as directed by the Engineer. Samples may be taken at the source or at the production plant, as applicable.

END OF SECTION
SECTION 02321
CEMENT STABILIZED SAND

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Cement stabilized sand material.

1.02 MEASUREMENT AND PAYMENT

A. No payment will be made for cement stabilized sand under this Section. Include payment for cement stabilized sand in unit price for applicable utility or structure installation section.

B. If use of cement stabilized sand is allowed based on the Engineer's direction, the extra unit price item will be paid on a per ton basis. A conversion between volume calculated based on theoretical limits and total weight will be made based on a ratio of 1.64 tons per cubic yard.

C. Refer to Paragraph 3.03 B for material acceptance criteria for partial payments.

1.03 REFERENCES


1.04 SUBMITTALS

A. Submittals shall conform to requirements of the Special Conditions.

B. Submit proposed target cement content and production data for sand-cement mixture in accordance with the requirements of Paragraph 2.03, Material Qualification.

1.05 DESIGN REQUIREMENTS

A. Sand-cement mixture shall produce a minimum unconfined compressive strength of 100 pounds per square inch in 48 hours.

1. Design will be based on strength specimens molded in accordance with ASTM D 558 at a moisture content within 3 percent of optimum and within 4 hours of batching.

2. Determine minimum cement content from production data and statistical history. Mix shall contain not less than 1.1 sacks of cement per ton of dry sand.

PART 2 - PRODUCTS

2.01 MATERIALS

A. Cement: Type I Portland cement conforming to ASTM C 150.

B. Sand: Clean, durable sand meeting grading requirements for fine aggregates of ASTM C 33, or requirements for bank run sand of Section 02320 - Utility Backfill Materials, and the following requirements:

1. Classified as SW, SP, SW-SM, SP-SM, or SM by the United Soil Classification System of ASTM D 2487.

2. Deleterious materials:
   a. Clay lumps, ASTM C 142; less than 0.5 percent.
   b. Lightweight pieces, ASTM C 123; less than 5.0 percent.
   c. Organic impurities, ASTM C 40, color no darker than the standard color.

3. Plasticity index of 4 or less when tested in accordance with ASTM D 4318.

C. Water: Potable water, free of oils, acids, alkalies, organic matter, or other deleterious substances, meeting requirements of ASTM C 94.
2.02 MIXING MATERIALS

A. Add required amount of water and mix thoroughly in a pugmill-type mixer.

B. Stamp batch ticket at plant with time of loading. Material not placed and compacted within 4 hours after mixing shall be rejected.

2.03 MATERIAL QUALIFICATION

A. Determine the target cement content of the material as follows:

1. Obtain samples of sand-cement mixtures at the production facility representing a range of cement content consisting of at least three points.
2. Complete the molding of samples within 4 hours after the addition of water.
3. Perform strength tests (average of two specimens) at 48 hours and 7 days.
4. Perform cement content tests on each sample.
5. Perform moisture content tests on each sample.
6. Plot average 48-hour strength vs. cement content
7. Record scale calibration date, sample date, sample time, molding time, cement feed dial settings, and silo pressure (if applicable).

B. Test the raw sand for the following properties at the point of entry into the pugmill:

1. Gradation.
2. Plasticity index.
3. Organic impurities.
5. Lightweight pieces.
7. Classification.

C. Present the data obtained in a format similar to that provided in the sample data form attached to this Section.

D. The target content may be adjusted if statistical history so indicates. For determination of minimum product performance use the formula:

\[ f'c + \frac{1}{2} \text{ standard deviation} \]

PART 3 - EXECUTION

3.01 PLACING

A. Place sand-cement mixture in a maximum 12-inch-thick loose lift and compact to 95 percent of ASTM D 558, unless otherwise specified. Refer to related specifications for thickness of lifts in other applications. The target moisture content during compaction is ± 3 percent of optimum. Perform and complete
compaction of sand-cement mixture within 4 hours after addition of water to mix at the plant.

B. Do not place or compact sand-cement mixture in standing or free water.

3.02 FIELD QUALITY CONTROL

A. Samples of delivered product will be taken in the field at point of delivery for testing in accordance with ASTM D 3665.

B. Four specimens shall be prepared and molded (for each sample obtained) in accordance with ASTM D 558, Method A, without adjusting the moisture content. Samples will be molded at approximately the same time the material is being used, but no later than 4 hours after water is added to mix.

C. After molding, specimens will be removed from the molds and sealed in a plastic bag or similar material to minimize moisture loss. Specimens will be cured at a room temperature between 60° and 80° F until ready for testing.

D. Specimens will be tested for compressive strength in accordance with ASTM D 1633, Method A. Two specimens will be tested at 48 hours plus or minus 2 hours and two specimens will be tested at 7 days plus or minus 4 hours.

E. A strength test will be the average of the strengths of two specimens molded from the same sample of material and tested at the same age. The average daily strength will be the average of the strengths of all specimens molded for one day's production and tested at the same age.

F. Precision and Bias: Test results shall meet the recommended guideline for precision in ASTM D 1633 Section 9.

G. Reporting: Test reports shall contain, as a minimum, the following information:

1. Supplier and plant number
2. Time material was batched
3. Time material was sampled
4. Test age (exact hours)
5. Average 48-hour strength
6. Average 7-day strength
7. Specification section number
8. Compliance / non-compliance
9. Mixture identification
10. Truck and ticket numbers
11. The time of molding
12. Moisture content at time of molding
13. Required strength
14. Test method designations
15. Compressive strength data as required by ASTM D 1633
3.03 ACCEPTANCE

A. The strength level of the material will be considered satisfactory if:
   1. The average 48-hour strength is greater than 100 psi with no individual strength test below 60 psi, or
   2. All 7-day individual strength tests exceed 100 psi.

B. The material will be considered acceptable for partial payment if any 7-day individual strength test (average of two specimens) is less than 100 psi but greater than 60 psi.

C. The material will be considered unacceptable and subject to removal and replacement at the Contractor’s expense if any individual strength test has a 7-day strength less than 60 psi.

D. If the moving average of any three daily 48-hour averages falls below 100 psi, the supplier shall discontinue shipment to the project until that plant can produce a material which exceeds 100 psi at 48 hours. A total of five 48-hour strength tests shall be made in this determination with no individual strength tests less than 100 psi.

E. The Engineer shall maintain a database of strength tests performed on 100-psi cement stabilized sand material. The statistical history shall be used for approval of material on future projects. The testing laboratory shall notify the Contractor, Engineer, and material supplier by facsimile or e-mail of all tests indicating results falling below specified strength requirements.

END OF SECTION
PART 1 - GENERAL

1.01 SCOPE

A. This section provides general requirements for dewatering, or otherwise controlling surface water and groundwater to provide suitable conditions for construction of the project. The term dewatering as used herein shall mean the removal of either groundwater or surface water or both as each specific instance may require.

B. This is a performance specification to design, furnish, install, and operate a dewatering system for the control of surface and groundwater during the construction of open cut excavations, tunnels, access shafts, structures, and appurtenances.

C. It is the sole responsibility of the Contractor to identify surface and groundwater conditions and to provide any and all labor, material, equipment, techniques and methods to lower, control and handle the surface water and groundwater as necessary for his construction methods and to monitor the effectiveness of this installed system and its effect on adjacent facilities.

D. The Contractor is solely responsible for any settlement and/or resultant damage caused by the dewatering operation.

E. Contractor shall operate, maintain, and modify the system(s) as required to conform to these specifications. Upon completion of the construction, Contractor shall remove the system(s) and restore the areas affected to their original conditions. For convenience in this section, excavations shall mean both open cut excavating/backfilling and tunneling.

F. The geotechnical information developed for this project is available to the Contractor in the office of the Engineer.

G. The development, drilling, and abandonment of all wells used in the dewatering system shall comply with Texas Water Commission regulations and the Texas Water Well Drillers Associations.

PART 2 - PRODUCTS

2.01 QUALIFICATIONS

A. All dewatering systems for tunneling, cut-and-cover excavations, shafts, manholes, and structures shall be installed by an experienced and reputable contractor demonstrating satisfactory experience in the local area with similar systems.
2.02 SUBMITALS

A. Submit complete drawings, details and layouts showing the proposed dewatering plans. The submittals shall be sufficiently detailed to allow the Engineer to fully evaluate the proposed dewatering systems. Include the following as required:

1. Names of equipment suppliers.
2. Names of installation subcontractors.
3. Plans for dewatering at access shafts and control of surface drainage.
4. Plan for dewatering for tunneling and cut-and-cover excavations, or otherwise controlling groundwater.
5. Eductor system layout and details.
6. Deep well locations and details.
7. Well point system layout and details.
8. Installation reports for eductors, deep wells and well points.
9. Water level readings from piezometers.
10. Detailed plans for coffer dams or diversion dams or diversion channel/structures.

PART 3 - EXECUTION

3.01 GENERAL RESPONSIBILITIES OF THE CONTRACTOR

A. The responsibilities of the Contractor shall specifically include, but not be limited to the following:

1. Obtain all necessary permits from agencies with control over the use of surface water and groundwater and matters affecting well installation, water discharge, and use of existing storm drains and natural water courses. As the review and permitting process may be lengthy, this condition is brought to the Contractor's attention for early action to pursue and submit for the required approvals, permits and licenses.
2. Take measures to prevent damage to properties, structures, sewers, water mains, and other utility installations, pavements, sidewalks, and work.
3. Modify the system at no cost to the Owner if after installation and while in operation it causes or threatens to cause damage to existing buildings, structures, utilities, or facilities.
4. Monitor the quality of the discharge from the dewatering system to determine if soil particles are being removed by the system.
5. Repair damage, disruption, or interference resulting directly or indirectly from dewatering operations at no cost to the owner and with the Engineer's approval.
6. The system shall be designed to limit the extent of groundwater lowering that would endanger or damage adjacent structures or property, and to safely convey detained or diverted surface waters.
7. The system shall be designed by, and installed under, the supervision of a registered professional engineer in the state of Texas who is experienced in the design, installation, and operation of construction dewatering systems.

8. Design the system to prevent the removal of natural, in-place soils. The system shall be such that after initial development, the quantity and size of soil particles will decrease until no soil particles are present in the water being pumped at any time after 24 hours initial pumping.

9. Do not discharge water from any dewatering operation into the sanitary sewer system.

3.02 DEWATERING FOR ACCESS SHAFTS, MANHOLES, STRUCTURES, AND CUT-AND-COVER CONSTRUCTION

A. Provide means such as ditches, swales, culverts, and grading away from excavations to prevent excessive surface water from entering the excavation. Particular attention should be given to adjacent streets and ditches so that flooding or high water in them will not enter the excavation. The dewatering system shall be designed, constructed, and operated in such a manner to not cause damage to properties, utilities and other construction.

B. Control the groundwater with well points, eductor systems, deep wells, grout curtains or other means, as necessary, to allow stable excavation.

C. Dewater, or otherwise relieve pressure, in underlying water bearing strata which may cause uplift problems in the excavation bottom.

D. Lower the groundwater level at least 2 feet below the access shaft floor, manhole bottom, structure slab, trench bottom, construction pit low point, or pipe bedding level so that the working area will be dry and firm and so that the utility and structures will be placed on firm ground. Any soil which becomes soft due to standing water or seepage will be removed and replaced with soil compacted to 95% maximum density per ASTM D698, or removed and replaced with other suitable material as approved by the Engineer.

E. Control the seepage and inflow of water into the sides of the excavation to prevent loss of fine sands and silts and settlement around the excavation which may damage adjacent utilities, paving, structures, and properties.

F. Maintain dewatering as required to maintain dry and stable surfaces for placement of concrete, fill or other details included in the construction, and to prevent anticipated uplift condition on the shaft, manhole, cut-and-cover excavation, or other structural excavation. Maintain the dewatering system until any concrete has attained adequate strength for removal of the dewatering system and until the constructed facilities are properly backfilled and protected.
3.03 MEASUREMENT AND PAYMENT

A. No separate payment for this item. The costs for this work shall be incidental to utility construction.
PART 1 - GENERAL

1.01 SECTION INCLUDES
   A. Ductile iron pipe and fittings for water lines, wastewater force mains, gravity pipelines, and storm sewers.

1.02 MEASUREMENT AND PAYMENT
   A. No separate payment will be made for work required under this section. Contractor will include all costs of the requirements of this section in appropriate bid item(s) on Bid Form.

1.03 REFERENCES
   G. ANSI A 21.51 (AWWA C 151) - Standard for Ductile-Iron Pipe, Centrifugally Cast, for Water and Other Liquids.
   H. ANSI A 21.53 (AWWA C 153) - Standard for Ductile Iron Compact Fittings, 3 inches through 24 inches and 54 inches through 64 inches for Water Service.
   K. ASTM F 477 - Elastomeric Seals (gaskets) for Joining Plastic Pipe.

M. AWWA C 105 - Polyethylene Encasement for Ductile-Iron Pipe Systems.

N. AWWA C 300 - Standard for Prestressed Concrete Pressure Pipe, Steel-Cylinder Type, for Water and other Liquids.

O. AWWA C 600 - Standard for Installation of Ductile-Iron Water Mains and Their Appurtenances.

P. SSPC-SP 6 - Steel Structures Painting Council, Commercial Blast Cleaning.


R. American Association of State Highway Transportation Officials (AASHTO).

1.04 SUBMITTALS

A. For pipes 24 inches and greater submit shop drawings signed and sealed by Professional Engineer registered in State of Texas showing the following:

   1. Manufacturer's pipe design calculations.

   2. Provide lay schedule of pictorial nature indicating alignment and grade, laying dimensions, fitting, flange, and special details, with plan and profile view of each pipe segment sketched, detailing pipe invert elevations, horizontal bends, restrained joints, and other critical features. Indicate station numbers for pipe and fittings corresponding to Drawings. Do not start production of pipe and fittings prior to review and approval by Engineer.

   3. Calculations and limits of thrust restraint.

   4. Class and length of joint.

B. Submit manufacturer's certifications that ductile iron pipe and fittings meet provisions of this Section and have been hydrostatically tested at factory and meet requirements of ANSI A 21.51.

C. Submit certifications that pipe joints have been tested and meet requirements of ANSI A 21.11.

D. Submit affidavit of compliance in accordance with ANSI A21.16 for fittings with fusion bonded epoxy coatings or linings.

PART 2 - PRODUCTS

2.01 DUCTILE IRON PIPE

A. Ductile Iron Pipe Barrels: ANSI A 21.15, ANSI A 21.50 or ANSI A 21.51; bear mark of Underwriters' Laboratories approval; minimum thickness Class 52, or as
shown on Drawings. Provide minimum thickness Class 53 for flanged pipe, and minimum thickness Class 52 for areas with pipe offset sections. Maximum allowable lead content of 0.25 percent per section 1417 of the Safe Drinking Water Act.

B. Provide pipe sections in standard lengths, not less than 18 feet long, except for special fittings and closure sections as indicated on shop drawings.

C. Modify pipe for cathodic protection. In lieu of furnishing ductile iron pipe for water lines with cathodic protection system, furnish ductile iron pipe with polyethylene encasement, provided the following criteria are met:

1. Provide minimum thickness class of 51.
2. Provide polyethylene encasement material and installation in accordance with AWWA C105 and backfill as specified. Minimum of two complete wraps of 8-mil-thick polyethylene.
3. Use polyethylene encasement for open cut installations only. For augered sections or sections installed inside a casing, provide coating in accordance with paragraph 2.05 D.1.
4. Adhere to other requirements specified herein (e.g., insulation kits, etc.).

D. For use of pressure class pipe for water lines, design pipe and fittings to withstand most critical simultaneous application of external loads and internal pressures. Base design on minimum of AASHTO HS-20 loading, AREMA E-80 loads and depths of bury as indicated on Drawings. Design pipes with Marston's earth loads for a transition width trench for zero to 16 feet of cover. Use Marston's earth loads for a trench width of O.D. (of pipe) + 4 feet for pipe greater than 16 feet of cover. Use Marston's equations for a trench condition in both open-cut and tunnel applications. Design for most critical groundwater level condition. Pipe design conditions:

1. Working pressure = 100 psi.
2. Hydrostatic field test pressure = 150 psi.
3. Maximum pressure due to surge = 150 psi.
4. Minimum Pressure due to surge = -5 psi.
5. Design tensile stress due to surge or hydrostatic test pressure: No greater than 50% minimum yield.
6. Design bending stress due to combined earth loads and surge or hydrostatic test pressure: No greater than 48,000 psi.
7. Unit weight of fill = 120 pcf.
8. Deflection lag factor (DI) = 1.2.
9. Bedding constant (K) = 0.1.
10. Moment coefficient = 0.16.
11. Fully saturated soil conditions hw=h=depth of cover above top of pipe.

E. Hydrostatic Test of Pipe: AWWA C 151, Section 5.2.1, at point of manufacture. Hold test for a minimum 2 minutes for thorough inspection of pipe. Repair or reject pipe revealing leaks or cracks.
F. Pipe Manufacturer for large diameter water lines: Minimum of 5 years of successful pipe installations in continuous service. Manufacturer must maintain on site or in plant enough fittings to satisfy the following requirements:

<table>
<thead>
<tr>
<th>Line Diameter</th>
<th>Required Bends*</th>
</tr>
</thead>
<tbody>
<tr>
<td>20 and 24 inches</td>
<td>Four 45° bends per 5,000 LF of water line</td>
</tr>
<tr>
<td>&gt; 24 inches</td>
<td>Four 22.5° bends per 10,000 LF of water line</td>
</tr>
</tbody>
</table>

*Based on total length of contract (minimum of four). Any combination of bends may be substituted at manufacturer’s option (i.e. two 22.5° bends are equivalent to one 45° bend) and will be counted as one fitting.

G. Manufacturer or supplier must be capable of delivering bends to job site within 12 hours of notification. Use fittings at direction of Engineer where unforeseen obstacles are encountered during construction. These fittings are in addition to any fittings called out in construction documents and must always be available.

H. Provide flange adapter with insulating kit as required when connecting new piping to existing piping and piping of different materials, unless otherwise approved by Engineer.

I. Clearly mark pipe section to show location and thickness/pressure class color coded.

2.02 JOINTS

A. Joint Types: ANSI A 21.11 push-on; ANSI A 21.11 mechanical joint; or ANSI A 21.16 flanged end. Provide push-on joints unless otherwise indicated on the Drawings or required by these specifications. For bolted joints, conform to requirements of AWWA C111; provide minimum 304 stainless steel for restraint joints.

B. Where restrained joints for buried service are required by Drawings, provide one of the following, or equal:

2. Flex-Ring or Lok-Ring by American Cast Iron Pipe Company.
3. TR-Flex or Field Lok by U.S. Pipe and Foundry Company.
4. One Bolt by One Bolt, Inc. (4 to 12 inches)
5. Sur-Grip by JCM Industries. (4 to 12 inches)

C. Threaded or grooved-type joints that reduce pipe wall thickness below minimum required are not acceptable.
D. Provide for restrained joints designed to meet test pressures required under Section 02515 - Hydrostatic Testing of Pipelines or Section 02532 - Force Mains, as applicable. Provide restrained joints for test pressure or maximum surge pressure as specified, whichever is greater for water lines. Do not use passive resistance of soil in determining minimum restraint lengths.

E. Bond rubber gasketed joints to provide electrical continuity along entire pipeline, except where insulating flanges are required by Drawings.

F. Make curves and bends by deflecting joints. Do not exceed maximum deflection recommended by pipe manufacturer for pipe joints or restraint joints. Submit details of other methods of providing curves and bends for consideration by Engineer. When other methods are deemed satisfactory, install at no additional cost to Owner.

2.03 GASKETS:

A. Furnish, when no contaminant is identified, plain rubber (SBR) gasket material in accordance with ANSI A21.11 or ASTM F 477 (One Bolt only); for flanged joints 1/8-inch-thick gasket in accordance with ANSI A 21.15.

2.04 FITTINGS

A. Use fittings of same size as pipe. Reducers are not permitted to facilitate an off-size fitting. Reducing bushings are also prohibited. Make reductions in piping size by reducing fittings. Line and coat fittings as specified for pipe they connect to.


C. Flanged Fittings: ANSI 21.10; ductile iron ANSI A 21.11 joints, gaskets, and lubricants, pressure rated at 250 psig.

D. Mechanical Joint Fittings: ANSI A 21.11; pressure rated at 250 psi.

E. Ductile Iron Compact Fittings for Water lines: ANSI A 21.53; 4-inch through 12-inch diameter fusion bonded epoxy-lined or cement mortar lining.

2.05 COATINGS AND LININGS

A. Water line Interiors: ANSI A21.4, cement lined with seal coat; ANSI A 21.16 fusion bonded epoxy coating for interior; comply with NSF 61.


C. Gravity Pipelines and Force Main Interiors:
1. Preparation: Commercial blast cleaning conforming to SSPC-SP6.
2. Liner thickness: Nominal 40 mils, minimum 35 mils, for pipe barrel interior; minimum 6 to 10 mils at gasket groove and outside spigot end to 6-inches back from end.
4. Acceptable Lining Materials:
   a. Provide approved virgin polyethylene conforming to ASTM D 1248, with inert fillers and carbon black to resist ultraviolet degradation during storage; heat bonded to interior surface of pipe and fittings.
   b. Ceramic Epoxy – Tnemec 431 or Protecto 401 or approved equal.
   c. D1 Fitting supplier shall notify Engineer 48 hours prior to application of internal coatings for D1 fittings. Engineer will inspect supplier’s premises to ensure supplier meets or exceeds minimum standards for surface preparation and proper application of specified internal linings. Engineer will review supplier’s procedures for surface preparation and lining application. No materials will be accepted without above inspection and procedure review.

D. Gravity Point Repair Pipe: For pipes which will be lined with high density polyethylene liner pipe or cured-in-place liner, provide cement-lined with seal coat in accordance with ANSI A 21.4. For pipes which will not be provided with named liner, provide pipe as specified in Paragraph 2.05B, Gravity Pipeline and Force Main Interiors.

E. Exterior:

1. Encasement and coatings requirement for water lines
   a. Open cut construction method:
      1) Provide double wrap polyethylene encasement applied in accordance with AWWA C105 or
      2) Provide polyurethane coating in accordance with Section 02527 – Polyurethane Coatings on Steel and Ductile Iron Pipe.
   b. Auger or casing construction method:
      1) Provide Polyurethane coating in accordance with Section 02527 – Polyurethane Coatings on Steel and Ductile Iron Pipe or
      2) Provide minimum thickness Class 52 pipe, double wrap with Polyethylene encasement. Place circumferential wraps of tape or plastic tie straps at two-foot intervals along the barrel of the pipe, and thoroughly seal each end of the polyethylene tube.
   c. Tunnel, casing, or direct bury conform to requirements of paragraph 2.05.E.

F. Polyethylene Wrap: For buried water lines not cathodically protected and gravity pipelines, including point repairs, provide polyethylene wrap unless otherwise specified or shown. Conform to requirements of Section 02528 - Polyethylene Wrap.

G. For flanged joints in buried service, provide petrolatum wrapping system, Denso, or equal, for the complete joint and alloy steel fasteners. Alternatively, provide bolts made of Type 304 stainless steel.

H. Pipe to be installed in potentially contaminated areas shall have coatings and linings recommended by the manufacturer for maximum resistance to the contaminants identified in the Phase II Environmental Site Assessment Report.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Conform to installation requirements of 02531 - Gravity Pipelines and 02532 - Force Mains, except as modified in this Section.

B. Install in accordance with AWWA C 600 and manufacturer’s recommendations.

C. Install all ductile iron pipe in polyethylene wrap, unless cathodic protection is provided. Do not use polyethylene wrap with a cathodic protection system.

D. Holiday Testing.

1. Polyurethane: Conform to requirements of Section 02527 - Polyurethane Coatings for Steel or Ductile Iron Pipe.

2. Fusion Bonded Epoxy: Conform to requirements for new fittings in ANSI A 21.16.

3.02 FIELD REPAIR OF COATINGS

A. Polyurethane: Conform to requirements of Section 02527 - Polyurethane Coatings for Steel or Ductile Iron Pipe.

B. Fusion Bonded Epoxy: Conform to requirements for new fittings in ANSI A 21.16.

END OF SECTION
SECTION 02502
STEEL PIPE AND FITTINGS

PART 1 -  GENERAL

1.01  SECTION INCLUDES

A. Steel pipe and fittings for water lines for aerial crossings, aboveground piping, and encasement sleeves. Do not bury steel pipe, unless it is large diameter water line.

B. Specifications identify requirements for small diameter less than or equal to 20 inches.

1.02  MEASUREMENT AND PAYMENT

A. Unit Prices.

1. No payment will be made for steel pipe and fittings under this Section.

B. Stipulated Price (Lump Sum). If Contract is Stipulated Price Contract, payment for work in this Section is included in total Stipulated Price.

1.03  REFERENCES

A. AASHTO - Standard Specifications for Highway Bridges.


E. ASTM A 105 - Standard Specification for Carbon Steel Pipe Forgings for Piping Applications


H. ASTM A 139 - Standard Specification for Electric-Fusion (ARC) - Welded Steel Pipe (NPS 4 and Over).


K. AWWA C 200 - Standard for Steel Water Pipe 6 inches and Larger.

L. AWWA C 206 - Standard for Field Welding of Steel Water Pipe.

M. AWWA C 207 - Standard for Steel Pipe Flanges for Waterworks Service - Sizes 4 inches through 144 inches.

N. AWWA C 210 - Standard for Liquid Epoxy Coating Systems for the Interior and Exterior of Steel Water Pipelines.

O. AWWA C 604 – Installation of Buried Steel Water Pipe – 4 inches and Larger.


Q. SSPC Good Painting Practice, Volume 1.

R. SSPC SP 1 - Surface Preparation Specification No. 1 Solvent Cleaning.

S. SSPC SP 5 - Joint Surface Preparation Standard White Blast Cleaning.

T. SSPC SP 6 - Surface Preparation Specification No. 6 Commercial Blast Cleaning.


V. SSPC VIS 1 - Visual Standard for Abrasive Blast Cleaned Steel.

1.04 SUBMITTALS

A. For aerial crossings and above ground piping, include lay schedule of new pipe and fittings indicating alignment and grade, laying dimensions, lining and coating systems, proposed welding procedures, fabrication, fitting, flange, and special details. Show station numbers for pipe and fittings corresponding to Drawings.

B. Submit manufacturer's certifications that pipe and fittings are new and unused.

C. Submit manufacturer's certifications that pipe and fittings have been hydrostatically tested at factory in accordance with AWWA C 200.

D. Submit manufacturer's affidavits that coatings and linings comply with applicable requirements of this Section and:

1. Polyurethane coatings were applied in strict accordance with manufacturer’s recommendation and allowed to cure at temperature 5 degrees above dew point.

2. Linings were applied and allowed to cure at temperature above 32 degrees F.
E. Submit certification from NACE Certified Coatings Inspector, having Level III certification for coatings and linings that steel pipe furnished on project was properly inspected and defective coatings detected were properly repaired.

1.05 QUALITY CONTROL

A. Prior to start of work, provide proof of certification of qualification for welders employed for type of work, procedures and positions involved. Provide welder qualifications in accordance with AWWA C 206.

B. Shop-applied coatings and linings; provide services of an independent coating and lining inspection service or testing laboratory with qualified coating inspectors. Perform inspection by NACE trained inspectors under supervision of NACE Level III Certified Coatings Inspector verifying compliance with same requirements specified in Paragraph 3.02.

C. Coatings: Measure temperature and dew point of ambient air before applying coatings. Inspect physical dimensions and overall condition of coatings. Inspect for visible surface defects, thickness, and adhesion of coating to surface and between layers.

D. Final Inspection:

1. Before shipment, inspect each finished pipe, fitting, special and accessory for markings, metal thickness, coating thickness, lining thickness (if shop applied), joint dimensions, and roundness.

2. Inspect for coating placement and defects. Test exterior coating for holidays.

   a. Inspect linings for thickness, pitting, scarring, and adhesion.

E. Ensure workmen engaged in manufacturing are qualified and experienced in performance of their specific duties.

PART 2 - PRODUCTS

2.01 STEEL PIPE

A. Provide steel pipe and encasement sleeves designed and manufactured in conformance with AWWA C 200 and AWWA M 11 except as modified herein. Steel to be minimum of ASTM A106, ASTM A 36, ASTM A 1011 Grade 36, ASTM A 53 Grade B, ASTM A 135 Grade B, or ASTM A 139 Grade B.
CARRIER PIPE

<table>
<thead>
<tr>
<th>Nominal Pipe Size</th>
<th>Min. Wall O.D (In.)</th>
<th>Min. Wall Thickness (In.)</th>
<th>Approx. Wt. Per L. F. Uncoated (Lb.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>4.50</td>
<td>0.250</td>
<td>11.35</td>
</tr>
<tr>
<td>6</td>
<td>6.625</td>
<td>0.280</td>
<td>18.97</td>
</tr>
<tr>
<td>8</td>
<td>8.625</td>
<td>0.322</td>
<td>28.55</td>
</tr>
<tr>
<td>10</td>
<td>10.75</td>
<td>0.365</td>
<td>40.48</td>
</tr>
<tr>
<td>12</td>
<td>12.75</td>
<td>0.375</td>
<td>49.56</td>
</tr>
<tr>
<td>16</td>
<td>16.00</td>
<td>0.375</td>
<td>62.58</td>
</tr>
<tr>
<td>20</td>
<td>20.00</td>
<td>0.375</td>
<td>78.60</td>
</tr>
</tbody>
</table>

B. Minimum Allowable Steel-Wall Thickness:

C. Notes for Carrier Pipe:

1. Review pipe and fitting design for conditions exceeding those specified herein.
2. Provide pipe with wall thickness of no less than listed in table above.

MINIMUM DIAMETER CASING PIPE (ENCEASMENT SLEEVES)

<table>
<thead>
<tr>
<th>Corresponding Casing Pipe Size (In.)</th>
<th>Min. Wall O.D (In.)</th>
<th>Min. Wall Thickness (In.)</th>
<th>Approx. Wt. Per L. F. Uncoated (Lb.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>8.625</td>
<td>0.219</td>
<td>19.64</td>
</tr>
<tr>
<td>10</td>
<td>10.75</td>
<td>0.219</td>
<td>24.60</td>
</tr>
<tr>
<td>12</td>
<td>12.75</td>
<td>0.219</td>
<td>29.28</td>
</tr>
<tr>
<td>16</td>
<td>16.00</td>
<td>0.219</td>
<td>36.86</td>
</tr>
<tr>
<td>18</td>
<td>18.00</td>
<td>0.25</td>
<td>47.39</td>
</tr>
<tr>
<td>20</td>
<td>20.00</td>
<td>0.250</td>
<td>52.73</td>
</tr>
<tr>
<td>24</td>
<td>24.00</td>
<td>0.250</td>
<td>63.41</td>
</tr>
</tbody>
</table>

D. Notes for Casing Pipe:

1. Provide casing pipe with wall thickness of no less than listed in table above.
3. Verify casing diameter required with dimensions of casing spacer.

E. Provide pipe sections in lengths of no less than 16 feet except as required for special sections, and no greater than 40 feet.

F. Provide short sections of steel pipe no less than 4 feet in length unless indicated on Drawings or specifically permitted by Project Manager.
G. Fittings: Factory forged for sizes 4 inches through 20 inches; long radius bends; beveled ends for field butt welding; wall thickness equal to or greater than pipe to which fitting is to be welded unless otherwise shown on Drawings.

H. Joints:
2. Electrically isolate flanged joints between steel and cast iron by using flange isolation. Use epoxy coated nuts and bolts to assemble the fittings.
3. Elbows to be standard weight seamless elbows per ASTM A106, Grade A or B

2.02 INTERNAL LINING SYSTEMS FOR STEEL PIPE, ALL INSTALLATIONS

A. A Supply steel pipe with epoxy lining, capable of conveying water at temperatures not greater than 140 degrees F. Provide linings conforming to American National Standards Institute/National Sanitation Foundation (ANSI/NFS) Standard 61 and certification to be from organization accredited by ANSI. Unless otherwise noted, coat exposed (wetted) steel parts of flanges, blind flanges, bolts, access manhole covers, etc., with epoxy lining, as specified.

B. Epoxy Lining AWWA C 210, White, or approved equal for shop and field applied, except as modified in this Section. Provide material from same manufacturer.

<table>
<thead>
<tr>
<th>Surface Preparation as recommended by manufacturer</th>
<th>SSPC-10 Near White Blast Clean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Finish Coat</td>
<td>AWWA C210. Provide Devoe Bar Rust 233H or approved equal.</td>
</tr>
</tbody>
</table>

1. Provide dry film thickness in accordance with product manufacturer recommendations. Do not exceed maximum DFT as recommended by manufacturer.
2. Factory Testing: In accordance with AWWA C210

2.03 EXTERNAL COATING SYSTEM FOR STEEL PIPE INSTALLED ABOVEGROUND AND IN VAULTS (EXPOSED)

A. Provide approved epoxy/polyurethane coating system as designated below. Provide material from same manufacturer.
Surface Preparation
as recommended by manufacturer

<table>
<thead>
<tr>
<th></th>
<th>SSPC SP 10</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Near White Blast Clean</td>
</tr>
</tbody>
</table>

Intermediate Coat

<table>
<thead>
<tr>
<th></th>
<th>Chemical Resistant Epoxy, or approved equal, AWWA C210</th>
</tr>
</thead>
</table>

Finish Coat

<table>
<thead>
<tr>
<th></th>
<th>Polyurethane, or approved equal Blue Fed Std. No. 15102 color as approved by Project Manager</th>
</tr>
</thead>
</table>

B. Total Allowable Dry Film Thickness (DFT) for System: as recommended by manufacturer.

C. Factory and field testing: in accordance with AWWA C210.

D. Clean bare pipe free from mud, mill lacquer, oil, grease, or another contaminant. Inspect and clean surfaces according to SSPC-SP-1 to remove oil, grease, and loosely adhering deposits prior to blast cleaning. Remove visible oil and grease spots by solvent wiping. Use only approved safety solvents that do not leave residue. Use preheating to remove oil, grease, mill scale, water, and ice provided pipe is preheated in uniform manner to avoid distortion.

E. Remove surface imperfections such as slivers, scabs, burrs, weld spatter, and gouges. Grind weld bead for proper coating application as recommended by coating manufacturer. Presence of metallic defects may be cause for rejection of pipe.

PART 3 - EXECUTION

3.01 PIPING INSTALLATION

A. Comply with the following:

1. Bedding and Backfilling: Conform to requirements of Section 02317 - Excavation and Backfill for Utilities.
2. For pipes with coating: Do not roll or drag pipe on ground, move pipe in such a manner as not to damage pipe or coating. Carefully inspect pipe for abrasions and repair damaged coating before pipe is installed.

B. Static Electricity:

1. Properly ground steel pipeline during construction as necessary to prevent build-up of static electricity.
2. Electrically test where required after installation is complete.
3.02 EXTERNAL COATING SYSTEM FOR STEEL PIPE INSTALLED ABOVE GROUND AND IN VAULTS (EXPOSED) AND EPOXY INTERNAL LINING SYSTEM.

A. Safety: Paints, coatings, and linings specified in this Section are hazardous materials. Vapors may be toxic or explosive. Protective equipment, approved by appropriate regulatory agency, is mandatory for personnel involved in painting, coating, and lining operations.

B. Workmanship:

1. Application: By qualified and experienced workers who are knowledgeable in surface preparation and application of high-performance industrial coatings.


C. Surface Preparation:

1. Prepare surfaces for painting by using abrasive blasting.

2. Schedule cleaning and painting so that detrimental amounts of dust or other contaminants do not fall on wet, newly painted surfaces. Protect surfaces not intended to be painted from effects of cleaning and painting operations.

3. Prior to blasting, clean surfaces to be coated or lined of grease, oil and dirt by steaming or detergent cleaning in accordance with SSPC SP 1.

4. Metal and Weld Preparation: Remove surface defects such as gouges, pits, welding and torch-cut slag, welding flux and spatter by grinding to 1/4-inch minimum radius.

5. Abrasive Material:

   a. Blast only as much steel as can be coated same day of blasting.

   b. Use sharp, angular, properly graded abrasive capable of producing depth of profile specified herein. Transport abrasive to job site in moisture-proof bags or airtight bulk containers. Copper slag abrasives are not acceptable.

   c. After abrasive blast cleaning, verify surface profile with replica tape such as Tes-Tex Coarse or Extra Coarse Press-O-Film Tape, or approved equal. Furnish tapes to Project Manager.

   d. Do not blast if metal surface may become wet before priming commences, or when metal surface is less than 5 degrees F above dew point.

6. Evaluate degree of cleanliness for surface preparation with use of SSPC Pictorial Surface Preparation Standards for Painting Steel Surfaces, SSPC-Vis 1.

7. Remove dust and abrasive residue from freshly blasted surfaces by brushing or blowing with clean, dry air. Test cleanliness by placing ¾-inch by 4-inch piece of clear Scotch type tape on blasted surface, then
removing and placing tape on 3x5 white index card. Reclean areas exhibiting dust or residue.

D. Coating and Lining Application:

1. Environmental Conditions: Do not apply coatings or linings when metal temperature is less than 50 degrees F; when ambient temperature is less than 5 degrees F above dew point; when expected weather conditions are such that ambient temperature will drop below 40 degrees F within 6 hours after application; or when relative humidity is above 85 percent. Measure relative humidity and dew point by use of sling psychrometer in conjunction with U.S. Department of Commerce Weather Bureau Psychometric Tables. Provide dehumidifiers for field-applied coatings and linings to maintain proper humidity levels.

2. Application Procedures:
   a. Apply in accordance with manufacturer's recommendations and requirements of this Section. Provide finish free of runs, sags, curtains, pinholes, orange peel, fisheyes, excessive over spray, or delamination's.
   b. Thin materials only with manufacturers recommended thinners. Thin only amount required to adjust viscosity for temperature variations, proper atomization and flow-out. Mix material components using mechanical mixers.
   c. Discard catalyzed materials remaining at end of day.

3. Thoroughly dry pipe before primer is applied. Apply primer immediately after cleaning surface. Apply succeeding coats before contamination of undersurface occurs.

4. Cure a minimum of 24 hours at 77 degrees F before successive coats are applied. During curing process, provide force air ventilation in volume sufficient to maintain solvent vapor levels below published threshold limit value. Apply successive coats within recoat threshold time as recommended by coating or lining manufacturer on printed technical data sheets or through written communications. Brush blast joints of pipe which have been shop primed and are to receive intermediate and finish coats in field prior to application of additional coats. After interior coatings are applied, provide forced air ventilation in sufficient volume and for sufficient length of time to ensure proper curing before filling pipe with water.

E. Testing of Coatings and Linings:

1. Inspect pipe for holidays and damage to coating:
   a. If test indicates no holidays and coating is damaged, remove damaged layers of coating and repair in accordance with coating manufacturer's recommendations.
2. Perform holiday test in accordance with NACE Standard Recommended Practice, RPO 188-90, Discontinuity (Holiday) Testing of Protective Coatings.

3. Begin testing of completed coating after coating has sufficiently cured, usually one to 5 days. Consult coating manufacturer for specific curing schedule.

4. Perform adhesion test on pipe in accordance with ASTM D 4541.

5. For coating thickness of 20 mils or less, test with wet sponge low-voltage holiday detector. For coating thickness in excess of 20 mils, test with high-voltage holiday detector. Perform electrical holiday test with 60-cycle current audio detector. Select test voltage as suggested in table below.

<table>
<thead>
<tr>
<th>Total Dry Film Thickness (mils)</th>
<th>Suggested Inspection (V)</th>
</tr>
</thead>
<tbody>
<tr>
<td>20 to 40</td>
<td>3,000</td>
</tr>
<tr>
<td>41 to 55</td>
<td>4,000</td>
</tr>
<tr>
<td>56 to 80</td>
<td>6,000</td>
</tr>
</tbody>
</table>

3.03 JOINTS AND JOINTING

A. Welded Joints:
   1. Field weld to be full penetration butt-welded joints for steel pipe and encasement sleeves for entire circumference.
   2. Owner will employ an independent certified testing laboratory to perform weld acceptance tests on welded joints. Testing Laboratory will test by X-ray methods for butt welds, for 100 percent of joint welds. Project Manager has final decision as to suitability of welds tested.

3.04 COATINGS AND LININGS INSPECTION RESPONSIBILITIES

A. Contractor is responsible for quality control of coatings and linings applications and testing and inspection stipulated in this Section. Project Manager is responsible for quality assurance and reserves the right to inspect or acquire services of an independent third-party inspector who is fully knowledgeable and qualified to inspect surface preparation and application of high-performance coatings at all phases of coatings and linings work, field- or shop-applied. Contractor is responsible for proper application and performance of coatings and linings whether or not Project Manager provides such inspection.

END OF SECTION
SECTION 02506
POLYVINYL CHLORIDE PIPE

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Polyvinyl chloride pressure pipe for water distribution, in nominal diameters 4 inches through 20 inches.

B. Polyvinyl chloride sewer pipe for gravity sewers in nominal diameters 4 inches through 60 inches.

C. Polyvinyl chloride pressure pipe for gravity sewers and force mains in nominal diameters 4 inches through 20 inches.

1.02 MEASUREMENT AND PAYMENT

A. Unit Prices.

1. No separate payment will be made for PVC pipe under this Section. Include cost in unit price for work included as specified in the following sections:

a. Section 02531 - Gravity Pipelines
b. Section 02532 - Force Mains

B. Stipulated Price (Lump Sum). If Contract is Stipulated Price Contract, payment for work in this Section is included in total Stipulated Price.

1.03 REFERENCES


I. ASTM D 2680 - Specification for Acrylonitrile-Butadiene-Styrene (ABS) and Poly (Vinyl Chloride) (PVC) Composite Sewer Piping.


K. ASTM D 3034 - Specification for Type PSM Poly (Vinyl Chloride) (PVC) Sewer Pipe and Fittings.


P. ASTM F 794 - Standard Specification for Poly (Vinyl Chloride) (PVC) Profile Gravity Sewer Pipe and Fittings Based on Controlled Inside Diameter.


V. AWWA C 909 - Standard for Molecularly Oriented Polyvinyl Chloride (PVCO) Pressure Pipe, 4 Inches through 12 Inches (100mm through 300 mm), for Water Distribution.
T. AWWA M23 – PVC Pipe – Design and Installation


W. NSF 61 – Drinking Water System Components

1.04 SUBMITTALS

A. Submit shop drawings showing design of new pipe and fittings indicating alignment and grade, laying dimensions, fabrication, fittings, flanges, and special details.

B. Contractor to review and submit PVC pipe manufacturers recommended installation procedures.

C. Calculations and limits of thrust restraint shall be based on AWWA M23, latest edition.

1.05 QUALITY CONTROL

A. Submit manufacturer’s certification that PVC pipe and fittings meet requirements of this Section and AWWA C 900, AWWA C 909, and AWWA C 905 for pressure pipe applications, or appropriate ASTM standard specified for gravity sewer pipe.

B. Submit manufacturer’s certification that PVC pressure pipe for water lines and force mains has been hydrostatically tested at factory in accordance with AWWA C 900, AWWA C 909, and AWWA C 905, and this Section.

C. When foreign manufacturer is proposed, have material tested for conformance to applicable ASTM requirements by certified independent testing laboratory located in United States. Certification from another source is not acceptable. Furnish copies of test reports to Project Manager for review. Cost of testing paid by Contractor.

D. Conduit shall be homogenous throughout and free from voids, cracks, inclusions and other defects, and shall be uniform as commercially practicable in color, density and other physical characteristics.
PART 2 - PRODUCTS

2.01 MATERIAL

A. Use PVC compounds in manufacture of pipe that contain no ingredient in amount that has been demonstrated to migrate into water in quantities considered to be toxic.

B. Furnish PVC pressure pipe manufactured from Class 12454 virgin PVC compounds as defined in ASTM D 1784. Use compounds qualifying for rating of 4000 psi for water at 73.4 °F per requirements of PPI TR3. Provide pipe, which is homogeneous throughout, free of voids, cracks, inclusions, and other defects, uniform as commercially practical in color, density, and other physical properties. Deliver pipe with surfaces free from nicks and scratches with joining surfaces of spigots and joints free from gouges and imperfections which could cause leakage.

C. Pipe shall be handled and stored per manufacture recommendations.

D. PVC Restrained Pipe:

1. Pipe Material:
   a. DR 18: For restrained joints where shown on Drawings.
   b. DR 14: For alternate to offset pipe sections shown on Drawings. Do not use PVC for offset sections with depth of cover greater than 20 feet or less than 4 feet. Do not use PVC in potentially petroleum contaminated areas.

E. Water Service.

1. Provide self-extinguishing PVC pipe that bears Underwriters' Laboratories' Laboratories mark of approval and is acceptable without penalty to Texas State Fire Insurance Committee for use in fire protection lines.

2. Bear National Sanitation Foundation Seal of Approval (NSF-PW).

F. Gaskets:

1. Gasket materials shall meet requirements of ASTM F 477. Use elastomeric factory-installed gaskets to make joints flexible and watertight.

2. Flat Face Mating Flange: Full faces 1/8-inch-thick ethylene propylene (EPR) rubber.

3. Raised Face Mating Flange: Flat ring 1/8-inch ethylene propylene (EDR) rubber, with filler gasket between OD of raised face and flange OD to protect flange from bolting moment.
G. Lubricant for rubber-gasketed joints: Water soluble, non-toxic, non-objectionable in taste and odor imparted to fluid, non-supporting of bacteria growth, having no deteriorating effect on PVC or rubber gaskets.

H. Do not use PVC in potentially or known contaminated areas.

I. Do not use PVC in areas exposed to direct sunlight.

2.02 WATER SERVICE PIPE

A. Pipe 4-inch through 20-inch: AWWA C 900, AWWA C 909, Class 150, DR 18; AWWA C 900, Class 200, DR 14 as alternate to offset pipe sections; nominal 20-foot lengths; cast-iron equivalent outside diameters.

B. Pipe 14-inch through 20-inch: AWWA C 905; DR 18; nominal 20-foot lengths; cast-iron equivalent outside diameter.

C. Provide Polyvinyl Chloride Pipe from approved manufacturers.

D. Make curves and bends by offsetting (i.e., deflecting joints). Do not exceed 80% of the maximum offset recommended by pipe manufacturer.

E. Hydrostatic Test: AWWA C 900, AWWA C 905, AWWA C 909, ANSI A 21.10 (AWWA C 110); at point of manufacture; submit manufacturer's written certification.

2.03 GRAVITY PIPE

A. PVC gravity pipeline shall be in accordance with provisions in following table:

<table>
<thead>
<tr>
<th>WALL CONSTRUCTION</th>
<th>ASTM DESIGNATION</th>
<th>SDR (MAX.)/STIFFNESS (MIN.)</th>
<th>DIAMETER SIZE RANGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>AWWA C900</td>
<td>DR 18 / N/A</td>
<td>4” to 24”</td>
<td></td>
</tr>
<tr>
<td>AWWA C909</td>
<td>DR 18 / N/A</td>
<td>4” to 12”</td>
<td></td>
</tr>
</tbody>
</table>
B. PVC storm sewer pipe shall be in accordance with provisions in following table:

<table>
<thead>
<tr>
<th>WALL CONSTRUCTION</th>
<th>MANUFACTURER</th>
<th>ASTM DESIGNATION</th>
<th>SDR (MAX.)/STIFFNESS (MIN.)</th>
<th>DIAMETER SIZE RANGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solid</td>
<td>J-M Pipe</td>
<td>AWWA C900</td>
<td>DR 18 / N/A</td>
<td>4” to 60”</td>
</tr>
<tr>
<td></td>
<td>NAPCO Pipe and Fitting</td>
<td>AWWA C909</td>
<td>DR 18 / N/A</td>
<td>4” to 12”</td>
</tr>
<tr>
<td></td>
<td>Diamond Uponor ETI</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

C. For sewers up to 12-inch diameter crossing over waterlines or crossing under waterlines with less than 2-feet separation, provide minimum 150 psi pressure-rated pipe conforming to ASTM D 2241 with suitable PVC adapter couplings.

D. Joints: Spigot and integral wall section bell with solid cross section elastomeric or rubber ring gasket conforming to requirements of ASTM D 3212 and ASTM F 477, or ASTM D 3139 and ASTM F 477. Gaskets shall be factory-assembled and securely bonded or otherwise held in place to prevent displacement. Manufacturer shall test sample from each batch conforming to requirements ASTM D 2444.

E. Fittings: Provide PVC gravity sewer sanitary bends, tee, or wye fittings for new pipeline construction. PVC pipe fittings shall be full-bodied, either injection molded, or factory fabricated. Saddle-type tee or wye fittings are not acceptable.

F. Conditioning. Conditioning of samples prior to and during tests is subject to approval by Project Manager. When referee tests are required, condition specimens in accordance with Procedure A in ASTM D 618 at 73.4 degrees F plus or minus 3.6 degrees F and 50 percent relative humidity plus or minus 5 percent relative humidity for not less than 40 hours prior to test. Conduct tests under same conditions of temperature and humidity unless otherwise specified. This is a brief summary of the test method, and the full current edition of the standard must be followed.

G. Pipe Stiffness. Determine pipe stiffness at 5 percent deflection in accordance with Test Method D 2412. Minimum pipe stiffness shall be 46 psi. For diameters 4-inch through 18-inch, test three specimens, each a minimum of 6 inches (152 mm) in length. For diameters 21-inch through 36-inch, test three specimens, each a minimum of 12 inches (305 mm) in length. This is a brief summary of the test method, and the full current edition of the standard must be followed.

H. Flattening. Flatten three specimens of pipe, prepared in accordance with Paragraph 2.03F, in suitable press until internal diameter has been reduced to 60 percent of original inside diameter of pipe. Rate of loading shall be uniform.
Test specimens, when examined under normal light and with unaided eye, shall show no evidence of splitting, cracking, breaking, or separation of pipe walls or bracing profiles. Perform the flattening test in conjunction with pipe stiffness test. This is a brief summary of the test method, and the full current edition of the standard must be followed.

I. Joint Tightness. Test for joint tightness in accordance with ASTM D 3212, except that joint shall remain watertight at minimum deflection of 5 percent. Manufacturer will be required to provide independent third-party certification for joint testing each diameter of storm sewer pipe. This is a brief summary of the test method, and the full current edition of the standard must be followed.

J. Purpose of Tests. Flattening and pipe stiffness tests are intended to be routine quality control tests. Joint tightness test is intended to qualify pipe to specified level of performance.

K. Saddle for pipe with 0.5-inch width and greater: Connect side sewer by drilling proper size round hole in wall of the main sewer pipe, inserting an approved pipe compression saddle. The Saddle shall meet requirements of ASTM C-923. Saddles will accept 4”, 6”, and 8” pipe. The lateral pipe shall be held in place by one stainless steel compression band with stainless steel nut and bolt (any AISI Series 300) type tightening device and meeting requirements of ASTM A240. A stainless-steel shear band shall wrap around the pipe a minimum of 380 degrees. Saddle may not protrude into mainline pipe.

2.04 FORCE MAIN PIPE

A. Provide approved PVC pressure pipe conforming to requirements for water service pipe and conforming to minimum working pressure rating specified in Section 02532 - Force Mains.

B. Acceptable pipe joints are restrained joint coupling in accordance with technical specification section 15064.

C. Fittings: Provide approved ductile iron fittings except furnish fittings with one of following approved internal linings:

1. Nominal 40 mils (35 mils minimum) virgin polyethylene complying with ASTM D 1248, heat fused to interior surface of fitting
2. Nominal 40 mils (35 mils minimum) polyurethane
3. Nominal 40 mils (35 mils minimum) ceramic epoxy
4. Nominal 40 mils (35 mils minimum) fusion bonded epoxy

2.05 BENDS AND FITTINGS FOR PVC PRESSURE PIPE

A. Fittings and bends to be designed for use at or above the pressure class of the pipe with which they are utilized and shall be designed to meet the zero leakage test requirements of ASTM D3139. Joint shall be bi-directionally restrained.
B. ANSI A 21.10 or ANSI A 21.53, ductile iron; ANSI A 21.11 single rubber gasket push-on type joint; minimum 150 psi pressure rating.

C. AWWA C900 DR18 fabricated one piece 5 degree bends. Manufactured by the heat forming and bending process.

PART 3 - EXECUTION

3.01 PROTECTION

A. Store pipe under cover out of direct sunlight and protect from excessive heat or harmful chemicals in accordance with manufacturer's recommendations.

B. Pipe shall be handled and stored per manufacture recommendations.

3.02 INSTALLATION

A. Pipe and couplings shall be homogeneous throughout and free from voids, cracks, inclusions, and other defects, and shall be as uniform as commercially practicable in color, density, and other physical characteristics.

B. Conform to requirements of Section 02531 - Gravity Pipelines, and Section 02532 - Force Mains, as applicable.

C. Install PVC pipe in accordance with Section 02317 - Excavation and Backfill for Utilities, ASTM D 2321 for Sewer Pipe, and manufacturer's recommendations.

D. Install PVC water service pipe to clear utility lines with minimum separation to avoids conflicts, unless otherwise shown on Drawings:

E. Avoid imposing strains that will overstress or buckle pipe when lowering pipe into trench.

F. Hand shovel pipe bedding under pipe haunches and along sides of pipe barrel and compact to eliminate voids and ensure side support. Ensure barrel is fully supported along entire length of pipe, prior to backfilling.

G. For PVC pipe installed by trenchless methods, provide integral restrained joints and pull pipe through hole or casing. For PVC pipe pushed through hole or casing, provide approved bell insertion protection system.

H. Store PVC pipe under cover out of direct sunlight. Protect pipe from excessive heat or harmful chemicals. Prevent damage by crushing or piercing.

I. Allow PVC pipe to cool to ground temperature before backfilling when assembled out of trench to prevent pullout due to thermal contraction.

J. Pipe Assembly Procedures
1. Do not remove gasket from pipe.
2. Lay pipe by inserting spigot end into bell flush with the insertion line or as recommended by pipe manufacturer.
3. Do not assemble joint by swinging or stabbing.
4. Do not assemble joint using machinery or equipment such as backhoe bucket.
5. At no time shall spigot go past insertion line or homing mark. Continuously observe and check each homing mark for proper length and install pipe with home mark visible.

3.03 PVC RESTRAINED MECHANISM

A. For low-profile coupling with spline-type joints:
   1. Do not apply lubricant to spline or pipe or coupling spline grooves.
   2. Do not use excessive force while inserting the spline through coupling.
   3. Insert spline until it is fully seated around circumference of pipe.

B. Field Cutting of Pipe Ends:
   1. Perform work by workers certified by manufacturer.
   2. Use a PVC pipe cutter and provide square ends.
   3. Follow manufacturer’s recommendation to disassemble restrained joint after it has been locked in place.
   4. For low-profile coupling with spline-type joints, use manufacturer approved power routing and grooving tool to field fabricate required pipe groove.

END OF SECTION
SECTION 02515
HYDROSTATIC TESTING OF PIPELINES

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Field hydrostatic testing of newly installed force main piping and pipelines.

B. Specifications identify requirements for both small-diameter (less than or equal to 20 inches) and large-diameter (greater than 20 inches) lines. When specifications for large-diameter lines differ from those for small-diameter lines, paragraphs for large-diameter lines will govern for large-diameter pipe.

1.02 MEASUREMENT AND PAYMENT

A. No separate payment will be made for work required under this section. Contractor will include all costs of the requirements of this section in the appropriate bid item(s) on the bid form.

PART 2 - PRODUCTS - Not Used

PART 3 - EXECUTION

3.01 PREPARATION

A. New mains shall be thoroughly disinfected in accordance with AWWA Standard C-651 and then flushed and sampled before being placed in service. Samples shall be collected for microbiological analysis to check the effectiveness of the disinfection procedure. Sampling shall be repeated if contamination persists. A minimum of one sample for each 1,000 feet of completed waterline will be required or at the next available sampling point beyond 1,000 feet as designated by the design engineer.

B. Hydrostatically test newly installed piping and pipelines after disinfection, if required, and before connecting to the Owner’s water distribution system.

C. Water for testing will be provided to Contractor at no charge by the Owner for the initial test and one (1) retest, if required.

D. For large-diameter lines, test pipelines in lengths between valves, or plugs, of not more than 4400 feet.

E. Small-diameter pipe shall be tested in lengths between valves, or plugs, of not more than 1,500 feet.

F. Conduct hydrostatic tests in presence of the Engineer.
3.02 TEST PROCEDURES

A. Furnish, install, and operate connections, pump, meter and gages necessary for hydrostatic testing.

B. Allow piping and pipeline to sit a minimum of 24 hours from time it is initially disinfected until testing begins, to allow pipe wall or lining material to absorb water. Periods of up to 7 days may be required for mortar lining to become saturated.

C. For small-diameter pipe, expel air and apply a minimum test pressure of 125 psi. For large-diameter pipe, expel air and apply a minimum test pressure of 150 psi.

D. Begin test by 9:00 a.m. unless otherwise approved by the Engineer. Maintain test pressure for 8 hours. If a large quantity of water is required to maintain pressure during test, testing shall be discontinued until cause of water loss is identified and corrected.

E. Keep valves inside pressure reducing stations closed during hydrostatic pressure test.

3.03 ALLOWABLE LEAKAGE FOR FORCE MAIN PIPELINES

A. During hydrostatic tests, no leakage will be allowed for sections of force main pipelines and piping consisting of welded joints.

B. Maximum allowable leakage for piping and lines with rubber gasketed joints: 10.63 gallons per inch nominal diameter per mile of pipe per 24 hours while testing at 125 psi or 11.65 gallons per inch nominal diameter per mile of pipe per 24 hours while testing at 150 psi.

3.04 CORRECTION FOR FAILED TESTS

A. Repair joints showing visible leaks on surface regardless of total leakage shown on test. Check valves and fittings to ensure that no leakage occurs that could affect or invalidate test. Remove any cracked or defective pipes, fittings, and valves discovered during pressure test and replace with new items.

B. The Engineer may require failed pipe to be disinfected after repair and prior to retesting. Contractor shall pay for water required for additional disinfection and retesting.

C. Repeat test until satisfactory results are obtained.
3.05 COMPLETION

A. Upon satisfactory completion of testing, remove risers remaining from disinfection and hydrostatic testing, and backfill excavation promptly.

END OF SECTION
PART 1 - GENERAL

1.01 SECTION INCLUDES
A. Air release and vacuum relief valves.

1.02 MEASUREMENT AND PAYMENT
A. No separate payment will be made for work required under this section. Contractor will include all costs of the requirements of this section in the appropriate bid item(s) on the bid form.

1.03 REFERENCES

1.04 SUBMITTALS
A. Submit manufacturer's product data for proposed valves for approval.

PART 2 - PRODUCTS

2.01 DESCRIPTION
A. Provide air release, air and vacuum valves, vacuum valves, and combination air valves designed to fulfill functions of air release (permit escape of air accumulated in line at high point of elevation while line is under pressure) and vacuum relief.

B. Provide inlet and outlet connections, and orifice as shown on Drawings.

C. Valve exterior: Painted with shop-applied primer suitable for contact with potable water.
2.02 MATERIALS

A. Air Release Valves: Provide approved air release valves ASTM A 48, Class 30, cast iron; float and leverage mechanism, ASTM A 240 or ASTM A 276 stainless steel; orifice and seat, stainless steel against Buna-N or Viton mechanically retained with hex head nut and bolt. Other valve internals shall be stainless steel or bronze.

B. Air Release and Vacuum Relief Valves: Provide single-body, standard combination valves or duplex-body custom combination valves as indicated on Drawings.

1. For 2-inch and 3-inch, single-body valves, provide inlet and outlet size as shown on Drawings and orifice sized for 100 psi working pressure.
   a. Valve materials: body, cover, and baffle, ASTM A 48, Class 35, or ASTM A 126, Grade B cast iron; plug or poppet, ASTM A 276 stainless steel; float, ASTM A 240 stainless steel; seat, Buna-N; other valve internals, stainless steel.

2. For 3-inch and larger duplex body valves as shown on Drawings, provide approved air release valve.
   a. Air and vacuum valve materials: body and cover, ASTM A 48, Class 35, cast iron; float, ASTM A 240 stainless steel; seat, Type 304, stainless steel and Buna-N; other valve internals, stainless steel or bronze.
   b. Air release valve: Constructed as specified in paragraph above for Air Release Valves.

C. Vacuum Relief Valves: Provide approved air inlet vacuum relief valves with flanged inlet and outlet connections as shown on Drawings. Provide air release valves in combination with inlet and outlet, and orifice as shown on Drawings. Valve shall open under pressure differential not to exceed 0.25 psi.

   Materials for vacuum relief valves: valve body, ASTM A 48, Class 35, cast iron; seat and plug, ASTM B 584 bronze, copper alloy 836; spring, ASTM A 313, Type 304, stainless steel; bushing, ASTM B 584 bronze, copper alloy 932; retaining screws, ASTM A 276, Type 304, stainless steel.

D. Manholes: As shown on Drawings conforming to requirements of Section 02082 - Precast Concrete Manholes.
PART 3 - EXECUTION

3.01 EARTHWORK

A. Conform to applicable provisions of Section 02317 - Excavation and Backfill for Utilities.

3.02 SETTING VALVES IN MANHOLES AND VAULTS

A. If required by Engineer, provide services of technical representative of valve manufacturer available on-site during installation of valves.

B. Prior to installing valves, remove foreign matter from within valves. Inspect valves in open and closed position to verify that parts are in satisfactory working condition.

C. Install valves and valve manholes and vaults where indicated on Drawings or as located by Engineer. Set manholes and vaults plumb and as detailed. Center manholes on valves. Compact cement-stabilized sand around each manhole and vault for minimum radius of 4 feet, or to undisturbed trench face when less than 4 feet. Provide above-ground vents for manholes and vaults as indicated on Drawings.

3.03 DISINFECTION AND TESTING

A. Disinfect valves and appurtenances and test as required by Section 02515 - Hydrostatic Testing of Pipelines.

3.04 PAINTING OF PIPING AND VALVES

A. Paint piping and valves located in manholes, stations, and above ground using approved paint.

END OF SECTION
PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Polyurethane coating system for use as steel pipe internal lining and external coatings, and external coating for ductile iron pipe.

1.02 MEASUREMENT AND PAYMENT

A. Unit Prices:
   1. No separate payment will be made for work performed under this Section. Include cost of polyurethane coatings in contract unit prices for steel pipe or ductile iron pipe.

B. Stipulated Price (Lump Sum): If Contract is Stipulated Price Contract, payment for work in this Section is included in total Stipulated Price.

1.03 REFERENCES

A. AWWA C 222 - Polyurethane Coatings for the Interior and Exterior of Steel Water Pipe and Fittings


C. ASTM D 522 - Standard Test Method for Mandrel Bend Test of Attached Organic Coatings


H. ASTM G 14 – Standard Test Method for Impact Resistance of Pipeline Coatings (Falling Weight Test)

J. NACE SP-0188 – Discontinuity (Holiday) Testing of Protective Coatings

K. NAPF 500-03 – Surface Preparation Standard for Ductile Iron Pipe and Fittings in Exposed Locations Receiving Special External Coatings and/or Special Internal Linings

L. SSPC-PA 2 - Measurement of Dry Paint Thickness with Magnetic Gauges.


N. SSPC-SP 1 – Solvent Cleaning Surface Preparation

O. SSPC-SP10 - Near-White Metal Abrasive Blast Surface Preparation

P. SSPC-SP11 – Power Tool Clean to Bare Metal

1.04 SAFETY

A. Secure, from manufacturer, Material Safety Data Sheet (MSDS) for polyurethane coatings and repair materials listed in this Section.

B. Safety requirements stated in this specification and in related sections apply in addition to applicable federal, state and local rules and regulations. Comply with instructions of coating manufacturer and requirements of insurance underwriters.

C. Follow handling and application practices of SSPC-PA Guide 10, and Coating Manufacturer's Material Safety Data Sheet.

1.05 SUBMITTALS

A. Submit coating manufacturer's catalog sheets, product data sheets, material data sheets and other manufacturer's information for all material provided. Include manufacturer's recommendation and instructions for surface preparation, application and curing.

B. Quality Control Submittals. Furnish the following:

1. Shop and field applicator’s experience with list of references substantiating compliance. Submit references of five successful projects completed within the last three years for each applicator. Each project listed should be at least 500 linear feet in length, unless otherwise approved by Project Manager.

2. Monitoring records for shop coated pipe, including coating “affidavit of compliance” to requirements of this Section stating that coatings were applied in factory, in accordance with manufacturer’s requirements, and AWWA C222.
3. Factory applied coatings: Coating manufacturer’s certification stating that the individual coating applicators have met the qualification certification requirements as specified in this Section.

4. Upon request by Project Manager, provide:
   a. Manufacturer’s coating application Quality Control Manual
   b. Coating Performance Test report with statement that no reformulations have been made subsequent to the coating tests performed for the report.
   c. Current test equipment calibration certificates

5. Provide administrative documents showing that QA/QC personnel in both shop and field are certified as NACE International Coating Inspector (Level III).

6. Field applied coatings: Environmental monitoring records.

1.06 QUALITY ASSURANCE

A. Shop and Field Coating Applicator’s Experience and Certification:
   1. Minimum 5 years’ practical experience in application of the specified products required for Coating Applicator and the coating application supervisor (Certified Applicator).
   2. Minimum 2 years’ practical experience in application of the specified coating system required for Coating application personnel whom have direct coating application responsibility.
   3. Certification by coating manufacturer as an approved coating applicator required for Coating Applicator.

B. Shop: Unless otherwise approved by Project Manager, coating manufacturer’s technical representative to be present for a minimum of three calendar days for technical assistance and instruction at the start of coating operations within the shop. During this visit, technical representative to observe surface preparation and coating application, and conduct or observe tests of coating to ensure conformance with application instructions, recommended methods, and conditions.

1.07 DELIVERY, STORAGE, AND HANDLING

A. Use standard closed containers to prevent gelling, thickening deleteriously or forming of gas within period of one year from date of manufacture.

B. Label each container of separately packaged component clearly and durably to indicate date of manufacture, manufacturer’s batch number, quantity, color, component identification and designated name or formula specification, number of coatings together with special instructions. Do not use coating components older than one year.
C. Deliver coating materials to pipe manufacturer in sealed containers showing designated name, batch number, color, date of manufacture and name of coating manufacturer.

D. Store material onsite in enclosures, out of direct sunlight in warm, ventilated and dry area. Protect from freezing.

E. Prevent puncture, inappropriate opening or other action which may lead to product contamination.

1.08 OBSERVATION OF WORK

A. Provide minimum 14 days advance notice to Project Manager before start of coating or lining work to allow for scheduling of shop or field observation.

B. Provide full access to Project Manager for all facilities and documentation regarding surface preparation, environmental conditions and coating applications.

C. Observation by Project Manager or waiver of observation does not relieve Contractor of his responsibility to perform work in accordance with Specifications.

D. Materials are subject to testing for conformance with this specification.

E. Project Manager may retain services of independent, third-party NACE CIP Level III- Certified Inspector for partial or full-time inspection of the work.

PART 2 - PRODUCT

2.01 GENERAL

A. Supply coating material in new, undamaged, labeled, unopened containers clearly and durably displaying date of manufacture, manufacturer’s batch number, component identification, component color, manufacturer’s name and product name. Store and handle in accordance with manufacturer’s written instructions. Discard coating material that exceeds manufacturer’s recommended shelf life, or is stored improperly, prior to usage, and replace with new material.

B. Clean, prime, and coat surfaces of pipe and fittings in accordance with referenced standards, written instructions by coating manufacturer, and these specifications.

C. Provide coating materials from single manufacturer. Product substitutions during project are not permitted without approval from Project Manager.

2.02 COATING MATERIAL

A. Coating System: ASTM D16 Type V thermoset, aromatic polyurethane plastic polymer in accordance with AWWA C222 (referred to as a polyurethane system).
B. Acceptable Materials:

1. DuraShield 210, 310 (External), DuraShield 210-61 NSF, 310-61 NSF (Internal), by LifeLast Inc., Pflugerville, TX,
2. Protec II (External), Protec II PW (Internal) by ITW PolySpec/Futura Coatings, Houston, TX,
3. Polyclad 777PL (External), Polyclad 767 (Internal) by Carboline, St. Louis, MO,
4. or approved equal.

C. Cured Coating Properties. In accordance with AWWA C222 except as follows:

1. ASTM E 96 Permeance using Water Procedure BW (App. X1): no more than 0.16 inch-lb.

2.03 SURFACE PREPARATION

A. The requirements listed below are for surface preparation procedures in the factory. For surface preparation in the field, refer to Part 3 – Execution.

B. Steel Pipe. In accordance with coating manufacturer’s requirements.

C. Ductile Iron Pipe. Prepare surface in accordance with manufacturer’s recommendations and NAPF 500-03.

1. Provide uncoated ductile iron pipe when polyurethane coatings are used. Do not apply asphaltic coating to ductile iron pipe and then attempt to remove prior to polyurethane coating application.
2. Do not apply surface preparation that is designed for steel pipe to ductile iron pipe. Unlike steel surfaces, it is possible to over blast the external surface of ductile iron pipe. Consult ductile iron pipe and polyurethane coating manufacturer regarding method of application and surface preparation to be used.

2.04 FACTORY APPLICATION OF POLYURETHANE

A. Equipment: As required by manufacturer.

B. Temperature: Minimum 5 degrees F above dew point temperature. Temperature of surface shall not be less than 50 degrees F during application or as per manufacturers recommendation.

C. Humidity: Heating of pipe surfaces may be required when relative humidity exceeds 80 percent.

D. Do not thin or mix resins; use as received. Store resins at temperature above 55 degrees F at all times, or as manufacturers recommendation.
E. Application: Conform to coating manufacturer's recommendations. Apply directly to substrate to achieve specified thickness. Multiple-pass, one-coat application process is permitted provided maximum allowable recoat time specified by coating manufacturer is not exceeded.

F. Recoat only when coating has cured less than maximum time specified by coating manufacturer. When coating has cured for more than recoat time, follow coating manufacturers recommendations for recoating.

G. Cure and perform cure test in accordance with manufacturer's recommendations prior to handling, inspection, testing, and placement in service.

2.05 FACTORY INSPECTION

A. Project Manager may inspect coatings at coating applicator's facilities.

B. Inspection procedures to be in accordance with AWWA C222. Conduct inspection any time after coating has reached initial cure. Repair in accordance with manufacturer's requirements and these specifications.

C. Remove rejected coating from the full length of pipe to bare metal and reapply using proper application methods.

2.06 HOLDBACK COATING SYSTEM

A. Provide holding primer for corrosion protection of cutbacks or holdbacks compatible with specified joint coating system and weld after backfilling requirements, where applicable.

B. Holdback coating to prevent corrosion of prepared pipe ends for duration of storage and construction and recommended for buried exposures.

C. Primer should not result in running or melting of coating and causing toxic fumes when heated during welding on weld after backfilling joints.

D. Apply holding primer in accordance with primer manufacturer's recommendations, but maintain clearances required for proper joint installation as recommended by pipe manufacturer.

E. Ductile Iron Joints: Apply coating to unlined pipe surfaces including inside of bell socket and outside of spigot. Coating thickness on sealing areas of spigot end of pipe exterior: minimum 8 mils (0.008 inch), maximum of 10 mils (0.010 inch). Maximum 10 mils may be exceeded in spigot end provided maximum spigot diameter as specified by pipe manufacturer is not exceeded and approved by pipe manufacturer.

F. Welded joints:
1. Field welded on the inside: Provide four-inch coating holdback on spigot end and six-inch coating holdback on bell end.

2. Field welded on the outside: Provide six-inch coating holdback on the spigot end, and four-inch coating holdback on the bell end.

2.07 THICKNESS

A. External Coatings: Minimum DFT of 25 mils (0.025 inch).


C. Thickness Determinations: Use Type 1 magnetic thickness gauge as described in SSPC-PA2 specification. No single gauge reading may be less than specified thickness.

D. Do not accept pipe with deficient coating thickness. If pipe in field is found to have a coating thickness as measured by SSPC PA-2 that is less than the specified thickness, the pipe segment shall be rejected.

2.08 FACTORY REPAIR OF INTERNAL AND EXTERNAL COATINGS

A. The procedures listed below are for repairs made to internal and external coatings in the factory. For field repairs, see Part 3 – Execution.

B. Defect size is defined as follows: Minor – less than 6 inches by greatest dimension. Major – exceeds 6 inches by greatest dimension.

C. General

1. Repair areas where holidays are detected or coating is visually damaged, such as blisters, bubbles, cuts, or other defects.

2. Provide coating repair materials that are compatible with the shop-applied coating system and approved by coating manufacturer.

3. Provide repair materials as required for the coating system and repair classification.

D. Repair Materials:

1. Provide polyurethane, single use kits that are supplied by parent coating manufacturer.

2. For major repairs in the shop, reapply using plural component spray equipment by a manufacturer certified coating applicator.

E. For internal coatings, five repairs maximum allowed per 100 square feet of pipe for internal linings. If this number is exceeded, pipe must be stripped of lining, reblasted, and recoated in factory.
PART 3 - EXECUTION

3.01 FIELD ENVIRONMENTAL CONTROLS

A. General

1. Do not apply coatings when:
   a. Surface or ambient temperatures exceed the maximum or minimum temperatures recommended by the coating manufacturer.
   b. In dust or smoke-laden atmosphere, blowing dust or debris, or under conditions that can cause icing on metal surface.
   c. When it is expected surface temperatures may drop below 5 degrees above dew point within 4 hours after application of coating.
   d. Whenever relative humidity exceeds 85 percent, or the maximum recommended by the coating manufacturer.

2. When weather conditions dictate, provide and operate heaters and dehumidification equipment to allow pipe surfaces to be prepared and coated as specified and in accordance with the manufacturers coating application recommendations.

3. Do not proceed with surface preparation and coating application activities until adequate temperature and humidity controls are in place and functioning within environmental limits specified.

4. Monitor ambient temperature, relative humidity, dew point, temperature, and pipe surface temperature (work area only) in strict conformance with manufacturer’s requirements, but not greater than 5 hours between measurements. Document and submit environmental monitoring records to Project Manager upon completion, if requested.

3.02 PIPE INSTALLATION

A. When required by Project Manager, provide services of pipe manufacturer’s representative for period of not less than 2 weeks at beginning of actual pipe laying operations to advise Contractor regarding installation including but not limited to handling and storing, cleaning and inspecting, coatings repairs, and general construction methods as to how they may affect pipe coatings.

B. When required by Project Manager, coating manufacturer’s technical representative to provide a written report to the Project Manager for each visit. Include copies of test data collected, description of observations, and all recommended corrective actions. Submit within five working calendar days after the visit. After corrective actions are complete, representative to certify application complies with manufacturer's coating application recommendations.

C. Use nylon straps, padded lifts and padded storage skids. Field cuts should be kept to minimum. Repair damage to coating due to handling or construction practices.
D. Just before each section of pipe is to be placed into trench, conduct visual and holiday inspection in accordance with AWWA C222. Repair defects in coating system before pipe is installed.

E. For field-welded joints, drape minimum 18-inch wide strip of heat-resistant material over top half of pipe on each side of the coating holdback to protect from weld spatter.

F. Provide transition from cement mortar lining to polyurethane lining in accordance with coating manufacturer’s recommendations and as approved by Project Manager.

3.03 FIELD REPAIR AND TOUCHUP

A. Apply repair and touchup materials in conformance with manufacturer’s recommendations.

B. Repair Procedure – Joints:

1. External Joints. Metal surface must be free of all dirt, dust, and surface corrosion prior to sleeve application. Where corrosion in the holdback area is visible, prepare surface in accordance with SSPC-SP11, Power Tool Cleaning to Bare Metal for steel pipe, or NAPF 500-03-03 Power Tool Cleaning for ductile iron pipe.

2. Internal Joints. Prepare surface and provide environmental controls in accordance with manufacturer’s recommendations.
   a. Remove oil or grease by solvent wiping pipe and adjacent coating in accordance with SSPC-SP1, Solvent Cleaning.
   b. Clean pipe surface in accordance with SSPC-SP11, Power Tool Cleaning to Bare Metal or abrasively blast in the field in accordance with SSPC-SP10, Near-White Metal Blast Cleaning. Clean the full circumference of the pipe and feather the edges of the existing polyurethane coating a minimum of two inches.
   c. Remove loose or damaged pipe lining at joint and repair as specified herein or extend joint lining.
   d. Apply lining material by hand or spray equipment. Provide material that is compatible with shop lining and approved by manufacturer.
   e. Provide a NACE Level II or III inspector experienced with the applied coating system to inspect surface preparation of the joint lining and document application conditions. Submit documentation to Project Manager.

C. Repair Procedure – Field Defects:

1. Repair Materials (subject to Project Manager’s approval):
   a. Heat-applied repair patches
b. Single use polyurethane coating kits that control mix ratios

c. Coating manufacturer’s polyurethane coating repair products

2. Repair Procedures:

a. Solvent clean in accordance with SSPC-SP1 for steel pipe or NAPF 500-03-01 for ductile iron pipe.

b. Power tool clean in accordance with SSPC-SP11 for steel pipe and NAPF 500-03-03 for ductile iron pipe. Feather the coating and provide overlap in accordance with a manufacturer’s recommendations.

c. Apply repair material as described above in accordance with manufacturer’s recommendations.

d. If a heat-applied repair patch is used, do not overlap patches or use more than one patch for a single repair. If repair area exceeds the size of a single patch, use alternate repair method as listed above.

D. Repair Procedure - Thermite Brazed Connection Bonds:

1. Remove polyurethane coating with power wire brush from area on metal surface which is to receive thermite brazed connection.

2. Grind metal surface to shiny metal with power grinder and coarse grit grinding wheel.

3. Apply thermite-brazed connection using equipment, charge and procedure recommended by manufacturer of thermite equipment.

4. Drape minimum 18-inch wide strip of heat-resistant material over top half of pipe on all sides during welding to protect from weld spatter.

5. After welded surface has cooled to temperature below 130 degrees F, apply protective coating repair material to weld, exposed pipe surface and damaged areas of polyurethane coating. A heat-applied repair patch may be used as approved by Project Manager.

6. Do not cover or backfill freshly repaired areas of coating at thermite-brazed connection until repair material has completely cured. Allow material to cure in conformance with manufacturer's recommendations.

END OF SECTION
PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Polyethylene wrap to be used in open-cut construction for cast iron and ductile iron pipe when cathodic protection system is not required by Drawings.

1.02 MEASUREMENT AND PAYMENT

A. No separate payment will be made for work under this Section. Contractor will include all costs of the requirements of this Section in the appropriate bid item(s) on the Bid Form.

1.03 REFERENCE

A. ASTM D 1248 - Polyethylene Plastics Molding and Extrusion Materials.

B. AWWA C 105 - Polyethylene Encasement for Ductile-Iron Piping Systems.

1.04 SUBMITTALS

A. Submit product data in accordance with the Special Conditions.

B. Submit product data for proposed film and tape for approval.

PART 2 - PRODUCTS

2.01 MATERIALS

A. Polyethylene Film: Tubular or sheet form without tears, breaks, holidays, or defects; conforming with requirements of AWWA C 105, 2.5 to 3 percent carbon black content, either low- or high-density:

1. Low-density polyethylene film. Low-density polyethylene film shall be manufactured of virgin polyethylene material conforming to the following requirements of ASTM D 1248.

a. Raw material:

1) Type: I
2) Class: C (black)
3) Grade: E-5
4) Flow rate (formerly melt index): 0.4 g/10 minute, maximum
5) Dielectric strength: Volume resistivity, 1015 ohm-cm, minimum

b. Physical properties:
1) Tensile strength: 1200 psi, minimum  
2) Elongation: 300 percent, minimum  
3) Dielectric strength: 800 V/mil thickness, minimum  

c. Thickness: Low-density polyethylene film shall have a normal thickness of 0.008 inch. The minus tolerance on thickness is 10 percent of the nominal thickness.  

2. High-density, cross-laminated polyethylene film. High-density, cross laminated polyethylene film shall be manufactured of virgin polyethylene material conforming to the following requirements of ASTM D 1248  
a. Raw material:  
   1) Type: III  
   2) Class: C (black)  
   3) Grade: P33  
   4) Flow rate (formerly melt index): 0.4 to 0.5g/10 minute, maximum  
   5) Dielectric strength: Volume resistivity, 1015 ohm-cm, minimum  

b. Physical properties:  
   1) Tensile strength: 5000 psi, minimum  
   2) Elongation: 100 percent, minimum  
   3) Dielectric strength: 800 V/mil thickness, minimum  

c. Thickness: Film shall have a nominal thickness of 0.004 inch. The minus tolerance of thickness is 10 percent of the nominal thickness.  

B. Polyethylene Tape: Provide 3-inch-wide, plastic-backed, adhesive tape; Paleocene No. 900, Scotchwrap No. 50, or approved equal.  

PART 3 - EXECUTION  

3.01 PREPARATION  

A. Remove lumps of clay, mud, and cinders from pipe surface prior to installation of polyethylene encasement. Prevent soil or embedment material from becoming trapped between pipe and polyethylene.  

B. Fit polyethylene film to contour of pipe to affect a snug, but not tight fit; encase with minimum space between polyethylene and pipe. Allow sufficient slack in contouring to prevent stretching polyethylene where it bridges irregular surfaces, such as bell-spigot interfaces, bolted joints, or fittings, and to prevent damage to polyethylene due to backfilling operations. Secure overlaps and ends with adhesive tape to hold polyethylene encasement in place until backfilling operations are complete.
3.02 INSTALLATION

A. Tubular Type (Method A):

1. Cut polyethylene tube to a length approximately 2 feet longer than pipe section. Slip tube around pipe, centering tube to provide 1-foot overlap on each adjacent pipe section and bunching it accordion-fashion lengthwise until it clears pipe ends.

2. Lower pipe into trench and make up pipe joint with preceding section of pipe. Make shallow bell hole at joints to facilitate installation of polyethylene tube.

3. After assembling pipe joint, make overlap of polyethylene tube. Pull bunched polyethylene from preceding length of pipe, slip it over end of adjoining length of pipe, and secure in place. Then slip end of polyethylene from adjoining pipe section over end of first wrap until it overlaps joint at end of preceding length of pipe. Secure overlap in place. Take up slack width at top of pipe to make a snug, but not tight, fit along barrel of pipe, securing fold at quarter points.

4. Repair cuts, tears, punctures, or other damage to polyethylene. Proceed with installation of next section of pipe in same manner.

B. Tubular Type (Method B):

1. Cut polyethylene tube to a length approximately 1 foot shorter than pipe section. Slip tube around pipe, centering it to provide 6 inches of bare pipe at each end. Take up slack width at top of pipe to make a snug, but not tight, fit along barrel of pipe, securing fold at quarter points; secure ends.

2. Before making up joint, slip 3-foot length of polyethylene tube over end of preceding pipe section, bunching in accordion-fashion lengthwise. After completing joint, pull 3-foot length of polyethylene over joint, overlapping polyethylene previously placed on each adjacent section of pipe by at least 1 foot; make each end snug and secure.

3. Repair cuts, tears, punctures, or other damage to polyethylene. Proceed with installation of next section of pipe in same manner.

C. Sheet Type:

1. Cut polyethylene sheet to a length approximately 2 feet longer than pipe section. Center length to provide 1-foot overlap on each adjacent pipe section, bunching sheet until it clears pipe ends. Wrap polyethylene around pipe so that sheet circumferentially overlaps top quadrant of pipe. Secure cut edge of polyethylene sheet at intervals of approximately 3 feet.
2. Lower wrapped pipe into trench and make up pipe joint with preceding section of pipe. Make shallow bell hole at joints to facilitate installation of polyethylene. After completing joint, make overlap and secure ends.

3. Repair cuts, tears, punctures, or other damage to polyethylene. Proceed with installation of next section of pipe in same manner.

D. Pipe-shaped Appurtenances: Cover bends, reducers, offsets, and other pipe-shaped appurtenances with polyethylene in same manner as pipe.

E. Odd-shaped Appurtenances: When it is not practical to wrap valves, tees, crosses, and other odd-shaped pieces in tube, wrap with flat sheet or split length of polyethylene tube by passing sheet around appurtenance and encasing it. Make seams by bringing edges together, folding over twice, and taping down. Tape polyethylene securely in place at valve stem and other penetrations.

F. Openings in Encasement: Create openings for branches, service taps, blow offs, air valves, and similar appurtenances by making an X-shaped cut in polyethylene and temporarily folding back film. After appurtenance is installed, tape slack securely to appurtenance and repair cut, as well as other damaged area in polyethylene, with tape. Service taps may also be made directly through polyethylene, with any resulting damaged areas being repaired as specified.

G. Junctions between Wrapped and Unwrapped Pipe: Where polyethylene-wrapped pipe joins an adjacent pipe that is not wrapped, extend polyethylene wrap to cover adjacent pipe for distance of at least 3 feet. Secure end with circumferential turns of tape. Wrap service lines of dissimilar metals with polyethylene or suitable dielectric tape for minimum clear distance of 3 feet away from cast or ductile iron pipe.

3.03 REPAIRS

A. Repair any cuts, tears, punctures, or damage to polyethylene with adhesive tape or with short length of polyethylene sheet or cut open tube, wrapped around pipe to cover damaged area, and secured in place.

END OF SECTION
PART 1 - GENERAL

1.01 SECTION INCLUDES
A. Gravity pipelines and appurtenances.

1.02 MEASUREMENT AND PAYMENT
A. Unit Prices.
   1. No separate payment will be made for work required under this Section. Contractor will include all costs of the requirements of this Section in the appropriate bid item(s) on the Bid Form.
B. Stipulated Price (Lump Sum). If Contract is Stipulated Price Contract, payment for work in this Section is included in total Stipulated Price.

1.03 SUBMITTALS
A. Submit proposed methods, equipment, materials and sequence of operations for sewer construction. Plan operations to minimize disruption of utilities to occupied facilities or adjacent property.
B. Test Reports: Submit test reports and inspection videos as specified in Part 3 of this Section. Videos become property of the Owner.

1.04 QUALITY ASSURANCE
A. Qualifications: Install a pipeline that is watertight both in pipe-to-pipe joints and in pipe-to-manhole connections. Perform testing in accordance with Section 02533 - Acceptance Testing for Pipelines.
B. Regulatory Requirements:
   1. Make notification to the Engineer if water lines are uncovered during pipeline installation where the minimum separation distance of 9 feet cannot be maintained.
   2. Lay gravity pipelines in straight alignment and grade.

1.05 PRODUCT DELIVERY, STORAGE, AND HANDLING
A. Inspect pipe and fittings upon arrival of materials at the job site.
B. Handle and store pipe materials and fittings to protect them from damage due to impact, shock, shear or free fall. Do not drag pipe and fittings along the ground. Do not roll pipe unrestrained from delivery trucks.
C. Use mechanical means to move or handle pipe. Employ acceptable clamps, rope or slings around the outside barrel of pipe and fittings. Do not use hooks, bars, or other devices in contact with the interior surface of the pipe to lift or move lined pipe.

D. Pipe shall be handled and stored per manufacture recommendations.

PART 2 - PRODUCTS

2.01 PIPE

A. Provide piping materials for gravity pipelines of the sizes and types indicated on the Drawings or as specified.

B. Unlined reinforced concrete pipe is not acceptable.

C. Pipe shall be color coded green.

2.02 PIPE MATERIAL SCHEDULE

A. Unless otherwise shown on the Drawings, use pipe materials that conform to requirements specified in one or more of the following Sections:

1. Section 02506 - Polyvinyl Chloride Pipe.
2. Section 02532 –Force Mains.

B. Where shown on the Drawings, provide pipe meeting the minimum class, dimension ratio, or other criteria indicated.

C. Pipe materials other than those listed above shall not be used for gravity pipelines.

2.03 BEDDING, BACKFILL, AND TOPSOIL MATERIAL

A. Bedding and Backfill: Conform to requirements of Section 02317 – Excavation, Trenching, Backfilling for Utilities and Section 02320 - Utility Backfill Material.

B. Topsoil: Conform to requirements of Section 02911 – Topsoil.

PART 3 - EXECUTION

3.01 PREPARATION

A. Prepare traffic control plans and set up street detours and barricades in preparation for excavation when construction will affect traffic.

B. Provide barricades, flashing warning lights, and warning signs for excavations. Maintain barricades and warning lights where work is in progress or where traffic is affected by work.
C. Perform work in accordance with OSHA standards. Employ trench safety system as specified in Section 01561 - Trench Safety System for excavations over 5 feet deep.

D. Immediately notify agency or company owning utility line if damaged, broken or disturbed. Obtain approval from Project Manager and agency or utility company for repairs or relocations, either temporary or permanent.

E. Remove old pavements and structures including sidewalks and driveways.

F. Install and operate dewatering and surface water control measures in accordance with Section 01578 – Control of Ground Water and Surface Water.

G. Do not allow sand, debris or runoff to enter sewer system.

3.02 DIVERSION PUMPING

A. Install and operate required bulkheads, plugs, piping, and diversion pumping equipment to maintain sewage flow and to prevent backup or overflow. Obtain approval for diversion pumping equipment and procedures from the Engineer.

B. Design piping, joints and accessories to withstand twice the maximum system pressure or 50 psi, whichever is greater.

C. In event of accidental spill or overflow, immediately stop overflow and take action to clean up and disinfect spillage. Promptly notify Project Manager so that required reporting can be made to Texas Commission on Environmental Quality and Environmental Protection Agency by Project Manager.

3.03 EXCAVATION

A. Earthwork: Conform to requirements of Section 02317 – Excavation, Trenching, and Backfilling for Utilities. Use bedding as indicated on Drawings.

B. Line and Grade: Establish the required uniform line and grade in the trench from benchmarks identified by the Engineer. Maintain this control for a minimum of 100 feet behind and ahead of the pipe-laying operation. Use laser beam equipment to establish and maintain proper line and grade of the work. Use of appropriately sized grade boards, which are substantially supported, is also acceptable. Protect the boards and location stakes from damage or dislocation.

C. Trench Excavation: Excavate pipe trenches to depths shown on Drawings and as specified in Section 02317 – Excavation, Trenching, and Backfilling for Utilities.

3.04 PIPE INSTALLATION BY OPEN CUT

A. Install pipe in accordance with the pipe manufacturer's recommendations and as specified in the following paragraphs.
B. Install pipe only after excavation is completed, bottom of trench fine graded, bedding material is installed, and trench has been approved by Project Manager.

C. Install pipe to the line and grade indicated. Place pipe so that it has continuous bearing of barrel on bedding material and is laid in the trench so that the interior surfaces of the pipe follow the grades and alignment indicated. Provide bell holes where necessary.

D. Install pipe with spigot ends toward downstream end of flow such that water flows into bell and out the spigot.

E. Form a concentric joint with each section of adjoining pipe to prevent offsets.

F. Keep interior of pipe clean as installation progresses. Remove foreign material and debris from pipe.

G. Provide lubricant, place and drive home newly laid sections with come-a-long winches to eliminate damage to sections. Install pipe to "home" mark where provided. Use of back hoes or similar powered equipment will not be allowed unless protective measures are provided and approved in advance by Project Manager.

H. Keep excavations free of water during construction and until final inspection.

I. When work is not in progress, cover the exposed ends of pipes with an approved plug to prevent foreign material from entering the pipe.

J. Where the length of stubs is not indicated, install a 4-foot length and seal the free end with an approved plug.

3.05 PIPE INSTALLATION OTHER THAN OPEN CUT

A. For installation of pipe by augering, jacking, or tunneling, conform to requirements of specification sections on tunneling augering, jacking and microtunneling work as appropriate.

3.06 INSTALLATION OF APPURTENANCES

A. Construct manholes to conform to requirements of Section 02081 - Cast-in-Place Concrete Manholes and Section 02082 - Precast Concrete Manholes, as applicable. Install frames, rings, and covers to conform to requirements of Section 02084 - Frames, Grates, Rings, and Covers.

3.07 INSPECTION AND TESTING

A. Visual Inspection: Check pipe alignment in accordance with Section 02533 - Acceptance Testing for Pipelines.

B. Mandrel Testing: Use a Mandrel Test to test flexible pipe for deflection. Refer to Section 02533 - Acceptance Testing for Pipelines.
C. Pipe Leakage Test. After backfilling a line segment and prior to tie-in of service connections, visually inspect gravity pipelines where feasible, and test for leakage in accordance with Section 02533 - Acceptance Testing for Pipelines. Maintain piezometer installed to conform with Section 01578 - Control of Ground Water and Surface Water, until acceptance testing is completed.

3.08 BACKFILL AND SITE CLEANUP

A. Backfill and compact soil in accordance with Section 02317 – Excavation, Trenching, and Backfill for Utilities.

B. Backfill trench in specified lifts only after pipe installation is approved by Project Manager.

C. Repair and replace removed or damaged pavement, curbs, gutters, and sidewalks.

D. Provide hydro-mulch seeding in areas of commercial, industrial or undeveloped land use over surface of ground disturbed during construction and not paved or not designated to be paved. Grade surface at uniform slope to natural grade as indicated on Drawings. Provide minimum of 4 inches of topsoil as specified in Section 02911 - Topsoil and apply hydro-mulch according to requirements of Section 02921 – Hydro-mulch Seeding.

E. Provide sodding in areas of residential land use over surface of ground disturbed during construction and not paved or not designated to be paved. Grade surface at uniform slope to natural grade as indicated on Drawings. Provide minimum of 4 inches of topsoil per Section 02911 - Topsoil.

3.09 POST-INSTALLATION TELEVISION INSPECTION

A. Prior to final acceptance of newly constructed gravity pipelines, perform cleaning and closed-circuit television inspection.

B. Upon completion of video review, Contractor will be notified regarding final acceptance of pipe segment.

END OF SECTION
SECTION 02532
FORCE MAINS

PART 1 - GENERAL

1.01 SECTION INCLUDES
A. Force mains.

1.02 MEASUREMENT AND PAYMENT
A. No separate payment will be made for work required under this Section. Contractor will include all costs of the requirements of this Section in the appropriate bid item(s) on the Bid Form.

1.03 REFERENCE STANDARDS
A. ACI 318 - Building Code Requirements for Reinforced Concrete.
B. ASTM D 696 - Standard Test Method for Coefficient of Linear Expansion of Plastics Between -30 degrees C and 30 degrees C.
C. ASTM D 1248 - Polyethylene Plastics Molding and Extrusion Materials.
G. ASTM D 2992 - Standard Practice for Obtaining Hydrostatic or Pressure Design Basis for "Fiberglass" (Glass-Fiber Reinforced Thermosetting-Resin) Pipe and Fittings.
K. Uni-Bell UNI-B-3 Polyvinyl Chloride (PVC) Pressure Pipe (complying with AWWA C 900).
1.04 SUBMITTALS

A. Submit proposed methods, equipment, materials, and sequence of operations for force main construction. Plan operations to minimize disruption of utilities to occupied facilities or adjacent property.

B. Submit shop drawings and design calculations for joint restraint systems using reinforced concrete encasement of pressure pipe and fittings.

C. Submit qualifications, proposed methods, equipment, materials, and sequence for acceptance testing of the pipeline. Submit evidence of experience with pipeline proving by pigging for at least three projects of equal or greater scope; project list shall include dates, size and length of pipe, location, owner name, contact person, and telephone number. Provide certificate of training by the manufacturer of the pigging equipment being used.

D. Submit test reports as specified in Part 3 of this Section.

PART 2 - PRODUCTS

2.01 PVC PIPE

A. Conform to requirements of Section 02506 - PVC Pipe.

2.02 THRUST RESTRAINT

A. Unless otherwise shown on the Drawings, provide fully bi-directional restrained PVC pipe with Fusible PVC or Restrained Joint Integral Bell PVC pipes.

B. Unless otherwise shown on the Drawings, provide concrete thrust blocking for force mains up, to prevent movement of buried lines under pressure at bends, tees, caps, and valves. Blocking shall be Portland cement concrete, as specified in Section 03300 – Cast in Place Concrete. Place concrete in accordance with details on the Drawings. Place thrust blocks between undisturbed ground and the fittings. Anchor fittings to thrust blocks so that pipe and fitting joints are accessible for repairs. Concrete shall extend from 6 inches below the pipe or fitting to 12 inches above.

C. For force mains larger than 12 inches in diameter, and where indicated on the Drawings, provide restrained joints conforming to the requirements of the force main pipe material specifications. Restrained joints shall be installed for the length of pipe on both sides of each bend or fitting for the full length shown on the Drawings.

D. Horizontal and vertical bends between zero- and 10-degrees deflection angle on pipes smaller than will not require thrust blocks or harnessed or restrained joints.

E. Horizontal and vertical bends between 10 degrees and 90 degrees deflection angle shall have thrust restraint as shown on the Drawings.
F. Provide thrust restraint at tees, plugs, blow off drains, valves, and caps, as indicated.

G. Reinforced concrete encasement of force main pipe and fittings may be used in lieu of manufactured joint restraint systems. Alternate joint restraint systems using reinforced concrete encasement shall conform to the following design requirements.

1. Design calculations shall be performed and sealed by a Professional Engineer licensed in the State of Texas.

2. Design calculations shall be based upon soil parameters quantified in the geotechnical report for the site where the alternative thrust restraint system is to be installed. If data is not available for the site, use parameters recommended by the geotechnical engineer.

3. The design system pressure shall be the specified test pressure.

4. The following safety factors shall be used in sizing the restraint system:
   a. Apply a factor of safety equal to 1.5 for passive soil resistance.
   b. Apply a factor of safety equal to 2.0 for soil friction.

5. The encasement shall be contained entirely within the standard trench width and terminate on both ends at a pipe bell or coupling.

6. Concrete encasement reinforcement steel shall be designed for all loads, including internal pressure and longitudinal forces. Concrete design shall be in accordance with ACI 318.

PART 3 - EXECUTION

3.01 PIPE INSTALLATION BY OPEN-CUT

A. Perform excavation, bedding, and backfill in accordance with Section 02317 – Excavation, Trenching, and Backfill for Utilities.

B. Wrap ductile-iron pipe and fittings with polyethylene. Polyethylene wrap shall not be installed on ductile iron pipe protected by a cathodic protection system.

C. Install pipe in accordance with the pipe manufacturer's recommendations and as specified in the following paragraphs.

D. Install pipe only after excavation is completed, the bottom of the trench is fine graded, bedding material is installed, and the trench has been approved by the Engineer.

E. Install pipe to the line and grade indicated. Place pipe so that it has continuous bearing of barrel on bedding material and is laid in the trench so that the interior surfaces of the pipe follow the grades and alignment indicated. Provide bell holes where necessary.
F. Install pipe with the spigot ends toward the direction of flow. Form a concentric joint with each section of adjoining pipe to prevent offsets.

G. Keep the interior of pipe clean as the installation progresses. Where cleaning after laying the pipe is difficult because of small pipe size, use a suitable swab or drag in the pipe and pull it forward past each joint immediately after the joint has been completed. Remove foreign material and debris from the pipe.

H. Provide lubricant, place and drive home newly laid sections with come-a-long winches so as to eliminate damage to sections. Install pipe to "home" mark where provided. Use of backhoes or similar powered equipment will not be allowed unless protective measures are provided and approved in advance by the Engineer.

I. Keep excavations free of water during construction and until final inspection.

J. When work is not in progress, cover the exposed ends of pipes with an approved plug to prevent foreign material from entering the pipe.

K. Where force main is to be installed under an existing water line with a separation distance of less than 2 feet, install one full joint length of pipe centered on the water line and maintain a minimum 6-inch separation distance.

3.02 PIPE INSTALLATION OTHER THAN OPEN-CUT

A. For installation of pipe by auguring, jacking, or tunneling, conform to requirements of specification section of auguring or tunneling work.

3.03 HYDROSTATIC TESTING

A. After the pipe and appurtenance have been installed, test line and drain. Prevent damage to the Work or adjacent areas. Use clean water to perform tests.

B. The Engineer may direct tests of relatively short sections of completed lines to minimize traffic problems or potential public hazards.

C. Test pipe in the presence of the Engineer.

D. Test pipe at 150 psig or 1.5 times design pressure of the pipe, whichever is greater. Design pressure of the force main shall be the rated total dynamic head of the lift station pump.

E. Test pipe at the required pressure for a minimum of 2 hours according to requirements of Uni-B-3.

F. Maximum allowable leakage shall be as calculated by the following formula:

\[
L = \frac{(S)(D)(P^{0.5})}{133,200}
\]

Where: \(L\) = Leakage in gallons per hour.
\[ S = \text{Length of pipe in feet.} \]
\[ D = \text{Inside diameter of pipe in inches.} \]
\[ P = \text{Pressure in pounds per square inch.} \]

G. Correct defects, cracks, or leakage by replacement of defective items or by repairs as approved by the Engineer.

H. Plug openings in the force main after testing and flushing. Use cast iron plugs or blind flanges to prevent debris from entering the tested pipeline.

3.04 PIGGING TEST

A. After completion of hydrostatic testing and prior to final acceptance, test force mains longer than 200 feet by pigging to ensure piping is free of obstructions.

B. Pigs: Provide proving pigs manufactured of an open-cell polyurethane foam body, without any coating or abrasives which would scratch or otherwise damage interior pipe wall surface or lining. Pigs shall be able to pass through reductions of up to 65 percent of the nominal cross-sectional area of the pipe. Pigs shall be able to pass through standard fittings such as 45-degree and 90-degree elbows, crosses, tees, wyes, gate valves, or plug valves, as applicable to the force main being tested.

C. Test Execution: Pigging test shall be conducted in the presence of the Engineer. Provide at least 48-hours' notice of scheduled pigging of the force main prior to commencing the test.

END OF SECTION
PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Acceptance testing of pipelines including:
   1. Visual inspection of pipes
   2. Mandrel testing for flexible pipes.
   3. Leakage testing of pipes.
   4. Leakage testing of manholes.
   5. Smoke testing of point repairs.

B. All tests listed in this Section are not necessarily required on this Project. Required tests are named in other Sections, which refer to this Section for testing criteria and procedures.

1.02 MEASUREMENT AND PAYMENT

A. No separate payment will be made for work under this Section. Contractor will include all costs of the requirements of this Section in the appropriate bid item(s) on the Bid Form.

1.03 REFERENCES


B. ASTM C 924 - Standard Practice for Testing Concrete Pipe Sewer Lines by Low Pressure Air Test Method.

C. ASTM D 3034 - Standard Specification for Type PSM Polyethylene (Vinyl Chloride) (PVC) Sewer Pipe and Fittings.

D. ASTM F 794 - Specification for Polyvinyl Chloride Large-Diameter Ribbed Gravity Sewer Pipe and Fittings Based on Controlled Inside Diameter.


F. 30 TAC 317.2 - Design Criteria for Sewage Systems.

G. Uni-Bell UNI-B-3 Polyvinyl Chloride (PVC) Pressure Pipe (Complying with AWWA C 900).
1.04 PERFORMANCE REQUIREMENTS

A. Gravity flow pipes are required to have a straight alignment and uniform grade between manholes.

B. Flexible pipe, including “semi-rigid” pipe, is required to show no more than 5 percent deflection. Test pipe no sooner than 30 days after backfilling of a line segment but prior to final acceptance using a standard mandrel to verify that installed pipe is within specified deflection tolerances.

C. Maximum allowable leakage for Infiltration or Exfiltration

1. The total exfiltration, as determined by a hydrostatic head test, shall not exceed 50 gallons per inch diameter per mile of pipe per 24 hours at a minimum test head of 2 feet above the crown of the pipe at the upstream manhole or 2 feet above the groundwater elevation, whichever is greater.

2. When pipes are installed more than 2 feet below the groundwater level, an infiltration test shall be used in lieu of the exfiltration test. The total infiltration shall not exceed 50 gallons per inch diameter per mile of pipe per 24 hours. Groundwater elevation must be at least 2 feet above the crown of the pipe at the upstream manhole.

3. Refer to Table 02533-1, Water Test Allowable Leakage, at the end of the Section, for measuring leakage in sewers. Perform leakage testing to verify that leakage criteria are met.

D. Perform air testing in accordance with requirements of this Section and the Texas Natural Resources Conservation Commission requirements. Refer to Table 02533-2, Time Allowed for Pressure Loss From 3.5 psig to 2.5 psig, Table 02533-3, Minimum Testing Times for Low Pressure Air Test, and Table 02533-4, Vacuum Test Timetable, at the end of this Section.

1.05 SUBMITTALS

A. Test Plan: Before testing begins and in adequate time to obtain approval through the submittal process, prepare and submit a test plan for approval by Engineer. Include testing procedures, methods, equipment, and tentative schedule. Obtain advance written approval for deviations from the Drawings and Specifications.

B. Test Reports: Submit test reports for each test on each segment of pipe.

1.06 GRAVITY PIPELINE QUALITY ASSURANCE

A. Repair, correct, and retest manholes or sections of pipe which fail to meet specified requirements when tested.

B. Provide testing reports and videotape of television inspection as directed by Engineer.
C. Upon completion of tape reviews by Engineer, Contractor will be notified regarding final acceptance of the sewer segment.

1.07 SEQUENCING AND SCHEDULING

A. Perform testing as work progresses. Schedule testing so that no more than 1,000 linear feet of installed sewer remains untested at any one time.

B. Coordinate testing schedules with Engineer. Perform testing under observation of Engineer.

PART 2 - PRODUCTS

2.01 DEFLECTION MANDREL

A. Mandrel Sizing: The rigid mandrel shall have an outside diameter (O.D.) equal to 95 percent of the inside diameter (I.D.) of the pipe. The inside diameter of the pipe, for the purpose of determining the outside diameter of the mandrel, shall be the average outside diameter minus two minimum wall thicknesses for O.D. controlled pipe and the average inside diameter for I.D. controlled pipe, dimensions shall be per appropriate standard. Statistical or other "tolerance packages" shall not be considered in mandrel sizing.

B. Mandrel Design: The rigid mandrel shall be constructed of a metal or a rigid plastic material that can withstand 200 psi without being deformed. The mandrel shall have nine or more "runners" or "legs" as long as the total number of legs is an odd number. The barrel section of the mandrel shall have a length of at least 75 percent of the inside diameter of the pipe. The rigid mandrel shall not have adjustable or collapsible legs, which would allow a reduction in mandrel diameter during testing. A proving ring shall be provided and used for modifying each size mandrel.

C. Proving Ring: Furnish a "proving ring" with each mandrel. Fabricate the ring of ½-inch thick, 3-inch-wide bar steel to a diameter 0.02 inches larger than approved mandrel diameter.

D. Mandrel Dimensions (5 percent allowance): Average inside diameter and minimum mandrel diameter is specified in Table 02533-5, Pipe vs. Mandrel Diameter, at the end of this Section. Mandrels for higher strength, thicker wall pipe or another pipe not listed in the table may be used when approved by the Engineer.

2.02 EXFILTRATION TEST

A. Water Meter: Obtain a transient water meter from the Owner for use when water for testing will be taken from the Owner’s system. Conform to Owner’s requirements for water meter use.

B. Test Equipment:
1. Pipe plugs.
2. Pipe risers where the manhole cone is less than 2 feet above highest point in pipe or service lead.

2.03 INFILTRATION TEST

A. Test Equipment:

1. Calibrated 90-degree V-notch weir.
2. Pipe plugs.

2.04 LOW PRESSURE AIR TEST

A. Minimum Requirement for Equipment:

1. Control panel.
2. Low-pressure air supply connected to control panel.
3. Pneumatic plugs: Acceptable size for diameter of pipe to be tested, capable of withstanding internal test pressure without leaking or requiring external bracing.
4. Air hoses from control panel to:
   a. Air supply.
   b. Pneumatic plugs.
   c. Sealed line for pressuring.
   d. Sealed line for monitoring internal pressure.

B. Testing Pneumatic Plugs: Place a pneumatic plug in each end of a length of pipe on the ground. Pressurize plugs to 25 psig; then pressurize sealed pipe to 5 psig. Plugs are acceptable if they remain in place against the test pressure without external aids.

2.05 GROUND WATER DETERMINATION

A. Equipment: Pipe probe or small diameter casing for ground water elevation determination.

2.06 SMOKE TESTING

A. Equipment:

1. Pneumatic plugs.
2. Smoke generator as supplied by Superior Signal Company, or an approved equal.
PART 3 - EXECUTION

3.01 PREPARATION

A. Provide labor, equipment, tools, test plugs, risers, air compressor, air hose, pressure meters, pipe probe, calibrated weirs, or any other device necessary for proper testing and inspection.

B. The selection of test methods and pressures for gravity pipelines shall be determined based on ground water elevation.

3.02 VISUAL INSPECTION OF GRAVITY PIPELINES

A. Check pipe alignment visually by flashing a light between structures. Verify if alignment is true and no pipes are misplaced. In case of misalignment or damaged pipe, remove and re-lay or replace pipe segment.

3.03 MANDREL TESTING FOR GRAVITY PIPELINES

A. Perform deflection testing on flexible and semi-rigid pipe to confirm pipe has no more than 5 percent deflection. Mandrel testing shall conform to ASTM D 3034. Perform testing no sooner than 30 days after backfilling of line segment, but prior to final acceptance testing of the line segment.

B. Pull the approved mandrel by hand through sewer sections. Replace any section of sewer not passing the mandrel. Mandrel testing is not required for stubs.

C. Retest repaired or replaced pipe sections.

3.04 LEAKAGE TESTING FOR GRAVITY PIPELINES

A. Test Options:

1. Test gravity pipes for leakage by either exfiltration or infiltration methods, as appropriate, or with low pressure air testing.

2. Test new or rehabilitated manholes with water or low-pressure air. Manholes tested with low pressure air shall undergo a physical inspection prior to testing.

3. Leakage testing shall be performed after backfilling of a line segment, and prior to tie-in of service connections.

4. If no installed piezometer is within 500 feet of the sewer segment, Contractor shall provide a temporary piezometer for this purpose.

B. Compensating for Ground Water Pressure:

1. Where ground water exists, install a pipe nipple at the same time sewer line is placed. Use a 1/2-inch capped pipe nipple approximately 10 inches long. Make the installation through manhole wall on top of the sewer line where line enters manhole.
2. Immediately before performing line acceptance test, remove cap, clear pipe nipple with air pressure, and connect a clear plastic tube to nipple. Support tube vertically and allow water to rise in the tube. After water stops rising, measure height in feet of water over invert of the pipe. Divide this height by 2.3 feet/psi to determine the ground water pressure to be used in line testing.

C. Exfiltration test:
1. Determine ground water elevation.
2. Plug sewer in downstream manhole.
3. Plug incoming pipes in upstream manhole.
4. Install riser pipe in outgoing pipe of upstream manhole if highest point in service lead (house service) is less than 2 feet below bottom of manhole cone.
5. Fill sewer pipe and manhole or pipe riser, if used, with water to a point 2-1/2 feet above highest point in sewer pipe, house lead, or ground water table, whichever is highest.
6. Allow water to stabilize for one to two hours. Take water level reading to determine drop of water surface, in inches, over a one-hour period, and calculate water loss (1 inch of water in 4 feet diameter manhole equals 8.22 gallons) or measure the quantity of water required to keep water at same level. Loss shall not exceed that calculated from allowable leakage according to Table 02533-1 at the end of this Section.

D. Infiltration test: Ground water elevation must be not less than 2.0 feet above highest point of pipe.
1. Determine ground water elevation.
2. Plug incoming pipes in upstream manhole.
3. Insert calibrated 90-degree V-notch weir in pipe on downstream manhole.
4. Allow water to rise and flow over weir until it stabilizes.
5. Take five readings of accumulated volume over a period of 2 hours and use average for infiltration. The average must not exceed that calculated for 2 hours from allowable leakage according to the Table 02533-1 at the end of this Section.

E. Low Air Pressure Test: When using this test conform to ASTM C 828, ASTM C 924, or ASTM F 1417, as applicable, with holding time not less than that listed in Table 02533-2.
1. Air testing for sections of pipe shall be limited to lines less than 36-inch average inside diameter.
2. Lines 36-inch average inside diameter and larger shall be tested at each joint. The minimum time allowable for the pressure to drop from 3.5 pounds per square inch gauge to 2.5 pounds per square inch during a joint test shall be 10 seconds, regardless of pipe size.
3. For pipe sections less than 36-inch average inside diameter:
a. Determine ground water level.
b. Plug both ends of pipe. For concrete pipe, flood pipe and allow 2 hours to saturate concrete. Then drain and plug concrete pipe.
c. After a manhole-to-manhole section of main has been sliplined and prior to any service lines being connected to new liner, plug liner at each manhole with pneumatic plugs.
d. Pressurize pipe to 4.0 psig. Increase pressure 1.0 psi for each 2.3 feet of ground water over highest point in system. Allow pressure to stabilize for 2 to 4 minutes. Adjust pressure to start at 3.5 psig (plus adjustment for ground water table). See Table 02533-2 at the end of this Section.
e. To determine air loss, measure the time interval for pressure to drop to 2.5 psig. The time must exceed that listed in the Table 02533-2 at the end of this Section for pipe diameter and length. For sliplining, use diameter of carrier pipe.

F. Retest: Any section of pipe, which fails to meet requirements, shall be repaired and retested.

3.05 TEST CRITERIA TABLES

A. Exfiltration and Infiltration Water Tests: Refer to Table 02533-1, Water Test Allowable Leakage, at the end of this Section.

B. Low Pressure Air Test:

1. Times in Table 02533-2 Time Allowed for Pressure Loss From 3.5 psig to 2.5 psig, at the end of this Section, are based on the equation from Texas Natural Resources and Conservation Commission (TNRCC) Design Criteria 317.2(a)(4)(B).

\[
T = 0.0850(D)(K)/(Q)
\]

where:

\[ T \quad \text{time for pressure to drop 1.0 pounds per square inch gauge in seconds} \]

\[ K = 0.000419 \text{ DL, but not less than 1.0} \]

\[ D = \text{average inside diameter in inches} \]

\[ L = \text{length of line of same pipe size in feet} \]

\[ Q = \text{rate of loss, 0.0015 ft}^3/\text{min.}/\text{sq. ft. internal surface} \]

2. Since a K value of less than 1.0 shall not be used, there are minimum testing times for each pipe diameter as given in Table 02533-3, Minimum Testing Times for Low Pressure Air Test.
C. Notes:

1. When two sizes of pipe are involved, the time shall be computed by the ratio of lengths involved.
2. Lines with a 27-inch average inside diameter and larger may be air tested at each joint.
3. Lines with an average inside diameter greater than 36 inches must be air tested for leakage at each joint.
4. If the joint test is used, a visual inspection of the joint shall be performed immediately after testing.
5. For joint test, the pipe is to be pressurized to 3.5 psi greater than the pressure exerted by groundwater above the pipe. Once the pressure has stabilized, the minimum times allowable for the pressure to drop from 3.5 pounds per square inch gauge to 2.5 pounds per square inch gauge shall be 10 seconds.

3.06 LEAKAGE TESTING FOR MANHOLES

A. After completion of manhole construction, wall sealing, or rehabilitation, but prior to backfilling, test manholes for water tightness using hydrostatic or vacuum testing procedures.

B. Plug influent and effluent lines, including service lines, with suitably sized pneumatic or mechanical plugs. Ensure plugs are properly rated for pressures required for test, follow manufacturer’s safety and installation recommendations. Place plugs a minimum of 6 inches outside of manhole walls. Brace invert to prevent lines from being dislodged if lines entering manhole have not been backfilled.

C. Vacuum testing:

1. Install vacuum tester head assembly at top access point of manhole and adjust for proper seal on straight top section of manhole structure. Following manufacturer’s instructions and safety precautions, inflate sealing element to the recommended maximum inflation pressure; do not over-inflate.
2. Evacuate manhole with vacuum pump to 10 inches mercury (Hg), disconnect pump, and monitor vacuum for the time period specified in Table 02533-4, Vacuum Test Timetable.
3. If the drop-in vacuum exceeds 1-inch Hg over the specified time period tabulated above, locate leaks, complete repairs necessary to seal manhole and repeat test procedure until satisfactory results are obtained.

D. Hydrostatic exfiltration testing shall be performed as follows:

1. Seal wastewater lines coming into the manhole with an internal pipe plug. Then fill the manhole with water and maintain it full for at least one hour.
2. The maximum leakage for hydrostatic testing shall be 0.025 gallons per foot diameter per foot of manhole depth per hour.

Dundee State Fish Hatchery Water Reuse – Effluent Pump Back
TPWD No. 1110061R
3. If water loss exceeds amount tabulated above, locate leaks, complete repairs necessary to seal manhole and repeat test procedure until satisfactory results are obtained.

3.07 SMOKE TEST PROCEDURE FOR POINT REPAIRS

A. Application: Perform smoke test to:

1. Locate points of line failure for point repair.
2. Determine if point repairs are properly made.
3. Determine if service connections have been reconnected to the rehabilitated sewer.
4. Check integrity of connections to newly replaced service taps to liners and to existing private service connections.

B. Limitations: Do not backfill service taps until completion of this test. Test only those taps in a single manhole section at any one time. Keep the number of open excavations to a minimum.

C. Preparation: Prior to smoke testing, give written notices to area residents no fewer than 2 days, nor more than 7 days, prior to proposed testing. Also give notice to local Police and Fire Departments 24 hours prior to actual smoke testing.

D. Isolate Section: Isolate the manhole section to be tested from adjacent manhole sections to keep smoke localized. Temporarily seal the annular space at manhole for slip lined sections.

E. Smoke Introduction:

1. Operate equipment according to manufacturer's recommendation and as approved by Engineer.
2. Conduct test by forcing smoke from smoke generators through pipeline main and service connections. Operate smoke generators for a minimum of 5 minutes.
3. Introduce smoke into upstream and downstream manhole as appropriate. Monitor the tap/connection for smoke leaks. Note sources of leaks.

F. Repair and Retest: Repair and replace any taps or connections noted as leaking and then retest. Taps and connections may be left exposed in only one manhole section at a time. If repair or replacement, testing or retesting, and backfilling of the excavation is not completed within one workday, properly barricade and cover each excavation as approved by Engineer.

G. Service Connections: On houses where smoke does not issue from plumbing vent stacks to confirm reconnection of sewer service to the newly installed liner pipe, perform a dye test to confirm reconnection. Introduce dye into the service line through a plumbing fixture inside the structure or a sewer cleanout.
immediately outside the structure and flush with water. Observe flow at service reconnection or downstream manhole. Detection of dye confirms a reconnection.

### Table 02533-1
**WATER TEST ALLOWABLE LEAKAGE**

<table>
<thead>
<tr>
<th>DIAMETER OF RISER OR STACK (INCHES)</th>
<th>VOLUME PER INCH OF DEPTH</th>
<th>ALLOWANCE LEAKAGE*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inch</td>
<td>Gallons</td>
<td>Pipe Size (Inches)</td>
</tr>
<tr>
<td>1</td>
<td>0.7854</td>
<td>6</td>
</tr>
<tr>
<td>2</td>
<td>3.1416</td>
<td>8</td>
</tr>
<tr>
<td>2.5</td>
<td>4.9087</td>
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<td>12.5664</td>
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<tr>
<td>5</td>
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<td>6</td>
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<td>8</td>
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<td>157.0808</td>
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</tr>
<tr>
<td>18</td>
<td>213.1326</td>
<td>42</td>
</tr>
</tbody>
</table>

For other diameters, multiply square of diameters by value for 1" diameter. Equivalent to 50 gallons per inch of inside diameter per mile per 24 hours.

*Allowable leakage rate shall be reduced to 10 gallons per inch of inside diameter per mile per 24 hours, when sewer is identified as located within the 25-year flood plain.

### Table 02533-2
**ACCEPTANCE TESTING FOR PIPELINES**

<table>
<thead>
<tr>
<th>Pipe Dia.(in)</th>
<th>Min.Time (min:sec)</th>
<th>Length for Min. Time (ft)</th>
<th>Time for Longer Length (sec)</th>
<th>Specification Time for Length (L) Shown (min:sec)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
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<td>6</td>
<td>5:40</td>
<td>398</td>
<td>0.8548</td>
<td>5:40</td>
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<tr>
<td>8</td>
<td>7:33</td>
<td>298</td>
<td>1.5196</td>
<td>7:30</td>
</tr>
<tr>
<td>15</td>
<td>14:10</td>
<td>159</td>
<td>5.3423</td>
<td>14:10</td>
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<td>18</td>
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<td>133</td>
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<td>31:10</td>
<td>72</td>
<td>25.8565</td>
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### Table 02533-3
MINIMUM TESTING TIMES FOR LOW PRESSURE AIR TEST

<table>
<thead>
<tr>
<th>PIPE DIAMETER (inches)</th>
<th>MINIMUM TIME (seconds)</th>
<th>LENGTH FOR MINIMUM TIME (feet)</th>
<th>TIME FOR LONGER LENGTH (seconds)</th>
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<tr>
<td>6</td>
<td>340</td>
<td>398</td>
<td>0.855 (L)</td>
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<td>8</td>
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<td>33</td>
<td>1870</td>
<td>72</td>
<td>25.856 (L)</td>
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### Table 02533-4
VACUUM TEST TIMETABLE

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<th>DEPTH IN FEET</th>
<th>TIME IN SECONDS BY PIPE DIAMETER</th>
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<tr>
<td></td>
<td>48”</td>
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<tr>
<td>4</td>
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<td>24</td>
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<tr>
<td>*</td>
<td>5.0</td>
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*Add T times for each additional 2-foot depth. (The values listed above have been extrapolated from ASTM C 924-85)
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<thead>
<tr>
<th>Material and Wall Construction</th>
<th>Nominal Size (Inches)</th>
<th>Average I.D. (Inches)</th>
<th>Minimum Mandrel Diameter (Inches)</th>
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<td>PVC-Solid (SDR 26)</td>
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<td>60</td>
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<td>57.361</td>
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SECTION 02911
TOPSOIL

PART 1 - GENERAL
1.01 SECTION INCLUDES
A. Furnishing and placing topsoil for finish grading and for seeding, sodding, and planting.

1.02 MEASUREMENT AND PAYMENT
A. Unless indicated in the BID FORM as a pay item, no separate payment will be made for work performed under this section. Include cost of work performed under this section in pay items of which this work is a component.

PART 2 - PRODUCTS
2.01 TOPSOIL
A. Topsoil shall be fertile, friable, natural sandy loam surface soil obtained from excavation or borrow operations having the following characteristics, tested and verified by a reputable lab:

1. pH value of between 5.5 and 6.5
2. Liquid limit: 50 or less
3. Plasticity index: 20 or less.
4. Gradation: maximum of 10 percent passing the No. 200 sieve.

B. Topsoil shall be reasonably free of subsoil, clay lumps, weeds, non-soil materials, and other litter or contamination. Topsoil shall not contain roots, stumps, and stones larger than 2 inches.

C. Obtain topsoil from naturally well drained areas where topsoil occurs at a minimum depth of 4 inches and has similar characteristics to that found at the placement site. Do not obtain topsoil from areas infected with a growth of, or reproductive parts of nut grass or other noxious weeds.

PART 3 - EXECUTION
3.01 EXAMINATION
A. Verify that excavation and embankment operations have been completed to correct lines and grades.
3.02 PLACEMENT

A. For areas to be seeded or sodded, scarify or plow existing material to a minimum depth of 4 inches, or as indicated on the Drawings. Remove vegetation and foreign inorganic material. Place 4 inches of topsoil on loosened material and roll lightly with an appropriate lawn roller to consolidate topsoil.

B. Increase depth of topsoil to 6 inches when placed over sand bedding and backfill materials.

C. For areas to receive shrubs or trees, excavate existing material and place topsoil to the depth and dimensions shown on the PLANS.

D. Remove spilled topsoil from curbs, gutters, and paved areas and dispose of excess topsoil in any legal manner.

3.03 PROTECTION

A. Protect topsoil from wind and water erosion until planting is completed.

END OF SECTION
SECTION 02921
HYDROMULCH SEEDING

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Scope: The work covered by this section consists of furnishing all plant, labor, materials, equipment, supplies, supervision and tools, and performing all work necessary for topsoiling smoothing, seeding, fertilizing, watering, maintenance, and cleanup of all areas disturbed during construction.

B. General: The hydromulch seeding operations, together with all other necessary related work, to conform to the requirements specified in this section. The area to be hydromulch seeded to be noted on PLANS.

1.02 MEASUREMENT AND PAYMENT

A. Unless indicated in the BID FORM as a pay item, no separate payment will be made for work performed under this section. Include cost of work performed under this section in Contract prices bid for items of which this work is a component.

B. Payment for hydromulch seeding will include and be full compensation for all labor, equipment, materials, supervision, and all incidental expenses for construction of these items, complete in place.

1.03 SUBMITTALS

A. Submit certification from supplier that each type of seed conforms to these specifications and the requirements of the Texas Seed Law. Certification shall accompany seed delivery.

B. Submit a certificate stating that fertilizer complies with these specifications and the requirements of the Texas Fertilizer Law.

PART 2 - PRODUCTS

2.01 MATERIALS

A. Topsoil shall be reasonably free of subsoil, clay lumps, weeds, non-soil materials, and other litter or contamination. Topsoil shall not contain roots, stumps, and stones larger than 2 inches.

B. Topsoil shall be fertile, friable, natural sandy loam surface soil having the following characteristics, tested and verified by a reputable lab:

1. pH value of between 5.5 and 6.5
2. Liquid limit: 50 or less
3. Plasticity index: 20 or less
4. Gradation: maximum of 10 percent passing the No. 200 sieve

C. Seed: Conform to U.S. Department of Agriculture rules and regulations of the Federal Seed Act and the Texas Seed Law. Use seed that has been treated with an approved fungicide. Container labels should show locality and date of harvest, percent purity, percent germination, name and type of seed, and sources of origin. Seed shall be certified 90 percent pure and furnish 80 percent germination and meet the following requirements:

1. Rye: Fresh, clean, Italian rye grass seed (Lolium multi-florum), mixed in labeled proportions. As tested, minimum percentages of impurities and germination must be labeled. Deliver in original unopened containers.
2. Bermuda: Extra-fancy, treated, lawn type common Bermuda (Cynodon dactylon). Deliver in original, unopened container showing weight, analysis, name of vendor, and germination test results.
3. Wet, moldy, or otherwise damaged seed will not be accepted.
4. Seed requirements, application rates, and planting dates are:

<table>
<thead>
<tr>
<th>Type A</th>
<th>Application Rate</th>
<th>Planting Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hullled Common Bermuda Grass</td>
<td>30</td>
<td>Oct. 1 to Apr. 15</td>
</tr>
<tr>
<td>Unhulled Common Bermuda Grass</td>
<td>20</td>
<td>Oct. 1 to Apr. 15</td>
</tr>
<tr>
<td>Annual Rye Grass (Gulf) or KY-31 Tall Fescue</td>
<td>15</td>
<td>Oct. 1 to Apr. 15</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Type B</th>
<th>Application Rate</th>
<th>Planting Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hullled Common Bermuda Grass</td>
<td>60</td>
<td>Apr. 15 to Oct. 1</td>
</tr>
<tr>
<td>Foxtail Millet</td>
<td>15</td>
<td>Apr. 15 to Oct. 1</td>
</tr>
</tbody>
</table>

D. Fertilizer: Dry and free flowing, inorganic, water-soluble commercial fertilizer, which is uniform in composition. Deliver in unopened containers, which bear the manufacturers, guaranteed analysis. Caked, damaged, or otherwise unsuitable fertilizer will not be accepted. Fertilizer shall contain minimum percentages of the following elements:

1. Nitrogen: 10 Percent
2. Phosphate: 20 Percent
3. Potash: 10 Percent
4. Application Rate: 300 pounds per acre except during the periods of April 15 through June 15, when the rate shall be increased to 400 pounds per acre.
E. Mulch:

1. Provide commercial quality wood fiber mulch consisting of wood mulch made from recovered wood materials.
2. Rate of application to be 2,000 pounds per acre.
3. Provide organic biodegradable tackifier manufactured from muciloids or guar gum. Apply at a rate recommended by the manufacturer.
4. Other soil binder compounds may be applied at the direction of the Owner.

PART 3 - EXECUTION

3.01 PREPARATION

A. Provide erosion and sedimentation control systems at the locations shown on PLANS. Such systems shall be of the type indicated and shall be constructed in accordance with the requirements shown on PLANS and set out in this section.

B. No clearing and grubbing or rough cutting, other than as specifically directed by the Owner to allow soil testing and surveying, shall be permitted until erosion and sedimentation control systems are in place.

C. Maintain existing erosion and sedimentation control systems located within the project site installed by others prior to start of construction under this contract until directed by the Owner to remove and discard the existing systems.

D. Inspect and repair or replace components of all erosion and sedimentation control systems as specified for each type of system. Unless otherwise directed, maintain the erosion and sedimentation control systems until the project is accepted by the Owner. Remove erosion and sedimentation control systems promptly when directed by the Owner. Discard removed materials offsite.

E. Remove and dispose of sediment deposits at the project spoil site. If a project spoil site is not designated on PLANS, dispose of sediment offsite at location not in or adjacent to stream or floodplain. Off-site disposal will be the responsibility of the Contractor. Sediment to be placed at the project site should be spread, compacted and stabilized in accordance with the Owner’s directions. Sediment shall not be allowed to flush into stream or drainage way. If sediment has been contaminated, it needs to be disposed of in accordance with existing federal, state and local regulations.

F. Equipment and vehicles shall be prohibited by the Contractor from maneuvering on areas outside of dedicated rights-of-way and easements for construction. Damages caused by construction traffic to erosion and sedimentation control systems shall be repaired immediately.

G. Contractor shall employ protective measures described in Section 01572 - Source Controls for Erosion and Sedimentation to avoid damage to existing trees
to be retained on the project site. Conduct all construction operations under this Contract in conformance with the erosion practices described in that section.

3.02 APPLICATION

A. After areas to receive hydromulch seeding have been completed to lines, grades, and sections shown on PLANS, apply seed, fertilizer and mulch at uniform average rates indicated in this section.

B. Weed Control Agent: Apply at manufacturer's recommended rate prior to hydromulching.

C. Suspend operations under conditions of drought, excessive moisture, high winds, or extreme or prolonged cold. Obtain Owner approval before resuming operations.

3.03 MAINTENANCE

A. Maintain grassed areas a minimum of 90 days, or as required to establish an acceptable turf. For areas seeded in the fall, continue maintenance the following spring until an acceptable turf is established. An acceptable turf area is when at least 70% of the seeded area is established.

B. Inspect seeded area at least once every 14 calendar days and within 24 hours of the end of a storm event of 0.5 inches or greater; or at a minimum of once every seven (7) calendar days.

C. Repair or replace damaged areas.

END OF SECTION
PART 1   GENERAL

1.01   DESCRIPTION

A. Scope:

1. CONTRACTOR shall provide all labor, materials, equipment, and incidentals as shown, specified, and required to furnish and install concrete forming. The Work also includes:

   a. Designing forming systems in accordance with requirements of ACI 347 and the Contract Documents.
   b. Providing forming to accommodate the Work under this and other Sections and building into forming items such as sleeves, anchorage devices, inserts, pipe embedments, reinforcing, and all other items to be embedded in concrete for which placement is not specifically provided under other Sections.

B. Coordination:

1. Review installation procedures under this and other Sections and coordinate installation of items that must be installed with or before concrete forming Work.

2. Coordinate forming Specifications with requirements for finished surfaces specified in Section 03300, Cast-In-Place Concrete.

C. Related Sections:

1. Section 03251, Concrete Accessories.

2. Section 03300, Cast-In-Place Concrete.

1.02   REFERENCES

A. Standards referenced in this Section are:

1. ACI 117, Specifications for Tolerances for Concrete Construction and Materials and Commentary.

2. ACI 301, Specifications for Structural Concrete.

3. ACI 347, Guide to Formwork for Concrete.

4. ASTM C805/C805M, Test Method for Rebound Number of Hardened Concrete.

5. ASTM C1074, Practice for Estimating Concrete Strength by the Maturity Method.
1.03 QUALITY ASSURANCE

A. Qualifications:

1. Professional Engineer:

   a. CONTRACTOR or formwork Supplier shall retain a registered professional engineer legally qualified to practice in same state as the Site. Professional engineer shall have at least five years experience designing formwork and falsework of the type required.

   b. Responsibilities include:

      1) Reviewing formwork and falsework performance and design criteria stated in the Contract Documents.
      2) Preparing written requests for clarifications or interpretations of performance or design criteria for submittal to ENGINEER by CONTRACTOR.
      3) Preparing or supervising preparation of design calculations verifying compliance of formwork and falsework with requirements of the Contract Documents.
      4) Signing and sealing all calculations.
      5) Certifying that:

         a) Design of formwork and falsework was performed in accordance with performance and design criteria stated in the Contract Documents, and
         b) Design conforms to all Laws and Regulations, and to prevailing standards of practice.

1.04 SUBMITTALS

A. Action Submittals: Submit the following:

1. Samples:

   a. Plywood form material used for smooth form finish, four inches square minimum.

B. Informational Submittals: Submit the following:

1. Shop Drawings: When requested by ENGINEER, submit Shop Drawings showing and indicating general construction of individual forms, including:

   a. Jointing.
   b. Special formed joints or reveals.
   c. Location, pattern, and details of form tie placement, removal, and repair procedures.
   d. Location and details for temporary openings.
   e. Other items that would visually affect the finished concrete.
2. Design of Temporary Measures: Design of formwork and falsework is CONTRACTOR’s responsibility. Submit the following:

a. Falsework layout drawings with the seal and signature of CONTRACTOR’s or Supplier’s professional engineer. Layout drawings shall show bracing details, waler arrangements, location of shores, joint forming details, and details at connections to previously placed concrete. ENGINEER’s review will be for general conformance to the requirements of the Contract Documents and ACI 347, as indicated for delegated design in the General Conditions.

b. Design calculations for formwork and falsework, when requested by ENGINEER.

c. Certification letter from CONTRACTOR’s or Supplier’s professional engineer stating that in-place falsework was inspected and complies with the intent of the falsework design.

3. Product Data: Manufacturer’s data for proprietary materials, including form coatings, manufactured form systems, ties and accessories.

4. Manufacturer’s Instructions: Installation instructions for proprietary materials, including form coatings, manufactured form systems, ties and accessories.

1.05 PRODUCT DELIVERY, STORAGE AND HANDLING

A. Delivery and Storage:

1. Upon delivery to the Site, place materials in area protected from weather.

2. Store materials in accordance with manufacturer’s recommendations.

3. Store materials above ground on framework or blocking. Cover wood for forms and other accessory materials with protective, waterproof covering. Provide for adequate air circulation or ventilation under cover.

B. Handle materials in accordance with the manufacturers’ recommendations. Do not damage materials during handling.

PART 2 PRODUCTS

2.01 SYSTEM PERFORMANCE

A. Design Criteria:

1. Design, erect, support, brace and maintain forming in accordance with ACI 347 so that forming safely supports vertical and lateral loads that might be applied, until such loads can be supported by the concrete structure. Carry vertical and lateral loads to ground by forming system or in-place construction that has attained adequate strength for the purpose. Construct forming so that concrete members and structures are of correct size, shape, alignment, elevation, and position.
2. Design forms and falsework to include values of live load, dead load, weight of moving equipment operated on forming, concrete mix, height of concrete drop, vibrator frequency, ambient temperature, foundation pressures, stresses, lateral stability, and other factors pertinent to safety of structure during construction.

3. Provide shores and struts with positive means of adjustment capable of taking up forming settlement during concrete placing operations, using wedges or jacks, or a combination thereof. Provide trussed supports when adequate foundations for shores and struts cannot be secured.

4. Support form facing materials by structural members spaced sufficiently close to prevent beyond tolerance deflection, in accordance with ACI 117. Fit forms placed in successive units for continuous surfaces to accurate alignment, free from irregularities and within allowable tolerances. For long-span members without intermediate supports, provide camber in forming as required for anticipated deflections resulting from weight and pressure of fresh concrete and construction loads.

5. Design and construct forming to be readily removable without impact, shock or damage to concrete surfaces and adjacent materials.

6. Provide forming sufficiently tight to prevent leakage of cement paste during concrete placing. Solidly butt joints and provide backup material at joints as required to prevent leakage and fins.

2.02 FORM MATERIALS

A. Forms for Smooth Finish Concrete:

1. Unless otherwise shown or indicated in the Contract Documents, construct forming for smooth concrete surfaces with plywood, metal, metal-framed plywood-faced, or other panel type materials acceptable to ENGINEER, to provide continuous, straight, smooth as-cast surfaces with no wood grain or other surface texture imparted by forming. Provide in largest practical sizes to minimize number of joints and to conform to joint system shown or specified in the Contract Documents. Provide form material with sufficient thickness to withstand pressure of newly placed concrete without bow or deflection.

B. Forms for Standard Finish Concrete:

1. Form concrete surfaces designated to have standard formed finish with plywood, lumber, metal, or other acceptable material. Provide lumber that is dressed on at least two edges and one side.

C. Form Ties:

1. Provide factory-fabricated metal form ties, designed to prevent form deflection, and to prevent spalling of concrete surfaces upon removal.
2. Unless otherwise shown or indicated in the Contract Documents, provide ties so that portion of tie remaining within concrete after removal of exterior parts of tie is at least 1.5 inches from the outer concrete surface. Unless otherwise shown or indicated in the Contract Documents, provide form ties that will leave a hole no larger than one-inch diameter in concrete surface.

3. Ties shall have waterstops on all exterior, below-grade walls, and walls subject to hydrostatic pressure.

4. Ties shall leave a uniform, circular hole when forms are removed.

5. Do not use removable ties unless accepted by ENGINEER. Removable ties are not allowed on exterior below-grade walls or walls subject to hydrostatic pressure. If removable ties are accepted, CONTRACTOR shall submit hole repair details for ENGINEER approval.

6. Wire ties are not allowed.

7. Do not use reinforcing bars shown by the Drawings as part of the form tie system unless approved by ENGINEER.

D. Form Coatings:

1. Provide commercial formulation form-coating compounds that will not bond with, stain, nor adversely affect concrete surfaces, and will not impair subsequent treatment of concrete surfaces requiring bond or adhesion, nor impede wetting of surfaces to be cured with water or curing compounds. For concrete surfaces that will be in contact with potable water or water that will be treated to become potable, form coating shall be a mineral oil base coating.

PART 3 EXECUTION

3.01 INSPECTION

A. Examine substrate and conditions under which the Work will be performed and notify ENGINEER in writing of unsatisfactory conditions. Do not proceed with the Work until unsatisfactory conditions are corrected.

3.02 FORM CONSTRUCTION

A. Construct forms in accordance with ACI 347; to the exact sizes, shapes, lines, and dimensions shown; as required to obtain accurate alignment, location, and grades; to tolerances specified; and to obtain level and plumb work in finish structures. Provide for openings, offsets, keyways, recesses, moldings, rustications, reglets, chamfers, blocking, screeds, bulkheads, anchorages and inserts, and other features required. Use selected materials to obtain required finishes. Finish shall be in accordance with approved mock-up or sample panel, when specified.
B. Allowable Tolerances:

1. Construct forming to provide completed concrete surfaces complying with tolerances specified in ACI 117, ACI 301, and ACI 347.
   a. Architectural finish forming, and where shown or indicated on the Drawings, shall be Class A surface, 1/8-inch offset.
   b. Other surfaces exposed to view shall be Class B surface, 1/4-inch offset.
   c. Other surfaces shall be Class C surface, 1/2-inch offset.

2. Tolerances apply to form offsets and to irregularities within the formed surface when measured with a straightedge over a five-foot distance.

C. Install forming and accessories for facilities in accordance with manufacturer’s instructions, Laws and Regulations, and the Contract Documents.

D. Fabricate forms for easy removal without damaging concrete surfaces. Provide crush plates or wrecking plates where stripping may damage cast concrete surfaces. Provide top forms for inclined surfaces where the slope is too steep to place concrete with bottom forms only. Kerf wood inserts for forming keyways, reglets, recesses, and the like, to prevent swelling and assure ease of removal.

E. Provide temporary openings where interior area of forming is inaccessible for cleanout, for inspection before concrete placement, and for placing concrete. Brace temporary closures and set tightly to forms to prevent loss of cement paste. Locate temporary openings on forms in locations as inconspicuous as possible, consistent with requirements of the Work. Form intersecting planes of openings to provide true, clean-cut corners, with edge grain of plywood not exposed as form for concrete.

F. Falsework:

1. Erect falsework and support, brace, and maintain falsework to safely support vertical, lateral, and asymmetrical loads applied until such loads can be supported by in-place concrete structures. Construct falsework so that adjustments can be made for take-up and settlement.

2. Provide wedges, jacks or camber strips to facilitate vertical adjustments. Carefully inspect falsework and formwork during and after concrete placement operations to determine abnormal deflection or signs of failure; make necessary adjustments to produce finished Work of required dimensions.

G. Forms for Smooth Finish Concrete:

1. Do not use metal cover plates for patching holes or defects in forms.

2. Provide sharp, clean corners at intersecting planes, without visible edges or offsets. Back joints with extra studs or girts to maintain true, square intersections.
3. Use extra studs, walers, and bracing to prevent bowing of forms between studs and to avoid bowed appearance in concrete. Do not use narrow strips of form material that will produce bow.

4. Assemble forms so they may be readily removed without damage to exposed concrete surfaces.

5. Form molding shapes, recesses, rustication joints and projections with smooth-finish materials, and install in forms with sealed joints to prevent displacement.

H. Corner Treatment:

1. Form exposed corners of beams, walls, foundations, bases and columns to produce smooth, solid, unbroken lines, except as otherwise shown or indicated in the Contract Documents. Chamfer exposed corners.

2. Form chamfers with 3/4-inch by 3/4-inch strips, unless otherwise shown or indicated in the Contract Documents, accurately formed and surfaced to produce uniformly straight lines and tight edge joints. Use rigid PVC chamfers for architecturally formed concrete. Extend terminal edges to required limit and miter chamfer strips at changes in direction.

3. Reentrant or internal and unexposed corners may be formed either square or chamfered.

I. Joints:

1. For joint treatment, comply with Section 03251, Concrete Accessories. Locate joints as shown and specified.

J. Openings and Built-In Work:

1. Provide openings in concrete forming shown or required under other Sections or other contracts. Refer to Paragraph 1.01B of this Section for coordination requirements.

2. Accurately place and securely support items to be built into forms.

K. Sealing Forming:

1. Forming joints shall be tight-fitting or otherwise sealed to prevent loss of cement paste.

2. Provide forming resting against concrete surfaces with compressible gasket material between the concrete and edge of form, to fill irregularities and create tight seal.

L. Cleaning and Tightening:
1. Thoroughly clean forms and adjacent surfaces to receive concrete. Remove chips, wood, sawdust, dirt, and other debris just before concrete is placed. Retighten forms immediately after placing concrete, as required to eliminate cement paste leaks.

M. Tie Hole Repair:

1. Repair tie holes in accordance with Section 03300, Cast-In-Place Concrete.

3.03 FORM COATINGS

A. Coat form contact surfaces with non-staining form-coating compound before installing reinforcing materials. Do not allow excess form coating material to accumulate in forms or come into contact with surfaces that will be bonded to fresh concrete. Apply in compliance with manufacturer's instructions.

B. Coat steel forms with non-staining, rust-preventative form oil, or otherwise protect against rusting. Do not use rust-stained steel forming.

C. For concrete surfaces that will be in contact with potable water or water that will be treated to become potable, form coating shall be mineral-oil base coating.

3.04 INSTALLATION OF EMBEDDED ITEMS

A. Set and build into forming anchorage devices and other embedded items, shown, specified, or required under other Sections. Refer to Paragraph 1.01B of this Section for coordination requirements. Use necessary setting drawings, diagrams, instructions, and directions.

B. Edge Forms and Screeds Strips for Slabs:

1. Set edge forms or bulkheads and intermediate screed strips for slabs to obtain required elevations and contours in finished slab surface. Provide and secure units to support screeds.

3.05 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. Before placing concrete, check ties, tie cones, tie waterstops, embedded items, form coatings, forming stability, alignment, and tolerances. Make corrections and adjustments to ensure forming complies with intent of the forming design, proper stability of forming systems, and accurate size and location of concrete members.

2. During concrete placing, check forming and related supports to ensure that forms are not displaced and that completed Work will be within specified tolerances.
3. If forms are unsatisfactory in any way, either before or during concrete placing, stop or postpone placing of concrete until defects are corrected as required by CONTRACTOR’s or Supplier’s professional engineer and accepted by ENGINEER.

3.06 REMOVAL OF FORMS

A. Determination of time between placing concrete and removing forms is CONTRACTOR’s responsibility. Requirements specified in this Section are minimum times and requirements intended to ensure that concrete will support its own weight, and do not consider additional effects of the construction. Additional effects of the construction shall be accounted for by CONTRACTOR when determining time for removing forming. Time for removing of forms is subject to ENGINEER’s acceptance.

B. Comply with requirements of ACI 301 and ACI 347, except as indicated in the Contract Documents.

C. Removal of Forms for Walls, Columns, Sides of Beams and Girders, and Slab and Foundation Edges:

1. Comply with requirements of the table below:

<table>
<thead>
<tr>
<th>Component</th>
<th>Average Daily Ambient Air Temperature (deg F)</th>
<th>Min. Concrete Compressive Strength for Form Removal</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Over 70 F</td>
<td>60 F to 70 F</td>
</tr>
<tr>
<td>Walls</td>
<td>One day</td>
<td>Two days</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Three days</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Columns</td>
<td>Two days</td>
<td>Three days</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Four days</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Side of beams and girders</td>
<td>One day</td>
<td>One day</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Two days</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Slab and foundation edges</td>
<td>One day</td>
<td>One day</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Two days</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

2. When average daily ambient air temperature is below 50 degrees F, do not remove forms until concrete attains minimum compressive strength indicated in the table above for form removal, and comply with Paragraph 3.06.C.3.b of this Section.

3. Concrete Strength Requirements for Form Removal:

a. For other than beams and elevated slabs, do not remove forms until concrete attains minimum concrete compressive strength indicated in Table 03100-A for form removal.

b. For beams and elevated slabs, do not remove supporting forms or shoring until concrete attains minimum of 90 percent of its specified compressive strength.
D. Alternative Criteria for Removing Forms for Walls, Columns, Sides of Beams and Girders, and Slab and Foundation Edges: CONTRACTOR has the option of submitting an alternative removal of forms table, together with supporting data, for ENGINEER’s acceptance. Supporting data shall include representative field data for each different placement ambient temperature condition and minimum of three tests per temperature condition to ensure that accurate correlation between concrete strength and placement temperature is obtained.

E. Determination of In-place Concrete Strength:

1. Determine compressive strength of in-place concrete by compression test specimens cured at the Site under the same conditions of temperature and moisture as the concrete member under consideration.

2. Alternately, determine compressive strength of in-place concrete by maturity factor procedure in accordance with ASTM C1074 and approved by ENGINEER. Location of embedded thermistors or thermocouples shall be as approved by ENGINEER.

F. When high-early strength concrete is used, time for removing the forms will be developed at the Site from the age/strength relationships established for the materials and proportions used by tests in accordance with ACI 301.

G. Continue curing, including bottom surfaces of slabs and beams, after form removal in accordance with Section 03300, Cast-In-Place Concrete.

3.07 PERMANENT SHORES

A. Provide permanent shores in accordance with ACI 347.

B. Reshores are not allowed.

3.08 RE-USE OF FORMS

A. Clean and repair surfaces of forms to be re-used in the construction. Do not use split, frayed, delaminated, or otherwise damaged form facing material. Apply form coating compound material to concrete contact surfaces as specified for forming.

B. When forms are extended for successive concrete placement, thoroughly clean surfaces, remove fins and laitance, and tighten forms to close all joints. Align and secure joints to avoid offsets. Do not use "patched" forms for exposed concrete surfaces. Form surfaces are subject to ENGINEER’s approval.

END OF SECTION
SECTION 03200
CONCRETE REINFORCING

PART 1 GENERAL

1.01 DESCRIPTION

A. Scope:

1. CONTRACTOR shall provide all labor, materials, equipment, and incidentals as shown, specified, and required to furnish and install concrete reinforcing.

2. Extent of concrete reinforcing is shown and indicated in the Contract Documents.

3. Work includes fabrication and placement of reinforcing including bars, ties, and supports, and welded wire fabric for concrete, encasements, and fireproofing.

B. Related Sections:

1. Section 03251, Concrete Accessories.

2. Section 05051, Anchor Systems.

1.02 REFERENCES

A. Standards referenced in this Section are:

1. ACI 315, Details and Detailing of Concrete Reinforcement.

2. ACI 318, Building Code Requirements for Structural Concrete.

3. ACI 350, Code Requirements for Environmental Engineering Concrete Structures.


5. ASTM A82, Specification for Steel Wire, Plain, for Concrete Reinforcement.

6. ASTM A185, Specification for Steel Welded Wire Reinforcement, Plain, for Concrete.

7. ASTM A615, Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement.

8. ASTM A706, Specification for Low-Alloy Steel Deformed and Plain Bars for Concrete Reinforcement.


1.03 QUALITY ASSURANCE

A. Qualifications:

1. Testing Laboratory: Shall meet requirements of ASTM E329 and shall have experience in the testing welded splices of reinforcing steel and tension testing of reinforcing bars set in adhesive in hardened concrete.

2. Installer of Adhesive Dowels: Shall be experienced and certified by manufacturer of adhesive as possessing necessary training for installing manufacturer’s products. Distributors or manufacturer’s representatives shall not provide product training unless qualified as certified trainers by anchor manufacturer.

B. Certifications:

1. Weld Procedures: For types of splices and grades of reinforcing used in the Work, weld procedures for welded reinforcing steel splices shall be certified in accordance with ANSI/AWS D1.4.

2. Welders: For types of splices and grades of reinforcing used in the Work, welders shall be certified for welding reinforcing steel splices in accordance with ANSI/AWS D1.4.

1.04 SUBMITTALS

A. Action Submittals: Submit the following:

1. Shop Drawings:

   a. Drawings for fabricating, bending, and placing concrete reinforcing. Comply with ACI 315, Parts A and B.

   b. For walls, show elevations at minimum scale of 1/4-inch to one foot.

      1) Elevations shall show all openings and reference details that identify additional reinforcing required around each opening.

      2) Elevations shall denote each wall intersection and reference a detail that identifies additional reinforcing required at wall intersection. As an alternate to providing separate details for each wall intersection, provide overall plan detailing only the additional wall intersection reinforcing for each wall intersection.
c. For slabs and mats, show top and bottom reinforcing on separate plan views.

1) Plans shall show all openings and shall reference details that identify additional reinforcing around each opening.

d. Show bar schedules, stirrup spacing, diagrams of bent bars, location of bar splices, length of lap splices, arrangements, and assemblies, as required for fabricating and placing concrete reinforcing unless otherwise noted.

e. Splices shall be kept to a minimum. Avoid, when possible, splices in regions of maximum tensile stresses.

f. Drawings detailing location of all construction and expansion joints, as required under Section 03251, Concrete Accessories, shall be submitted and approved before Shop Drawings for reinforcing are submitted.

g. Drawings detailing location, spacing, edge distance, and embedment depth of adhesive dowels. Adhesive system shall be submitted and approved before Shop Drawings with adhesive dowels are submitted.

2. Product Data:

a. Manufacturer’s product data for adhesive, if not submitted under other Sections.

b. Adhesive manufacturer’s test data and ICC ES report to verify specified capacity of adhesive dowels.

B. Informational Submittals: Submit the following:

1. Certificates:

a. Steel manufacturer’s certificates of mill analysis, tensile, and bend tests for reinforcing steel.

b. Certification of welders and weld procedures for splices.

c. Adhesive manufacturer’s certification verifying that installer is qualified and using proper installation procedures.

2. Manufacturer’s Instructions:

a. Installation instructions for adhesive systems.

3. Special Procedure Submittals; Description of reinforcing weld locations and weld procedures.

1.05 DELIVERY, HANDLING, AND STORAGE

A. Deliver concrete reinforcing products to Site bundled, tagged, and marked. Use metal tags indicating bar size, lengths, and other information corresponding to markings on approved Shop Drawings.

B. Store concrete reinforcing products to prevent damage and accumulation of dirt and excessive rust. Store on heavy wood blocking so that reinforcing does not come into contact with the ground.
PART 2 PRODUCTS

2.01 MATERIALS

A. Reinforcing Bars: Shall be deformed in accordance with ASTM A615, and as follows:

1. Provide Grade 60 for all bars, unless indicated otherwise.

2. At beams and columns forming frames and wall boundary elements, where shown on the Drawings, provide ASTM A706 or ASTM A615, Grade 60, with tested actual maximum yield stress of 78,000 psi and ratio of actual tested tensile strength to
tested yield strength not less than 1.25.

B. Mechanical Couplers: Reinforcement bars may be spliced with mechanical connection. Connection shall be full mechanical connection that shall develop in tension or compression, as required, at least 125 percent of specified yield strength (fy) of bar in
correspondence with ACI 318 and ACI 350. Where splices at the face of wall are shown or
approved by ENGINEER, form saver-type mechanical couplers may be used. Form-
saver couplers shall have integral plates designed to positively connect coupler to
formwork.

C. Steel Wire: Shall be in accordance with ASTM A82.

D. Welded Smooth Wire Fabric: Shall be in accordance with ASTM A185.

1. Furnish in flat sheets, not rolls.

E. Column Spirals: Hot-rolled rods for spirals, conforming to ASTM A615.

F. Supports for Reinforcement: Bolsters, chairs, spacers, and other devices for spacing,
supporting and fastening reinforcing in place.

1. Use wire bar type supports complying with CRSI 1 MSP recommendations, except
as specified in this Section. Do not use wood, brick, or other unacceptable
materials.

2. For slabs on grade, use precast concrete blocks, four inches square in plan, with
embedded tie wire as specified by CRSI 1 MSP. Precast concrete blocks shall have
same or higher compressive strength as specified for concrete in which they are
located.

3. For concrete surfaces where legs of supports are in contact with forms, provide
supports complying with CRSI 1 MSP as follows:

a. At formed surfaces in contact with soil, weather, or liquid, or located above liquid,
supports shall be CRSI Class 1 for maximum protection. Plastic coating on legs
shall extend at least 0.5-inch upward from form surface.

b. At interior dry surfaces (not located above liquid), supports shall be either Class
1 or Class 2 for moderate protection.
4. Over waterproof membranes, use precast concrete chairs.

G. Adhesive Dowels:

1. Dowels:
   a. Dowel reinforcing bars shall be deformed in accordance with ASTM A615, Grade 60.

2. Adhesive:
   a. Requirements for adhesive are specified under requirements for concrete adhesive anchors in Section 05051, Anchor Systems.

2.02 FABRICATION

A. General: Fabricate reinforcing bars to conform to required shapes and dimensions, with fabrication tolerances complying with CRSI 1 MSP. In case of fabricating errors, do not re-bend or straighten reinforcing in manner that injures or weakens material.

B. Unacceptable Materials: Reinforcing with one or more of the following defects is not allowed:

   1. Bar lengths, bends, and other dimensions exceeding specified fabrication tolerances.

   2. Bends or kinks not shown on approved Shop Drawings.

   3. Bars that do not meet or exceed their ASTM specification requirements when hand-wire-brushed, with respect to cross section, nominal weight, or average height of deformations.

PART 3 EXECUTION

3.01 INSPECTION

A. Examine the substrate and conditions under which concrete reinforcing is to be placed and notify ENGINEER in writing of unsatisfactory conditions. Do not proceed with Work until unsatisfactory conditions have been corrected.

3.02 INSTALLATION

A. Comply with applicable recommendations of Laws and Regulations, applicable standards, and CRSI 1 MSP for details and methods of reinforcing placement and supports.

B. Clean reinforcing to remove loose rust and mill scale, earth, ice, and other materials that reduce or destroy bond with concrete.
C. Position, support, and secure reinforcing against displacement during formwork construction and concrete placing. Locate and support reinforcing by metal chairs, runners, bolsters, spacers, and hangers, as required.

1. Place reinforcing to obtain minimum concrete coverages specified in ACI 318, ACI 350, and the Contract Documents. Arrange, space, and securely tie bars and bar supports together with 16-gage wire to hold reinforcing accurately in position during concrete placing. Set wire ties so that twisted ends are directed away from exposed concrete surfaces.

2. Prior to placing concrete, using surveyor’s level or string line, demonstrate to ENGINEER that specified cover of reinforcing has been attained.

3. Do not secure reinforcing steel to forms with wire, nails, or other ferrous metal. Metal supports subject to corrosion shall not touch formed or exposed concrete surfaces.

D. Allowable Placing Tolerances: Comply with ACI 318, Chapter 7 - Details of Reinforcement, and ACI 350, Chapter 7 - Details of Reinforcement, except as specified in this Section:

1. Concrete surfaces in contact with liquid shall have minimum of two inches of concrete over reinforcing steel.

E. Provide sufficient number of supports of strength required to carry reinforcing. Do not place reinforcing bars more than two inches beyond last leg of continuous bar support. Do not use supports as bases for runways for concrete conveying equipment and similar construction loads.

F. Lap Splices:

1. Provide standard reinforcing splices by lapping ends, placing bars in contact, and tying tightly with wire. Comply with requirements shown for minimum lap of spliced bars as shown on the Drawings.

G. Install welded wire fabric in lengths as long as practical. Lap adjoining pieces at least one full mesh and lace splices with 16-gage wire. Do not make end laps midway between supporting beams, or directly over beams of continuous structures. Offset end laps in adjacent widths to prevent continuous laps.

H. Mechanical Couplers:

1. Mechanical butt splices shall be in accordance with recommendations of mechanical splicing device manufacturer. Butt splices shall develop 125 percent of specified minimum yield tensile strength of spliced bars or of smaller bar in transition splices. Bars shall be flame-dried before butt splicing. Provide adequate jigs and clamps or other devices to support, align, and hold longitudinal centerline of bars being butt spliced in straight line.
I. Welded Splices:

1. When field welding of reinforcing is required on the Drawings or allowed by ENGINEER in writing, welding of reinforcing bars shall conform to ANSI/AWS D1.4. Preheating and rate of cooling requirements shall be based on bar steel chemistry and ANSI/AWS D1.4. Welded splices shall be sized and constructed to transfer minimum of 125 percent of specified minimum yield tensile strength of spliced bars or of smaller bar in transition splices. Unless otherwise allowed by Engineer in writing, welding of crossing bars (tack welding) for assembly of reinforcement is prohibited.

2. Welding of wire to wire, and of wire or welded wire fabric to reinforcing bars or structural steels, shall conform to applicable provisions of ANSI/AWS D1.4 and ENGINEER’s requirements for the particular application.

3. After completing welding on coated reinforcing bars, repair coating damage as specified in this Section. Welds and steel splice members, when used to splice bars, shall be coated with same material used for repair of coating damage.

J. Adhesive Dowels:

1. Comply with manufacturer’s written installation instructions and requirements of this Section.

2. Drill holes to adhesive system manufacturer’s recommended drill bit diameter and to specified depth. Drill holes in hammering and rotation mode with carbide-tipped drill bits complying with tolerances indicated in ANSI B212.15. Core-drilled holes shall not be permitted.

3. Before setting adhesive dowel, hole shall be made free of dust and debris by method recommended by adhesive system manufacturer. Brush the hole with adhesive system manufacturer-approved brush and blow hole clean with clean, dry, oil-free compressed air to remove all dust and loose particles. Hole shall be dry as defined by adhesive system manufacturer.

4. Before injecting adhesive, obtain ENGINEER’s concurrence that hole is dry and free of oil and other contaminants.

5. Prior to injecting adhesive into the drilled hole, dispense to an appropriate location for waste an initial amount of adhesive from the mixing nozzle until adhesive is a uniform color, indicating that product is properly mixed.

6. Inject adhesive into hole through injection system-mixing nozzle and extension tubes (as required) placed to bottom of hole. Withdraw nozzle’s discharge end as adhesive is placed while keeping nozzle immersed to prevent formation of air pockets. Fill hole to depth that ensures that excess material is expelled from hole during dowel placing.
7. Twist dowel during insertion into partially-filled hole to ensure full wetting of rod surface with adhesive. Insert rod slowly to avoid developing air pockets.

8. Provide adequate curing in accordance to adhesive system manufacturer’s requirements prior to continuing with adjoining or adjacent Work that could impose or impart load on the dowels. Do not begin adjoining or adjacent Work until dowels are successfully tested or when approved by ENGINEER.

9. Limitations:
   a. Installation Temperature: Comply with manufacturer's instructions for installation temperature requirements. Provide temporary protection and other measures, such as heated enclosures, necessary to ensure that base material temperature complies with requirements of adhesive systems manufacturer during installation and adhesive system curing.
   b. Oversized Holes: Advise ENGINEER immediately if size of drilled hole is larger than recommended by adhesive system manufacturer. Cost of corrective measures, including but not limited to redesign of dowels due to decreased capacities, shall be paid by CONTRACTOR.

3.03 FIELD QUALITY CONTROL

A. Site Inspections and Tests:
   1. General:
      a. Do not place concrete until reinforcing is inspected, and permission for placing concrete is granted by ENGINEER. Concrete placed in violation of this provision will be rejected.
      b. Do not close up formwork for walls and other vertical members until reinforcing is inspected, and permission for placing concrete is granted by ENGINEER. Concrete placed in violation of this provision will be rejected.
      c. Correct defective Work by removing and replacing or correcting, as required by ENGINEER.
      d. CONTRACTOR shall pay cost of corrections and subsequent testing required to confirm integrity of post-installed anchors.
      e. Testing laboratory shall submit test results to CONTRACTOR and ENGINEER within 24 hours of completion of test.

   2. Site Tests:
      a. OWNER will employ testing laboratory to perform field quality testing of adhesive dowels at the Site.
         1) Testing shall comply with ASTM E488.
         2) Test at least ten percent of each type of adhesive dowel. If one or more dowels fail the test, CONTRACTOR shall pay cost to test all dowels of same diameter and type installed on the same day as the failed dowel.
3) Test dowels to 60 percent of specified yield strength. ENGINEER will direct which dowels are to be tested.
4) Apply test loads with hydraulic ram.
5) Displacement of dowels shall not exceed D/10, where D is nominal diameter of dowel.

3. Inspection of Welded Splices: OWNER will employ testing laboratory to perform field quality control testing of welded splices. All welded splices shall be visually inspected. Radiographically test minimum of five percent of butt splice welds. Repair defective welds so that welds are completely sound.

END OF SECTION
PART 1 GENERAL

1.01 DESCRIPTION

A. Scope:

1. CONTRACTOR shall provide all labor, materials, equipment, and incidentals as shown, specified, and required to furnish and install concrete accessories.

B. Related Sections:

1. Section 03100, Concrete Forming.

2. Section 03600, Grouting.

1.02 REFERENCES

A. Standards referenced in this Section are:

1. ACI 301, Standard Specifications for Structural Concrete.


1.03 SUBMITTALS

A. Action Submittals: Submit the following:

1. Shop Drawings:

   a. Layout of construction and expansion joint locations. Submit and obtain approval prior to submitting concrete reinforcement Shop Drawings.

   b. For construction and expansion joints that require waterstops, submit layout of locations showing waterstop details. Indicate waterstop type, waterstop joint conditions, and details on how joint conditions will be handled.

   c. Detail for joining PVC to steel waterstops.

   d. Layout of all control joint locations.

B. Informational Submittals: Submit the following:

1. Manufacturer’s Instructions: Manufacturer’s specifications and installation instructions for all materials required.
1.04 DELIVERY, STORAGE AND HANDLING

A. Transportation and Handling of Products:

1. Deliver materials to Site to ensure uninterrupted progress of the Work.

B. Storage and Protection:

1. Store concrete joint materials on platforms or in enclosures or covered to prevent contact with ground and exposure to weather and direct sunlight. Comply with manufacturer’s storage and protection requirements.

PART 2 PRODUCTS

2.01 WATERSTOPS

A. Polyvinyl Chloride (PVC):

1. Material Requirements:

   a. Waterstops shall be extruded from elastomeric PVC compound containing plasticizers, resins, stabilizers, and other materials necessary to meet requirements of the Contract Documents and requirements of CRD-C572. Do not use reclaimed or scrap material.
   b. Tensile strength of finished waterstop: 1,400 psi, minimum.
   c. Ultimate elongation of finished waterstop: 280 percent, minimum.
   d. Minimum thickness shall be 3/8-inch over entire width of waterstop.
   e. Provide waterstops with minimum of seven ribs equally spaced at each end on each side. First rib shall be at the edge. Ribs shall be a minimum of 1/8-inch in height.
   f. Provide waterstops with hog rings or factory-installed grommets anchored to exterior ribs to facilitate tying waterstop in position.

2. Split waterstops are not allowed.

3. Construction Joints: Waterstops shall be flatstrip ribbed type, six-inch minimum width, unless otherwise shown or indicated in the Contract Documents.

4. Expansion Joints: Waterstops shall be centerbulb ribbed type, nine-inch minimum width, unless otherwise shown or indicated in the Contract Documents. Centerbulb shall have minimum outside diameter of 7/8-inch.

5. Product and Manufacturer: Provide one of the following:

   a. W.R. Meadows, Inc.
   b. DCA Construction Products.
   d. Paul Murphy Plastics Company.
e. Vinylex Corporation.
f. Or equal.

B. Hydrophilic Waterstop Materials:

1. General Material Properties:
   a. Bentonite-free, and expandable by minimum of 80 percent of dry volume in presence of water to form watertight joint seal without damaging concrete in which material is cast. Provide only where shown or indicated in the Contract Documents.
   b. Material shall be composed of resins and polymers that absorb water and cause an increase in volume in completely reversible and repeatable process. Waterstop material shall be dimensionally stable after repeated wet-dry cycles with no deterioration of swelling potential.
   c. Select materials that are recommended by manufacturer for type of liquid to be contained.

2. Hydrophilic Rubber Waterstop:
   b. Product and Manufacturer: Provide one of the following:
      1) Duroseal Gasket, by BBZ USA, Inc.
      2) Adeka Ultraseal MC-2010M, by Asahi Denka Kogyo K.K.
      4) Or equal.

3. Hydrophilic Sealant:
   a. Hydrophilic sealant shall adhere firmly to concrete, metal, and PVC in dry or damp condition. When cured sealant shall be elastic indefinitely.
   b. Product and Manufacturer: Provide one of the following:
      1) Duroseal Paste, by BBZ USA, Inc.
      2) Adeka Ultraseal P-201, by Asahi Denka Kogyo K.K.
      4) SikaSwell S, by Sika Corporation.
      5) Or equal.

2.02 PREFORMED EXPANSION JOINT FILLER
A. Provide preformed expansion joint filler complying with ASTM D1752, Type I (sponge rubber) or Type II (cork).

2.03 CONCRETE CONSTRUCTION JOINT ROUGHENER
A. Provide water-soluble non-flammable, surface-retardant roughener.
B. Product and Manufacturer: Provide one of the following for the types of joints specified:

1. Rugasol-S, by Sika Corporation for horizontal joints only.

2. Concrete Surface Retarder-Formula S, by Euclid Chemical Company, for horizontal joints only.

3. Concrete Surface Retarder-Formula F, by Euclid Chemical Company, for vertical joints only.

4. TK-6100 Concrete Form Surface Retarder, by TK Products.

5. Or equal.

2.04 EPOXY BONDING AGENT

A. Provide a two-component epoxy-resin bonding agent.

B. Product and Manufacturer: Provide one of the following:

1. Sikadur 32 Hi-Mod LPL, by Sika Corporation.

2. Eucopoxy LPL, by the Euclid Chemical Company.


4. Or equal.

2.05 EPOXY-CEMENT BONDING AGENT

A. Provide three component epoxy resin-cement blended formulated as bonding agent.

B. Product and Manufacturer: Provide one of the following:

1. Sika Armatec 110 EpoCem, as manufactured by Sika Corporation.

2. Duralprep A.C., as manufactured by the Euclid Chemical Company.

3. Emaco P24, as manufactured by MBT/ChemRex.

4. Or equal.

2.06 JOINT SEALANT AND ACCESSORIES

A. Exterior and Interior Horizontal and Vertical Joints; Submerged and Intermittently Submerged in Potable Water or Water That Will be Treated to Become Potable:

1. One-component Polyurethane Sealant:

   a. Products and Manufacturers: Provide one of the following:
1) Sikaflex-1a by Sika Corporation.
2) Or equal.

b. One-component, moisture cured, gun grade, polyurethane sealant, complying with:

1) FS TT-S-00230C, Type II, Class A; ASTM C920, Type S, Grade NS, Class 25.
2) Adhesion-in-Peel, FS TT-S-00230C, ASTM C794 (minimum five pounds.):
   Glass, minimum 20 pounds per linear inch; Aluminum, minimum 20 pounds per linear inch; Concrete, minimum 20 pounds per linear inch.
3) Hardness (Standard Conditions), ASTM D2240: 20 to 25 (Shore A).
4) Stain and Color Change, FS TT-S-00227E and ASTM C510: No discoloration or stain.
5) Accelerated Aging, ASTM C793: No change in sealant characteristics after 250 hours in weatherometer.
6) Rheological Vertical Displacement at 120 degrees F, FS TT-S-00227E: No sag.
7) VOC Content: 100 g/L, maximum.
8) Listed in NSF/ANSI 61

2. Two-component Polyurethane Sealant:

a. Products and Manufacturers: Provide one of the following:

1) Sikaflex- 2c NS by Sika Corporation.
2) Or equal.

b. Two-component, moisture cured, gun grade, polyurethane sealant, complying with:

1) FS TT-S-00227E, Type II, Class A; ASTM C920, Type M, Grade NS, Class 25.
2) Adhesion-in-Peel, FS TT-S-00227E, ASTM C794 (Minimum five pounds per linear inch with no adhesion failure): 18 pounds.
3) Hardness (Standard Conditions), ASTM C661: 25 (Shore A).
4) Stain and Color Change, FS TT-S-00227E and ASTM C510: No discoloration or stain.
5) Accelerated Aging, ASTM C793: No change in sealant characteristics after 250 hours in weatherometer.
6) Rheological Vertical Displacement at 120 degrees F, FS TT-S-00227E: No sag.
7) VOC Content: 220 g/L, maximum.
8) Listed in NSF/ANSI 61

B. Exterior and Interior Vertical Joints; Non-submerged:

1. Two-component Polyurethane Sealant:
a. Products and Manufacturers: Provide one of the following:

1) Sikaflex- 2c NS by Sika Corporation.
2) Dymeric 240 FC by Tremco Sealant/Waterproofing Division of RPM International, Inc.
3) Or equal.

b. Polyurethane based, two-component elastomeric sealant complying with:

1) FS TT-S-00227E: Type II (non-sag) Class A and ASTM C920, Type M, Grade NS, Class 25.
2) Adhesion-in-Peel, FS TT-S-00227E and ASTM C794: (Minimum five pounds per linear inch with no adhesion failure): 10 pounds.
3) Hardness (Standard Conditions), ASTM C661: 25 to 35 (Shore A).
4) Stain and color change, FS TT-S-00227E and ASTM C510: No discoloration or stain.
5) Accelerated Aging, ASTM C793: No change in sealant characteristics after 250 hours in weatherometer.
6) Rheological Vertical Displacement at 120 degrees F, FS TT-S-00227E: No sag.
7) VOC Content: 100 g/L, maximum.

C. Exterior and Interior Horizontal Joints; Non-submerged:

1. Two-component Polyurethane Sealant:

a. Products and Manufacturers: Provide one of the following:

1) Sikaflex- 2c SL by Sika Corporation.
2) THC/900 by Tremco Sealant/Waterproofing Division of RPM International, Inc.
3) Or equal.

b. Polyurethane based, two-component elastomeric, self-leveling sealant complying with the following:

1) FS TT-S-00227E, Type I (self-leveling) Class A. and ASTM C920, Type M, Grade P, Class 25.
2) Water Immersion Bond, FS TT-S-00227E: Elongation of 50 percent with no adhesive failure.
3) Hardness (Standard Conditions), ASTM C661: 35 to 45.
4) Stain and Color Change, FS TT-S-00227E and ASTM C510: No discoloration or stain.
5) Accelerated Aging, ASTM C793: No change in sealant characteristics after 250 hours in weatherometer.
6) VOC Content: 165 g/L, maximum.

D. Miscellaneous Materials:
1. Joint Cleaner: As recommended by calking and sealant manufacturer.

2. Joint Primer and Sealer: As recommended for compatibility with calking and sealant by calking and sealant manufacturer.

3. Bond Breaker Type: Polyethylene tape or other plastic tape as recommended for compatibility with calking and sealant by calking and sealant manufacturer, to be applied to sealant-contact surfaces where bond to substrate or joint filler must be avoided for proper performance of calking and sealant. Provide self-adhesive tape where applicable.

4. Sealant Backer Rod: Compressible rod stock polyethylene foam, polyethylene jacketed polyurethane foam, butyl rubber foam, neoprene foam or other flexible, permanent, durable non-absorptive material as recommended for compatibility with calking and sealant by calking and sealant manufacturer. Provide size and shape of rod that will control joint depth for sealant placement, break bond of sealant at bottom of joint, form optimum shape of sealant bead on back side, and provide highly-compressible backer to minimize possibility of sealant extrusion when joint is compressed.

5. Low-temperature Catalyst: As recommended by calking and sealant manufacturer.

2.07 CONCRETE BOND BREAKERS

A. Provide asphalt-saturated rag felt building paper, not less in weight than commercially known as 15 pound felt building paper, which weighs 15 pounds per 100 square feet.

B. Chemical Bond Breaker:

1. Provide medium solids resin solution chemical concrete bond breaker complying with ASTM C309, Type I, Class B.

PART 3 EXECUTION

3.01 INSPECTION

A. CONTRACTOR and installing Subcontractor, if any, shall examine substrate and conditions under which the Work is to be performed and notify ENGINEER in writing of unsatisfactory conditions. Do not proceed with the Work until unsatisfactory conditions are corrected.

3.02 CONSTRUCTION JOINTS

A. Comply with requirements of ACI 301 and the Contract Documents.

B. Locate and install construction joints as shown or indicated on the Drawings. Where not shown or indicated, locate joints to not impair strength of the structure; position joints at points of minimum shear. Location of joints shall be approved by ENGINEER.
addition to joints shown or indicated on the Drawings, locate construction joints as follows:

1. In foundation mats, locate joints at spacing of approximately 40 feet. Joints shall be located within middle third of element span, unless otherwise shown or indicated on the Drawings. Element span shall be considered distance between piles or, as determined by ENGINEER, distance between bearing elements, such as columns, exterior walls and interior walls. Place concrete in strip pattern, unless otherwise shown or indicated on the Drawings.

2. In walls, locate joints at a maximum spacing of 40 feet. Locate joints away from wall intersections a minimum of one-quarter of the clear span distance between wall intersections measured horizontally.

3. In structural slabs and beams, joints shall be located within middle third of element span and shall be located in compliance with ACI 301, unless otherwise shown or indicated on the Drawings.

4. In slabs on grade, locate joints at spacing of approximately 40 feet. Place concrete in strip pattern, unless otherwise shown or indicated on the Drawings.

C. Horizontal Joints:

1. Roughen concrete at interface of construction joints by abrasive blasting, hydroblasting, or using surface retardants and water jets to expose aggregate and remove accumulated concrete on projecting rebar immediately subsequent to form stripping, unless otherwise approved by ENGINEER. Immediately before placing fresh concrete, thoroughly clean existing contact surface using stiff brush or other tools and stream of pressurized water. Surface shall be clean and wet, and free from pools of water at time of placing fresh concrete.

2. Remove laitance, waste mortar, and other substances that may prevent complete adhesion. Where joint roughening was performed more than seven days prior to concrete placing or where dirt or other bond reducing contaminants are on surface, perform additional light abrasive blasting or hydroblasting to remove laitance and all bond-reducing materials just prior to concrete placement.

3. Provide over contact surface of concrete a six-inch layer of Construction Joint Grout as specified in Section 03600, Grouting. Place fresh concrete before grout has attained its initial set. Placement of grout may be omitted if concrete mix has slump increased to at least six inches by addition of high range water reducer.

D. Vertical Joints:

1. Apply roughener to the form in thin, even film by brush, spray, or roller in accordance with manufacturer's instructions. After roughener is dry, concrete may be placed.

2. When concrete has been placed, remove joint surface forms as early as necessary to allow for removal of surface retarded concrete. Forms covering member surfaces
shall remain in place as required under Section 03100, Concrete Forming. Wash loosened material off with high-pressure water spray to obtain roughened surface subject to approval by ENGINEER. Alternately, surface shall be roughened by abrasive blasting or hydroblasting to expose aggregate. Outer one-inch of each side of joint face shall be masked and protected from blasting to avoid damaging member surface.

3.03 EXPANSION JOINTS

A. Comply with requirements of ACI 301 and this Section.

B. Locate and install expansion joints as shown and indicated in the Contract Documents. Install joint filler in accordance with manufacturer’s instructions. Install sealants as specified in this Section.

3.04 CONTROL JOINTS

A. Provide control joints in non-water bearing slabs on grade as shown or indicated on the Drawings. Where control joints are not shown or indicated on the Drawings, space control joints at 24 to 36 times thickness of slab in both directions. Locate control joints only at places approved by ENGINEER.

B. A groove, with depth of at least 25 percent of the member thickness, shall be tooled, formed, or saw-cut in concrete. Groove shall be filled with joint sealant material.

C. Where control joint is formed by sawcutting, make sawcut in presence of ENGINEER immediately after concrete has set sufficiently to support the saw and be cut without damage to concrete. Keep concrete continually moist during cutting. Joints shall be approximately 1/8-inch wide.

D. Control joints may be formed with tool or by inserting joint forming strip. After concrete has achieved design strength, remove upper portion of joint forming strip and fill void with sealant.

3.05 ISOLATION JOINTS

A. Provide isolation joint where sidewalk or other slab on grade abuts a concrete structure and slab on grade is not shown doweled into that structure. Form isolation joint by 1/2-inch joint filler with upper 1/2-inch of joint filled with sealant.

3.06 WATERSTOPS

A. General:

1. Comply with ACI 301 and this Section. Make joints in accordance with manufacturer’s instructions.

2. Provide PVC waterstops, except where otherwise shown or indicated on the Drawings.
3. Provide waterstops in all joints where concrete construction is below grade or intended to retain liquid. Install waterstop to the higher of: at least 12 inches above grade, or 12 inches above overflow liquid level in tanks.

4. Waterstops shall be fully continuous for extent of joint and with waterstops in intersecting joints. Maintain waterstop continuity at transitions between waterstops in joints at different levels and orientations.

5. In vertical joints in walls that are free at the top, waterstops shall extend no closer than six inches from top of wall.

6. In placing concrete around horizontal waterstops, with waterstop flat face in horizontal plane, work the concrete under waterstops by hand to avoid forming air and rock pockets.

B. Polyvinyl Chloride Waterstop:

1. Waterstops shall be positively held from displacement during concrete placing. Tie waterstops to reinforcement or other rigid supports at maximum spacing of 18 inches so that waterstop is securely and rigidly supported in proper position during concrete placing. Continuously inspect waterstops during concrete placing to ensure proper positioning.

2. Perform splicing in waterstops by heat sealing adjacent waterstop sections in accordance with manufacturer’s printed recommendations. The following is required:
   a. Material shall not be damaged by heat sealing.
   b. Splices shall have tensile strength of not less than 60 percent of unspliced material’s tensile strength.
   c. Maintain the continuity of waterstop ribs and of its tubular center axis.

3. Only butt-type joints of ends of two identical waterstop sections shall be made while material is in forms.

4. Prefabricated PVC Waterstop Joint:
   a. Joints with waterstops involving more than two ends to be jointed together, and joints that involve an angle cut, alignment change, or joining of two dissimilar waterstop sections, shall be prefabricated by CONTRACTOR or manufacturer prior to placing in the forms.
   b. Prefabricated joints shall have minimum of 2.0 feet of waterstop material beyond joint in each direction.
   c. Install prefabricated joint assembly in the forms and butt-weld each two-foot end to a straight-run portion of waterstop in place in the forms.

5. Where centerbulb waterstop intersects and is jointed with non-centerbulb waterstop, seal end of centerbulb using additional PVC material as required.
6. Symmetrical halves of waterstops shall be equally divided between concrete placements at joints and centered within joint width, unless shown or indicated otherwise in the Contract Documents. Place centerbulb waterstops in expansion joints so that centerbulb is centered on joint filler material.

7. When waterstop is installed in the forms or embedded in first concrete placement and waterstop remains exposed to atmosphere for more than four days, implement suitable precautions to shade and protect exposed waterstop from direct rays of sun during entire exposure, until exposed portion of waterstop is embedded in concrete.

8. Protect waterstop placed in joints intended for future concrete placement from direct rays of the sun by temporary means until permanent cover is installed, so that waterstop is not exposed to direct rays of the sun for more than four days total.

C. Hydrophilic Rubber Waterstop and Sealant:

1. Where a hydrophilic rubber waterstop or sealant is required in accordance with the Contract Documents, or where approved by ENGINEER, install waterstop or sealant in accordance with manufacturer’s instructions and recommendations; except, as modified in the Contract Documents.

2. When requested by ENGINEER, provide manufacturer’s technical assistance at the Site.

3. Locate waterstop or sealant as near as possible to center of joint. Waterstop or sealant shall be continuous around entire joint. Minimum distance from edge of waterstop to face of the member shall be three inches.

4. Where hydrophilic rubber waterstop is used in combination with PVC waterstop, hydrophilic rubber waterstop shall overlap PVC waterstop for minimum of six inches. Fill contact surface between hydrophilic rubber waterstop and PVC waterstop with hydrophilic sealant.

5. Where wet curing methods are used, apply hydrophilic rubber waterstop and sealant after curing water is removed and just prior to closing up of the forms for concrete placement. Protect hydrophilic rubber waterstop and sealant from direct rays of sun and from becoming wet prior to concrete placement. If material becomes wet and expands, allow material to dry until material has returned to original cross sectional dimensions before placing concrete.

6. Install hydrophilic rubber waterstop in bed of hydrophilic sealant, before skinning and curing begins, so that irregularities in concrete surface are completely filled and waterstop is bonded to sealant. After sealant has cured, install concrete nails, with washers of a diameter equal to waterstop width, to secure waterstop to concrete at maximum spacing of 1.5 feet.

7. Prior to installing hydrophilic sealant, wire brush or sandblast the concrete surface to remove laitance and other materials that may interfere with bonding. Metal and PVC surfaces to receive sealant shall be cleaned of paint and any material that may
interfere with bond. When sealant alone is shown or indicated in the Contract Documents, place sealant placed in built-up bead which has a triangular cross section with each side of triangle at least 3/4-inch long, unless otherwise indicated in the Contract Documents. Do not place concrete until sealant has cured as recommended by sealant manufacturer.

3.07 BONDING AGENT

A. Use epoxy bonding agent for bonding of fresh concrete to concrete that has been in place for at least 60 days, and for bonding to existing concrete.

B. Use epoxy-cement bonding agent for the following:
   1. Bonding toppings and concrete fill to concrete that has been in place for at least 60 days, and for bonding to existing concrete.
   2. For locations where bonding agent is required and concrete cannot be placed within open time period of epoxy bonding agent.

C. Use cement-water slurry as bonding agent for toppings and concrete fill to new concrete. Cement water slurry shall be worked into surface with stiff bristle broom and place the concrete before cement-water slurry dries.

D. Handle and store bonding agent in accordance with manufacturer’s printed instructions and safety precautions.

E. Mix bonding agent in accordance with manufacturer’s instructions.

F. Before placing fresh concrete, thoroughly roughen and clean hardened concrete surfaces and coat with bonding agent not less than 1/16-inch thick. Place fresh concrete while bonding agent is still tacky (within its open time), without removing in-place bonding agent coat, and as directed by manufacturer.

3.08 BEARING PAD INSTALLATION

A. Neoprene Bearing Pad: Install with water insensitive adhesive in accordance with manufacturer’s instructions.

END OF SECTION
PART 1 GENERAL

1.01 DESCRIPTION

A. Scope:

1. Provide all labor, materials, equipment, and incidentals as shown, specified, and required to furnish and install cast-in-place concrete.

2. The Work includes providing concrete consisting of portland cement, fine and coarse aggregate, water, and approved admixtures; combined, mixed, transported, placed, finished, and cured. The Work also includes:

   a. Providing openings in concrete to accommodate the Work under this and other Sections, and building into the concrete all items such as sleeves, frames, anchorage devices, inserts, and all other items to be embedded in concrete Work.

B. Coordination:

1. Review installation procedures under other Sections and coordinate installation of items to be installed in the concrete Work.

C. Classifications of Concrete:

1. Class “A” concrete shall be steel-reinforced and includes the following:

   a. All concrete, unless otherwise shown or indicated.

2. Class “B” concrete shall be placed without forms or with simple forms, with little or no reinforcing, and includes the following, unless otherwise shown or indicated:

   a. Concrete fill within structures.
   b. Duct banks.
   c. Unreinforced encasements.
   d. Curbs and gutters.
   e. Sidewalks.
   f. Thrust blocks.

3. Class “D” concrete shall be unreinforced and used where required as concrete fill under foundations, filling abandoned piping, and where “lean concrete” or “mudmat” is shown or indicated in the Contract Documents.

D. Related Sections:

1. Section 03251, Concrete Accessories.
2. Section 03600, Grouting.

1.02 REFERENCES

A. Standards referenced in this Section are:

1. AASHTO M 182, Specification for Burlap Cloth Made From Jute or Kenaf and Cotton Materials.

2. AASHTO TP23, Test Method for Water Content of Freshly Mixed Concrete Using Microwave Oven Drying.

3. ACI 117, Specifications for Tolerances for Concrete Construction and Materials and Commentary.

4. ACI 214R, Evaluation of Strength Test Results of Concrete.

5. ACI 301, Specifications for Structural Concrete.

6. ACI 302.1R, Guide for Concrete Floor and Slab Construction.


11. ACI 318, Building Code Requirements for Structural Concrete and Commentary.


13. ASTM C31/C31M, Practice for Making and Curing Concrete Test Specimens in the Field.

14. ASTM C33, Specification for Concrete Aggregates.


16. ASTM C42/C42M, Test Method for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete.


19. ASTM C138/C138M, Test Method for Density (Unit Weight), Yield, and Air Content (Gravimetric) of Concrete.


24. ASTM C172, Practice for Sampling Freshly Mixed Concrete.

25. ASTM C231, Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method.


27. ASTM C309, Specification for Liquid Membrane-Forming Compounds for Curing Concrete.


30. ASTM C618, Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete.

31. ASTM C882/C882M, Test Method for Bond Strength of Epoxy-Resin Systems Used with Concrete by Slant Shear.

32. ASTM C989, Specification for Ground Granulated Blast-Furnace Slag for Use in Concrete and Mortars.


34. ASTM C1077, Practice for Laboratories Testing Concrete and Concrete Aggregates for Use in Construction and Criteria for Laboratory Evaluation.

35. ASTM C1240, Specification for Silica Fume Used in Cementitious Mixtures.


38. ASTM E96/E96M, Test Methods for Water Vapor Transmission of Materials

40. ASTM E1643, Practice for Installation of Water Vapor Retarders Used in Contact with Earth or Granular Fill Under Concrete Slabs.

41. ASTM E1745, Specification for Water Vapor Retarders Used in Contact with Soil or Granular Fill under Concrete Slabs.

42. NSF/ANSI 61, Drinking Water System Components - Health Effects.

1.03 QUALITY ASSURANCE

A. Qualifications:

1. Concrete Testing Laboratory:

   a. Employ independent testing laboratory experienced in design and testing of concrete materials and mixes to perform material evaluation tests and to design concrete mixes. Employ different laboratories for design of concrete mixes and field testing.

      1) Testing agency shall be in accordance with ASTM E329 and ASTM C1077.
      2) Testing laboratory shall have been inspected and passed within previous two years by Cement and Concrete Reference Laboratory (CCRL) of NIST for: testing concrete aggregates, and for preparing and testing concrete trial batches with or without admixtures. Testing laboratory shall provide documentation indicating how deficiencies, if any, in most recent CCRL inspection report were corrected.
      3) Selection of testing laboratory is subject to OWNER’s acceptance.
      4) Submit written description of proposed concrete testing laboratory giving qualifications of personnel, laboratory facilities, and equipment, and other information requested by ENGINEER.

2. Water Reducing Admixture Manufacturer:

   a. Water-reducing admixtures shall be manufactured under strict quality control in facilities operated under a quality assurance program. Submit copy of manufacturer’s quality assurance handbook to document program existence.
   b. Manufacturer shall maintain a concrete testing laboratory approved by CCRL at NIST.
   c. Manufacturer shall be capable of providing services of qualified field service representatives at the Site.

B. Laboratory Trial Batch:

   1. Each concrete mix design specified shall be verified by laboratory trial batch, unless indicated otherwise.
2. For classes of concrete that require air-entrainment, test the trial batch at highest percentage of air allowed for that class of concrete.

3. Perform the following testing on each trial batch:
   a. Aggregate gradation for fine and coarse aggregates.
   b. Fly ash testing to verify meeting specified properties, unless fly ash Supplier submits certification by an independent testing laboratory.
   c. Slump.
   d. Air content.
   e. Compressive strength based on three cylinders each tested at seven days and at 28 days.

4. Submit for each trial batch the following information:
   a. Project identification name and number (if applicable).
   b. Date of test report.
   c. Complete identification of aggregate source of supply.
   d. Tests of aggregates for compliance with the Contract Documents.
   e. Scale weight of each aggregate.
   f. Absorbed water in each aggregate.
   g. Brand, type, and composition of cementitious materials.
   h. Brand, type, and amount of each admixture.
   i. Amounts of water used in trial mixes.
   j. Proportions of each material per cubic yard.
   k. Gross weight and yield per cubic yard of trial mixtures.
   l. Measured slump.
   m. Measured air content.
   n. Compressive strength developed at seven days and 28 days, from not less than three test cylinders cast for each seven day and 28 day test, and for each design mix.
   o. Shrinkage test results where required and as specified in this Section. Report results and averages for original length and at zero, seven, 14, 21, and 28 days of drying.

C. Certification of Concrete Mix:

1. The requirement for trial batch will be waived upon compliance with requirements of this Paragraph. Verify compressive strength of each specified mix by data from series of at least 30 consecutive tests that have been made within previous 12 months. Test is the average strength of all specimens of the same age fabricated from sample taken from a single batch of concrete. Tests shall have been made on concrete with identical mix design to mix design proposed for the Work, including sources of aggregate and manufacturers of cementitious materials and admixtures. Tests shall average above specified strength with no individual test falling more than 500 psi below specified strength and no three consecutive tests averaging below specified strength. Standard deviation for series of tests shall not exceed 640 psi in accordance with ACI 214.
D. Component Supply and Compatibility:
   1. Provide all admixture materials from a single manufacturer.

1.04 SUBMITTALS

A. Action Submittals: Submit the following:
   1. Shop Drawings:
      a. List of concrete materials and proportions for the proposed concrete mix designs.
         Include data sheets, test results, certifications, and mill reports to qualify the
         materials proposed for use in the mix designs. Do not start laboratory trial batch
         testing until this submittal is approved by ENGINEER.
      b. Laboratory Trial Batch Reports: Submit laboratory test reports for concrete
         cylinders, materials, and mix design tests.
      c. Ready-mixed Concrete: Submit the following information.
         1) Physical capacity of mixing plant.
         2) Trucking facilities available.
         3) Estimated average amount of the specified concrete that can be produced
            and delivered to the Site during a normal, eight-hour day, excluding output to
            other customers.
   2. Product Data:
      a. Manufacturers’ specifications with application and installation instructions for
         proprietary materials and items, including admixtures and bonding agents.
   3. Samples:
      a. Submit Samples of materials as specified and as requested by ENGINEER.
         Include with each Sample names of product and Supplier, and description.

B. Informational Submittals: Submit the following:
   1. Certifications:
      a. Notarized certification of conformance to reference standards used in this
         Section, when required by ENGINEER.
   2. Delivery Tickets: Copies of all delivery tickets for each load of concrete delivered to
      or mixed at the Site. Each delivery ticket shall contain the information in
      accordance with ASTM C94 along with project identification name and number (if
      any), date, mix type, mix time, quantity and amount of water introduced.

1.05 PRODUCT DELIVERY, STORAGE, AND HANDLING

A. Transportation, Delivery, and Handling:
1. Materials used for concrete shall be clean and free from foreign matter during transportation and handling, and kept separate until measured and placed into concrete mixer.

2. Implement suitable measures during hauling, piling, and handling to ensure that segregation of coarse and fine aggregate particles does not occur and grading is not affected.

B. Storage:

1. For storage, provide bins or platforms with hard, clean surfaces.

PART 2 PRODUCTS

2.01 GENERAL

A. All cementitious materials, admixtures, curing compounds, and other industrial-produced materials used in concrete, or for curing or repairing of concrete, that can contact potable water or water that will be treated to become potable shall be listed in NSF/ANSI 61.

2.02 CEMENTITIOUS MATERIALS

A. Cement:

1. Portland cement shall be Type I/II ASTM C150.

2. Portland cement shall be produced by one facility. Alternate cement sources may be used provided that mix design has been approved and acceptable trial batch verifying performance has been made.

3. Do not use cement that has deteriorated because of improper storage or handling.

B. Fly Ash Mineral Admixture:

1. Mineral admixtures, when used, shall conform to the requirements of ASTM C618 Class F, except as follows:
   a. The loss on ignition shall be a maximum of four percent.
   b. The maximum percent of sulfur trioxide (SO3) shall be 4.0.

2. Fly ash shall be considered to be a cementitious material.

3. Laboratory trial batches shall be tested to determine compliance with strength requirements, times of setting, slump, slump loss, and shrinkage characteristics.

C. For all classes of concrete, when Type II Cement is used, fly ash shall be used within the following percentages by weight. When Type I Cement is used, fly ash shall be used
such that total tricalcium aluminate content (C3A) of the resulting cementitious material is not greater than eight percent.

1. When fly ash is used, material shall have minimum of 20 percent and maximum of 25 percent of total weight of cementitious material.

2.03 AGGREGATES

A. General:

1. Aggregates shall conform to ASTM C33, Class Designation 4M, and as specified in this Section.

2. Do not use aggregates containing soluble salts or other substances, such as iron sulfides, pyrite, marcasite, ochre, or other materials, that can cause stains on exposed concrete surfaces.

B. Fine Aggregate:

1. Provide clean, sharp, natural sand free of loam, clay, lumps, and other deleterious substances.

2. Dune sand, bank run sand, and manufactured sand are unacceptable.

C. Coarse Aggregate:

1. Provide clean, uncoated, processed aggregate containing no clay, mud, loam, or foreign matter, as follows:
   a. Crushed stone, processed from natural rock or stone.
   b. Washed gravel, either natural or crushed. Slag, pit gravel, and bank run gravel are unacceptable.

2.04 WATER

A. Water used in producing and curing concrete shall be clean and free of injurious quantities of oils, acids, alkalis, organic materials, and other substances that may be deleterious to concrete and steel.

2.05 CONCRETE ADMIXTURES

A. Provide admixtures in accordance with product manufacturer’s published instructions. Admixtures shall be compatible with each other. Admixtures shall not contain thiocyanates, shall not contain more than 0.05 percent chloride ion, and shall be non-toxic in the concrete mix after 30 days. Do not use admixtures that have not been incorporated and tested in the accepted mixes, unless otherwise approved by ENGINEER.

1. Air entraining admixture shall be vinsol resin or vinsol rosin-based.

C. Water-Reducing Admixture: ASTM C494, Type A.

1. Proportion Class “A” and Class “B” concrete with non-air entraining, normal setting, water-reducing, aqueous solution of modified organic polymer. Admixture shall not contain lignin, nitrates, or chlorides added during manufacturing.

D. High Range Water-Reducing Admixture (HRWR): ASTM C494, Type F/G.

1. Use high range water-reducing admixture in the concrete classifications so specified or indicated. Use of HRWR admixture is allowed at CONTRACTOR’s option in all other classifications of concrete. When used, HRWR admixture shall be added to concrete in accordance with admixture manufacturer’s published instructions. Specific admixture formulation shall be as recommended by admixture manufacturer for Project conditions.

E. Set Control Admixtures: In accordance with ASTM C494. Use the following as required:

1. Type B, Retarding.
2. Type C, Accelerating.
3. Type D, Water reducing and Retarding.
4. Type E, Water reducing and Accelerating.
5. Type F, Water-reducing, high range admixtures.
6. Type G, Water-reducing, high range, and retarding admixtures.

F. Calcium Chloride: Do not use calcium chloride.

G. Shrinkage Reducing Admixture:

1. Shrinkage reducing admixture may be used in mix design when necessary to conform to specified shrinkage limitations, provided that specified strength requirements are complied with and there is no reduction in sulfate resistance in the concrete and no increase in concrete permeability.

2.06 PROPORTIONING AND DESIGN OF MIXES

A. Prepare concrete design mixes in accordance with the table below:

<table>
<thead>
<tr>
<th>Concrete Class</th>
<th>Coarse Aggregate(1)</th>
<th>Minimum</th>
<th>Max. W/CM(4)</th>
<th>Slump(2)</th>
<th>Air (%)</th>
<th>Min. Comp Strength(3) (psi)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Size A</td>
<td>Size B</td>
<td>Cementitious (lbs/cu yd)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Dundee State Fish Hatchery Water Reuse – Effluent Pump Back
TPWD No. 1110061
### Notes Applicable to Table:

1. Coarse aggregate size numbers refer to ASTM C33. Where Size A and B are designated in Table 03300-A, it is intended that the smaller Size B aggregate is to be added, replacing a portion of the coarse or fine aggregate, in the minimum amount necessary to make a workable and pumpable mix with sand content not exceeding 41 percent of total aggregate.

2. Slumps indicated are prior to addition of high range water reducer (super plasticizer).

3. Mix designs shall be made for all but Class “D”, which does not require trial batch, so that the compressive strength achieved for laboratory trial batches will not be less than 125 percent of specified design strength.

4. Quantity of water to be used in the determination of water-cementitious materials (W/CM) ratio shall include free water on aggregates in excess of SSD and water portion of admixtures.

### B. Adjustment to Concrete Mixes:

Mix design adjustments may be requested by CONTRACTOR when characteristics of materials, Site conditions, weather, test results, or other circumstances warrant; at no additional cost to OWNER and as approved by ENGINEER. Before using adjusted concrete mixes, laboratory test data and strength results shall be submitted to and approved by ENGINEER.

### C. Admixtures:

1. Use air-entraining admixture in concrete, unless otherwise shown or indicated. Add air-entraining admixture at admixture manufacturer’s prescribed rate to produce concrete at point of placement having air content within prescribed limits.

2. Use water-reducing or high-range water-reducing admixtures in all Class “A” concrete.

3. Use amounts of admixtures recommended by admixture manufacturer for climatic conditions prevailing at the Site at time of placing. Adjust quantities and types of admixtures as required to maintain quality.

### D. If adding water at the Site is desired, withhold water at the batch plant so that specified water-cement (or cementitious material) ratio is not exceeded. Addition of water shall be accordance with ASTM C94. After high-range water-reducing admixture is incorporated into the batch, addition of water is not allowed.

### E. Slump Limits with High-Range Water Reducer:

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**CAST-IN-PLACE CONCRETE**

<table>
<thead>
<tr>
<th>Class “A”</th>
<th>No. 57</th>
<th>No. 8</th>
<th>564</th>
<th>0.42</th>
<th>4” max.</th>
<th>6 +/- 1</th>
<th>4,000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class “B”</td>
<td>No. 57 or No. 67</td>
<td>517</td>
<td>0.50</td>
<td>4” max.</td>
<td>6 +/- 1</td>
<td>3,000</td>
<td></td>
</tr>
<tr>
<td>Class “D”</td>
<td>Any ASTM C33</td>
<td></td>
<td></td>
<td>No requirements</td>
<td></td>
<td>2,000</td>
<td></td>
</tr>
</tbody>
</table>
1. Slump shall not exceed four inches prior to adding high-range water reducer and shall not exceed eight inches, measured at point of placement, after adding high-range water reducer.

F. Shrinkage Limitation:

1. Concrete shrinkage for specimens cast in laboratory from trial batch with total water of 30.2 gallons per cubic yard or less, as measured at 21-day drying age and at 28-day drying age shall not exceed 0.039 percent and 0.045 percent, respectively. For trial batch with total water of 32.7 gallons per cubic yard or greater respective limits shall not exceed 0.035 percent and 0.040 percent. Limits in between shall be linear interpolated. Use mix design for construction that complies with trial batch shrinkage requirements. Shrinkage limitations apply to Class “A” concrete.

2. Trial Batch Does Not Comply with Shrinkage Limitation:

   a. If trial batch results do not comply with shrinkage limitation specified in the Contract Documents, redesign the mix to reduce shrinkage.
   b. After mix has been repeatedly redesigned and ENGINEER is satisfied that all reasonable means to provide concrete mix that complies with shrinkage requirement have been exercised; and mix design still fails to comply with shrinkage limitation in the Contract Documents, ENGINEER reserves the right to accept the higher-shrinkage mix, provided that the quantity of shrinkage reinforcing in structures is increased.
   c. “Reasonable means” will be construed as reducing the total water content to a maximum of 27 gallons per cubic yard, having the large aggregate blended so that eight percent to 18 percent of combined aggregate is retained on each sieve, using an alternate aggregate source, and a combination of these means.
   d. Basis for shrinkage reinforcing increase will be proportional to amount that shrinkage value is over the specified shrinkage limitation and will be determined by ENGINEER. The cost of providing additional shrinkage reinforcement will be paid by the Owner.

2.07 BONDING AGENT

A. Provide epoxy and epoxy-cement bonding agents in accordance with Section 03251, Concrete Accessories.

2.08 CONCRETE CURING MATERIALS

A. Absorptive Cover: Burlap cloth made from jute or kenaf, weighing approximately 10 ounces per square yard and complying with AASHTO M 182, Class 3.

B. Curing Mats: Shall be heavy carpets or cotton mats, quilted at four inches on centers, and weighing minimum of 12 ounces per square yard when dry.

C. Moisture-Retaining Cover: Provide one of the following, complying with ASTM C171:

   1. Waterproof paper.
2. Polyethylene film.

3. White burlap polyethylene sheet.

D. Liquid Curing Compound: ASTM C309 Type 1-D (water retention requirements):
   1. Provide fugitive dye.
   2. Curing compound shall be applied by roller or power sprayer.
   3. Product shall be listed in NSF/ANSI 61.

2.09 FINISHING AIDS

A. Evaporation Retardant:
   1. Product and Manufacturer: Provide one of the following:
      a. Confilm, by Master Builders.
      b. Eucobar, by Euclid Chemical Company.
      c. SikaFilm, by Sika Corporation.
      d. Or equal.

2.10 CRACK INJECTION MATERIALS

A. Structural Crack Repair System:
   1. Epoxy for Injection: Low-viscosity, high-modulus moisture insensitive type.
   2. Products and Manufacturers: Provide one of the following:
      a. Sikadur 35, Hi-Mod L.V. and Sikadur 31, Hi-Mod Gel, by Sika Corporation.
      b. Eucopoxy Injection Resin, by Euclid Chemical Company.
      c. Or equal.
   3. Product shall be listed in NSF/ANSI 61.

B. Non-structural Crack Repair System:
   1. Hydrophobic Polyurethane Chemical Grout:
      a. Provide hydrophobic polyurethane that forms a flexible gasket.
      b. Products and Manufacturers: Provide one of the following:
         1) SikaFix HH LV, by Sika Chemical Company.
         2) Hydro Active Flex SLV, by De Neef Construction Chemicals, Inc.
         3) Or equal.
      c. Shrinkage limit shall not exceed 4.0 percent in accordance with ASTM D1042.
      d. Minimum elongation of 250 percent in accordance with ASTM D3574.
e. Minimum tensile strength of 150 psi in accordance with ASTM D3574.
f. Product shall be listed in NSF/ANSI 61.

2. Hydrophilic Acrylate-Ester Resin:
   a. Hydrophilic crack repair system shall be acrylate-ester resin that forms a flexible gasket and increase in volume a minimum of 50 percent when in contact with water.
   b. Products and Manufacturers: Provide one of the following:
      1) Duroseal Multigel 850, manufactured by BBZ USA, Inc.
      2) Or equal.
   c. Product shall be listed in NSF/ANSI 61.

2.11 CONCRETE REPAIR MATERIALS
A. Concrete repair mortar shall be pre-packaged, polymer-modified cementitious repair mortar with the following minimum properties:
   1. Compressive Strength at One Day: 2,000 psi (ASTM C109).
   2. Compressive Strength at 28 Days: 6,000 psi (ASTM C109).
   3. Bond Strength at 28 Days: 1,800 psi (ASTM C882 modified).
   4. Material shall be listed in NSF/ANSI 61.

B. Products and Manufacturers: Provide one of the following:
   1. Five Star Structural Concrete, by Five Star Products, Inc. Use formulation recommended by manufacturer for the specific application conditions.
   2. SikaTop 122 Plus, SikaTop 123 Plus, SikaTop 111 Plus, or Sikacem 133, by Sika Corporation. Use formulation from among those listed in this paragraph recommended by manufacturer for specific application conditions.
   3. Emaco S88-CA or S66-CR, by Master Builders Inc. Use formulation from among those listed in this paragraph recommended by manufacturer for specific application conditions.
   4. Verticoat, Verticoat Supreme, or Euco SR-VO, by Euclid Chemical Company. Use formulation from among those listed in this paragraph recommended by manufacturer for specific application conditions.
   5. Or equal.

C. Cement Mortar: Shall consist of mix of one part cement to 1.5 parts sand with sufficient water to form trowelable consistency. Minimum compressive strength at 28 days shall be 4,000 psi. Where required to match the color of adjacent concrete surfaces, blend.
white portland cement with standard portland cement so that, when dry, patching mortar matches the color of surrounding concrete.

2.12 VAPOR RETARDER

A. Vapor Retarder:

1. Vapor retarder membrane shall comply with the following:
   a. Water Vapor Transmission Rate, ASTM E96: 0.04 perms or lower.
   b. Water Vapor Retarder, ASTM E1745: Meets or exceeds Class C.
   c. Thickness of Retarder (plastic), ACI 302 1R: Not less than 10 mils.

2. Products and Manufacturers: Provide one of the following:
   a. Stego Wrap 10-mil Vapor Retarder, by Stego Industries LLC.
   b. Griffolyn 10-mil, by Reef Industries.
   c. Moistop Ultra, by Fortifiber Industries.
   d. Or equal.

B. Accessories:

1. Provide accessories by same manufacturer as vapor retarder.

2. Seam Tape:
   a. Tape shall have water vapor transmission rate (ASTM E96) of 0.3 perms or lower.
   b. Products and Manufacturers: Provide one of the following:
      1) Stego Tape by Stego Industries LLC.
      2) Griffolyn Fab Tape by Reef Industries.
      3) Moistop Tape by Fortifiber Industries.
      4) Or equal.

3. Vapor Proofing Mastic:
   a. Mastic shall have a water vapor transmission rate ASTM E96, 0.3 perms or lower.

4. Pipe Boots:
   a. Construct pipe boots from vapor barrier material, pressure sensitive tape, mastic, or a combination thereof, in accordance with manufacturer’s recommendations.

2.13 SOURCE QUALITY CONTROL

A. Concrete materials may require testing, as directed by ENGINEER, at any time during the Work if concrete quality is in question. Provide access to material stockpiles and facilities at all times. Tests shall be done at no expense to OWNER.
PART 3 EXECUTION

3.01 INSPECTION

A. Examine the substrate and conditions under which the Work will be performed and notify ENGINEER in writing of unsatisfactory conditions. Do not proceed with the Work until unsatisfactory conditions have been corrected.

3.02 CONCRETE MIXING

A. General:

1. Concrete may be produced at batch plants or by the ready-mixed process. Batch plants shall comply with recommendations of ACI 304R and have sufficient capacity to produce concrete of qualities required and in quantities required to comply with the accepted Progress Schedule. All plant facilities are subject to acceptance of ENGINEER.

2. Mixing:

   a. Mix concrete with a rotating type batch machine, except where hand mixing of very small quantities is approved by ENGINEER.
   b. Remove hardened accumulations of cement and concrete from drum and blades to ensure proper mixing action.
   c. Replace mixer blades upon loss of ten percent of mixer blades’ original height.

B. Site Mixing:

1. When Site mixing of concrete is approved by ENGINEER mix all materials for concrete in a drum-type batch mixer.

   a. For mixers of one cubic yard or smaller capacity, continue mixing at least 1.5 minutes but not more than five minutes after all ingredients are in the mixer, before any part of batch is released.
   b. For mixers of capacity larger than one cubic yard, increase minimum 1.5 minutes of mixing time by 15 seconds for each additional cubic yard or fraction thereof.

2. Do not exceed mixer manufacturer’s published rating of the mixer, or mixer nameplate capacity, for total volume of materials used per batch.

3. Equip mixer with automatic controls for proportioning materials and proper, measured quantities.

4. Do not exceed 45 minutes total elapsed time between intermingling of damp aggregates and cement to discharge of completed mix.

C. Ready-Mix Concrete:

a. Plant Equipment and Facilities: Conform to requirements of NRMCA certification.
b. Mix concrete in revolving-type truck mixers that are in good condition and produce thoroughly-mixed concrete conforming to the Contract Documents.
c. Do not exceed rated capacity of mixer.
d. Mix concrete for minimum of two minutes after arrival at the Site, or as recommended by mixer manufacturer.
e. Do not allow drum to mix while in transit.
f. Mix at proper speed until concrete is discharged from mixer.
g. Maintain adequate facilities at the Site for continuous delivery of concrete at required rates.
h. Provide access to mixing plant for ENGINEER upon request.

D. Maintain equipment in proper operating condition, with drums cleaned before charging each batch. Schedule rates of delivery to prevent delay of placing concrete after mixing, or holding dry-mixed materials too long in mixer before the adding water and admixtures.

3.03 TRANSPORTING CONCRETE

A. Transport and place concrete not more than 90 minutes after water has been added to the dry ingredients.

B. Avoid spilling and separation of concrete mixture during transportation.

C. Do not place concrete in which the ingredients have separated.

D. Do not retemper partially set concrete.

E. Use suitable equipment for transporting concrete from mixer to forms.

3.04 PREPARATION FOR CONCRETING

A. Submit to ENGINEER laboratory trial batch test results for proposed mixes at least 15 days prior to start of Work. Do not begin concrete production until associated laboratory trial batch test result submittal has been approved by ENGINEER.

B. Notify ENGINEER a minimum of 24 hours in advance of placing concrete to allow for inspection of form work, joints, waterstops, reinforcement, embedded items, and vapor retarders. The section to be placed shall be fully prepared for concrete placement at the time of notice. Confirm inspection status with ENGINEER a minimum of 4 hours prior to concrete placement. Do not begin placing concrete until Work is in conformance with the Contract Documents.

C. Subgrade surfaces shall be thoroughly wetted by sprinkling, prior to the placing of any concrete, and these surfaces shall be kept moist by frequent sprinkling up to the time of placing concrete thereon. The surface shall be free from standing water, mud, and debris at the time of placing concrete.

D. Reinforcing steel and embedded items shall be completely cleaned of mortar, loose rust, form release compounds, dirt, or any other substance which would interfere with proper
bonding with concrete. Protective coatings on embedded aluminum items shall continuously cover the surface to be in contact with concrete. Any defects in the coating shall be repaired.

E. Do not place concrete until flow of water entering space to be filled with concrete has been properly stopped or has been diverted by pipes, or other means, and carried out of the forms, clear of the Work. Do not deposit concrete underwater, and do not allow water to rise on concrete surfaces until concrete has attained its initial set. Do not allow water to flow over concrete surface in manner and or velocity that will injure concrete surface finish. Provide temporary pumping or other dewatering operations for removing water as required.

F. Prepare joint surfaces in accordance with Section 03251, Concrete Accessories.

G. Installation of Vapor Retarder:

1. Provide vapor retarder under slabs-on-grade and outside walls to receive resilient floor finishes, carpet, ceramic and slate tile, chemical resistant coatings, and where shown or indicated on the Drawings.

2. Install in accordance with manufacturer’s instructions, ASTM E1643, and the following:

   a. Unroll vapor retarder with longest dimension parallel with direction of the pour.
   b. Lap vapor retarder over footings and seal to foundation walls.
   c. Overlap vapor retarder joints by six inches and seal with vapor retarder manufacturer’s tape.
   d. Seal penetrations, including pipes, in accordance with vapor retarder manufacturer’s instructions.
   e. Penetration of vapor retarder is not allowed except for reinforcing steel and permanent utilities.
   f. Repair damaged areas of vapor retarder by providing, for each damaged area, patch of vapor retarder material and overlapping damaged area with the patch by six inches on each side, and securely and continuously taping all four sides of patch to undamaged vapor retarder.

3.05 CONCRETE PLACEMENT

A. General:

1. Place concrete continuously, so that no concrete will be placed on concrete that has hardened sufficiently to cause formation of seams or planes of weakness within the section. If section cannot be placed continuously, provide construction joints in accordance with Section 03251, Concrete Accessories.

2. Deposit concrete as nearly as practical in its final location to avoid segregation due to rehandling or flowing. Do not subject concrete to action that may cause segregation.
3. Screed concrete that is to receive other construction to proper level to avoid excessive skimming or grouting.

4. Do not use concrete that becomes non-plastic and unworkable, or does not conform to required quality limits, or that has been contaminated by foreign materials. Do not use retempered concrete. Remove rejected concrete from the Site and dispose of it in conformance with Laws and Regulations.

5. Do not place concrete until forms, bracing, reinforcing, and embedded items are each in final position and secure.

6. Do not place footings in freezing weather unless adequate precautions are taken against frost action.

7. Do not place footings, piers or pile caps on frozen soil.

8. Unless otherwise instructed, place concrete only when ENGINEER is present.

9. Allow minimum of three days between adjoining concrete placements.

B. Bonding for Next Concrete Pour:

1. Prepare for bonding of fresh concrete to concrete that has set but is not fully cured, as follows:
   a. Thoroughly wet the surface, but allow no free-standing water.
   b. For horizontal surfaces place a six-inch layer of Construction Joint Grout, as specified in Section 03600, Grouting, over the hardened concrete surface.
   c. Place fresh concrete before the grout has attained its initial set.

2. Accomplish bonding of fresh concrete to fully cured, hardened, existing concrete by using a bonding agent as specified in Section 03251, Concrete Accessories.

C. Concrete Conveying:

1. Handle concrete from point of delivery at the Site, transfer to concrete conveying equipment, and transfer to locations of final deposit as rapidly as practical by methods that prevent segregation and loss of concrete mix materials.

2. Provide mechanical equipment for conveying concrete to ensure continuous flow of concrete at delivery end of conveyor. Provide runways for wheeled concrete conveying equipment from concrete delivery point to locations of final deposit. Keep interior surfaces of conveying equipment, including chutes, free of hardened concrete, debris, water, snow, ice, and other deleterious materials.

3. Do not use chutes for distributing concrete, unless accepted by ENGINEER.

4. Pumping concrete is allowed, however do not use aluminum pipe for conveying concrete.
D. Placing Concrete into Forms:

1. Deposit concrete in forms in horizontal layers not deeper than 18 inches each and in manner that avoids inclined construction joints. Where placement consists of several layers, place concrete at such rate that concrete being integrated with fresh concrete while still plastic.

2. Do not allow concrete to free-fall within the form from height exceeding four feet. Where high-range water reducer is used to extend slump to at least six inches, maximum allowable free-fall of concrete is six feet. Use “elephant trunks” to prevent free-fall and excessive splashing of concrete on forms and reinforcing. Discontinue free-falls in excess of four feet if there is evidence of segregation.

3. Remove temporary spreaders in forms when concrete placing has reached elevation of such spreaders.

4. Consolidate concrete placed in forms by mechanical vibrating equipment supplemented by hand-spading, rodding, or tamping. Use equipment and procedures for consolidating concrete in accordance with applicable recommended practices in ACI 309. Vibration of forms and reinforcing is not allowed unless otherwise accepted by ENGINEER.

5. Where height of concrete placement in walls exceeds 14 feet, provide temporary windows in formwork to facilitate vibration. Properly close temporary windows when height of concrete approaches windows. Determine location, size, and spacing of temporary windows to suit equipment used.

6. Do not use vibrators to transport concrete inside of forms. Insert and withdraw vibrators vertically at uniformly-spaced locations not farther than the visible effectiveness of the vibrator. Place vibrators to rapidly penetrate the layer of concrete and at least six inches into the preceding layer. Do not insert vibrators into lower layers of concrete that have begun to set. At each insertion, limit the duration of vibration to time necessary to consolidate concrete and complete embedment of reinforcing and other embedded items without causing segregation of concrete mix.

7. Do not place concrete in beam and slab forms until concrete previously placed in columns and walls is no longer plastic.

8. Prevent voids in the concrete. Force concrete under pipes, sleeves, openings, and inserts from one side until visible from the other side.

E. Placing Concrete Slabs:

1. Deposit and consolidate concrete slabs in continuous operation, within limits of construction joints, until placing of a slab panel or section is completed.

2. Consolidate concrete during placing operations using mechanical vibrating equipment, so that concrete is thoroughly worked around reinforcing and other embedded items and into corners.
3. Consolidate concrete placed in beams and girders of supported slabs, and against bulkheads of slabs on ground, as specified in this Article for formed concrete structures.

4. Bring slab surfaces to correct elevation and level. Smooth the surface, leaving surface free of humps or hollows. Do not sprinkle water on surface while concrete is plastic. Do not disturb slab surfaces prior to commencing concrete finishing.

5. Where slabs are placed in conditions of high temperature or wind that could lead to formation of plastic shrinkage cracks, provide evaporation retardant applied in accordance with retardant manufacturer’s recommendations, when required by ENGINEER.

F. Quality of Concrete Work:

1. Concrete shall be solid, compact, and smooth, and free of laitance, cracks, and cold joints.

2. Concrete for liquid-retaining structures, and concrete in contact with earth, water, or exposed directly to the elements shall be watertight.

3. Cut out and properly replace to extent directed by ENGINEER, or repair to satisfaction of ENGINEER, surfaces with cracks or voids, that are unduly rough, or are defective in any other way. Thin patches or plastering are unacceptable.

4. Leaks through concrete that exhibit flowing water, and cracks, holes, or other defective concrete in areas of potential leakage, shall be repaired and made watertight.

5. Repair, removal, and replacement of defective concrete as directed by ENGINEER shall be at no additional cost to OWNER.

G. Cold Weather Placing:

1. Protect concrete Work from physical damage or reduced strength that could be caused by frost, freezing, or low temperatures, in compliance with ACI 306 and the Contract Documents.

2. When air temperature has fallen to or may be expected to fall below 40 degrees F, provide adequate means to maintain temperature in area where concrete is being placed between 50 degrees F and 70 degrees F for at least seven days after placing. Provide temporary housings or coverings including tarpaulins or plastic film. Maintain temporary heating and protection as necessary so that ambient temperature does not fall more than 30 degrees F in the 24 hours following the seven-day period. Avoid rapid dry-out of concrete due to overheating, and avoid thermal shock due to sudden cooling or heating.

3. When air temperature has fallen to or is expected to fall below 40 degrees F, uniformly heat water and aggregates before mixing for concrete as required to obtain
concrete mixture temperature not less than 55 degrees F and not more than 85 degrees F at point of placement.

4. Do not use frozen materials or materials containing ice or snow. Do not place concrete on frozen subgrade or on subgrade containing frozen materials. Before placing concrete, verify that forms, reinforcing, and adjacent concrete surfaces are entirely free of frost, snow, and ice.

5. Do not use salt or other materials containing antifreeze agents. Do not use chemical accelerators or set-control admixtures unless approved by ENGINEER and tested in mix design proposed for use.

H. Hot Weather Placing:

1. When hot weather conditions exist that would impair the quality and strength of concrete, place concrete in compliance with ACI 305 and the Contract Documents.

2. When ambient air temperature is at or above 90 degrees F and rising, cool ingredients before mixing concrete to maintain concrete temperature at time of placement below 80 degrees F. When ambient air temperature is at or above 90 degrees F and falling, cool the ingredients before mixing concrete to maintain concrete temperature at time of placement below 85 degrees F. In no case shall the concrete temperature at time of placement exceed 90 degrees F.

3. Mixing water may be chilled, or chopped ice may be used to control concrete temperature provided the water equivalent of ice is calculated in total amount of mixing water. If required, reduce the time from addition of mix water to placement, or use set-retarding admixture.

4. Cover reinforcing materials with water-soaked burlap if ambient air temperature becomes too hot, so that reinforcing material temperature does not exceed ambient air temperature immediately before embedment of reinforcing in concrete.

5. Wet forms thoroughly before placing concrete.

6. Do not place concrete at temperature that causes difficulty from loss of slump, flash set, or cold joints.

7. Do not use set-control admixtures unless approved by ENGINEER in mix design.

8. Obtain ENGINEER's approval of substitute methods and materials proposed for use.

I. Underwater Placing:

1. Concrete placement in water will be allowed if conditions render it impossible or inadvisable to dewater excavations or liquid-retaining structures before placing concrete, and only when allowed by ENGINEER in writing.

2. Revise and submit concrete mix design to suit underwater placement, and obtain ENGINEER's approval before commencing underwater placement of concrete.
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Deposit concrete by tremie method or other suitable means in continuous placement to prevent forming layers or intrusion of water.

3.06 FINISHING OF FORMED SURFACES

A. Standard Form Finish:

1. Standard form finish shall be basically smooth and even, but is allowed to have texture imparted by the form material used. Repair defects in accordance with the Contract Documents.

2. Use standard form finish for the following:
   a. Exterior vertical surfaces from foundation up to one foot below grade.
   b. Vertical surfaces not exposed to view.
   c. Other areas shown or indicated.

B. Smooth Form Finish:

1. Produce smooth form finish by selecting form materials that will impart smooth, hard, uniform texture. Arrange panels in orderly and symmetrical manner with minimum of seams. Repair and patch defective areas in accordance with the Contract Documents.

2. Use smooth form finish for the following:
   a. Exterior surfaces exposed to view.
   b. Surfaces to be covered with coating material. Coating material may be applied directly to concrete or may be a covering bonded to concrete such as waterproofing, dampproofing, painting, or other similar system.
   c. Interior vertical surfaces of liquid-containers.
   d. Interior and exterior exposed beams and undersides of slabs.
   e. Surfaces to receive abrasive blasted finish.
   f. Surfaces to receive smooth rubbed or grout cleaned finish.
   g. Other areas shown or indicated.

C. Smooth Rubbed Finish:

1. Provide smooth rubbed finish to concrete surfaces that have received smooth form finish and where defects have been repaired, as follows:
   a. Rubbing of concrete surfaces not later than the day after form removal.
   b. Moistening of concrete surfaces and rubbing with carborundum brick or other abrasive until uniform color and texture is produced. Do not apply cement grout other than that created by the rubbing process.

2. Use smooth rubbed finish for the following:
   a. Interior exposed walls and other vertical surfaces.
   b. Exterior exposed walls and other vertical surfaces down to one foot below grade.
c. Interior and exterior horizontal surfaces, except exterior exposed slabs and steps.
d. Interior exposed vertical surfaces of liquid-containing structures down to one foot below normal operating liquid level.
e. Other areas shown or indicated.

D. Grout Cleaned Finish:

1. Provide grout cleaned finish to concrete surfaces that have received smooth form finish and where defects have been repaired, as follows:
   a. Combine one part portland cement to 1.5 parts fine sand by volume, and mix with water to consistency of thick paint. Blend standard portland cement and white portland cement, in proportions determined by trial patches, so that final color of dry grout will closely match adjacent concrete surfaces.
   b. Thoroughly wet concrete surface and apply grout uniformly by brushing or spraying immediately to wetted surfaces. Scrub surface with cork float or stone to coat surface and fill surface holes. Remove excess grout by scraping, followed by rubbing with clean burlap to remove visible grout film. Keep grout damp during setting period by using fog spray on surface for at least 36 hours after final rubbing. Complete each area the same day the area is started, with limits of each area being natural breaks in the finished surface.

2. Use grout cleaned finish for the following:
   a. Interior exposed walls and other vertical surfaces.
   b. Exterior exposed walls and other vertical surfaces down to one foot below grade.
   c. Interior and exterior horizontal surfaces, except exterior exposed slabs and steps.
   d. Interior exposed vertical surfaces of liquid-containing structures down to one foot below normal operating liquid level.
   e. Other areas shown.

E. Related Unformed Surfaces:

1. At tops of walls, horizontal offsets, and similar unformed surfaces occurring adjacent to formed surfaces, strike off smooth and finish with texture matching adjacent formed surfaces. Continue final surface treatment of formed surfaces uniformly across adjacent unformed surfaces, unless otherwise shown or indicated.

3.07 SLAB FINISHES

A. Float Finish:

1. After placing concrete slabs, do not work the surface further until ready for floating. Begin floating when surface water has disappeared or when concrete has stiffened sufficiently. Check and level the surface plane to tolerance not exceeding 1/4-inch in ten feet when tested with a ten-foot straightedge placed on surface at not less than two different angles. Cut down high spots and fill low spots. Uniformly slope
surfaces to drains. Immediately after leveling, refloat surface to uniform, smooth, granular texture.

2. Use float finish for the following:
   a. Interior exposed horizontal surfaces of liquid-containing structures, except those to receive grout topping.
   b. Exterior below-grade horizontal surfaces.
   c. Surfaces to receive additional finishes, except as shown or indicated.

B. Trowel Finish:

1. After floating, begin first trowel finish operation using power-driven trowel. Begin final troweling when surface produces a ringing sound as trowel is moved over the surface.

2. Consolidate concrete surface by the final hand troweling operation. Finish shall be free of trowel marks, uniform in texture and appearance, and with surface plane tolerance not exceeding 1/8-inch in ten feet when tested with a ten foot straight edge. Grind smooth surface defects that would otherwise project through applied floor covering system.

3. Use trowel finish for the following:
   a. Interior exposed slabs, unless otherwise shown or indicated.
   b. Slabs that receive one of the following: resilient flooring, carpeting, or ceramic tile.

C. Non-Slip Broom Finish:

1. Immediately after float finishing, slightly roughen concrete surface by brooming in direction perpendicular to main traffic route. Use fine fiber-bristle broom, unless otherwise directed by ENGINEER. Coordinate required final finish with ENGINEER before applying finish.

2. Use non-slip broom finish for the following:
   a. Exterior exposed horizontal surfaces subject to lightweight foot traffic.
   b. Interior and exterior concrete steps and ramps.

D. Scratched Finish:

1. After providing float finish, roughen concrete surface with rake before concrete’s final set. Amplitude of surface shall be minimum of 1/4-inch.

2. Provide scratched finish for the following:
   a. Horizontal surfaces that will receive grout topping or concrete equipment pad.
   b. Surfaces so indicated on the Drawings or elsewhere in the Contract Documents.
3.08 CONCRETE CURING AND PROTECTION

A. General:

1. Protect freshly placed concrete from premature drying, excessive cold or hot temperatures, and maintain without drying at relatively constant temperature for period necessary for hydration of cement and proper hardening of concrete.

2. Start curing after placing and finishing concrete, as soon as free moisture has disappeared from concrete surface. Keep surface continuously moist during entire curing period. Cure for a minimum of 10 days and in accordance with ACI 301 procedures. For concrete sections over 30-inches thick, the curing period shall be for a minimum of 14 days. Avoid rapid drying at end of final curing period.

3. For curing, use water that is free of impurities that could etch or discolor exposed concrete surfaces.

4. Confine water for curing to area being cured.

B. Curing Methods: Curing methods are specified below. Curing methods to be used on each type of concrete surface are specified elsewhere in this Article.

1. Water Curing. Cure by one of the following methods:
   a. Keep concrete surface continuously wet.
   b. Ponding or immersion.
   c. Continuous water-fog spray.
   d. Covering concrete surface with curing mats, thoroughly saturating mats with water, and keeping mats continuously wet with sprinklers or porous hoses. Place curing mats to cover concrete surfaces and edges with four-inch horizontal lap over adjacent mats; provide eight-inch lap over adjacent mats at vertical surfaces. If necessary, weigh down curing cover to maintain contact with concrete surface.

2. Form Curing. Cure by one of the following methods:
   a. Forms shall be maintained and loosened during curing period.
   b. Immediately after forms are loosened or removed, continue with the required curing method as applicable, for remainder of curing period.
   c. Where wood forms are kept in place, apply water to keep forms wet.

3. Moisture Retaining Cover Curing. Cure as follows:
   a. Cover concrete surfaces with the required moisture retaining cover for curing concrete, placed in widest practical width with sides and ends lapped at least three inches and sealed using waterproof tape or adhesive. Immediately repair holes or tears during curing period using cover material and waterproof tape.

4. Liquid Compound Curing. Cure as follows:
a. Unless otherwise approved by ENGINEER, provide water curing or form curing. Request to use liquid curing compound will be considered by ENGINEER on case-by-case basis. Construction joints, formed surfaces prior to receiving specified form finish, and concrete to receive surface treatment where surface treatment will be bonded to concrete surface (such as, but not limited to grout fill, hardener, coatings, lining, water repellent, painting, resilient flooring, terrazzo flooring, ceramic tile, quarry tile, chemical resistant coatings, or other applications) shall be water-cured or form-cured.

b. In liquid-retaining structures, provide water curing or form curing, unless other curing method is approved by ENGINEER. Requests to use liquid curing compound will be considered by ENGINEER on case-by-case basis. Request shall provide valid construction reason or safety reason for using liquid compound curing including reason why other curing methods are not viable.

c. Apply curing compounds immediately after final finishing or after terminating water curing. Apply curing compound in continuous operation by power spray equipment in accordance with curing compound manufacturer’s directions. If areas are subjected to rainfall within three hours after completing curing compound application, area shall be recoated. Maintain coating continuity and repair areas damaged during curing period.

d. When liquid curing compound is used, apply first coat of liquid curing compound at compound manufacturer’s recommended coverage rate, and subsequently apply second coat at identical rate, thus providing twice the curing compound manufacturer’s recommended coverage.

e. At end of curing period, remove liquid curing compound where required.

C. Formed Surfaces: Use the following curing methods:

1. Walls That Will Retain Liquid or That are Under Ground Surface:
   a. If forms are wood, form curing is allowed for entire curing period. If forms are steel, form curing is allowed for maximum of three days after which forms shall be removed so that concrete is free of the forms for remainder of the curing process.
   b. Immediately after the forms are loosened or removed, continue with water curing for remainder of curing period.
   c. When wall surface will not receive surface treatment and when allowed by ENGINEER, use of liquid curing compound is allowed. Before using liquid compound curing, use water curing or form curing for at least the first three days of curing.

2. Formed Slab Underside and Beam Surfaces Where Will Retain Liquid:
   a. Form curing is allowed for the full curing period.
   b. Immediately after forms are loosened or removed, continue with water curing for remainder of curing period.
   c. When slab surface will not receive surface treatment and when allowed by ENGINEER, use of liquid curing compound is allowed.

3. Vertical Joint Surfaces and Surfaces to Receive Surface Treatment:
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a. Form curing is allowed for entire curing period.
b. Immediately after forms are loosened or removed, continue with water curing for remainder of curing period.


D. Unformed Surfaces: Treat with one of the following curing methods:

1. Slabs and Mats That Will Retain Liquid or are Below Ground Surface:
   a. Water curing.
   b. Moisture-retaining cover curing when allowed by ENGINEER.
   c. When slab or mat surface will not receive surface treatment and when allowed by ENGINEER, use of liquid curing compound is allowed. Before using liquid compound curing, use water curing or form curing for at least the first three days of curing.

2. Construction Joint Surfaces and Slab and Mat Surfaces to Receive Surface Treatment.
   a. Water curing.
   b. Moisture-retaining cover curing.


E. Temperature of Concrete During Curing:

1. When ambient temperature is 40 degrees F or less, continuously maintain concrete temperature between 50 degrees F and 70 degrees F throughout curing period. When necessary, before concrete placing provide for temporary heating, covering, insulation, or housing as required to continuously maintain specified temperatures and moisture conditions throughout concrete curing period. Provide cold weather protection in accordance with ACI 306.

2. When the ambient temperature is 80 degrees F and above, or during other climatic conditions that would cause too-rapid drying of concrete, before starting concrete placing, provide wind breaks and shading as required, and fog spraying, wet sprinkling, or moisture retaining coverings as required. Continuously protect concrete throughout concrete curing period. Provide hot weather protection in accordance with ACI 305, unless otherwise specified.

3. Maintain concrete temperature as uniformly as possible, and protect from rapid ambient temperature changes. Avoid concrete temperature changes that exceed five degrees F in one hour and 50 degrees F in 24-hour period.

F. Protection:
1. During curing period, protect concrete from damaging mechanical disturbances including load stresses, heavy shock, excessive vibration, and damage by rain and flowing water. Protect finished concrete surfaces from damage by subsequent construction operations.

3.09 CONCRETE INSTALLATION TOLERANCES

A. Installation Tolerances:

1. Concrete placement tolerances, unless otherwise specified in the Contract Documents, shall be in accordance with ACI 117.

2. Notify ENGINEER in writing when concrete placement does not conform with required tolerances, as soon as the condition is known to CONTRACTOR.

3. When concrete installation does not conform to required tolerances, do not repair or correct by grinding unless specified in the Contract Documents or approved by ENGINEER in writing.

4. Verification Measurements:

   a. If surfaces where tolerances are in question, obtain measurements to verify conformance with tolerances in manner acceptable to ENGINEER.
   b. If surfaces tolerances are in question, cost of obtaining measurements shall be at no additional cost to the OWNER.
   c. Before obtaining measurements, obtain ENGINEER’s acceptance of method proposed for obtaining measurements.
   d. After obtaining measurements, submit measurements to ENGINEER.

5. Submit with verification measurements submittal proposed method to rectify out-of-tolerance concrete. Do not start repair Work without obtaining ENGINEER’s approval.

3.10 FIELD QUALITY CONTROL

A. Field Testing Services:

1. OWNER will employ testing laboratory to perform field quality control testing for concrete. ENGINEER will direct the testing requirements.

2. Testing laboratory will make standard compression test cylinders and entrained air tests as specified in this Article, under observation of ENGINEER or Resident Project Representative.

3. Testing laboratory will provide all labor, material, and equipment required for sampling and testing concrete, including: scale, glass tray, cones, rods, molds, air tester, thermometer, and other incidentals required.

4. CONTRACTOR shall provide all curing and necessary cylinder storage.
B. Field Testing Services:

1. CONTRACTOR shall employ an independent testing laboratory to perform field quality control testing for concrete. ENGINEER will direct where samples are to be obtained.

2. Testing laboratory shall make standard compression test cylinders and entrained air tests as specified in this Article, under direct observation by ENGINEER or Resident Project Representative.

3. Testing laboratory will provide all labor, material, and equipment required for sampling and testing concrete, including: scale, glass tray, cones, rods, molds, air tester, thermometer, and other incidentals required.

4. Provide all curing and necessary cylinder storage as specified in Division 1.

5. Refer to Article 1.03 of this Section for required testing laboratory qualifications.

C. Quality Control Testing During Construction:

1. Perform sampling and testing for field quality control during placement of concrete, as follows:

   a. Sampling Fresh Concrete: ASTM C172.
   b. Slump: ASTM C143; one test for each concrete load at point of discharge.
   c. Concrete Temperature: ASTM C1064; one for every two concrete loads at point of discharge, and when a change in the concrete is observed. Test each load when time from batching to placement exceeds 75 minutes.
   d. Air Content: ASTM C231; one for every two concrete load at point of discharge, and when a change in the concrete is observed.
   e. Unit Weight: ASTM C138; one for every two concrete loads at point of discharge, and when a change in the concrete is observed.
   f. Compression Test Specimens:

      1) In accordance with ASTM C31; make one set of compression cylinders for each 50 cubic yards of concrete, or fraction thereof, of each mix design placed each day. Each set shall be four standard cylinders, unless otherwise directed by ENGINEER.
      2) Cast, store, and cure specimens in accordance with ASTM C31.
      3) Test and record the following when cylinders are cast: slump, concrete temperature, air content, and unit weight.

   g. Compressive Strength Tests:

      1) In accordance with ASTM C39; one specimen tested at seven days, and three specimens tested at 28 days.
      2) Adjust mix design if test results are unsatisfactory and resubmit for approval.
      3) Concrete that does not comply with strength requirements will be considered as defective Work.
h. Water/Cementitious Materials Ratio: Perform test when required by ENGINEER in accordance with AASHTO TP23.

i. Within 24 hours of completion of test, testing laboratory will submit certified copy of test results to CONTRACTOR and ENGINEER.

D. Evaluation of Field Quality Control Tests:

1. Do not use concrete delivered to final point of placement having slump, concrete temperature, total air content or unit weight outside specified values.

2. Water/Cementitious Materials Ratio:

   a. When water content testing indicates water/cementitious materials ratio to exceed specified requirements by greater than 0.02, remaining batches required to complete concrete placement shall have water content decreased in the mix and water reducing admixture dosage increased as required to bring subsequently-batched concrete within specified water/cementitious materials ratio.

   b. Perform additional testing to verify compliance with specified water/cementitious materials ratio.

   c. Do not resume concrete production for further concrete placement until CONTRACTOR has identified cause of excess water in the mix and revised batching procedures, or adjusted the mix design (and obtained ENGINEER’s associated approval) to bring water/cementitious materials ratio into conformance with the Contract Documents.

3. Compressive Strength:

   a. Compressive strength tests for laboratory-cured cylinders will be acceptable if the averages of all sets of three consecutive compressive strength tests results equal or exceed specified 28-day design compressive strength of the associated type or class of concrete, and no individual strength test falls below required compressive strength by more than 500 psi.

   b. Questionable Field Conditions During Concrete Placement:

      1) Where questionable field conditions exist during concrete placement or immediately thereafter, strength tests of specimens cured under field conditions will be required by ENGINEER to check adequacy of curing and protecting of concrete placed. Specimens shall be molded at the same time and from the same samples as laboratory-cured specimens.

      2) Provide improved means and procedures for protecting concrete when 28-day compressive strength of field-cured cylinders is less than 85 percent of companion laboratory cured cylinders.

      3) When laboratory-cured cylinder strengths are appreciably higher than minimum required compressive strength, field-cured cylinder strengths need not exceed minimum required compressive strength by greater than 500 psi even though the 85 percent criterion may not be met.

      4) If individual tests of laboratory-cured specimens produce strengths more than 500 psi below the required minimum compressive strength, or if tests of field-
cured cylinders indicate deficiencies in protection and curing, provide additional measures to ensure that load-bearing capacity of the structure is not jeopardized or impaired. If likelihood of low-strength concrete is confirmed and evaluations indicate load-bearing capacity may have been reduced, perform tests of cores from the concrete in question at CONTRACTOR’s expense.

c. If compressive strength tests fail to indicate compliance with minimum requirements of the Contract Documents, concrete represented by such tests will be considered defective.

E. Testing Concrete Structure for Strength:

1. When there is evidence that strength of in-place concrete does not comply with the Contract Documents, CONTRACTOR shall employ the services of concrete testing laboratory to obtain cores from hardened concrete for compressive strength determination. Cores and tests shall comply with ASTM C42 and the following:

a. Obtain at least three representative cores from each concrete member or suspect area of concrete at locations directed by ENGINEER.

b. Strength of concrete for each series of cores will be acceptable if average compressive strength is at least 85 percent of specified compressive strength and no single core is less than 75 percent of required 28-day required concrete compressive strength.

c. Testing laboratory shall submit test results to ENGINEER on same day that tests are completed. Include in test reports Project name and number (if any), date of sampling and testing, CONTRACTOR name, name of concrete testing laboratory, exact location of test core in the Work, type or class of concrete represented by core sample, nominal maximum size aggregate, design compressive strength, compression breaking strength, and type of break (corrected for length-diameter ratio), direction of applied load to core with respect to horizontal plane of concrete as placed, and moisture condition of the core at time of testing.

2. Fill core holes solid with non-shrink grout in accordance with Section 03600, Grouting, and finish to match adjacent concrete surfaces.

3. If results of core tests are unacceptable or if it is impractical to obtain cores, perform static load test and evaluations complying with ACI 318 and ACI 350, as directed by ENGINEER.

F. Concrete Tolerance Verification Measurements: Refer to Article 3.09 of this Section.

G. Supplier’s Services:

1. Water-Reducing Admixture Manufacturer: Furnish services of qualified concrete technician employed by admixture manufacturer to assist in proportioning concrete for optimum use of admixture. Concrete technician shall advise on proper addition of
admixture to concrete and on adjustment of concrete mix proportions to meet changing conditions at the Site.

3.11 MISCELLANEOUS CONCRETE ITEMS

A. Temporary Openings:

1. Openings in concrete walls and slabs required for passage of Work are allowed only upon approval of ENGINEER.

2. Temporary openings made in concrete shall be provided with waterstop in below-ground or liquid-retaining members and structures. Reinforcement going through and around the opening shall be made continuous to provide continuity and shall be approved by the ENGINEER.

3. Temporary openings that remain in concrete structures shall be filled with the same class of concrete as the adjoining construction, after the Work causing need for temporary opening is complete, unless otherwise shown or directed by ENGINEER. Mix, place, and cure concrete as specified in this Section to blend with in-place construction. Provide miscellaneous concrete filling shown or required to complete the Work.

B. Bases or Pads for Piping, Panels, and Equipment:

1. Unless specifically shown or indicated otherwise, provide concrete bases or pads for equipment, floor-mounted panels, and floor-mounted supports for piping and similar construction. Provide all concrete pad and base Work not specifically included under other Sections.

2. Dimensions and Elevations:

   a. Coordinate and construct bases and pads to dimensions shown or indicated, or as required to comply with equipment, panel, or piping manufacturer’s requirements and elevations indicated on the Drawing.
   
   b. Unless otherwise shown or indicated, place concrete bases for equipment up to one-inch below the equipment manufacturer’s base or mounting plate.
   
   c. Where specific dimensions or elevations are not shown or indicated, bases and pads shall be six inches thick and extend three inches outside dimensions of the equipment, panel, or supports.

3. Finish: Bases and pads outside of areas to receive non-shrink grout shall have smooth trowel finish, unless special finish such as terrazzo, ceramic tile, quarry tile, or heavy-duty concrete topping is required. In such cases, provide appropriate concrete finish. Surfaces of bases and pads to receive non-shrink grout shall have broom finish.

C. Curbs:
1. Provide monolithic finish to interior curbs by stripping forms while concrete is still green followed by steel-troweling surfaces to hard, dense finish with corners, intersections, and terminations slightly rounded.

2. Exterior curbs shall have rubbed finish for vertical surfaces and broomed finish for top surfaces.

3.12 REPAIR OF CONCRETE PLACED UNDER THIS CONTRACT

A. Repair of Formed Surfaces:

1. Repair the following defects in all formed finishes:
   a. Spalls, air bubbles, rock pockets, form depressions, and other defects that are more than 1/4-inch in depth.
   b. Holes from tie rods and other form tie systems.
   c. Fins, offsets, and other projections that extend more than 1/4-inch beyond designated concrete member surface.
   d. Structural cracks, as defined by ENGINEER.
   e. Non-structural cracks greater than 0.010-inch wide as defined by ENGINEER. In liquid-retaining structures, elevated slabs subject to the elements or washdowns, below-grade members, and cracks that evidence leakage. Where it is not possible to verify whether a crack is leaking, repair the crack.

2. Repair the following defects in smooth-finish surfaces, in addition to those listed above in this Section:
   a. Spalls, air bubbles, rock pockets, form depressions, and other defects that extend to more than 1/2-inch in width in any direction, no matter how deep.
   b. Spalls, air bubbles, rock pockets, form depressions, and other defects of any size that exceed three in number in a 12-inch by 12-inch area, or 12 in number in a three-foot by three-foot area.
   c. Fins, offsets, and other projections shall be completely removed and smoothed.
   d. Scratches and gouges in concrete surface.
   e. Texture and color irregularities. In liquid-retaining surfaces, texture and color irregularities need not be repaired when greater than 12 inches below minimum normal operating liquid surface elevation, except where such defects are indicative of reduced durability.

3. Where smooth rubbed or grout cleaned finish is specified, minor surface defects repairable by the finishing process need not be repaired prior to finish application, when approved by ENGINEER.

B. Method of Repair of Formed Surfaces:

1. Immediately after removing forms, repair and patch defective areas with cement mortar or concrete repair mortar as directed by ENGINEER. Make repairs made to liquid-retaining structures and below-grade surfaces with repair mortar only. Repair
form tie holes in liquid-retaining or below-grade surfaces with non-shrink grout in accordance with Section 03600, Grouting.

2. Honeycombs, Rock Pockets, and Holes Left by Tie Rods and Bolts:
   a. Cut out honeycomb, rock pockets, voids, and holes left by tie rods and bolts, down to solid concrete but, in no case, to depth less than one-inch for cement mortar and 1/2-inch for repair mortar. Make edges of cuts perpendicular to concrete surface.
   b. Before placing cement mortar, thoroughly clean and brush-coat area to be patched with specified bonding agent.
   c. When using concrete repair mortar, use of bonding agent is optional; prepare the surface and place mortar in accordance with mortar manufacturer’s recommendations.
   d. Repairs at exposed-to-view surfaces shall match the color of surrounding concrete, except color matching is not required for interior surfaces of liquid-retaining surfaces up to one foot below typical minimum liquid level. Impart texture to repaired surfaces to match texture of existing adjacent surfaces. Provide test areas at inconspicuous locations to verify mixture, texture, and color match before proceeding with patching.
   e. Compact mortar in place and strike off slightly higher than the surrounding surface.

3. Structural Cracks: Pressure-grout structural cracks using injectable epoxy installed using pressurized system. Apply in accordance with epoxy manufacturer’s directions and recommendations.

4. Non-structural Cracks: Shall be pressure-grouted using hydrophobic or hydrophilic resin. Install in accordance with resin manufacturer’s directions and recommendations.

5. Determination of the crack type shall be made by the ENGINEER.

6. Holes Through Concrete:
   a. Using plunger-type gun or other suitable device, fill holes extending through concrete from least-exposed face, using flush stop held at exposed face; completely fill the hole with specified repair material.
   b. At below-grade and liquid-containing members, fill holes with concrete repair mortar and use color-matched cement mortar for outer two inches at exposed-to-view surfaces.

7. Where powerwashing or scrubbing is not adequate, abrasive blast exposed-to-view surfaces that require removal of stains, grout accumulations, sealing compounds, and other substances marring the surfaces. Use sand finer than No. 30 and air pressure from 15 to 25 psi.

C. Repair of Unformed Surfaces:
1. Test unformed surfaces, such as monolithic slabs, for smoothness and to verify surface plane to specified tolerances for each surface and finish. Correct low and high areas in accordance with this Section.

2. Test unformed surfaces sloped to drain for trueness of slope, in addition to smoothness, using template having the required slope. Correct high and low areas in accordance with this Section.

3. Repair finish of unformed surfaces containing defects that adversely affect concrete durability. Surface defects include crazing, cracks in excess of 0.01-inch wide, spalling, popouts, honeycombs, rock pockets, and other objectionable conditions.

4. Repair structural cracks in all structures and non-structural cracks in liquid-retaining structures. In liquid-retaining structures, where dry face of concrete member can be observed, repair all cracks evidencing any rate of water flow through crack. Where dry face of member cannot be observed, repair all cracks.

D. Methods of Repair of Unformed Surfaces:

1. Correct high areas in unformed surfaces by grinding, after concrete has cured sufficiently so that repairs can be made without damage to adjacent areas.

2. Correct low areas in unformed surfaces, during or immediately after completion of surface finishing, by cutting out low areas and replacing with fresh concrete. Finish repaired areas to blend into adjacent concrete. Where repairs are required and concrete has already set, sawcut around perimeter of area to be repaired to depth of 1/2-inch and remove concrete so that minimum thickness of repair is 1/2-inch. Apply specified concrete repair mortar in accordance with repair mortar manufacturer’s directions and recommendations.

3. Repair defective areas, except random cracks and single holes not exceeding one-inch diameter, by cutting out and replacing with fresh concrete. Remove defective areas to sound concrete with clean, square cuts, and expose reinforcing steel with at least 3/4-inch clearance all around. Minimum thickness of repair shall be 1.5 inches. Dampen concrete surfaces in contact with patching concrete and brush with specified bonding agent. Place patching concrete while bonding agent is tacky. Mix patching concrete of same materials and proportions to provide concrete of same classification as original, adjacent concrete. Place, compact, and finish as required to blend with adjacent finished concrete. Cure in the same manner as adjacent concrete.

4. Repair isolated, random, non-structural cracks (in members that are not below grade or liquid-retaining), and single holes not greater than one-inch diameter, by dry-pack method. Groove top of cracks, and cut out holes to sound concrete, and clean repair area of dust, dirt, and loose particles. Dampen all cleaned concrete surfaces and brush with the specified bonding agent. Place dry-pack before cement grout takes its initial set. Mix dry-pack, consisting of one part portland cement to 2.5 parts fine aggregate passing No. 16 mesh sieve, using only enough water as required for
handling and placing. Compact dry-pack mixture in place and finish to match adjacent concrete. Keep patched areas continuously moist for at least 72 hours.

5. Structural cracks shall be pressure-grouted using injectable epoxy. Apply in accordance with epoxy manufacturer’s directions and recommendations.

6. Non-structural cracks in below-grade and liquid-retaining structures shall be pressure-grouted using hydrophilic resin. Apply in accordance with resin manufacturer’s directions and recommendations.

7. Determination of crack type will be by ENGINEER.

E. Other Methods of Repair:

1. Repair methods not specified in this Section may be used when approved by ENGINEER.

END OF SECTION
PART 1 GENERAL

1.01 DESCRIPTION

A. Scope:

1. CONTRACTOR shall provide all labor, materials, equipment, and incidentals as shown, specified, and required to furnish and install grout and perform grouting Work.

B. Coordination:

1. Review installation procedures under this and other Sections and coordinate installation of items to be installed with or before grouting Work.

C. Related Sections:

1. Section 03251, Concrete Accessories.
2. Section 03300, Cast-In-Place Concrete.

D. Application and Grout Material:

1. The following is a listing of grouting applications and the corresponding type of grout material to be provided for the associated application. Unless shown or indicated otherwise in the Contract Documents, provide grout in accordance with the following:

<table>
<thead>
<tr>
<th>Application</th>
<th>Required Grout Material Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beam and column (one- or two-story height) base plates and precast concrete</td>
<td>Class II Non-Shrink</td>
</tr>
<tr>
<td>bearing less than 16 inches in the least dimension</td>
<td></td>
</tr>
<tr>
<td>Column base plates and precast concrete bearing (greater than two-story</td>
<td>Class I Non-Shrink</td>
</tr>
<tr>
<td>height or larger than 16 inches in the least dimension)</td>
<td></td>
</tr>
<tr>
<td>Base plates for storage tanks and other non-motorized equipment, and</td>
<td>Class I Non-Shrink (unless otherwise recommended by equipment</td>
</tr>
<tr>
<td>motorized equipment or machinery less than 50 horsepower</td>
<td>manufacturer)</td>
</tr>
<tr>
<td>Motorized equipment or machinery equal to and greater than 50 horsepower,</td>
<td>Class III Non-Shrink Epoxy (unless otherwise recommended by</td>
</tr>
<tr>
<td>and motorized equipment or machinery equipment less than 50 horsepower</td>
<td>equipment manufacturer)</td>
</tr>
</tbody>
</table>

TPWD No. 1110061
| Subject to severe shock loads or high vibration | Class II Non-Shrink (Class I where placement time exceeds 15 minutes) |
| Filling blockout spaces for embedded items such as railing posts, guide frames for hydraulic gates, and similar applications | Grout Fill or grout toppings less than four inches thick |
| Class II Non-Shrink (Class I where placement time exceeds 15 minutes) | Grout Fill |
| Grout fill greater than four inches thick | Class "B" Concrete in accordance with Section 03300, Cast-In-Place Concrete |
| Grout for setting filter underdrain blocks, and for filling voids between filter underdrain blocks, and for filling voids between filter underdrain blocks and walls | Filter Underdrain Blocks Grout |
| Applications not listed above, where grout is indicated on the Drawings | Class I Non-Shrink, unless shown or indicated otherwise |

### 1.02 REFERENCES

A. Standards referenced in this Section are:

1. ACI 211.1, Practice for Selecting Proportions for Normal, Heavyweight, and Mass Concrete.
2. ACI 301, Structural Concrete for Buildings.
3. ASTM C33/C33M, Specification for Concrete Aggregates.
8. ASTM C827, Test Method for Change in Height at Early Ages of Cylindrical Specimens of Cementitious Mixtures.
9. ASTM C882/C882M, Test Method for Bond Strength of Epoxy-Resin Systems Used With Concrete By Slant Shear.


1.03 QUALITY ASSURANCE

A. Qualifications:

1. Grout Testing Laboratory:
   a. Independent testing laboratory employed for design and testing of grout materials and mixes shall comply with testing laboratory requirements in Section 03300, Cast-in-Place Concrete and other applicable requirements in the Contract Documents.

2. Manufacturer: Shall have a minimum of five years experience of producing products substantially similar to that required and shall be able to submit documentation of at least five satisfactory installations that have been in successful operation for at least five years each.

3. Manufacturer’s Field Service Technician: When required, provide services of manufacturer’s full-time employee, factory-trained in handling, use, and installing the products required, with at least five years of experience in field applications of the products required.

B. Trial Batch:

1. Each grout fill and construction joint grout mix proportion and design shall be verified by laboratory trial batch or field experience methods. Comply with ACI 211.1 and submit to ENGINEER a report with the following data:
   a. Complete identification of aggregate source of supply.
   b. Tests of aggregates for compliance with specified requirements.
   c. Scale weight of each aggregate.
   d. Absorbed water in each aggregate.
   e. Brand, type, and composition of cement.
   f. Brand, type, and amount of each admixture.
   g. Amounts of water used in trial mixes.
   h. Proportions of each material per cubic yard.
   i. Unit weight and yield per cubic yard of trial mixtures.
   j. Measured slump.
   k. Measured air content.
   l. Compressive strength developed at seven days and 28 days, from not less than three test specimens cast for each seven-day and 28-day test, and for each design mix.
2. Laboratory Trial Batches: When laboratory trial batches are used to select grout proportions, prepare test specimens and conduct strength tests as specified in ACI 301.

3. Field Experience Method: When field experience methods are used to select grout proportions, establish proportions as specified in ACI 301.

1.04 SUBMITTALS

A. Action Submittals: Submit the following:

1. Shop Drawings:
   a. Schedule of Project-specific grout applications, installation locations, and the grout type proposed for each.
   b. List of grout materials and proportions for the proposed mix designs. Include data sheets, test results, certifications, and mill reports to qualify the materials proposed for use in the mix designs. Do not start laboratory trial batch testing until submittal is approved by ENGINEER.
   c. Trial Batch Reports: Submit laboratory test reports for grout materials and mix design tests.

2. Product Data:
   a. Data sheets, certifications, and manufacturer’s specifications for all materials proposed for use.

B. Informational Submittals: Submit the following:

1. Manufacturer’s Instructions:
   a. Special instructions for shipping, storing, protecting, and handling.
   b. Installation instructions for the materials.

2. Supplier Reports:
   a. Submit written report of results of each visit to Site by Supplier’s field service technician, including purpose and time of visit, tasks performed, and results obtained. Submit within two days of completion of visit to the Site.

3. Qualifications Statements:
   a. Testing laboratory, when not submitted under other Sections.
   b. Manufacturer, when submittal of qualifications is required by ENGINEER.
   c. Manufacturer’s field service technician, when submittal of qualifications is required by ENGINEER.
1.05 PRODUCT DELIVERY, STORAGE AND HANDLING

A. Storage of Materials: Store grout materials in a dry location, protected from weather and protected from moisture.

PART 2 PRODUCTS

2.01 GENERAL

A. All grout materials, admixtures, cementitious materials, and other materials used in grout that contact potable water or water that will be treated to become potable shall be listed in NSF/ANSI 61.

2.02 NON-SHRINK GROUT MATERIALS

A. General: Non-shrink grout shall be a prepackaged, inorganic, flowable, non-gas-liberating, non-metallic, cement-based grout requiring only the addition of water. Manufacturer’s instructions shall be printed on each bag or container in which the materials are packaged. Specific formulation for each type or class of non-shrink grout specified in this Section shall be that recommended by the grout manufacturer for the particular application.

B. Class I Non-Shrink Grout:

1. Class I non-shrink grouts shall have a minimum 28-day compressive strength of 7,000 psi. Use grout for precision grouting and where water-tightness and non-shrink reliability in both plastic and hardened states is critical, in accordance with Table 03600-A in this Section.

2. Products and Manufacturer: Provide one of the following:
   a. MasterFlow 928, by Master Builders, Inc.
   b. Five Star Grout, by Five Star Products, Inc.
   c. Hi-Flow Grout, by Euclid Chemical Company.
   d. Or equal.

3. Comply with ASTM C1107/C1107M, Grade C and B (as modified below) when tested using amount of water required to achieve the following properties:
   a. Fluid consistency (20 to 30 seconds) shall be in accordance with ASTM C939.
   b. At temperatures of 45, 73.4, and 95 degrees F.

4. Length change from placing to time of final set shall not have shrinkage greater than the expansion measured at three or fourteen days. Expansion at three or fourteen days shall not exceed the 28-day expansion.

5. Non-shrink property shall not be based on chemically-generated gas or gypsum expansion.
6. Fluid grout shall pass through the flow cone, with continuous flow, one hour after mixing.

C. Class II Non-Shrink Grout:

1. Class II non-shrink grouts shall have minimum 28-day compressive strength of 7,000 psi. Use grout for general-purpose grouting applications in accordance with Table 03600-A in this Section.

2. Products and Manufacturer: Provide one of the following:
   a. MasterFlow 100, by Master Builders, Inc.
   b. FSP Construction Grout, by Five Star Products, Inc.
   c. NS Grout, by Euclid Chemical Company.
   d. Or equal.

3. Comply with ASTM C1107/C1107M and the following when tested using the quantity of water required to achieve the following properties:
   a. Flowable consistency (140 percent flow in accordance with ASTM C230/C230M, five drops in 30 seconds).
   b. Fluid working time of at least 15 minutes.
   c. Flowable for at least 30 minutes.

4. When tested, grout shall not bleed at maximum allowed water.

5. Non-shrink property shall not be based on chemically-generated gas or gypsum expansion.

D. Class III Non-Shrink Epoxy Grout:

1. Epoxy grout shall be a pourable, non-shrink, 100-percent solids system.

2. Products and Manufacturer: Provide one of the following:
   a. E3G, by Euclid Chemical Company.
   b. Sikadur 42 Grout Pak LE, by Sika Corporation.
   c. HP Epoxy Grout, by Five Star Products, Inc.
   d. Or equal.

3. Epoxy grout system shall have three components: resin, hardener, and specially blended aggregate, all pre-measured and prepackaged. Resin component shall not contain non-reactive diluents. Resins containing butyl glycidyl ether (BGE) or other highly volatile and hazardous reactive diluents are unacceptable. Variation of component ratios is not allowed without specific recommendation by manufacturer. Manufacturer’s instructions shall be printed on each container in which products are packaged.
4. The following properties shall be attained with the minimum quantity of aggregate allowed by epoxy grout manufacturer.

   a. Vertical volume change at all times before hardening shall be between zero percent shrinkage and 4.0 percent expansion when measured in accordance with ASTM C827 (modified for epoxy grouts by using an indicator ball with specific gravity between 0.9 and 1.1).
   b. Length change after hardening shall be less than 0.0006-inch per inch and coefficient of thermal expansion shall be less than 0.00003-inch per inch per degree F when tested in accordance with ASTM C531.
   c. Compressive creep at one year shall be less than 0.001-inch per inch when tested under a 400-psi constant load at 140 degrees F in accordance with ASTM C1181.
   d. Minimum seven-day compressive strength shall be 14,000 psi when tested in accordance with ASTM C579.
   e. Grout shall be capable of maintaining at least a flowable consistency for minimum of 30 minutes at 70 degrees F.
   f. Shear bond strength to portland cement concrete shall be greater than shear strength of concrete when tested in accordance with ASTM C882/C882M.
   g. Minimum effective bearing area shall be 95 percent.

2.03 GROUT MATERIALS OTHER THAN NON-SHRINK GROUT

A. General: Materials for grouts (other than non-shrink grouts) shall be in accordance with Section 03300, Cast-In-Place Concrete, except as otherwise specified in this Section.

B. Grout Fill:

   1. Grout fill shall be comprised of cement, fine aggregate, coarse aggregate, water, and admixtures proportioned and mixed in accordance with this Section.

      a. Minimum Compressive Strength: 4,000 psi at 28 days.
      b. Maximum Water-Cement Ratio: 0.45 by weight.
      c. Coarse Aggregate: ASTM C33/C33M, No. 8 size.
      d. Fine Aggregate: ASTM C33/C33M, approximately 60 percent by weight of total aggregate.
      e. Air Content: Seven percent (plus or minus one percent).
      f. Minimum Cement Content: 564 pounds per cubic yard.
      g. Slump for grout fill shall be adjusted to match placing and finishing conditions, and shall not exceed four inches.

C. Construction Joint Grout:

   1. Construction joint grout shall be comprised of cement, fine aggregate, coarse aggregate, water, and admixtures proportioned with similar cementitious characteristics as Class “A” concrete specified in Section 03300, Cast-In-Place Concrete. Mix design shall result in grout that is flowable with high mortar content. Mix requirements are:
a. Minimum Compressive Strength: 4,500 psi at 28 days.
b. Maximum Water-Cement Ratio: 0.42 by weight.
c. Coarse Aggregate: ASTM C33/C33M, No. 8 size.
d. Fine Aggregate: ASTM C33/C33M, approximately 60 percent by weight of total aggregate.
e. Air Content: Seven percent (plus or minus one percent).
f. Minimum Cement Content: 752 pounds per cubic yard.
g. Slump for Construction Joint Grout: Seven inches (plus or minus one inch).

D. Filter Underdrain Blocks Grout:

1. Grout shall comply with Article 2.1 of this Section. Grout shall consist of one part cement to two parts sand with shrinkage-reducing admixture. Class I or Class II non-shrink grout may be used in lieu of filter underdrain blocks grout.

   a. Minimum Compressive Strength: 4,000 psi at 28 days.
   b. Maximum Water-Cement Ratio: 0.45 by weight.

2.04 CURING MATERIALS

A. Curing materials shall comply with Section 03300, Cast-in-Place Concrete, and shall be as recommended by the manufacturer of prepackaged grouts.

PART 3 EXECUTION

3.01 INSPECTION

A. Examine substrate and conditions under which grouting will be performed and notify ENGINEER in writing of unsatisfactory conditions. Do not proceed with the Work until unsatisfactory conditions are corrected.

3.02 INSTALLATION

A. General:

1. Place grout as shown and indicated, and in accordance with Laws and Regulations and grout manufacturer’s instructions. If manufacturer’s instructions conflict with the Contract Documents, obtain clarification or interpretation from ENGINEER before proceeding.

2. Consistency of non-shrink grouts shall be as required to completely fill the space to be grouted for the particular application. Do not install grout for dry-packing without approval of ENGINEER. When dry-packing is approved by ENGINEER, dry-pack consistency shall be such that grout has sufficient water to ensure hydration and grout strength development, and remains plastic, moldable, and that does not flow.

3. Grouting shall comply with temperature and weather limitations in Section 03300, Cast-In-Place Concrete.
4. Cure grout in accordance with grout manufacturer’s instructions for prepackaged
group and Section 03300, Cast-In-Place Concrete, for grout fill.

B. Columns and Beams:

1. After shimming columns and beams to proper elevation, securely tighten anchors.
   Properly form around base plates allowing sufficient room around edges for placing
   grout. Provide adequate depth between bottom of base plate and top of concrete
   base to assure that void is completely filled with non-shrink grout.

C. Equipment Bases:

1. Install equipment in accordance to manufacturer’s recommendations, Laws, and
   Regulations, and the Contract Documents. After shimming equipment to proper
   elevation, securely tighten anchors. Properly form around base plates, allowing
   sufficient room around edges for placing grout. Provide adequate depth between
   bottom of equipment base and top of concrete base to ensure that voids are
   completely filled with non-shrink grout.

D. Handrail Posts:

1. After posts have been properly inserted into holes or sleeves, fill annular space
   between posts and sleeve with non-shrink grout. Bevel grout at juncture with post
   so that water will flow away from post.

E. Construction Joints:

1. Place a six-inch minimum thick layer of construction joint grout over contact surface
   of concrete at interface of horizontal construction joints in accordance with Section
   03251, Concrete Accessories, and Section 03300, Cast-In-Place Concrete.

F. Grout Fill:

1. All mechanical, electrical, and finish work shall be completed prior to placing grout
   fill. Base slab shall be provided with a scratched finish in accordance with Section
   03300, Cast-In-Place Concrete. Roughen existing slabs shall by abrasive blasting or
   hydroblasting exposing aggregates to ensure bonding to base slab.

2. Minimum thickness of grout fill shall be one-inch. Where finished surface of grout fill
   is to form an intersecting angle of less than 45 degrees with concrete surface
   against which grout will be placed, form a key in the concrete surface at the
   intersection point. Key shall be minimum of 3.5 inches wide by 1.5 inches deep.

3. Thoroughly clean and wet base slab prior to placing grout fill. Do not place grout fill
   until slab is completely free of standing water. A thin coat of neat Type II cement
   slurry shall be broomed into surface of slab. Place grout fill while slurry is wet.
   Grout fill shall be compacted by rolling or tamping, brought to elevation, and floated.
   In tanks and basins where scraping-type equipment will be installed, grout fill shall
   be screeded by blades attached to revolving mechanism of equipment in
accordance with procedures recommended by equipment manufacturer after grout is brought to elevation.

4. Grout fill placed on sloping slabs shall be installed uniformly from bottom of slab to top, for full width of placement.

5. Test grout fill surface with a straight edge to detect high and low spots; immediately correct high and low spots in grout fill. When grout fill has hardened sufficiently, grout fill shall be steel troweled to provide a smooth surface free of bug holes and other imperfections. While an acceptable type of mechanical trowel may be used in this operation, the last pass over the grout fill surface shall be by hand-troweling. During finishing, do not apply the following to the grout fill surface: water, dry cement, or mixture of dry cement and sand.

6. Cure and protect grout fill in accordance with Section 03300, Cast-In-Place Concrete.

3.03 FIELD QUALITY CONTROL

A. Field Testing Services:

1. OWNER will employ testing laboratory to perform field quality control testing for grout. ENGINEER will direct the testing requirements.

2. CONTRACTOR shall provide all curing and necessary cube storage as specified in Division 1.

B. Quality Control Testing During Construction:

1. Grout Fill: Perform sampling and testing for field quality control during grout fill placing as follows:

   b. Slump: ASTM C143; one test for each load of grout at point of discharge.
   c. Air Content: ASTM C231; one sample for every two grout loads at point of discharge, and when a change in the grout is observed.
   d. Compression Test Specimens:

      1) In accordance with ASTM C109/C109M; make one set of compression cubes for each 50 cubic yards of grout, or fraction thereof, of each mix design placed each day. Each set shall be four standard cubes, unless otherwise directed by ENGINEER.

C. Evaluation of Field Quality Control Tests:

1. Do not use grout, delivered to final point of placement, having slump or total air content that does not comply with the Contract Documents.
2. Compressive strength tests for laboratory-cured cubes will be acceptable if averages of all sets of three consecutive compressive strength test results equal or exceed the required 28-day design compressive strength of the associated type of grout.

3. If the compressive strength tests do not comply with the requirements in the Contract Documents, the grout represented by such tests will be considered defective and shall be removed and replaced, or subject to other action required by ENGINEER, at CONTRACTOR's expense.

D. Manufacturer's Services:

1. Manufacturers of proprietary materials shall make available upon 72 hours notification the services of qualified, full time employee, experienced in serving as a field service technician for the products required, to aid in assuring proper use of products under the actual conditions at the Site.

END OF SECTION
PART 1   GENERAL

1.01   DESCRIPTION

A. Scope:

1. CONTRACTOR shall provide all labor, materials, equipment, and incidentals as shown, specified, and required to furnish and install anchor systems.

2. This Section includes all anchor systems required for the Work, but not specified under other Sections.

B. Coordination:

1. Review installation procedures under this and other Sections and coordinate installation of items to be installed with or before anchor systems Work.

1.02   REFERENCES

A. Standards referenced in this Section are:

1. ACI 318, Building Code Requirements for Structural Concrete.

2. ACI 350, Code Requirements for Environmental Engineering Concrete Structures.

3. ACI 355.2, Qualification of Post-Installed Mechanical Anchors in Concrete.

4. ASTM A194/A194M, Specification for Carbon and Alloy Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both.

5. ASTM A276, Specification for Stainless Steel Bars and Shapes.


11. ASTM C579, Test Methods for Compressive Strength of Chemical-Resistant Mortars, Grouts, Monolithic Surfacing, and Polymer Concretes.


27. ICC-ES AC308, Acceptance Criteria for Post-Installed Adhesive Anchors in Concrete Elements.


30. NSF/ANSI 61, Drinking Water System Components – Health Effects.
1.03 QUALITY ASSURANCE

A. Qualifications:

1. Testing Laboratory: Shall comply with ASTM E329 and shall be experienced in tension testing of post-installed anchoring systems.

2. Post-installed Anchor Installer: Shall be experienced and trained by post-installed anchor system manufacturer in proper installation of manufacturer’s products. Product installation training by distributors or manufacturer’s representatives is unacceptable unless the person furnishing the training is qualified as a trainer by the anchor manufacturer.

1.04 SUBMITTALS

A. Action Submittals: Submit the following:

1. Shop Drawings:
   a. Listing of all anchor systems products intended for use in the Work including product type, intended location in the Project, and embedded lengths.

2. Product Data:
   a. Manufacturer’s specifications, load tables, dimension diagrams, acceptable base material conditions, acceptable drilling methods, and acceptable bored hole conditions.
   b. When required by ENGINEER, copies of valid ICC ES reports that presents load-carrying capacities and installation requirements for anchor systems.

B. Informational Submittals: Submit the following:

1. Certificates:
   a. For each type of anchor bolt or threaded rod, submit copies of laboratory test reports and other data required to demonstrate compliance with the Contract Documents.
   b. Post-installed anchor system manufacturer’s certification that installer received training in the proper installation of manufacturer’s products required for the Work.

2. Manufacturer’s Instructions:
   a. Installation instructions for each anchor system product proposed for use, including bore hole cleaning procedures and adhesive injection, cure and gel time tables, and temperature ranges (storage, installation and in-service).

3. Field Quality Control Submittals:
a. Submit results of field quality control testing and inspections performed by testing laboratory.

1.05 DELIVERY, STORAGE AND HANDLING

A. Storage and Protection:

1. Keep materials dry during delivery and storage.

2. Store adhesive materials within manufacturer’s recommended storage temperature range.

3. Protect anchor systems from damage at the Site. Protect products from corrosion and deterioration.

PART 2 PRODUCTS

2.01 SYSTEM PERFORMANCE

A. General:

1. At locations where conditions dictate that Work specified in other Sections is to be of corrosion resistant materials, provide associated anchor systems of stainless steel materials, unless other corrosion-resistant anchor system material is specified. Provide anchor systems of stainless steel materials where stainless steel materials are required in the Contract Documents.

2. Stainless Steel Nuts:

   a. For anchor bolts and adhesive anchors, provide ASTM A194/A194M, Grade 8S (Nitronic 60) stainless steel nuts for stainless steel anchors used for anchoring equipment, gates, and weirs, and other locations, if any, where the attachment will require future removal for operation or maintenance. Provide lock washer or double nuts on each anchorage device provided for equipment, as required by equipment manufacturer.

   b. For other locations, provide for each anchorage device a nut as specified or as required by anchor manufacturer. When ASTM A194/A194M, Grade 8S (Nitronic 60) nuts are not required for anchor bolts and adhesive anchors as specified in this Section, provide anti-seizing compound where stainless steel rods are used with stainless steel nuts of the same type.

3. Materials that can contact potable water or water that will be treated to become potable shall be listed in NSF/ANSI 61.

B. Design Criteria

1. Size, Length, and Load-carrying Capacity: Comply with the Contract Documents. When size, length or load-carrying capacity of anchor system is not otherwise shown or indicated, provide the following:

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Dundee State Fish Hatchery Water Reuse – Effluent Pump Back
TPWD No. 1110061
ANCHOR SYSTEMS

a. Anchor Bolts: Provide size, length, and capacity required to carry design load based on values and requirements of Paragraph 3.02A of this Section. For conditions outside limits of critical edge distance and spacing in Paragraph 3.02A of this Section, minimum anchor bolt embedment as shown or indicated in Paragraph 3.02A of this Section apply and capacity shall be based on requirements of Laws and Regulations, including applicable building codes.

b. Adhesive Anchors, Expansion Anchors, or Concrete Inserts: Provide size, length, type, and capacity required to carry design load. Anchor capacity shall be based on the procedures required by the building code in effect at the Site. Where Evaluation Service Reports issued by the ICC Evaluation Service are required in this Section, anchor capacities shall be based on design procedure required in the applicable ICC Evaluation Service Report.

1) General: Determine capacity considering reductions due to installation and inspection procedures, embedment length, strength of base fastening materials, spacing, and edge distance, as indicated in the manufacturer’s design guidelines. For capacity determination, concrete shall be assumed to be in the cracked condition, unless calculations demonstrate that the anchor system will be installed in an area that is not expected to crack under any and all conditions of design loading.

2) Concrete Adhesive Anchors: Unless otherwise shown or indicated in the Contract Documents or approved by ENGINEER, provide minimum embedment depth of the greater of the following: required to develop tensile strength of anchor, or a minimum embedment of 10 anchor diameters; and minimum anchor spacing and edge distance of 12 anchor diameters.

3) distance as indicated in anchor manufacturer’s instructions.

4) Concrete Expansion Anchors: Unless otherwise shown or indicated in the Contract Documents or approved by ENGINEER, provide minimum embedment depth of six anchor diameters, and minimum anchor spacing and edge distance of seven anchor diameters.

5) Concrete Undercut Anchors: Unless otherwise shown or indicated in the Contract Documents, or approved by ENGINEER, provide minimum anchor spacing and edge distance as tabulated in anchor manufacturer’s instructions.

2. Design Loads. Comply with the Contract Documents. When design load of supported material, equipment, or system is not otherwise shown or indicated, provide the following:

a. Equipment Anchors: Use design load recommended by equipment manufacturer. When equipment can be filled with fluid, use loads that incorporate equipment load and load imposed by fluid.

b. Pipe Hangers and Supports: Use full weight of pipe, and fluid contained in pipe that are tributary to the support plus the full weight of valves and accessories located between the hanger or support being anchored and the next hanger or support.

c. Hangers and Supports for Electrical Systems, and HVAC, Plumbing, and Fire Suppression Systems and Piping: Use the full weight of supported system that is tributary to the support plus the full weight of accessories located between the
hanger or support being anchored and the next hanger or support. When piping or equipment is to be filled with fluid, anchor systems shall be sized to support such loads in addition to the weight of the equipment, piping, or system, as applicable.

d. Delegated Design: When anchor systems are used for supporting materials, equipment, or systems delegated to a design professional retained by CONTRACTOR, Subcontractor, or Supplier, provide anchor system suitable for loads indicated in delegated design documents and consistent with the design intent expressed in the Contract Documents.

C. Application:

1. Anchor Bolts:
   a. Where anchor bolt is shown or indicated, use cast-in-place anchor bolt unless another anchor type is approved by ENGINEER.
   b. Provide anchor bolts as shown or indicated, or as required to secure structural element to appropriate anchor surface.

2. Concrete Adhesive Anchors:
   a. Use where adhesive anchors are shown or indicated for installation in concrete.
   b. Suitable for use where subject to vibration.
   c. Suitable for use in exterior locations or locations subject to freezing.
   d. Suitable for use in submerged, intermittently submerged, or buried locations.
   e. Do not use in overhead applications, unless otherwise shown or approved by ENGINEER.
   f. Do not use for pipe hangers, unless otherwise shown or approved by ENGINEER.

3. Concrete Wedge Expansion Anchors:
   a. Use where expansion anchors are shown or indicated for installation in concrete.
   b. Do not use where subject to vibration.
   c. Do not use in exterior locations or locations subject to freezing.
   d. Do not use in submerged, intermittently submerged, or buried locations.
   e. Suitable for use in overhead applications.

4. Drop-in Expansion Anchors:
   a. Use drop-in expansion anchors installed in concrete where light-duty anchors are required to support piping or conduit two-inch diameter or smaller.
   b. Do not use for attaching safety-related systems, such as piping conveying hazardous or potentially hazardous materials, or fire suppression systems.
   c. Do not use where subject to vibration.
   d. Do not use at submerged, intermittently submerged, or buried locations.
   e. Do not use in exterior locations or locations subject to freezing.
   f. Suitable for use in overhead applications.
5. Concrete Undercut Anchors:
   a. Use where undercut anchors are shown or indicated for installation in concrete.
   b. Suitable for use where subject to vibration.
   c. Do not use in submerged, intermittently submerged, or buried locations.
   d. Do not use in exterior locations or locations subject to freezing.
   e. Suitable for use in overhead applications.

6. Concrete Inserts:
   a. Use only where shown or indicated in the Contract Documents.
   b. Allowed for use to support pipe hangers and pipe supports for pipe size and loading recommended by the concrete insert manufacturer.

7. Drive-In Expansion Anchors:
   a. Use drive-in expansion anchors installed in concrete, precast concrete, grouted masonry units, or brick, where light-duty anchors are required to support piping or conduit one-inch diameter and smaller.
   b. Do not use for attaching safety-related systems, such as piping conveying hazardous or potentially hazardous materials, or fire suppression systems.
   c. Do not use in overhead applications.

2.02 MATERIALS

A. Anchor Bolts:

   1. Interior Dry Non-corrosive Locations: Provide straight threaded carbon steel rods complying with ASTM F1554, Grade 36, with heavy hex nuts complying with ASTM A563 Grade 36, unless otherwise shown or indicated on the Drawings. Hooked anchor bolts are unacceptable.

   2. Exterior, Buried, Submerged Locations, or When Exposed to Wastewater: Provide stainless steel straight threaded rods complying with ASTM F593, AISI Type 316, Condition A, with ASTM F594, AISI Type 316, stainless steel nuts. Provide ASTM A194/A194M, Grade 8S (Nitronic 60) stainless steel nuts where required. Other AISI types may be used when approved by ENGINEER. Hooked bolts are unacceptable.

   3. Equipment: Provide anchor bolts complying with material requirements of this Section and equipment manufacturer’s requirements relative to size, embedment length, and anchor bolt projection. Anchor bolts shall be straight threaded rods with washers and nuts as specified in this Section. Hooked bolts are unacceptable.

   4. Anchoring of Structural Elements: Provide anchor bolts of size, material, and strength shown or indicated in the Contract Documents.

B. Concrete Adhesive Anchors:

   1. General:
a. Adhesive anchors shall consist of threaded rods anchored into hardened concrete using an adhesive system.

2. Products and Manufacturers: Provide one of the following:

c. Or equal.

3. Adhesive:

a. Adhesive system shall use two-component adhesive mix.
b. Epoxy adhesives shall comply with physical requirements of ASTM C881/C881M, Type IV, Grade 2 and 3, Class A, B, and C, except gel times.
c. Adhesives shall have a current evaluation report by ICC Evaluation Service for use in both cracked and uncracked concrete with seismic recognition for SDC A through F as tested and assessed in accordance with ICC-ES AC308.
d. Adhesives shall have minimum bond strength and minimum design bond strength (bond strength multiplied by strength reduction factor) in accordance with Table 05051-A:

<table>
<thead>
<tr>
<th>Anchor</th>
<th>Uncracked Concrete</th>
<th>Cracked Concrete</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rod Diameter / Dowel Size</td>
<td>Bond Strength (psi)</td>
<td>Design Bond Strength (psi)</td>
</tr>
<tr>
<td>3/8-inch / #3</td>
<td>2040</td>
<td>1300</td>
</tr>
<tr>
<td>1/2-inch / #4</td>
<td>1920</td>
<td>1200</td>
</tr>
<tr>
<td>5/8-inch / #5</td>
<td>1830</td>
<td>1150</td>
</tr>
<tr>
<td>3/4-inch / #6</td>
<td>1760</td>
<td>1050</td>
</tr>
<tr>
<td>7/8-inch / #7</td>
<td>1670</td>
<td>900</td>
</tr>
<tr>
<td>1-inch / #8</td>
<td>1650</td>
<td>1050</td>
</tr>
<tr>
<td>1.25-inch/ #10</td>
<td>1580</td>
<td>1000</td>
</tr>
</tbody>
</table>

Table Notes:
1. Bond strengths listed for hammer-drilled, dry hole.
2. Bond strengths listed for maximum short term concrete temperature of 110 degrees F and maximum long term concrete temperature of 75 degrees F.

4. Anchor:

a. Provide continuously-threaded, AISI Type 316 stainless steel adhesive anchor rod. Threaded rods shall comply with the concrete adhesive anchor manufacturer’s specifications as included in the ICC Service Evaluation Report for the anchor submitted. Nuts shall have specified proof load stresses equal to

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or greater than the minimum tensile strength of the stainless steel threaded rod used. Provide ASTM A194/A194M, Grade 8S (Nitronic 60) stainless steel nuts where required.

C. Concrete Wedge Expansion Anchors:

1. General:
   a. Concrete wedge expansion anchors shall consist of stud, wedge, nut, and washer.

2. Products and Manufacturers: Provide one of the following:
   a. Kwik Bolt TZ Wedge Anchor, by Hilti Fastening Systems, Inc.
   b. Or equal.


4. Interior Dry Non-corrosive Locations: Provide carbon steel anchors complete with nuts and washers, zinc plated, in accordance with ASTM B633.

5. Other Locations: Provide expansion anchors complete with nuts and washers, AISI Type 304 stainless steel anchor body, in accordance with ASTM A276 or ASTM A493.

6. Concrete wedge expansion anchors shall have a current ICC Evaluation Service Report for use in both cracked and uncracked concrete with seismic recognition in seismic design Categories A through F when tested and assessed in accordance with ICC-ES AC193.

D. Drop-in Expansion Anchors:

1. General:
   a. Drop-in expansion anchors shall each consist of an internally threaded, deformation-controlled expansion anchor with pre-assembled expander plug.

2. Products and Manufacturers: Provide one of the following:
   a. HDI Drop-In Anchors, by Hilti Fastening Systems, Inc.
   b. Drop-In Anchor, by Simpson Strong-Tie Company, Inc.
   c. Or equal.

3. Provide carbon steel anchors complete with nuts and washers, zinc plated, in accordance with ASTM B633, complying with physical requirements of FS A-A-
55614, Type I. Anchors shall be flush or shell type. Provide low-profile anchors for use in precast concrete planks.

E. Concrete Undercut Anchors:

1. General:
   a. Each concrete undercut anchor shall consist of threaded stud, thick-walled expansion sleeve, expander coupler, and nut and washer. Anchors shall be pre-set type or through-set type, as shown on the Drawings.

2. Products and Manufacturers: Provide one of the following:
   a. HDA Undercut Anchor, by Hilti Fastening Systems, Inc.
   b. DUC Ductile Undercut Anchor, by USP Structural Connectors.
   c. Or equal

3. Provide concrete undercut expansion anchors in accordance with ACI 318 and ACI 350, Appendix D. Demonstrate suitability of cracked concrete undercut anchors in accordance with ACI 355.2 prequalification tests.

4. Installed anchor shall exhibit form fit between bearing elements and the undercut in the concrete.

5. Interior Dry Non-Corrosive Locations: Provide carbon steel anchors, complete with nuts and washers, zinc plated, in accordance with ASTM B633.

6. Other Locations: Provide stainless steel anchors, complete with nuts and washers, manufactured of AISI Type 316 stainless steel or materials complying with ISO 3506-1 and having corrosion resistance equivalent to AISI Type 316 stainless steel.

7. Concrete undercut anchors shall have a current ICC Evaluation Service Report for use in both cracked and uncracked concrete for seismic recognition for seismic design Categories A through F when tested and assessed in accordance with ICC-ES AC193.

F. Concrete Inserts:

1. Manufacturers: Provide products of one of the following:
   a. Unistrut Corporation.
   b. Cooper B-Line, Inc.
   c. Anvil International, Inc.
   d. Or equal.

2. Spot Concrete Inserts:
   a. Provide inserts recommended by insert manufacturer for required loading. Inserts shall comply with ANSI/MSS SP-58, malleable iron, Type 18. Spot
inserts shall allow for lateral adjustment and have means for attachment to forms. Provide nuts compatible with insert and to suit threaded hanger rod sizes.

3. Continuous Concrete Inserts:
   a. Provide inserts recommended by insert manufacturer for required loading. Inserts shall be continuous type and shall be manufactured from minimum 12-gage cold-formed channel sections, complying with ASTM A1011/A1011M, stainless steel, Grade 33, complete with styrofoam inserts, end caps, and means for attaching to forms. Provide channel nuts compatible with insert suitable for threaded hanger rod sizes.

4. Provide inserts with plain finish.

G. Drive-In Expansion Anchors:

1. General:
   a. Drive-In expansion anchors shall each consist of stainless steel drive pin and expanding alloy body.

2. Products and Manufacturers: Provide one of the following:
   a. Metal HIT Anchor, by Hilti Fastening Systems, Inc.
   c. Or equal.


H. Unless approved by ENGINEER, do not use power-actuated fasteners or other types of bolts and fasteners not specified in this Section.

I. Anti-Seizing Compound:

1. Products and Manufacturers: Provide one of the following:
   c. Or equal.

2. Provide pure nickel anti-seizing compound.

PART 3 EXECUTION

3.01 INSPECTION

A. Examine conditions under which materials will be installed and advise ENGINEER in writing of conditions detrimental to proper and timely completion of the Work. Do not proceed with the Work until unsatisfactory conditions are corrected.
3.02 INSTALLATION

A. Anchor Bolts:

1. Provide anchor bolts as shown or indicated in the Contract Documents, or as required to secure structural element to the appropriate anchor surface.

2. Locate and accurately set anchor bolts using templates or other devices as required, prior to placing concrete. Wet setting of anchor bolts is unacceptable.

3. Protect threads and shank from damage during installation and subsequent construction operations.

4. Unless otherwise shown or approved by ENGINEER anchor bolts shall comply with Table 05051-B:

<table>
<thead>
<tr>
<th>Bolt Diameter (inch)</th>
<th>Minimum Embedment (inch)</th>
<th>Minimum Edge Distance and Spacing (inch)</th>
<th>Shear (lb)</th>
<th>Tension (lb)</th>
<th>Minimum Embedment (inch)</th>
<th>Minimum Edge Distance and Spacing (inch)</th>
<th>Shear (lb)</th>
<th>Tension (lb)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/2</td>
<td>6</td>
<td>9</td>
<td>1,262</td>
<td>2,420</td>
<td>8.5</td>
<td>12.75</td>
<td>1,660</td>
<td>3,190</td>
</tr>
<tr>
<td>5/8</td>
<td>7.5</td>
<td>11.25</td>
<td>2,010</td>
<td>3,860</td>
<td>10.5</td>
<td>15.75</td>
<td>2,640</td>
<td>5,080</td>
</tr>
<tr>
<td>3/4</td>
<td>9</td>
<td>13.5</td>
<td>2,974</td>
<td>5,720</td>
<td>13</td>
<td>19.5</td>
<td>3,910</td>
<td>7,520</td>
</tr>
<tr>
<td>7/8</td>
<td>10.5</td>
<td>15.75</td>
<td>4,106</td>
<td>7,890</td>
<td>15</td>
<td>22.5</td>
<td>5,400</td>
<td>10,390</td>
</tr>
<tr>
<td>1</td>
<td>12</td>
<td>18</td>
<td>5,386</td>
<td>10,360</td>
<td>17</td>
<td>25.5</td>
<td>7,090</td>
<td>13,450</td>
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<tr>
<td>1/8</td>
<td>13.5</td>
<td>20.25</td>
<td>6,787</td>
<td>13,052</td>
<td>19</td>
<td>28.5</td>
<td>8,930</td>
<td>16,580</td>
</tr>
<tr>
<td>1/4</td>
<td>15</td>
<td>22.5</td>
<td>8,617</td>
<td>16,572</td>
<td>21</td>
<td>31.5</td>
<td>11,340</td>
<td>20,040</td>
</tr>
</tbody>
</table>

Table Notes:
1. Table is based on ACI 318 and ACI 350, Appendix D, \( f'_c = 4000 \) psi. Table 05 05 33-B is not applicable to anchor bolts embedded in grouted masonry.
2. Critical edge distance and spacing are indicated in the table. Capacity of anchor bolts for other combination of edge distances and spacing shall be evaluated in accordance with ACI 318 and ACI 350, Appendix D.
3. Values for shear and tension listed are not considered to act concurrently. Interaction of tension and shear will be evaluated by ENGINEER in accordance with ACI 318 and ACI 350, Appendix D.
B. Adhesive Anchors, Undercut Anchors, and Expansion Anchors – General:

1. Prior to drilling, locate existing reinforcing steel in vicinity of proposed holes. If reinforcing conflicts with proposed hole location, obtain ENGINEER’s approval of alternate hole locations to avoid drilling through or damaging existing reinforcing bars.

C. Adhesive Anchors:

1. Comply with manufacturer’s written installation instructions and the following.

2. Drill holes to adhesive system manufacturer’s recommended drill bit diameter to the specified depth. Drill holes in hammering and rotation mode with carbide-tipped drill bits that comply with the tolerances of ANSI B212.15. Core-drilled holes are unacceptable.

3. Before setting adhesive anchor, hole shall be made free of dust and debris by method recommended by adhesive anchor system manufacturer. Hole shall be brushed with adhesive system manufacturer-approved brush and blown clean with clean, dry, oil-free compressed air to remove all dust and loose particles. Hole shall be dry as defined by adhesive system manufacturer.

4. Before injecting adhesive, obtain ENGINEER’s concurrence that hole is dry and free of oil and other contaminants.

5. Prior to injecting adhesive into the drilled hole, dispense, to a location appropriate for such waste, an initial amount of adhesive from the mixing nozzle, until adhesive is uniform color.

6. Inject adhesive into hole through injection system-mixing nozzle and necessary extension tubes, placed to bottom of hole. Discharge end shall be withdrawn as adhesive is placed but kept immersed to prevent formation of air pockets. Fill hole to depth that ensures that excess material is expelled from hole during anchor placement.

7. Twist anchors during insertion into partially-filled hole to guarantee full wetting of rod surface with adhesive. Insert rod slowly to avoid developing air pockets.

8. Provide adequate curing in accordance to adhesive system manufacturer’s requirements prior to continuing with adjoining Work that could place load on installed adhesive anchors. Do not begin adjoining Work until adhesive anchors are successfully tested or when allowed by ENGINEER.

9. Limitations:

   a. Installation Temperature: Comply with manufacturer’s instructions for installation temperature requirements. Provide temporary protection and other measures, such as heated enclosures, necessary to ensure that base material temperature
complies with anchor systems manufacturer’s requirements during installation and curing of adhesive anchor system.

b. Oversized Holes: Advise ENGINEER immediately if size of drilled hole is larger than recommended by anchor system manufacturer. Cost of corrective measures, including but not limited to redesign of anchors due to decreased anchor capacities, shall be paid by CONTRACTOR.

c. Embedment depths shall be based on installation in normal-weight concrete with compressive strength of 2,500 psi when embedded in existing concrete, and 4,000 psi when embedded in new concrete.

D. Expansion Anchors:

1. Comply with expansion anchor manufacturer’s written installation instructions and the following:

2. Drill holes using anchor system manufacturer’s recommended drill bit diameter and to the specified depth. Drill holes in hammering and rotation mode with carbide-tipped drill bits complying with tolerances of ANSI B212.15. Core drilled holes are unacceptable.

3. Before installing anchor, hole shall be made free of dust and debris by method recommended by anchor system manufacturer. Hole shall be brushed with anchor system manufacturer-approved brush and blown clean with clean, dry, oil-free compressed air to remove all dust and loose particles.

4. Before installing anchor, obtain ENGINEER’s concurrence that hole is dry and free of oil and other contaminants.

5. Protect threads from damage during anchor installation. Drive anchors not less than four threads below surface of the attachment. Set anchors to anchor manufacturer’s recommended torque using a torque wrench.

E. Concrete Undercut Anchors:

1. Comply with undercut anchor manufacturer’s written installation instructions and the following.

2. Protect threads from damage during anchor installation.

3. Drill hole to anchor manufacturer’s specified depth and diameter using a drill bit matched to the specific anchor.

4. Before setting the undercut anchor, hole shall be free of dust and debris using method recommended by undercut anchor system manufacturer. Hole shall be blown clean with clean, dry, oil-free compressed air to remove all dust and loose particles.

5. Insert the anchor by hand until anchor reaches bottom of hole.
6. Set anchor in accordance with manufacturer’s instructions using anchor manufacturer’s specified setting tool.

7. Verify that the setting mark is visible on the threaded rod above the sleeve.

8. Anchor shall be set to manufacturer’s recommended torque, using a torque wrench.

F. Concrete Inserts:
   1. Comply with concrete insert manufacturer’s installation instructions.
   2. Inserts shall be flush with slab bottom surface.
   3. Protect embedded items from damage during concrete placing. Ensure that embedded items are securely fastened to prevent movement during concrete placing, and ensure that embedded items do fill with concrete during concrete placing.
   4. Inserts intended for piping greater than four-inch diameter shall be provided with hooked rods attached to concrete reinforcing.

G. Anti-Seizing Compound:
   1. Provide anti-seizing compound in accordance with anti-seizing compound manufacturer’s installation instructions, at locations indicated in Paragraph 2.01B of this Section.
   2. Do not use anti-seizing compound at locations where anchor bolt or adhesive anchor will contact potable water or water that will be treated to become potable.

3.03 CLEANING
A. After embedding concrete is placed, remove protection and clean bolts and inserts.

3.04 FIELD QUALITY CONTROL
A. Site Tests:
   1. OWNER will employ testing agency to perform field quality tensile testing of post-installed anchors at the Site.
      a. Testing shall comply with ASTM E488.
      b. Test at least ten percent of all types of post-installed anchors. If one or more post-installed anchors fail the test, CONTRACTOR shall pay cost of testing, or at ENGINEER’s option CONTRACTOR may arrange for testing paid by CONTRACTOR, for all post-installed anchors of same diameter and type installed on the same day as the failed anchor. If anchors installed on the same day as the failed anchor also fail the test, ENGINEER may require retesting of all anchors of the same diameter and type installed in the Work. CONTRACTOR shall be responsible for retesting costs.
c. Test post-installed anchors to 50 percent of ultimate tensile capacity of post-installed anchor. ENGINEER will direct which anchors are to be tested.
d. Apply test loads with hydraulic ram.
e. Displacement of post-installed anchors shall not exceed D/10, where D is nominal diameter of anchor being tested.

2. Correct defective Work by removing and replacing or correcting, as directed by ENGINEER.

3. CONTRACTOR shall pay for all corrections and subsequent testing required to confirm integrity of post-installed anchors.

4. Testing agency shall submit test results to CONTRACTOR and ENGINEER within 24 hours of completion of test.

B. Manufacturer’s Services:

1. Provide at the Site services of qualified adhesive manufacturer’s representative during initial installation of adhesive anchor systems to train CONTRACTOR’s personnel in proper installation procedures. Manufacturer’s representative shall observe to confirm that installer demonstrates proper installation procedures for adhesive anchors and adhesive material.

END OF SECTION
PART 1 GENERAL

1.01 SUMMARY

A. Scope:

1. CONTRACTOR shall provide all labor, materials, equipment and incidentals as shown on the Drawings, specified and required to furnish miscellaneous metal fabrications, including surface preparation and shop priming.

B. The extent of miscellaneous metal fabrications Work is shown on the Drawings and includes items fabricated from iron, steel and aluminum shapes, plates, bars, castings and extrusions, which are not a part of the structural steel or other metal systems covered by other Sections of these Specifications.

C. The types of miscellaneous metal items include, but are not limited to the following:

1. Aluminum ladders.
2. Extruded aluminum stair nosings.
4. Miscellaneous framing and supports.
5. Miscellaneous accessories and fasteners.
6. Seat Angles, supports and brackets.

D. Related Sections:

1. Section 05051, Anchor Systems.
2. Section 05520, Aluminum Handrails and Railings.

1.02 QUALITY ASSURANCE

A. Reference Standards: Comply with the applicable provisions and recommendations of the following, except as otherwise shown and specified:

1. ASTM A 36, Specification for Carbon Structural Steel.
2. ASTM A 153, Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
4. ASTM A 276, Stainless and Heat-Resisting Steel Bars and Shapes.


7. ASTM B 211, Specification for Aluminum and Aluminum-Alloy Bars, Rods and Wire.


10. AWS D1.1, Structural Welding Code.

11. NAAMM, Metal Finishes Manual.

12. OSHA.

B. Field Measurements:

1. Take field measurements where required prior to preparation of Shop Drawings and fabrication to ensure proper fitting of the Work.

C. Shop Assembly:

1. Preassemble items in the shop to the greatest extent possible, so as to minimize field splicing and assembly of units at the project site. Disassemble units only to the extent necessary for shipping and handling limitations. Clearly mark units for reassembly and coordinated installation.

1.03 SUBMITTALS

A. Shop Drawings: Submit for approval the following:

1. Fabrication and erection details of all assemblies of miscellaneous metal Work. Include plans, elevations, and details of sections and connections. Show anchorage and accessory items. Include setting drawings and templates for location and installation of miscellaneous metal items and anchorage devices.

2. Copies of manufacturer's specifications, load tables, dimension diagrams, anchor details, and installation instructions for products to be used in miscellaneous metal Work.

PART 2 PRODUCTS

2.01 MATERIALS

A. Steel Plates, Shapes and Bars: ASTM A 36.
B. Aluminum:

1. Alloy and Temper: Provide alloy and temper as shown on the Drawings or specified, or as otherwise recommended by the aluminum producer or finisher.


4. Bars, Rods and Wire: ASTM B 211.

C. Stainless Steel Plates, Sheets and Bars: ASTM A 276, Type 316 stainless steel.

1. Use Type 316 stainless steel unless shown otherwise in the Drawings.

D. Stainless Steel Fasteners and Fittings: ASTM A 320.

E. Surface Preparation and Shop Priming: All steel shall be primed in the shop.

F. Galvanizing: All galvanizing of fabricated steel items shall comply with the requirements of ASTM A 123.

G. Aluminum Finish: Provide an Architectural Class I anodized finish for all aluminum work unless specifically shown or specified to be mill or other finish.

2.02 MISCELLANEOUS METAL ITEMS

A. Aluminum Ladders:

1. Fabricate ladders for the locations shown on the Drawings, with dimensions, spacings, details and anchorages as shown on the Drawings, and specified. Comply with the requirements of ANSI A14.3, except as otherwise shown on the Drawings or specified.

   a. Unless otherwise shown on the Drawings, provide 1 1/2-inch diameter Schedule 40 side rails, spaced 18-inches apart, minimum.

   b. Provide extruded square rungs, spaced 12-inches on centers, maximum with non-slip surface on the top of each rung. Adhesive strips for non-slip surfaces will not be allowed.

2. Fit rungs in centerline of side rails, plug weld and grind smooth on outer rail faces.

3. Support each ladder at top and bottom and at intermediate points spaced not more than five feet on centers. Use welded or bolted brackets, designed for adequate support and anchorage, and to hold the ladder clear of the wall surface with a minimum of 7-inches clearance from wall to centerline of rungs. Unless otherwise shown on the Drawings, or approved by the ENGINEER, extend rails 42-inches above top rung, and return rails to wall or structure, unless other secure handholes are provided. If the adjacent structure does not extend above the top rung, goose neck the extended rails back to the structure to provide secure ladder access.
4. Use extruded aluminum conforming to alloy and temper of the 5000 series alloys.

B. Fall Prevention System: All ladders greater than 12-feet-0-inches in height shall be provided with a fall prevention system. The system shall meet OSHA standards.

1. The system shall consist of a rail permanently attached to the ladder to which a harness belt is attached. The rail shall be notched and constructed of aluminum. Ladder attachments shall be provided as required by the manufacturer. A removable extension section shall be provided at the top of the ladder.

2. Product and Manufacturer: Provide one of the following:
   b. Vi-Go Ladder Climbing Safety System by Miller Fall Protection

C. Aluminum Stairs:


2. Stair Treads:
   a. Aluminum of same type specified under Aluminum Grating.
   b. Of sizes indicated on the Drawings and 1-3/4 inch minimum depth with cast abrasive type safety nosings.


4. Fasteners: Type 316 stainless steel.

D. Extruded Aluminum Stair Nosings:

1. Fabricate of sizes and configurations required for the Work.
   a. Unless otherwise shown on the Drawings, provide ribbed abrasive filled type, using black abrasive filler.

2. Provide anchors for embedding in concrete, either integral or applied to treads, as standard with the manufacturer.

3. Product and Manufacturer: Provide stair nosings by one of the following:
   b. Wooster Products Incorporated.

E. Bollards: Unless shown otherwise in the Drawings, provide 8-inch diameter, Schedule 40 galvanized steel pipe, 4-feet-0-inches above grade, 4-feet-0-inches below grade. Fill with concrete and mound top. Bollards shall be primed in the shop. Surface preparation and painting shall conform to the requirements of Section 09900.
F. Miscellaneous Framing and Supports:

1. Provide miscellaneous metal framing and supports, which are not a part of the structural steel framework and are required to complete the Work.

2. Fabricate miscellaneous units to the sizes, shapes and profiles shown on the Drawings or, if not shown on the Drawings, of the required dimensions to receive adjacent grating, plates, tanks, doors, or other work to be retained by the framing. Except as otherwise shown on the Drawings, fabricate from structural shapes, plates, and bars, of all welded construction using mitered corners, welded brackets and splice plates and a minimum number of joints for field connection. Cut, drill and tap units to receive hardware and similar items to be anchored to the Work.

3. Equip units with integrally welded anchors for casting into concrete or building into masonry. Furnish inserts if units must be installed after concrete is placed.
   a. Except as otherwise shown on the Drawings, space anchors, 24-inches on centers, and provide units the equivalent of 1-1/4 by 1/4 by 8-inch strips.
   b. All material shall be Type 316 stainless steel unless noted otherwise in the Drawings.

G. Fasteners and Fittings: Provide Type 316 stainless steel, for all aluminum fabrications, and zinc coated hardware for all galvanized fabrications, unless otherwise shown on the Drawings or specified.

H. Surface Preparation and Shop Priming: All miscellaneous metal fabrications shall be primed in the shop.

I. Aluminum Finish: Provide an Architectural Class 1 anodized finish, AA M32C22 A41, clear, as specified in NAAMM Manual.

PART 3 EXECUTION

3.01 INSTALLATION

A. Set miscellaneous metal fabrications accurately in location, alignment and elevation, plumb, level, true and free of rack, measured from established lines and levels. Brace temporarily or anchor temporarily in formwork where fabrications are to be built into concrete, masonry or similar construction.

B. Anchor securely as shown on the Drawings or as required for the intended use, using concealed anchors wherever possible.

C. Fit exposed connections accurately together to form tight hairline joints. Weld steel connections, which are not to be left as exposed joints, but cannot be shop welded because of shipping size limitations. Grind steel joints smooth and touch up shop paint coat. Do not weld, cut or abrade the surfaces of exterior units, which have been hot-dip galvanized after fabrication, and are intended for bolted or screwed field connections.

D. Protection of Aluminum from Dissimilar Materials:

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1. Coat all surfaces of aluminum in contact with dissimilar materials, such as concrete, grout, masonry and steel or other dissimilar metals with the following:
   a. Cast Aluminum: Heavy coat of bituminous paint.
   b. Extruded Aluminum: Two coats of clear lacquer.

2. Do not extend coating beyond contact surfaces. Remove coating where exposed-to-view in the finished Work.

E. All welds to be coated shall be grinded smooth according to NACE “Surface Preparation of Welds Prior to Coating”.

END OF SECTION
PART 1   GENERAL

1.01   DESCRIPTION

A.   Scope:

1.   CONTRACTOR shall provide all labor, materials, tools, equipment, and incidentals as shown, specified, and required to furnish and install aluminum handrail and railing systems. The Work also includes:

   a.   Providing openings in, and attachments to, aluminum handrail and railing systems to accommodate the Work under this and other Specification Sections. Provide all items for aluminum handrails and railings, including anchorages, fasteners, studs, and other items required for which provision for is not specifically included under other Sections.

2.   Aluminum handrails and railings Work shall include components and features shown and specified, and all components and features available from specified manufacturers required for providing complete aluminum handrail and railing system in accordance with the Contract Documents.

B.   Coordination:

1.   Review installation procedures under this and other Sections and coordinate installation of items to be installed with or before aluminum handrails and railings Work.

2.   Aluminum handrail and railing locations shall comply with Laws and Regulations.

C.   Related Sections:

1.   Section 03600, Grouting.

2.   Section 05051, Anchor Systems.

3.   Section 09900, Paints and Painting.

1.02   REFERENCES

A.   Standards referenced in this Section are:


12. NAAMM/Architectural Metal Products Division (AMP), Pipe Railing Manual.

13. NAAMM/AMP AMP 501 Finishes for Aluminum.

1.03 QUALITY ASSURANCE

A. Qualifications:

1. Manufacturer:
   a. Upon request manufacturer shall submit document at least five years successful experience in fabricating aluminum handrail and railing systems of scope and type similar to that required.

2. Professional Engineer:
   a. CONTRACTOR or handrail and railing manufacturer shall retain a registered professional engineer legally qualified to practice in same state as the Site. Professional engineer shall have at least five years experience designing aluminum handrails and railings.
   b. Responsibilities include:
      1) Reviewing aluminum handrail and railing system performance and design criteria stated in the Contract Documents.
2) Preparing written requests for clarifications or interpretations of performance or design criteria for submittal to ENGINEER by CONTRACTOR.
3) Preparing or supervising preparation of design calculations verifying compliance of aluminum handrail and railing system with requirements of the Contract Documents.
4) Signing and sealing all calculations.
5) Certifying that:
   a) Design of aluminum handrail and railing system was performed in accordance with performance and design criteria stated in the Contract Documents, and
   b) Design conforms to all applicable local, state, and federal Laws and Regulations, and to prevailing standards of practice.

3. Installer:
   a. Retain a single installer trained and with record of successful experience in installing aluminum handrail and railing systems.
   b. Installer shall have record of successfully installing aluminum handrail and railing systems in accordance with recommendations and requirements of manufacturer, or shall provide evidence of being acceptable to the manufacturer.
   c. Installer shall employ only tradesmen with specific skill and successful experience in the type of Work required.
   d. When requested by ENGINEER, submit name and qualifications of installer with the following information for at least three successful, completed projects:
      1) Names and telephone numbers of owner and architect or engineer responsible for each project.
      2) Approximate contract cost of the aluminum handrail and railing systems for which installer was responsible.
      3) Amount (linear feet) of aluminum handrail and railing installed.

B. Component Supply and Compatibility:
   1. Obtain all materials furnished under this Section regardless of component manufacturer, from a single aluminum handrail and railing system manufacturer.
   2. Aluminum handrail and railing system manufacturer shall review and approve or prepare all Shop Drawings and other submittals (except for delegated design submittals, when professional engineer is retained by other than handrail and railing manufacturer) for all components furnished under this Section.
   3. Components shall be specifically constructed for specified service conditions and shall be integrated into overall assembly by aluminum handrails and railings manufacturer.

C. Regulatory Requirements: Comply with Laws and Regulations including:
   1. OSHA Part 1910.23, Guarding Floor and Wall Openings and Holes.
D. Certifications:

1. Submit certification, signed by authorized officer of manufacturer and notarized, stating that handrail and railing systems comply with the design prepared by the professional engineer.

2. Submit certification, signed by authorized officer of CONTRACTOR and notarized, stating that all components and fittings are furnished by the same manufacturer.

1.04 SUBMITTALS

A. Action Submittals: Submit the following:

1. Shop Drawings:
   a. Drawings for fabrication and installation of aluminum handrail and railing systems with sizes of members, pipe wall thickness, information on components, and anchorage devices. Show all anchorages. Provide details drawn at scale of 1.5-inch equal to one foot.
   b. Indicate required location of posts.
   c. Indicate locations and details of all expansion joints, if any.
   d. Indicate locations and details of gaps across seismic joints, if any.
   e. Profile drawings of aluminum handrail and railing system components.
   f. Custom detail drawings. Details of forming, jointing, sections, connections, internal supports, trim and accessories. Provide details drawn at scale of 1.5-inch equal to one foot.

2. Product Data:
   a. Manufacturer’s specifications, standard detail drawings, and installation instructions for aluminum handrail and railing systems.
   b. Manufacturer’s catalogs showing complete selection of standard and custom components and miscellaneous accessories for selection by ENGINEER.

3. Delegated Design Submittals:
   a. Design Data:
      1) Design computations or complete structural analysis of handrail and railing systems, signed and sealed by professional engineer. Professional engineer’s seal shall be clearly legible, including state of registration, registration number, and name on seal.
      2) Certification by professional engineer that professional engineer has performed design of aluminum handrail and railing systems in accordance with performance and design criteria stated in the Contract Documents, and that design conforms to all local, state, and federal Laws and Regulations, and to prevailing standards of practice.
b. ENGINEER will review Samples for finish, color, joint tolerances, workmanship, and general component assembly only. Compliance with other requirements is the responsibility of the CONTRACTOR.

B. Informational Submittals: Submit the following:

1. Certificates:
   a. Certification on source of supply, as specified in Article 1.03 of this Section.
   b. Manufacturer certification specified in Article 1.03 of this Section.

2. Qualifications Statements: Submit qualifications for the following:
   a. Manufacturer, when requested by ENGINEER.
   b. Professional engineer.
   c. Installer, when requested by ENGINEER. Qualifications statement shall include record of experience with references specified.

C. Closeout Submittals: Submit the following:

1. Maintenance Manuals: Furnish detailed maintenance manuals that include the following:
   a. Product name and number.
   b. Detailed procedures for routine maintenance and cleaning, including cleaning materials, application methods and precautions in use of products that may be detrimental to finish when improperly applied.
   c. Handrail and railings systems manufacturer’s current catalog including individual parts.
   d. Maintenance manuals shall be in accordance with Division 1 and General Conditions.

D. Maintenance Material Submittals: Submit the following:

1. Extra Stock Materials:
   a. After completing installation, deliver to OWNER 10 percent of actual quantity of each handrail and railing system component used in the Work.
   b. Label each piece or sealed container with name and product number.

1.05 DELIVERY, STORAGE AND HANDLING

A. Storage and Protection:

1. Keep products off ground using pallets, platforms, or other supports. Protect products from corrosion and deterioration.

B. Handling of Products:
1. Do not subject handrail and railing products to bending or stress.

2. Do not damage edges or handle products in a manner that will cause scratches, warping, or dents.

3. Protect handrails and railings by paper or coating as acceptable to handrail and railing manufacturer, against scratching, splashes of mortar, paint, and other marring during transportation, handling, and erection. Protect until completion of adjacent work.

1.06 GUARANTEE

A. Guarantee: Manufacturer shall provide written guarantee of availability of replacement parts and components for period of at least five years after completion of the Project.

PART 2 PRODUCTS

2.01 SYSTEM PERFORMANCE

A. System Description: Aluminum handrail and railing system shall consist of equally spaced horizontal rails with totally concealed mechanical fasteners, internally threaded tubular rivets and components fastened to posts spaced no more than five feet on centers and system of handrails supported from adjacent construction by mounting brackets spaced at no more than five feet on centers.

B. Design Criteria and Performance Criteria:

1. Design, fabricate, and install aluminum handrail and railing systems to withstand the most critical effects resulting from the following loads (loads listed below do not act concurrently):

   a. Uniform Load: 50 pounds per foot, applied at top in any direction.
   b. Concentrated Load: 200 pounds single load, applied at any point along the top in any direction.
   c. Components: Intermediate rails (all rails except the handrail), balusters, and panel fillers, if any, shall withstand horizontally-applied normal load of 50 pounds on an area equal to one square foot, including openings and space between rails. Reactions due to this loading are not required to be superimposed to loading specified for main supporting members of handrails and railings.
   e. Limit deflection in each single span of railing and handrail to 1.5-inch maximum, and to 1/4-inch maximum on railing posts. Applied loads shall not produce permanent deflection in the completed Work when loads are removed.

2. Thermal Control: Provide adequate expansion within fabricated systems that allows for thermal expansion and contraction caused by material temperature change of 140 degrees F to -20 degrees F without warp or bow of system components.
Distance between expansion joints shall be based on providing 1/4-inch wide joint at 70 degrees F, which accommodates movement of 150 percent of calculated amount of movement for specified temperature range.

3. Where handrail and railing systems cross expansion joints in the building or structure, provide expansion joints in handrail and railings systems.

4. For posts located at or near end of runs as shown, uniformly space intermediate posts as required to conform to loading and deflection criteria specified, at intervals no greater than maximum post spacing specified. Where posts are shown for handrails along both sides of walkways and other similar locations, locate posts opposite each other; do not stagger post locations.

2.02 MANUFACTURERS

A. Products and Manufacturers: Provide one of the following:
   2. Alumaguard, by Alumaguard – A division of Bettinger West, Inc.
   3. Or equal.

2.03 MATERIALS

A. Extruded Aluminum Architectural and Ornamental Shapes: ASTM B221, Alloy 6063-T52.

B. Aluminum Forgings: ASTM B247.

C. Extruded or Drawn Aluminum Pipe and Tube:
   1. ASTM B429 or ASTM B241/B241M, Alloy 6063-T5, 6063-T52, or 6063-T832 as required by loadings, deflections, and post spacing specified.
   2. Provide Schedule 40 pipe, minimum, unless conditions of detail and fabrication require extra-heavy pipe to comply with Specifications. Rails and posts shall have minimum outside diameter of 1.90 inches.

D. Reinforcing Bars: Urethane foam-filled, Schedule 80, 23 inches long 6061-T6 aluminum reinforcing bars or tubes with outside diameter same as inside diameter of post.

E. Anchors and Fastenings:
   1. For anchors and fasteners, use Type 316 stainless steel; minimum 3/8-inch diameter.
   2. Provide minimum of four bolt fasteners per post where surface-mounted posts are shown. Components shall be in accordance with manufacturer’s recommendations and as approved or accepted (as applicable) by ENGINEER on submittals.
3. Anchors: In accordance with Section 05051, Anchor Systems.

F. Castings:
   1. Provide high-strength aluminum alloy brackets, flanges, and fittings suitable for anodizing as specified.
   2. Aluminum alloy sand castings: ASTM B26/B26M.

G. Connector Sleeves: Schedule 40, five-inch long by 1.610-inch diameter.

H. Sockets: Provide six-inch deep by 2.5-inch outside diameter aluminum sockets with 3.5-inch wide socket cover on bottom of each socket and on top and bottom of removable post sockets.

I. Chain, Snaps, and Eye Bolts: Provide oblong 1/4-inch welded link, Type 316 stainless steel chain weighing 57 pounds per cubic foot, each link 1.25-inch by 7/16-inch. Provide Type 316 stainless steel eyebolts, 1/4-inch stainless steel threaded quick links and heavy-duty swivel snaps with spring loaded latch.

J. Gates: For each gate in handrail or railing system, provide the following:
   2. Latches and Stops: One latch and stop with rubber bumper and one-inch diameter plastic knobs.

K. Custom Cover Flanges: 1/4-inch high by four-inch diameter, aluminum.

L. Non-shrink Grout: Comply with Section 03600, Grouting.

M. Toeboards:
   1. Provide extruded Alloy 6063-T5 or T52 aluminum alloy toeboards, unless railing is mounted on curbs or other construction of sufficient height and type to comply with OSHA 1910.23. Bars or plates are not acceptable.
   2. Unless otherwise specified, toeboards shall comply with OSHA 1910.23, Section (e).

N. System Components and Miscellaneous Accessories: Provide complete selection of manufacturer’s standard and custom aluminum handrail and railing systems components and miscellaneous accessories required. Show type and location of all such items on Shop Drawings and other submittals as applicable.

2.04 FABRICATION

A. General: Unless otherwise shown or specified, provide typical non-welded construction details and fabrication techniques recommended in NAAMM/AMP Pipe Railing Manual and NAAMM/AMP AMP 501.
B. Fabricate handrail and railing systems true to line and level, with accurate angles surfaces and straight edges. Fabricate corners without using fittings. Provide bent-metal corners to smallest radius possible without causing grain separation or otherwise impairing the Work. Form elbow bends and wall returns to uniform radius, free from buckles and twists, with smooth finished surfaces, or use prefabricated bends. Provide not less than four-inch outside radius.

C. Provide chains across openings in railings where shown. Attach one end of each chain to an eyebolt in post and other end attached by means of swivel eye snap hook to similar eyebolt in opposite post.

D. Remove burrs from exposed edges.

E. Close aluminum pipe ends by using prefabricated fittings.

F. Weep Holes:
   1. Fabricate joints that will be exposed to weather to exclude water.
   2. Provide 15/64-inch diameter weep holes at lowest possible point on each post in handrail and railing systems.
   3. Provide pressure relief holes at closed ends of handrail and railing systems.

G. Toeboards:
   1. Provide manufacturer’s standard toeboard, that accommodates movement caused by thermal change specified without warping or bowing toeboards.
   2. Provide manufacturer’s standard toeboard, which accommodates storage for removable socket covers.
   3. Coordinate and cope toeboard as required to accommodate cover flanges at posts.
   4. Toeboards shall follow curvature of railing. Where railing is shown to have curved contours at corners, or other locations, toeboard shall likewise be curved to follow line of railing system.

H. Reinforcing Bars: Provide reinforcing bar friction-fitted at each post in railing system. Extend reinforcing bars of tubes six inches into cast-in-place sleeves or other types of supporting brackets.

I. Mechanically Fitted Component Pipe Handrail and Railing System:
   1. Use non-welded pipe handrail and railing system with posts, top and intermediate rail(s), and flush joints.
   2. Provide top and two (2) intermediate horizontal rail(s), equally spaced.
3. Use Type 304/305 stainless steel blind rivets and Type 304/305 stainless steel self-tapping screws in assembling components of the Work.

2.05 FINISHES

A. General:

1. Prepare surfaces for finishing in accordance with recommendation of aluminum producer and the aluminum finisher or processor.

2. Adjust and control direction of mechanical finishes specified to achieve best overall visual effect in the Work.

3. Color and Texture Tolerance: Provide uniform color and continuous mechanical texture for aluminum components. ENGINEER reserves the right to reject aluminum materials because of color or texture variations that are visually objectionable, but only where variation exceed range of variations established by manufacturer prior to fabrication, by means of range of Samples approved by ENGINEER.


B. Finish:

1. Mechanically finish aluminum by wheel or belt polishing with aluminum oxide grit of 180 to 220 size, using peripheral wheel speed of 6,000 feet per minute; AA Designation - M32 Medium Satin Directional Texture.

2. Hand-Rubbed Finish: Where required to complete the Work and provide uniform, continuous texture, provide hand-rubbed finish to match medium satin directional texture specified to even out and blend satin finishes produced by other means.

C. Cleaning:

1. Provide non-etching chemical cleaning by immersing aluminum in inhibited chemical solution, as recommended by coating applicator, to remove lard oil, fats, mineral grease, and other contamination detrimental to providing specified finishes.

2. Clean and rinse with water between steps as recommended by aluminum manufacturer.

D. Exposed Aluminum Anodic Coating: Provide anodic coatings as specified that do not depend on dyes, organic or inorganic pigments, or impregnation processes to obtain color. Apply coatings using only the alloy, temperature, current density, and acid electrolytes to obtain specified colors in compliance with designation system and requirements of NAAMM/AMP Pipe Railing Manual and NAAMM/AMP AMP 501. Comply with the following:

1. Provide Architectural Class I high density anodic treatment by immersing the components in tank containing solution of 15 percent sulfuric acid at 70 degrees F...
with 12 amperes per square foot of direct current for minimum of sixty minutes; AA Designation A41 Clear.

2. Physical Properties:
   a. Anodic Coating Thickness, ASTM B244: Minimum of 0.7-mils thick.
   b. Anodic Coating Weight, ASTM B137: Minimum of 32 mg/sq. in.
   c. Resistance to Staining, ASTM B136: No stain after five minutes dye solution exposure.
   d. Salt Spray, ASTM B117: 30,000 hours exposure with no corrosion or shade change.

3. Seal finished anodized coatings using deionized boiling water to seal pores and prevent further absorption.

4. Products and Manufacturers: Provide one of the following:
   a. Alumilite 215 Clear by Aluminum Company of America, Inc.
   b. Or equal.

2.06 SOURCE QUALITY CONTROL
A. Allowable Tolerances:
   1. Limit variation of cast-in-place inserts, sleeves and field-drilled anchor and fastener holes to the following:
      b. Alignment: Plus-or-minus 1/4-inch.
      c. Plumbness: Plus-or-minus 1/8-inch.
   2. Minimum Handrails and Railings Systems Plumb Criteria:
      a. Limit variation of completed handrail and railing system alignment to 1/4-inch in 12 feet with posts set plumb to within 1/16-inch in 3.0 feet.
      b. Align rails so variations from level for horizontal members and from parallel with rake of stairs and ramps for sloping members do not exceed 1/4-inch in 12.0 feet.
   3. Provide “pencil-line” thin butt joints.

PART 3 EXECUTION
3.01 INSPECTION
A. Examine conditions under which Work will be performed and notify ENGINEER in writing of conditions detrimental to proper and timely completion of the Work. Do not proceed with installation until unsatisfactory conditions are corrected.
B. Verify to ENGINEER the gage of aluminum pipe railing posts and rails brought to the Site by actual measurement of on-Site material in presence of ENGINEER.

3.02 INSTALLATION

A. General:

1. Do not erect components that are scarred, dented, chipped, discolored, otherwise damaged, or defaced. Remove from Site railing and handrail system components that have holes, cuts, gouges, deep scratches, or dents of any kind. Repairs to correct such Work will not be accepted. Remove and replace with new material.

2. Comply with installation and anchorage recommendations of NAAMM/AMP Pipe Railing Manual and NAAMM/AMP AMP 501 in addition to requirements specified and approved or accepted (as applicable) submittals.

B. Fastening to In-Place Construction:

1. Remove protective plastic immediately before installing.

2. Adjust handrails and railings prior to securing in place, to ensure proper matching at butting joints and correct alignment throughout their length. Plumb posts in each direction. Secure posts and rail ends to building or structure as follows:

   a. Anchor posts to stair stringers with stringer or support flanges, angle type or floor type as required by conditions, shop-connected to posts and bolted to steel supporting members. Flanges shall be as recommended by manufacturer. Verify that reinforcing bars are inserted into posts before installation. Do not install posts without reinforcing bar.

   b. Side-mount posts by fastening them securely in brackets attached to steel or concrete fascia as shown and in accordance with approved or accepted (as applicable) submittals.

   c. Provide removable railing sections where shown. Provide removable railing system posts with friction-fitted reinforcing bar in each post. Provide sockets with socket covers stored in extruded toeboard. Provide aluminum pipe collars for all removable posts. Accurately locate sleeves to match post spacing.

   d. Provide posts set in concrete with an aluminum floor cover flange.

3. Use devices and fasteners recommended by handrail and railing systems manufacturer and as shown on approved or accepted (as applicable) submittals.

C. Cutting, Fitting, and Placement:

1. Perform cutting, drilling and fitting required for installation. Set the Work accurately in location, alignment, and elevation, plumb, level, true, and free of rack, measured from established lines and levels.
2. Fit exposed connections accurately together to form tight hairline joints. Do not cut or abrade surfaces of units that have been finished after fabrication, and are intended for field connections.

3. Make permanent field splice connections using stainless steel blind rivets and five-inch minimum length connector sleeves. Tight press-fit field splice connectors and install in accordance with manufacturer’s written instruction. Install two blind rivets per joint on 180-degree centers.

4. Make splices as near as possible to posts, but not exceeding 12 inches from nearest post.

5. Field welding is not allowed. Make splices using pipe splice lock employing a single allen screw to lock joint.

6. Provide hinged gates as shown.

7. Provide chain sections as shown. Provide one chain length with fastening accessories for top and each intermediate rail.

8. Secure handrails to walls with wall brackets and end fittings as shown. Drill wall plate portion of the bracket to receive one bolt, unless otherwise shown for concealed anchorage. Locate brackets as shown or, if not shown, at not more than five feet on centers. Provide flush type wall return fittings with same projection shown for wall brackets. Secure wall brackets and wall return fittings to building or structure. Refer to Section 05051, Anchor Systems.

9. Securely fasten toeboards in place with not more than 1/4-inch clearance above floor level.

10. Drill one 15/64-inch diameter weep hole not more than 1/4-inch above top of location of solid reinforcing bar or tube in each post.

D. Fastening to Existing Construction:

1. Provide heavy-duty floor flange and anchorage devices and fasteners where necessary for securing handrail and railing systems components to existing construction; including stainless steel threaded fasteners for concrete and masonry inserts, toggle bolts, through-bolts, lag bolts and other connectors as required. Refer to Section 05051, Anchor Systems.

2. Use devices and fasteners recommended by handrail and railing systems manufacturer and as shown on approved or accepted (as applicable) submittals.

E. Expansion Joints:

1. Provide slip joint with internal sleeve extending not less than two inches beyond joint on each side.
2. Construct expansion joints as for field splices, except fasten internal sleeve securely to one side of rail only.

3. Locate joints within six inches of posts.

F. Protection from Dissimilar Materials:

1. Coat aluminum surfaces in contact with dissimilar materials such as concrete, masonry, and steel, in accordance with Section 09900, Paints and Painting.

2. Do not extend coating beyond contact surfaces. Remove coating where exposed-to-view in the finished Work.

3.03 CLEANING AND REPAIRING

A. Cleaning:

1. Clean exposed surfaces of handrail and railing systems after completion of installation. Comply with recommendations of both handrail and railing system manufacturer and finish manufacturer. Do not use abrasives or unacceptable solvent cleaners. Test cleaning techniques on an unused section of railing before employing cleaning technique.

2. Remove stains, dirt, grease, and other substances by washing handrails and railings systems thoroughly using clean water and soap; rinse with clean water.

3. Do not use acid solution, steel wool, or other harsh abrasives.

4. If stain remains after washing, remove defective sections and replace with new material complying with this Section.

B. Handrails and railings shall be free of dents, burrs, scratches, holes, and other blemishes. Replace damaged or otherwise defective Work with new material that complies with this Section at no additional cost to OWNER.

C. Prior to Substantial Completion, replace adjacent work marred by the Work of this Section.

END OF SECTION
SECTION 05530
ALUMINUM GRATING

PART 1 GENERAL

1.01 DESCRIPTION
A. Scope:
   1. CONTRACTOR shall provide all labor, materials, equipment, and incidentals as shown, specified, and required to furnish and install aluminum grating and frames.
   2. The Work includes:
      a. Providing grating, frames, and appurtenances.
      b. Providing openings in aluminum grating to accommodate the Work under this and other Sections, and attaching to aluminum grating all items such as sleeves, bands, studs, fasteners, and items required for which provision is not specifically included under other Sections.

B. Coordination:
   1. Review installation procedures under this and other Sections and coordinate installation of items to be installed with or before aluminum grating Work.

C. Related Sections:
   1. Section 09900, Paints and Painting.

1.02 REFERENCES
A. Standards referenced in this Section are:
   4. NAAMM MBG 531, Metal Bar Grating Manual.
   5. NAAMM MBG 533, Welding Specifications for Fabrication of Steel, Aluminum and Stainless Steel Bar Grating.

1.03 QUALITY ASSURANCE
A. Qualifications:
1. Manufacturer: Shall have at least five years experience manufacturing products substantially similar to those required and shall be able to submit documentation of at least five installations in satisfactory operation for at least five years each.

B. Component Supply and Compatibility:

1. Obtain all products and materials included in this Section regardless of component manufacturer from a single aluminum-grating manufacturer.

2. Aluminum grating manufacturer shall review and approve or prepare all Shop Drawings and other submittals for all products and materials furnished under this Section.

3. Components shall be suitable for the specified service conditions and be integrated into overall assembly by aluminum grating manufacturer.

4. Provide only one type of aluminum grating exclusively throughout the Project.

1.04 SUBMITTALS

A. Action Submittals: Submit the following:

1. Shop Drawings:
   a. Fabrication and erection of all Work. Include plans, elevations, and details of sections and connections. Show anchorage and accessory items.
   b. Setting drawings and templates for location and installation of anchorage devices.

2. Product Data:
   a. Manufacturer’s specifications, load tables, dimension diagrams, anchor details and installation instructions.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Shipping, Handling and Unloading:

1. Deliver materials to the Site to ensure uninterrupted progress of the Work. Deliver anchor bolts and anchorage devices to be embedded in cast-in-place concrete in ample time to prevent delaying the Work.

B. Storage and Protection:

1. Protect materials from corrosion and deterioration.

2. Do not store materials in contact with concrete or other materials that might cause corrosion, staining, scratching, or damage materials or finish.
PART 2 PRODUCTS

2.01 SYSTEM PERFORMANCE

A. Aluminum Grating: Provide aluminum grating complying with the following:

1. Grating Design Loads: Uniform live load shall be as shown or indicated in the Contract Documents. Where live load is not shown or indicated, uniform live and concentrated loads shall be as indicated below, whichever results in the greater design stresses.
   a. Live Load: 100 psf; Concentrated Load: 500 lbs per foot of grating width at center span.

2. Maximum Clear Span Deflection for Uniform Live Loads: 1/120 of span, but not more than 1/4-inch.

3. Maximum Fiber Stress: 12,000 psi.

4. Do not install aluminum grating in areas subject to vehicular traffic.

5. Minimum Size of Members:
   a. Minimum size of bearing bars shall be within standard mill tolerance as indicated in load tables in NAAMM MBG 531 for applicable loading and deflection requirements.
   b. Minimum dimensions of cross bars shall be as indicated in tables of Minimum Standard Cross Bars and Connecting Bars in NAAMM MBG 531.

6. Banding bar shall be 1/4-inch thick minimum. Top of banding bar shall be flush with top of grating, unless otherwise shown or indicated. Banding bar shall be 1/4-inch shorter than the bearing bar height.


2.02 MANUFACTURERS

A. Grating, Products and Manufacturers: Provide one of the following:


2. Swage-Locked I-Bar Grating, by AMICO.


4. Or equal.
2.03 MATERIALS

A. Bearing Bars: Aluminum alloy 6061-T6 or alloy 6063-T6, complying with ASTM B221.

B. Cross Bars or Bent Connecting Bars: Aluminum alloy 6061-T6 or alloy 6063-T6, complying with either ASTM B221 or ASTM B210.

C. Frames: Aluminum alloy 6061-T6 or alloy 6063-T6, complying with ASTM B221.

D. Stud anchors welded to steel supports and other fasteners shall be Type 316 stainless steel.

2.04 FABRICATION

A. Use materials of minimum depth and thickness specified and required to comply with performance criteria in the Contract Documents.

B. Provide grating as follows:

1. Grating Type: Aluminum I-bar with swage-locked cross bars at right angles to bearing bars.

2. Depth: Two-inch minimum.


4. Cross-Bars: Swage-locked to bearing bars at maximum spacing of four inches on centers.

5. Surface: Grooved.

6. Finish: Mill.

C. Provide cutouts in grating for passage of piping, electrical conduit, valve stems, columns, ducts, and similar work. Where more than two bearings bars are included in a cut out, provide banding bars of same dimensions as bearing bars around opening welded to grating component parts.

D. Gratings shall be accurately fabricated, free from warps, twists, and other defects that would affect grating appearance and grating serviceability.

E. Welding shall conform to requirements of NAAMM MBG 533. Welds shall be ground smooth at top surfaces and bearing surfaces.

F. Openings in and edges of gratings sections shall be banded with banding bars. Weld bands to intersecting members.
G. Size each section of grating to weigh not more than 100 pounds, unless otherwise indicated in the Contract Documents.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine conditions under which Work is to be performed and notify ENGINEER in writing of conditions detrimental to proper and timely completion of the Work. Do not proceed with installation until unsatisfactory conditions are corrected.

B. Check all dimensions at the Site after piping and equipment are in place and determine exact locations of openings and cutouts.

3.02 INSTALLATION

A. Fastening to In-Place Construction:

1. Use anchorage devices and fasteners to secure aluminum grating to supporting members or prepared openings, as recommended by manufacturer.

2. Weld Type 316 stainless steel stud bolts to receive saddle clip or flange block anchors to supporting steel members. Drill for machine bolts when supports are aluminum.

B. Cutting, Fitting, and Placing:

1. Perform cutting, drilling and fitting required for installation. Set the Work accurately in location, alignment and elevation, plumb, level, true, and free of rack. Do not use wedges or shimming devices.

2. Where gratings are penetrated by piping, electrical conduit, ducts, structural members, or similar protrusions, cut openings neatly and accurately to size and attach banding bar as specified.

3. Divide panels into sections only to extent required for installation where aluminum grating is to be installed around previously installed piping, electrical conduit, ducts, structural members, or similar protrusions.

C. Aluminum gratings in concrete floors shall be removable and arranged in sizes to be readily lifted. Provide aluminum gratings in concrete with aluminum angle frames with mitered corners and welded joints. Grind exposed joints smooth. Frames shall have welded anchors set into concrete. Angle size shall match grating depth selected for flush fit.

D. Clearance at ends or between sections of grating shall be a maximum of 1/4-inch.

E. Tops of aluminum gratings shall be set flush with surrounding construction.
F. Aluminum gratings shall be set with full and uniform end bearing on frames to preclude rocking movement; do not use wedges or similar shimming devices.

G. Protection of Aluminum from Dissimilar Materials: Coat aluminum surfaces in contact with dissimilar materials such as concrete, masonry, steel, or other metals, in accordance with Section 09900, Paints and Painting.

END OF SECTION
PART 1  GENERAL

1.01  DESCRIPTION

A.  Scope:

1.  CONTRACTOR shall provide all labor, materials, equipment and incidentals as shown, specified and required to furnish and install floor access hatch covers.

2.  The Work also includes:

   a.  Providing openings in and attachments to floor access hatch covers to accommodate the Work under this and other Sections, and providing for floor access hatch covers items such as anchorage devices, and all items required for which provision is not specifically included under other Sections.

B.  Coordination:

1.  Review installation procedures under this and other Sections and coordinate the installation of items to be installed with or before floor access hatch covers Work.

C.  Related Sections:

1.  Section 09900, Paints and Painting.

1.02  REFERENCES

A.  Standards referenced in this Section:

1.  AASHTO Standard Specifications for Highway Bridges.


1.03  QUALITY ASSURANCE

A.  Qualifications:

1.  Manufacturer:

   a.  Manufacturer shall have not less than five years experience producing products substantially similar to those specified and, upon ENGINEER’s request, shall submit documentation of not less than five satisfactory installations in place for not less than five years each.

B.  Component Supply and Compatibility:
1. Obtain all products included in this Section regardless of the component manufacturer from a single floor access hatch covers manufacturer. Furnishing covers from more than one manufacturer is unacceptable.

2. Floor access hatch covers manufacturer shall prepare, or shall review and approve, all Shop Drawings and other submittals for all components furnished under this Section.

3. Components shall be suitable for specified service conditions and shall be integrated into the overall assembly by the floor access hatch covers manufacturer.

1.04 SUBMITTALS

A. Action Submittals: Submit the following:

1. Shop Drawings:
   a. Detailed plans and other drawings showing location of products and direction of door swing; floor access hatch cover schedules indicating cover location, material, type, loading capacity, and other information; and fabrication details for the access hatch covers Work, including materials, thickness of metals, finishes, latching or locking provisions, type of anchorages, and accessory items.

2. Product Data:
   a. Copies of manufacturer’s literature and specifications for each type of floor access hatch incorporated in the Work.

B. Informational Submittals: Submit the following:

1. Supplier Instructions:
   a. Installation data, including setting drawings and templates.

2. Qualifications Statements:
   a. Manufacturer, when requested by ENGINEER.

1.05 DELIVERY, STORAGE AND HANDLING

A. Packing and Shipping:

1. Protect mill finish and other finish during shipping and installation by an attached, adhesive-backed vinyl material that is removable during and after installation of the access hatch cover.

B. Storage and Protection:

1. Protect steel members and packaged materials from corrosion and deterioration.
1.06 WARRANTY

A. General Warranty: The special warranty specified in this Article shall not deprive OWNER of other rights or remedies OWNER may otherwise have under the Contract Documents and shall be in addition to, and run concurrent with, other warranties made by CONTRACTOR under the Contract Documents. The obligations of CONTRACTOR under the Contract Documents shall not be limited in any way by the provisions of the specified special warranty.

B. Special Warranty:

1. Provide manufacturer’s written warranty, running to the benefit of OWNER, agreeing to correct, or at option of OWNER, remove or replace structural components of the products specified in this Section found to have defect in material and workmanship during a period of five years after the date of Substantial Completion.

PART 2 PRODUCTS

2.01 GENERAL

A. General:

1. Provide manufacturer’s standard fabricated access hatch cover units, modified when necessary to comply with the Contract Documents. Where standard units are not available for the sizes and types required, provide custom-fabricated units of the same quality as manufacturer’s similar standard-sized units.

2. Fabricate each access hatch cover unit in the shop, complete with anchors, gaskets, hardware, and accessory items, as required.

2.02 CHANNEL-FRAME TYPE ACCESS HATCH COVERS

A. Aluminum Floor Access Hatch Covers – Channel Frame Type:

1. Design Live Load: 300 pounds per square foot.

2. Products and Manufacturers: Provide one of the following:

   a. Single-Leaf Door Aluminum Access Hatch Cover:

   1) Model TPS, by U.S.F Fabrication, Inc.
   2) Type J-AL, by The Bilco Company.
   3) Or equal.

   b. Double-Leaf Door Aluminum Access Hatch Cover:

   1) Model TPD, by U.S.F. Fabrication, Inc.
   2) Type JD-AL, by The Bilco Company.
   3) Or equal.
3. Cover: Not less than 1/4-inch thick, aluminum diamond-pattern plate cover. Provide flush drop-handle for lifting the cover.

4. Frame: Extruded aluminum channel frame with manufacturer’s standard anchor tabs or continuous anchor flange around perimeter for anchorage to concrete.

5. Drain Coupling: 1.5-inch diameter NPT threaded drain coupling welded under the channel frame for connection of a drain pipe.

6. Gasket: EPDM gasket mechanically attached to the channel frame.

7. Hinges: Type 316 stainless steel, heavy-duty butt hinges with Type 316 stainless steel pin fastened to door with Type 316 stainless steel tamper-resistant bolts.

8. Latch: Type 316 stainless steel, watertight, slam-type latch with inside lever handle and outside removable exterior turn/lift handle fastened to leaf (door) with tamper-resistant Type 316 stainless steel bolts. Latch release shall be protected by a flush, gasketed, removable screw plug.

9. Lift Assistance: Open-style stainless steel compression springs with Type 316 stainless steel guide tubes. Automatic Type 316 stainless steel hold-open arm with grip handle release.


B. Provide Schedule 40 PVC drain piping from the floor access hatch cover channel frame routed as indicated in the Contract Documents.

PART 3 EXECUTION

3.01 INSPECTION

A. Examine areas and conditions under which floor access hatch cover Work will be performed and notify ENGINEER in writing of conditions detrimental to proper and timely completion of the Work. Do not proceed with the Work until unsatisfactory conditions are corrected.

3.02 INSTALLATION

A. Install floor access hatch covers in accordance with approved Shop Drawings and other approved submittals, the Contract Documents, and manufacturer’s instructions.

B. Set floor access hatch covers level and true to line or grade, without warp or rack.

C. Drain Piping for Channel Frames:

1. Provide drain piping from the floor access match cover channel frame routed as shown or indicated on the Drawings.
2. Provide drain piping from the floor access hatch cover channel frame and route to the nearest floor drain or sump pit in a manner that does not obstruct access for facility operations and maintenance.

3. After installation, fill drain piping with water. Drain piping shall be free of visible leaks.

D. Protection of Aluminum from Dissimilar Materials: Coat surfaces of aluminum in contact with dissimilar materials such as concrete, masonry, steel, and other metals in accordance with Section 09900, Paints and Painting.

3.03 ADJUSTING AND CLEANING

A. Adjust leafs of floor access hatch covers as necessary to provide proper operations.

B. Remove stains, concrete splatter, oils, grease, and other foreign materials necessary and provide clean, finished surfaces.

END OF SECTION
SECTION 09900
PAINTS AND PAINTING

PART 1 - GENERAL
1.01 SECTION INCLUDES
A. Surface preparation and field painting application.
B. Shop preparation and shop prime coating when specified in other Sections of these Specifications.
C. A free choice of manufacturer’s standard factory mixed or mechanically proportioned intermixed colors. A color schedule will be furnished after manufacturer of material has been selected.

1.02 MEASUREMENT AND PAYMENT
A. No separate payment will be made for work required under this Section. Contractor will include all costs of the requirements of this Section in the appropriate bid item(s) on the Bid Form.

1.03 REFERENCES
A. ASTM D16 - Definitions of Terms Rating to Paint, Varnish, Lacquer, and Related Products.
C. SSPC-SP13/NACE 6 – Standard for the Surface Preparation of Concrete.
E. Painting and Decorating Contractors of America (PDCA) - Painting - Architectural Specifications Manual.

1.04 DEFINITIONS
A. Conform to ASTM D16 for interpretation of terms used in this Section.

1.05 SUBMITTALS
A. Product Data: Provide data on all finishing products, including color charts/chips for each product submitted.
B. Inspection Devices: Furnish inspection devices, in good working conditions for the detection of holidays, and the measurement of coating thickness (wet and dry).
C. Provide mask, gloves and other protective materials, and/or clothing recommended by the paint manufacturer.

D. Provide special, temporary, ventilation required by the paint manufacturer.

1.06 QUALIFICATIONS

A. Manufacturer: Company specializing in manufacturing the Products specified in this section with minimum 10 years documented experience.

B. Applicator: Company specializing in performing the work of this section with minimum 5 years documented experience approved by manufacturer.

1.07 REGULATORY REQUIREMENTS

A. Conform to applicable locally adopted codes for flame and smoke rating requirements for finishes.

1.08 DELIVERY, STORAGE, AND HANDLING

A. Deliver, store, protect, and handle products according to manufacturer’s instructions.

B. Deliver products to site in sealed and labeled containers; inspect to verify acceptability.

C. Container label to include manufacturer’s name, type of paint, brand name, lot number, brand code, coverage, surface preparation, drying time, cleanup requirements, color designation, and instructions for mixing and reducing.

D. Store paint materials at minimum ambient temperature of 45 degrees F and a maximum of 90 degrees F in ventilated area, and as required by manufacturer’s instructions. Do not store materials outdoors.

1.09 ENVIRONMENTAL REQUIREMENTS

A. Do not apply material when surface and ambient temperature are outside the temperature ranges required by the paint product manufacturer.

B. Do not apply exterior coatings during rain or snow, or when relative humidity is outside the humidity ranges required by the paint product manufacturer.

C. Minimum Application Temperature for Latex Paints: 45 degrees F for interiors; 50 degrees F for exterior; unless required otherwise by manufacturer's instructions.

D. Minimum Application Temperature for Varnish Finishes: 65 degrees F for interior or exterior, unless required otherwise by manufacturer's instructions.

E. Provide lighting level of 80-ft candles measured mid-height at substrate surface.
1.10 EXTRA MATERIALS

A. Provide 3 gallons of each color of each coating of material specified for Owner's maintenance use. Provide in individual gallon quantities.

B. Label each container with manufacturer's name, product number, color number, date and name and number of building rooms where used, equipment or piping coated, etc.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. See Schedule in Part 3 for manufacturers, types, surfaces by exposure to be painted, the paint system to use and minimum dry mil thickness.

B. The following manufacturers (with the abbreviated name used in the Painting Schedule) are approved for use. Use the products of only one manufacturer:

1. Devoe & Reynolds Co. (Devoe).
2. Pittsburgh Paints, (PPG).
4. The Valspar Corporation, (Valspar).
5. The Sherwin Williams Co., (Sherwin).
6. Tnemec (Tnemec)

C. Products of a manufacturer other than those named may be accepted if proof is submitted, prepared by an independent testing laboratory, that the products, item by item, are the same generic type and equal to those specified in composition, durability, utility, coverage, and appearance for the intended use.

2.02 MATERIALS

A. Coatings: Ready mixed, except field-catalyzed coatings. Field tinting of colors will not be allowed.

B. Accessory Materials: Linseed oil, shellac, turpentine, paint thinners and other materials not specifically indicated but required to achieve the finishes specified, of commercial quality.

C. Patching Materials: Latex filler.

D. Fastener Head Cover Materials: Latex filler.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Verify site conditions.
B. Verify that surfaces and substrate conditions are ready to receive work as instructed by the product manufacturer.

C. Examine surfaces scheduled to be finished prior to commencement of work. Report any condition that may potentially affect proper application.

D. Test shop applied primer for compatibility with subsequent cover materials.

E. Measure moisture content of surfaces using an electronic moisture meter. Do not apply finishes unless moisture content of surfaces is below the following maximums:

1. Plaster and Gypsum Wallboard: 12 percent.
2. Masonry, Concrete, and Concrete Unit Masonry: 12 percent.
4. Exterior Wood: 15 percent, measured in accordance with ASTM D2016.
5. Starting work constitutes acceptance (on the Contractor's part) of conditions and substrates and full responsibilities for the quality and suitable for the finished work.

3.02 PREPARATION

A. Remove or mask electrical plates, hardware, light fixture trim, escutcheons, and fittings prior to preparing surfaces or finishing.

B. Correct defects and clean surfaces which affect work of this section. Remove existing coatings that exhibit loose surface defects.

C. Seal with shellac and seal marks which may bleed through surface finishes.

D. Impervious Surfaces: Remove mildew by scrubbing with solution of tri-sodium phosphate and bleach. Rinse with clean water and allow surface to dry.

E. Gypsum Board Surfaces: Fill minor defects with filler compound. Spot prime defects after repair.

F. Concrete and Unit Masonry Surfaces Scheduled to Receive Paint Finish: Remove dirt, loose mortar, scale, salt or alkali powder, and other foreign matter. Remove oil and grease with a solution of tri-sodium phosphate; rinse well and allow to dry. Remove stains caused by weathering of corroding metals with a solution of sodium metasilicate after thoroughly wetting with water. Allow drying.

G. Interior Wood Items Scheduled to Receive Paint Finish: Wipe off dust and grit prior to priming. Seal knots, pitch streaks, and sappy sections with sealer. Fill nail holes and cracks after primer has dried; sand between coats.

H. Exterior Wood Scheduled to Receive Paint Finish: Remove dust, grit, and foreign matter. Seal knots, pitch streaks, and sappy sections. Fill nail holes with tinted exterior caulking compound after prime coat has been applied.
3.03 APPLICATION

A. Apply products in accordance with manufacturer's instructions.

B. Do not apply finishes to surfaces that are not dry.

C. Apply each coat to uniform finish.

D. Apply each coat of paint slightly darker than preceding coat unless otherwise approved.

E. Sand surfaces required lightly between coats to achieve required finish.

F. Vacuum clean surfaces free of loose particles. Use tack cloth just prior to applying next coat.

G. Allow applied coat to dry before next coat is applied.

H. Prime concealed surfaces of interior and exterior woodwork with primer paint.

3.04 FIELD QUALITY CONTROL

A. Field inspection and testing will be performed under direction of the Engineer.

B. Test questionable coated areas.

3.05 CLEANING

A. Collect waste material that may constitute a fire hazard, place in closed metal containers and remove daily from site.

3.06 PAINTING SCHEDULE

A. Exterior Concrete Masonry Units:

1. Step one: Scrape off all loose mortar. Remove all dust, dirt, grease, and other foreign matter.

2. Step two: Apply one of the following systems with the block filler indicated in sufficient coats and mill thickness to provide a uniform smooth surface.

   a. Sherwin Williams:
      1) Prime coat with one (1) coat of Sherwin-Williams Heavy Duty block filler B42W46 at the rate of 50-60 sq. ft. per gallon.
      2) Finish coat with two (2) coats of Sherwin-Williams DTM Acrylic coating B66-100 to achieve 2.5 – 4.0 mils DFT per coat.

   b. PPG:
1) Prime coat with one (1) coat of PPG Pitt-Glaze Interior/Exterior Block Filler Latex 16-90 at the rate of 64 – 138 sq. ft. per gallon.
2) Finish coat with two (2) coats of PPG Pitt-Tech Interior/Exterior High Gloss DTM Industrial Enamel 90-374 Series to achieve 2.0 – 3.0 mils DFT per coat.

c. Tnemec:
1) Prime coat with one (1) coat of Tnemec Series 1254-1205 Epoxo Block WB at the rate of 50 – 60 sq. ft. per gallon
2) Finish coat with two (2) coats of Tnemec Series 6 Tneme-Cryl to achieve 2.0 – 3.0 mils DFT per coat.

B. Interior Concrete Masonry Units (Includes Pre-cast concrete ceiling):

1. Step one: Remove dust, mortar drippings, and other foreign matter.
2. Step two: Apply one of the following systems with the block filler indicated in sufficient coats and mill thickness to provide a uniform smooth surface.

   a. Devoe:
   1) 52901 De-Vo-Ko Bloxfil Latex Block Filler, tinted.
   2) One (1) coat 23xx Velour Alkyd Eggshell Enamel, roller stippled, 1.7 mils.

   b. PPG:
   1) PPG Speedhide Interior/Exterior Latex Masonry Block Filler6-7.
   2) One (1) coat PPG Speedhide Interior Lo-Sheen Alkyd Enamel 6-90 Series, roller stippled, to achieve a 1.9 mils DFT.

   c. P & L:
   1) Primafil 200.
   2) One (1) coat Vitra-Shield, roller stippled, 2.0 mils.

   d. Valspar:
   1) 79-W-8 Latex Block Filler, white or tinted if needed.
   2) One (1) coat 31 Series Semi-Gloss Enamel, 2.0 mils dry.

   e. Sherwin:
   1) Heavy Duty Block Filler, B42 W46, not tinted.
   2) One (1) coat Pro-Mar Alkyd Egg-Shell Enamel, B33 W100, 2 mils.

   f. Tnemec:
   1) Tnemec Series 1254-1205 Epoxo Block WB
   2) Tnemec Series 6 Tneme-Cryl, 2.0 dry mils.

C. Drywall:

1. Step one: Spackle all scratches, nail holes, dents, and other abrasions. When dry, sand surfaces smooth and vacuum clean.
2. Step two: Apply one of the following systems.
   a. Devoe: 4.8 mils system
      1) One (1) coat 50801 Devoe Vinyl Primer, 0.8 mil.
      2) Two (2) coats 21xx Velour Alkyd Flat Interior, 2 mils each.
   b. Tnemec: 5.5 mil system
      1) One (1) coat Series 51-1204 PVA Sealer, 1.5 dry mils
      2) Two (2) coats Series 6 Tneme-Cryl, 2.0 dry mils per coat
   c. PPG: 5.0 mil system
      1) One (1) coat PPG Speedhide Interior Latex Primer Sealer 6-2, to achieve 1.0 mils DFT.
      2) Two (2) coats PPG Speedhide Interior Lo-Sheet Alkyd Enamel 6-90 Series, to achieve 2.0 mils DFT per coat.

D. Interior Wood Painted:
   2. Step two: Apply one (1) coat of one of the following primers.
      a. Devoe: 51701 Wonder-Tones Acrylic Latex Enamel Undercoat, 1.5 mils.
      b. PPG: PPG Seal Grip Interior Alkyd Enamel Undercoater 17-956, 2 mils.
      c. P & L: Interior trim primer, 1 mil.
      d. Valspar: Alkyd First Coater 17-W-4, 2 mils dry.
      e. Sherwin: Wall and Wood Primer B49 W 2, 2 mils.
      f. Tnemec: Series 10-99W Tnemec Primer, 2.0 mils.
   3. Step three: Apply two coats of same paint as adjacent walls.
      a. Tnemec: Two (2) coats Series 1029 Enduratone, 2.0 dry mils per coat.
      b. PPG: Two (2) coats Pitt-Tech Interior/Exterior Satin DTM Industrial Enamels 90-474 Series

E. Exterior Wood:
   2. Step two: Apply one of the following systems:
      a. Devoe: 4.7 mils system
1) One (1) coat 1102 All Weather Alkyd House Paint Primer, 2.3 mils.
2) Two (2) coats 70xx Mirrolac Alkyd Urethane Gloss Enamel, 1.2 mils each.

b. PPG: 6 mils system
1) One (1) coat PPG Speedhide Exterior Alkyd Wood Primer 6-9, 2 mils.
2) Two (2) coats PPG Speedhide Gloss Oil Interior/Exterior Gloss 6-282 Series, 2 mils each.

c. P & L: 4.75 mils system
1) One (1) coat Permalize Exterior Primer, 2.25 mils.
2) Two (2) Coats Effecto Enamel, 1.25 mils each.

d. Valspar: 5 mils system
1) One (1) coat Alkyd First Coated 17-W-4, 2 mils dry.
2) Two (2) coats 12 Series Alkyd Enamel, 1.5 mils dry per coat.

e. Sherwin: 6.2 mils system
1) One (1) coat A-100 Exterior Wood Primer Y24 W20, 2.2 mils.
2) Two (2) coats Industrial Enamel B54 Series, 2 mils each.

f. Tnemec: 6 mil system
1) One (1) coat Series 10-99W Tnemec Primer, 2.0 dry mils.
2) Two (2) coats Series 6 Tneme-Cryl, 2.0 dry mils per coat.

F. Interior Electrical Room Floors:

1. Step one: Prepare the Floor per SSPC-SP13 or NACE 6. The surface must be clean, dry, sound and offer sufficient profile to achieve adequate adhesion. Minimum substrate cure is 28 days at 75°F. Remove all the form release agents, curing compounds, salts, efflorescence, laitance, and other foreign matter by abrasive blast cleaning, shotblasting, mechanical scarification, or suitable chemical means. Verify pH between 8.0 and 12.0. Allow the concrete to dry thoroughly prior to coating. If “bugholes” are present, or if the concrete has been damaged, the surface should be repaired using ArmorSeal ExpressPatch or Tnemec Series 63-1500 Filler and Surfacer.

2. Step two: Apply one of the following systems.

a. Sherwin: 11 mil system
1) One (1) coat ArmorSeal 33 Epoxy Primer/Sealer, B58AQ33/B60VQ33, 8 mils dry per coat.
2) One (1) coat ArmorSeal 1000HS Epoxy, B67-2000/B67V2002, 3 – 5 mils dry per coat.

b. Sherwin: 6 mil system
PAINTS AND PAINTING

1) One (1) coat ArmorSeal 1000HS Epoxy, B67-2000/B67V2002, 3 mils dry per coat. (Reduce 25% with R7K54)
2) One (1) coat ArmorSeal 1000HS Epoxy, B67-2000/B67V2002, 3 – 5 mils dry per coat.

c. Sherwin: 18 mil system
   1) One (1) coat ArmorSeal 33 Epoxy Primer/Sealer, B58AQ33/B60VQ33, 8 mils dry film thickness.
   2) One (1) coat ArmorSeal 650 SL/RC Epoxy, B58Q-650/B60VQ655, 10-30 mils dry per coat.

d. Tnemec: 6 mil system
   1) One (1) coat Tnemec Series 66 Hi-Build Epoxoline applied at 3 mils.
   2) One (1) coat Tnemec Series 66 Hi-Build Epoxoline applied at 4 mils.

e. PPG: 10 mil system
   1) One (1) coat PPG Aquapon High Build Semi-Gloss Polyamide Epoxy Coating 97-130 Series at 5 mils.
   2) One (1) coat PPG Aquapon High Build Semi-Gloss Polyamide Epoxy Coating 97-130 Series at 5 mils.

G. Interior Laboratory, Shower & Locker Room Floors:

1. Step one: Prepare the Floor per SSPC-SP13 or NACE 6. The surface must be clean, dry, and sound and offer sufficient profile to achieve adequate adhesion. Reference ICRI CSP 3. Minimum substrate cure is 28 days at 75°F. Remove all the form release agents, curing compounds, salts, efflorescence, laitance, and other foreign matter by abrasive blast cleaning, shotblasting, mechanical scarification, or suitable chemical means. Verify pH between 8.0 and 12.0. Allow the concrete to dry thoroughly prior to coating. If “bugholes” are present, or if the concrete has been damaged, the surface should be repaired using Tnemec Series 63-1500 Filler and Surfacer.

2. Rolled Radius Cove Base:

   a. One (1) coat Tnemec Series 201 Epoxoprime applied at 6.0 to 8.0 dry mils or PPG PMC Megaseal HSPC 100% Solids Epoxy Primer/Sealer 99-12700 applied at 6.0 – 10.0 mils DFT.
   b. Mortar coat of Tnemec Series 222 Deco-Tread or PPG PMC MegaSeal SL Self-Leveling Epoxy Floor Coating 99-12600, mixed to provide adequate hang without slumping and applied to a height of 4 inches.
   c. One (1) coat Tnemec Series 284 Deco-Clear applied at 8.0 to 10.0 dry mils or PPG PMC MegaSeal SL Self-Leveling Epoxy Floor Coating 99-12600 (clear) applies at 10.0 – 30.0 mils DFT.
3. Coating System:
   a. One (1) coat Tnemec Series 222 Deco-Tread or PPG PMC MegaSeal SL Self-Leveling Epoxy Floor Coating 99-12600 applied at 20 mils. Broadcast aggregate to rejection. Sand, sweep and vacuum after the coating has cured.
   b. One (1) coat Tnemec Series 222 Deco-Tread or PPG PMC MegaSeal SL Self-Leveling Epoxy Floor Coating 99-12600 applied at 20 mils. Broadcast aggregate to rejection. Sand, sweep and vacuum after the coating has cured.
   c. One (1) coat Tnemec Series 284 Deco-Clear applied at 8.0 to 10.0 mils or PPG PMC MegaSeal SL Self-Leveling Epoxy Floor Coating 99-12600, at 10.0 – 30.0 mils, or as required to achieve the desired level of skid-resistance as approved by the Owner.

H. Interior Chemical Room Floors:
   1. Step one: Prepare the Floor per SSPC-SP13 or NACE 6. The surface must be clean, dry, sound and have a surface profile conforming to ICRI 310.2R CSP 3-5. Minimum substrate cure is 28 days at 75 F. Remove all the form release agents, curing compounds, salts, efflorescence, laitance, and other foreign matter by abrasive blast cleaning, shotblasting, or mechanical scarification. Verify pH between 8.0 and 12.0. Allow the concrete to dry thoroughly prior to coating. If “bugholes” are present, or if the concrete has been damaged, the surface should be repaired using Dura-Plate 2300 Waterbased Epoxy Cementitious Resurfacer. Steel surfaces to be coated shall be prepared per SSPC-SP10 Near White Blast Cleaning and shall have a minimum surface profiles of 2 mils. Pits, welds and transitioning sharp edges between the concrete and steel surfaces shall be filled with Steel Seam FT-910 Epoxy Patching and Surfacing Compound.
   2. Step two: coating systems.
      a. Sherwin: Highly Chemical Resistant System:
         1) One (1) coat Corobond 100 Epoxy Primer/Sealer applied at 4.0-6.0 mils dry per coat.
         2) Horizontal: One (1) coat Cor-Cote HCR Epoxy with 19 lbs of Type S Aggregate per 1.25 gallons applied at 60-70.0 mils dry.
            Vertical: One (1) coat Cor-Cote HCR Epoxy with 70 lbs Type T Aggregate per 1.25 gallons.
      3. One (1) coat Cor-Cote HCR FF Epoxy applied at 15-20 mils dry.
3.07 SCHEDULE COLORS

A. The Owner will prepare color schedule after review of Submittals.

END OF SECTION
PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Preparing surfaces, providing adequate conditions for proper workmanship, and furnishing and applying the protective coating materials required for metallic and plastic surfaces.

B. Color-code painting of piping and piping identification signs and markers.

1.02 MEASUREMENT AND PAYMENT

A. No separate payment will be made for work required under this Section. Contractor will include all costs of the requirements of this Section in the appropriate bid item(s) on the Bid Form.

1.03 REFERENCES


B. ANSI/AWWA C213 - Fusion-bonded Epoxy Coating for the Interior and Exterior of Steel Water Pipelines.

C. AWWA 102 – Coating Steel Water-Storage Tanks

D. AWWA 103 – Factory Coated Bolted Carbon Steel Tanks for Water Storage


J. SSPC-PA1 - Paint Application Specification No. 1.

K. SSPC-PA2 - Paint Application Specification No. 2.

L. SSPC- Paint 16 - Coal Tar Epoxy-Polyamide Black (or Dark Red) Paint.

M. SSPC-SP1 - Solvent Cleaning.
N. SSPC-SP2 - Hand Tool Cleaning.
O. SSPC-SP3 - Power Tool Cleaning.
P. SSPC-SP5 - White Metal Blast Cleaning.
Q. SSPC-SP6 - Commercial Blast Cleaning.
R. SSPC-SP7 - Brush-off Blast Cleaning.
S. SSPC-SP10 - Near-white Blast Cleaning.
T. SSPC AB-1 – Abrasive Standard No. 1

1.04 DEFINITIONS
A. Paint, coatings, or finishes as used in this Section include surface treatments, emulsions, enamels, paints, epoxy resins, and other protective coatings, with the exceptions of galvanizing or anodizing, whether used as a pretreatment, primer, intermediate coat, or finish coat.

B. DFT means minimum dry film thickness.

1.05 PERFORMANCE REQUIREMENTS
A. See the Drawings and other Specifications to determine how coatings under this Section will be applied. Paint or coat new and modified surfaces in conformance with this Section.

B. Coating system schedules summarize surfaces to be coated, required surface preparation, and coating systems to be applied. Coating notes on Drawings are used to show exceptions to schedules, to show or extend limits of coating systems, or to clarify or show details for application of coating systems.

C. Do not apply protective coatings to the following surfaces unless specifically named or shown to be coated:

1. Concrete.
2. Stainless steel, bronze, brass, or aluminum.
3. Machined surfaces.
4. Grease fittings.
5. Glass.
7. Platform gratings, stair treads, door thresholds, and other walk surfaces.
8. Galvanized steel electrical conduit and associated galvanized and factory-coated junction boxes and electrical panels.
9. Galvanized surfaces inside buildings and not exposed to view.
10. Manhole and valve covers and rings, storm water inlet gratings, covers, and frames.
1.06 SUBMITTALS

A. Submit the following information at least 30 days prior to protective coating work:

1. Coating Materials List: Eight copies of a coating materials list naming the manufacturer and the coating number, keyed to the coating systems described in this Section. Submit the list prior to or at the time of sample submittal.

2. Paint Manufacturer’s Information: For each coating system to be used, submit the following data:
   a. Paint manufacturer’s data sheet for each product proposed, including statements on the suitability of the material for the intended use.
   b. Technical and performance information that demonstrates compliance with the system performance and material requirements.
   c. Paint manufacturer’s instructions and recommendations on surface preparation and application.
   d. Colors available for each product, where applicable.
   e. Compatibility of shop and field applied coatings, where applicable.
   f. Material Safety Data Sheet for each product used.

B. Samples:

1. Submit color samples of paint, finishes, and other coating materials on 8-1/2-inch by 11-inch sheet metal or heavy cardstock. Have each sheet completely coated over its entire surface with one protective coating material, type, and color.

2. Provide two sets of color samples to match each color selected by the Engineer from the manufacturer’s standard color sheets. If custom-mixed colors are indicated, prepare color samples using color formulations prepared to match the color samples furnished by the Engineer.

3. Submit one 15-pound sample of each abrasive proposed to be used for surface preparation for submerged and severe service coating systems.

1.07 QUALIFICATIONS

A. Where protective coatings are to be applied by a subcontractor, employ a subcontractor who possesses a valid state license as required for performance of painting and coating work called for in this Specification.

B. Submit 5 references that show that the painting subcontractor has previous successful experience with the indicated or comparable coating systems. Include the name, address, and the telephone number for the owner of each installation for which the painting subcontractor provided the protective coating.

1.08 ENVIRONMENTAL REQUIREMENTS

A. Ventilate area where coating is being applied. Post and enforce “NO SMOKING OR OPEN FLAME” signs until coating has cured.
B. Provide lighting level of 80-foot candles (860 lx) measured mid-height at substrate surface.

C. Restrict worker access and construction traffic from area where coating is being applied or is curing.

1.09 WARRANTY INSPECTION AND MAINTENANCE

A. Warranty Inspection:

1. A warranty inspection may be conducted during the eleventh month following completion of coating and painting. The Contractor and a representative of the coating material manufacturer shall attend this inspection.

2. The Engineer may, by written notice to the Contractor, reschedule the warranty inspection to another date within the one-year correction period, or may cancel the warranty inspection altogether. Cancellation of the warranty inspection does not relieve the Contractor of his responsibilities under the Contract Documents.

3. Repair defective work discovered during the warranty inspection in accordance with these Specifications.

B. Extended Maintenance of Chemical Tank Lining Systems: Promptly repair defects in the chemical resistant sheet lining system for a period of 2 years after the lining has been placed into service. Such maintenance includes repair of the chemical tank and any equipment or facilities damaged by the corrosive action of the chemicals.

PART 2 - PRODUCTS

2.01 COATINGS CRITERIA

A. Suitability: Use suitable coating materials as recommended by the manufacturer.

B. Compatibility: In any coating system, use only compatible materials from a single manufacturer. Give particular attention to compatibility of primers and finish coats. If necessary, apply a barrier coat or tie coat between existing prime coat and subsequent field coats to ensure compatibility.

C. Containers: Supply coating materials in sealed containers that plainly show the designated name, formula or specification number, batch number, color, date of manufacture, and name of manufacturer, all plainly legible at the time of use.

D. Colors: Use colors and shades of colors of all coats of paint as indicated on the coating schedules or selected by the Engineer. Make each coat of a slightly different shade to facilitate inspection of surface coverage of each coat. The Engineer will select finish colors from the manufacturer’s standard color samples.

E. Substitute or Equal Products:
1. To establish equality, furnish satisfactory documentation from the manufacturer of the proposed substitute product that the material meets the indicated requirements and is equivalent or better in the following properties:

   a. Resistance to abrasion and physical damage.
   b. Resistance to chemical attack.
   c. Life expectancy.
   d. Ability to recoat in future.
   e. Solids content by volume.
   f. Dry film thickness per coat.
   g. Compatibility with other coatings.
   h. Suitability for the intended service.
   i. Temperature limitations in service and during application.
   j. Type and quality of recommended undercoats and topcoats.
   k. Ease of application.
   l. Ease of repairing damaged areas.
   m. Stability of colors.

2. For substitutions submit protective coating materials that are standard products produced by recognized manufacturers who are regularly engaged in production of such materials for essentially identical service conditions. Where requested, provide the Engineer with the names of not less than 10 successful applications of the proposed manufacturer’s products, which comply with these requirements.

2.02 INDUSTRIAL COATING SYSTEMS

A. Material Sources: Each of the following manufacturers can supply many of the specified industrial coating materials. Where manufacturers and paint numbers are listed, it is to show the type and quality of coatings that are required. Proposed substitute materials will be considered as indicated under paragraph 2.01E. Provide industrial coating materials that have a record of satisfactory performance in industrial plants, manufacturing facilities, and water and wastewater treatment plants.

1. Ameron (PPG PMC).
2. Carboline Coatings Company.
4. Glidden Coatings and Resins (PPG PMC).
7. Tnemec Company.
8. Valspar Corporation (PPG PMC).
9. 3M

B. Provide coating system specified herein applicable to media serviced unless noted otherwise in plans or specifications.
1. System 1 - Aliphatic Polyurethane: Two-component aliphatic acrylic polyurethane coating. Provide superior color and gloss retention, resistance to splash from acid and alkaline chemicals, resistance to chemical fumes and severe weathering and with a minimum solids content of 58 percent by volume. As primer use a rust inhibitive 2-component epoxy coating with a minimum solids content of 68 percent by volume.

   a. Prime coat:
      1) DFT = 4 mils
      2) Products: Ameron Amercoat 385, Carboline Carboguard 60 series, Tnemec 69, Sherwin Williams Macropoxy 646 or equal.

   b. Finish coats (one or more):
      1) DFT = 3 mils
      2) Products: Ameron Amershield, Carboline 134 HG, Tnemec 74, Sherwin Williams Acrolon Ultra or equal.

   c. Total system DFT = 7 mils.
   d. Apply more than one finish coat as necessary to produce a finish with uniform color and texture.

1A System 1A – Solvent free aromatic polyurethane hybrid: Two – component polyurethane hybrid. Provides protection from microbiologically induced corrosion (MIC) and hydrogen sulfide corrosion found in wastewater treatment service. Must be WL approved ANSI/NSF STD.61 potable water. Provides cold temperature curing, fast cure & walk on time, excellent barrier properties, low permeability, single – coat application 70-125 MILS, DFT, true monolithic film on steel surfaces, outstanding abrasion/impact/tear resistance. Combines polyurethane and polyurea technologies to form a Hybrid Polyurethane.

   a. Surface Preparation: SSPC-SP10, near white blast, blast profile 3.0-5.0MILS
   b. Flat Surfaces: One coat 25.0-30MILS DFT
      : Bolt trays & seams: one coat 40.0 – 80MILS DFT

   c. Products: Reactamine 760 by carboline.
   d. Total system DFT – 25.0 – 30MILS
   e. Apply one coat as necessary to produce a finish with uniform color & texture.

2. System 2 - Inorganic Zinc/Polyurethane: For prime coat, use inorganic zinc primer that is water or solvent-based, self-curing, zinc silicate 2-component inorganic coating which contains at least 85 percent of metallic zinc by weight in the dried film, and is recommended by the coating manufacturer as a primer for this system. As intermediate coat use a high-build, 2-component epoxy with a solids content of at least 70
percent by volume. For finish coats use a 2-component aliphatic acrylic
or polyester polyurethane coating material that provides superior color
and gloss retention, resistance to chemical fumes and severe weathering,
and a minimum solids content of 58 percent by volume.

a. Prime coat:
   1) DFT = 3 mils
   2) Products: Ameron Dimetcote 21-5 or 21-9, Sherwin Williams Zinc
      Clad II, Carboline Carbozinc 11 or equal.

b. Intermediate coat:
   1) DFT = 4 mils
   2) Products: Ameron Amercoat 385, Sherwin Williams Macropoxy 646,
      Carboline Carboguard 60 series or equal.

c. Finish coats (one or more):
   1) DFT = 3 mils
   2) Products: Ameron Amershield, Sherwin Williams Acrolon Ultra,
      Carboline 134 HG or equal.

d. Total system DFT = 10 mils.
e. Apply intermediate coat in excess of 4 mils DFT or in more than one
   coat as necessary to completely cover the inorganic zinc primer and
   prevent application bubbling of the polyurethane finish coat.
f. Apply more than one finish coat as necessary to produce a finish with
   uniform color and texture.
g. If inorganic zinc primer is used as a pre-construction or shop-applied
   primer, and there are damaged or uncoated areas, spot blast the
   damaged area with abrasive and then coat with the specified material.

3. System 3 - Inorganic Zinc, Water-Based: Water-based, self-curing, zinc
   silicate coating with a 2-component inorganic coating material that
   contains at least 85 percent of metallic zinc by weight in the dried film.

a. Prime coat and finish coat (one):
   1) DFT = 3 mils
   2) Products: Ameron Dimetcote 21-5, Sherwin Williams Zinc Clad XI,
      Carboline Carbozinc 11 WB or equal.

b. Total system DFT = 3 mils.

   with a fungicide additive having a minimum solids content of 35 percent
   by volume. Apply a prime coat as recommended by manufacturer.
   Select coating material, which is available in the ANSI safety colors.

a. Prime coat:
1) DFT = 2 mils
2) Products: As recommended by manufacturer.

b. Finish coats (2 or more):
1) DFT = 6 mils
2) Products: Ameron 220, Carboline 3359, Tnemec 6, Sherwin Williams DTM Acrylic or equal.

c. Total system DFT = 8 mils.

5. System 5 - Epoxy, Equipment: Two-component, rust-inhibitive, polyamide-cured epoxy coating material with a re-coatable finish that is available in a wide selection of colors. Minimum solids content of 66 percent by volume. Resistant to service conditions of condensing moisture, splash and spillage of lubricating oils, and frequent washdown and cleaning.
   a. Prime coat:
   1) DFT = 3 mils
   2) Products: Ameron Amercoat 385P, Tnemec 69, Carboline Carboguard 60 series, Sherwin Williams Macropoxy 646 or equal.

b. Prime coat (where shop applied):
   1) DFT = 3 mils
   2) Products: Universal primer, Ameron 185 HS, Tnemec 50-330 or 161, Carboline Carbocoat 150, Sherwin Williams Macropoxy 646 or equal.

c. Finish coats (2 or more):
   1) DFT = 6 mils
   2) Products: Ameron 385, Tnemec 69, Carboline Carboguard 60 series, Sherwin Williams Macropoxy 646 or equal.

d. Total system DFT = 9 mils.

6. System 6 - Aliphatic Polyurethane, Fiberglass: Two-component, aliphatic polyurethane coating material with superior color and gloss retention, resistance to splash from acid and alkaline chemicals, and resistance to chemical fumes and severe weathering. Use a primer, tie coat, or mist coat recommended by the manufacturer.
   b. Finish coats (2 or more):
7. System 7 - Alkyd Enamel: High quality, gloss or semi-gloss, medium long oil alkyd finish with a minimum solids content of 49 percent by volume. Apply primer as recommended by manufacturer.

   a. Prime coat:
      1) DFT = 3 mils
      2) Products: Ameron 5105, Tnemec P4-55, Carboline Carbocoat 115, Sherwin Williams Kem Kromik Universal or equal.

   b. Finish coats (2 or more):
      1) DFT = 3 mils
      2) Ameron 5401 HS, Tnemec 2H, Carbocoat 115, Sherwin Williams Industrial Enamel or equal.

   c. Total system DFT = 6 mils.

8. System 8 - Aluminum Metal Isolation: One coat of a high-build polyamide epoxy paint.

   a. Products: Tnemec P66, Carboline Carboguard 60 series, Sherwin Williams Macropoxy 646 or equal

   b. Total system DFT = 8 mils.


   a. Prime coat and finish coat (2 or more):
      1) DFT = 3 mils
      2) Products: Tnemec Series 39-1061, Ameron 878, Carboline Themaline 4700 Aluminum, Sherwin Williams Heat-Flex Hi-Temp 1000 or equal.

   b. Total system DFT = 3 mils.

2.03 SUBMERGED AND SEVERE SERVICE COATING SYSTEMS

A. Materials Sources: The manufacturers’ products listed in this paragraph are materials which satisfy the material descriptions of this paragraph and have a documented successful record for long-term submerged or severe service conditions. Proposed substitute products will be considered as indicated under paragraph 2.01E.

B. System 100 - Amine-Cured Epoxy: High-build, amine-cured, epoxy resin with a solids content of at least 80 percent by volume. Suitable for long-term immersion
service in potable water and municipal wastewater. For potable water service, select a coating material listed by the NSF International as in compliance with NSF Standard 61.

1. Prime coat and finish coats (3 or more):
   a. DFT = 16 mils
   b. Products: Ameron 39, Tnemec 139, Carboline Carboguard 691 series, Sherwin Williams Tank Clad HS or equal.

2. For coating of valves and non-submerged equipment, DFT = 12 mils.

C. System 101 - Polyamide Cured Epoxy: High-build, polyamide epoxy resin with a solids content of at least 56 percent by volume. Suitable for long-term immersion in potable water and municipal wastewater. For potable water service, select a coating material listed by the NSF International as in compliance with NSF Standard 61.

1. Prime coat and finish coats (3 or more):
   a. DFT = 12 mils
   b. Products: Tnemec 20, Valspar 32PWR, Carboline Carboguard 61 series, Sherwin Williams Macropoxy 646 or equal.

D. System 102 - Coal Tar Epoxy: High-build 2-component amine or polyamide-cured coal tar epoxy with a solids content of at least 68 percent by volume. Suitable for long-term immersion in wastewater and for coating of buried surfaces. Conforming to Mil Spec DOD-P-23236, or to SSPC Paint 16. Prime coats are for use as a shop primer only. Omit prime coat when both surface preparation and coating are performed in the field.

1. Prime coat:
   a. DFT = 1.5 mils
   b. Products: Ameron 83HS, Tnemec P66, Carboline Bitumastic 300M, Sherwin Williams Copoxy Shop Primer or equal.

2. Finish coats (2 or more):
   a. DFT = 16 mils
   b. Products: Ameron 78 HB, Tnemec 46 H-413, Carboline Bitumastic 300M, Sherwin Williams Hi-Mil Sher-Tar Epoxy or equal.

3. Total system DFT = 17.5 mils.

E. System 103 - Fusion Bonded Epoxy: 100 percent powder epoxy applied in accordance with the ANSI/AWWA C213, except that surface preparation shall be as specified in the coating system schedule of this Section. Apply the coating using the fluidized bed process.
1. **Liquid Epoxy**: For field repairs, use a liquid epoxy applied in not less than 3 coats to provide a DFT of 15 mils. Use a liquid epoxy, which is 100 percent solids epoxy as recommended by the powder epoxy manufacturer.

2. **Coating**:
   - DFT = 16 mils
   - Products: Scotchkote 134 or 206N, or equal.

3. Total system DFT = 16 mils.

4. For coating of valves, DFT = 12 mils.

**F. System 104 - Chemical Resistant Sheet Lining**:

1. **Materials**: Use natural rubber, chlorobutyl rubber, ethylene propylene diene monomer (EPDM) rubber, chloroprene polymer (neoprene) rubber, or chlorosulfonated polyethylene (Hypalon) rubber sheet lining material. Submit the shop drawings containing technical information that confirms the suitability of the lining material system for long-term immersion in each chemical to be stored. Service temperatures are expected to be up to 150 degrees F.

   - **c. Natural rubber (soft) sheet lining material**: Soft natural rubber formulated for steam curing at atmospheric pressure. Provide a minimum lining thickness of 3/16-inch. Supply B. F. Goodrich compound 83160, or equal.
   - **e. EPDM sheet lining material**: Synthetic rubber suitable for use as a lining for 50 percent sulfuric acid solution and formulated for autoclave or steam curing under pressure.
   - **f. Hypalon sheet lining material**: Synthetic rubber suitable for use as a lining for 50 percent sulfuric acid solution.

2. Use primers, adhesives, activators, accelerators, and other necessary materials as recommended by the sheet material manufacturer.

3. **Metal Surface Preparation**: Prior to abrasive blast cleaning, prepare the base metal as required by the sheet lining material manufacturer’s installation instructions. If the instructions differ from these specifications,
provide the highest degree of cleaning and surface preparation. Perform abrasive blast cleaning in accordance with this Section.

4. Install lining materials in accordance with the material manufacturer’s written installation instructions. Line interior surfaces including piping, vents, fittings, flange faces, manhole covers, and blind flanges.

5. Test the lining system for holidays in accordance with this Section before and after curing.

6. Cure the lining system by steam using the time and temperature as required by the material manufacturer.

G. System 105 - Vinyl Ester: Vinyl ester resin coating material with an inert flake pigment. Suitable for immersion service in 30 percent hydrochloric acid and 30 percent sulfuric acid solutions.

1. Coating: (2 or more coats):
   a. DFT = 40 mils
   b. Products: Carboline Plasite 4100, Sherwin Williams Magnalux 304 or equal
   c. Prime coat: As recommended by the material manufacturer.

PART 3 - EXECUTION

3.01 MANUFACTURER’S SERVICES

A. Require the protective coating manufacturer to furnish a qualified technical representative to visit the project site for technical support as may be necessary to resolve field problems attributable or associated with manufacturer’s products.

B. For submerged and severe service coating systems, require the paint manufacturer to furnish the following services:

1. At least 6 hours of on-site instruction on the proper surface preparation, use, mixing, application, and curing of the coating systems.

2. Observe action of the start of surface preparation, mixing, and application of the coating materials for each coating system by the manufacturer’s representative.

3.02 WORKMANSHIP

A. Use skilled craftsmen and experienced supervision.

B. Apply coating to produce an even film of uniform thickness. Give special attention to edges, corners, crevices, and joints. Ensure thorough cleaning and an adequate thickness of coating material. Apply coatings to produce finished surfaces free from runs, drops, ridges, waves, laps, brush marks, and variations in color, texture, and finish. Effect complete hiding so that the addition of another coat would not increase the hiding. Give special attention to ensure that edges,
corners, crevices, welds, and similar areas receive a film thickness equivalent to adjacent areas. Protect installations by use of drop cloths or other precautionary measures.

C. If surfaces are damaged, clean, repair, and refinish to original condition.

3.03 STORAGE, MIXING, AND THINNING OF MATERIALS

A. Manufacturer’s Recommendations: Unless otherwise indicated, strictly comply with the coating manufacturer’s printed recommendations and instructions for thinning, mixing, handling, applying, and protecting its coating materials, for preparation of surfaces for coating, and for all other procedures relative to coating.

B. Use protective coating materials within the manufacturer’s recommended shelf life.

C. Storage and Mixing: Store coating materials under conditions recommended by the Material Safety Data Sheets. Keep coating materials thoroughly stirred, strained, and with uniform consistency during application. Do not mix coatings of different manufacturers.

3.04 PREPARATION FOR COATING

A. Cleaning and Touch-up: Clean surfaces to receive protective coatings. Examine surfaces to be coated. Correct surface defects before application of any coating material. Touch up marred or abraded spots on shop-primed and on factory-finished surfaces prior to coating application. Verify that surfaces to be coated are dry and free of visible dust.

B. Protection of Surfaces Not to be Coated: Protect surfaces, which are not to receive protective coatings during surface preparation, cleaning, and coating operations.

C. Remove, mask or otherwise protect hardware, lighting fixtures, switch plates, machined surfaces, couplings, shafts, bearings, nameplates on machinery, and other surfaces to be painted. Provide drop cloths to prevent coating materials from falling on or marring adjacent surfaces. Protect the working parts of mechanical and electrical equipment from damage during surface preparation and coating operations. Mask openings in motors to prevent entry of coating or other materials.

D. Do not damage adjacent work during blast cleaning operations. Conduct spray painting under carefully controlled conditions. Promptly repair any damage to adjacent work or adjoining property occurring from blast cleaning or coating operations.
E. Protection of Painted Surfaces: Coordinate cleaning and coating so that dust and other contaminants from the cleaning process will not fall on wet, newly coated surfaces.

3.05 SURFACE PREPARATION STANDARDS

A. The following referenced surface preparation standards of the Steel Structures Painting Council form a part of this Specification:

1. Solvent Cleaning (SSPC-SP1): Removal of oil, grease, soil, salts, and other soluble contaminants by cleaning with solvent, vapor, alkali, emulsion, or steam.


4. White Metal Blast Cleaning (SSPC-SP5): Removal of visible rust, oil, grease, soil, dust, mill scale, paint, oxides, corrosion products, and foreign matter by blast cleaning.

5. Commercial Blast Cleaning (SSPC-SP6): Removal of visible oil, grease, soil, dust, mill scale, rust, paint, oxides, corrosion products, and other foreign matter, except that staining is limited to no more than 33 percent of each square inch of surface area.

6. Brush-off Blast Cleaning (SSPC-SP7): Removal of all visible oil, grease, soil, dust, loose mill scale, loose rust, and loose paint.

7. Near-white Blast Cleaning (SSPC-SP10): Removal of visible oil, grease, soil, dust mill scale, rust, paint, oxides, corrosion products, and other foreign matter, except that staining is limited to no more than 5 percent of each square inch of surface area.

3.06 METAL SURFACE PREPARATION (UN GALVANIZED)

A. Provide the minimum abrasive-blasting surface preparation as indicated in the coating system schedules at the end of this Section. Where there is a conflict between these specifications and the coating manufacturer's printed recommendations for the intended service, the higher degree of cleaning applies.

B. Perform metal surface preparation in conformance with the current SSPC Standards and this Section. Blast-clean surfaces match standard samples in NACE Standard TM-01-70.

C. Remove oil, grease, welding fluxes, and other surface contaminants prior to blast cleaning using solvent cleaning in SSPC-SP1.

D. Have sharp edges rounded or chamfered and burrs, surface defects and welded splatter ground smooth prior to blast cleaning.
E. Abrasive Blast Materials:

1. Select the type and size of abrasive to produce a surface profile that meets the coating manufacturer’s recommendation for the particular coating and service conditions. As abrasives for submerged and severe service coating systems use clean, hard, sharp cutting crushed slag. Do not use automated blasting systems for surfaces that will be in submerged service. Do not use metal shot or grit for surfaces that will be in submerged service, even if subsequent abrasive blasting is planned with hard, sharp-cutting crushed slag.

2. Mineral and slag abrasive materials shall conform to the requirements of the Society for Protective Coating’s Abrasive Specification No. 1, SSPC-AB1. Abrasives are to be Class A, less than 1% crystalline silica. The conductivity of the abrasive (indicative of water-soluble contaminants) shall not exceed 500 microsiemen (micromhos) when tested in accordance with ASTM-D4943. The contractor shall provide to the Engineer qualifications and conformance testing performed and documented in accordance with Section 5 of SSPC-AB1, prior to using the abrasive material. Abrasive materials expressly prohibited from use include sand and copper slag.

F. Do not reuse abrasive except when an automated blasting system is used for surfaces that will be in non-submerged service. For automated blasting systems, use clean, oil-free abrasives. In the abrasive mix use at least 50 percent grit.

G. Comply with the applicable federal, state, and local air pollution control regulations for blast cleaning.

H. For air-blast cleaning supply compressed air at adequate pressure from well-maintained compressors equipped with oil and moisture separators, which remove at least 95 percent of the contaminants.

I. Clean surfaces of dust and residual particles of the cleaning operation using dry air-blast cleaning, vacuuming, or another approved method prior to painting.

J. In enclosed areas and other areas where dust may settle, vacuum the surface clean and wipe it with a tack cloth.

K. Remove damaged or defective coating by the specified blast cleaning to meet the clean surface requirements before recoating.

L. If the specified abrasive blast cleaning will damage adjacent work, the area to be cleaned is less than 100 square feet, and the coated surface will not be submerged in service, then SSPC-SP2 - Hand Tool Cleaning or SSPC-SP3 - Power Tool Cleaning, may be used.

M. Completely remove shop-applied coatings of unknown composition before the specified coatings are applied. Examine valves, castings, ductile or cast iron pipe, and fabricated pipe or equipment for the presence of shop-applied
temporary coatings. Completely remove temporary coatings by solvent cleaning per SSPC-SP1 before starting abrasive blast cleaning.

N. Use the solvent cleaning method to clean shop-primed equipment in the field before finish coats are applied.

3.07 SURFACE PREPARATION FOR GALVANIZED FERROUS METAL

A. For galvanized ferrous metal use the alkaline cleaned method per SSPC-SP1 to remove oil, grease, and other contaminants detrimental to adhesion of the protective coating system.

B. Apply pretreatment coatings of surfaces in accordance with the printed recommendations of the coating manufacturer.

3.08 SURFACE PREPARATION OF FERROUS SURFACES WITH EXISTING COATINGS

A. Preparatory Cleaning: Remove grease, oil, heavy chalk, dirt, or other contaminants by solvent or detergent cleaning prior to abrasive blast cleaning. Determine the generic type of the existing coatings by laboratory testing.

B. Abrasive Blast Cleaning: Provide the degree of cleaning specified in the coating system schedule for the entire surface to be coated. If the degree of cleaning is not indicated in the schedule, remove deteriorated coatings by abrasive blast cleaning to SSPC-SP6 - Commercial Blast Cleaning. Clean areas of tightly adhering coatings to SSPC-SP7 - Brush-off Blast Cleaning, with the remaining thickness of existing coating not to exceed 3 mils.

C. Incompatible Coatings: If coatings to be applied are not compatible with existing coatings, apply intermediate coatings conforming to the paint manufacturer's recommendation for the indicated coating system or completely remove the existing coating prior to abrasive blast cleaning. Make a small trial application for compatibility prior to painting large areas.

D. Unknown Coatings: Completely remove coatings of unknown composition prior to application of new coatings.

E. Water-abrasive or Wet-abrasive Blast Cleaning: Where specified or where job site conditions do not permit dry-abrasive blasting for industrial coating systems due to dust or air pollution considerations, water-abrasive blasting or wet-abrasive blasting may be used. In both methods, use paint-compatible corrosion inhibitors. Begin the coating application as soon as surfaces are dry. Perform water-abrasive blasting using high-pressure water with sand injection. In both methods, use equipment that is commercially produced with a successful service record. Do not use wet-blasting methods for submerged and severe-service coating systems, unless specified.
3.09 PLASTIC, FIBERGLASS, AND NONFERROUS METALS SURFACE PREPARATION

A. Unless otherwise indicated, for equipment, or parts of equipment which are not submerged in service, shop-prime them and then finish-coat them in the field after installation. For methods, materials, application equipment, and other details of shop painting, comply with this Section. If the shop primer requires top coating within a specified period of time, apply the finish coat in the shop and then touch-up the paint after installation.

B. Perform surface preparation and coating work in the field for equipment, or parts and surfaces of equipment which are submerged or inside an enclosed hydraulic structure when in service, except for pumps and valves.

C. For certain pieces of equipment, it may be undesirable or impractical to apply finish coatings in the field. Such equipment may include engine generator sets, equipment such as electrical control panels, switchgear or main control boards, submerged parts of pumps, ferrous metal passages in valves, or other items where it is not possible to obtain the required quality in the field. For such equipment prime and finish-coat it in the shop and touch it up in the field after installation. Use the identical material for touch up that was used for shop painting. Require the manufacturer of each such piece of equipment to certify as part of its shop drawings that the surface preparation is in accordance with these specifications. Submit the coating material data sheet with the shop drawings for the equipment.

D. For certain small pieces of equipment, the manufacturer may have a standard coating system, which is suitable for the intended service conditions. In such cases, the final determination of suitability will be made during review of the shop drawing submittals. Equipment of this type generally includes only indoor equipment such as instruments, small compressors, and chemical metering pumps.

E. Protect shop-painted surfaces during shipment and handling. Protect surfaces with padding or blocking. Lift equipment with canvas or nylon slings. Do not expose primed surfaces to the weather for more than 2 months before being top coated or less time if recommended by the coating manufacturer.

F. Repair damage to shop-applied coatings in accordance with this Section and the coating manufacturer’s printed instructions.

G. Make certain that the shop primers and field topcoats are compatible and meet the requirements of this Section. Submit copies of applicable coating manufacturer’s data sheets with equipment shop drawings.

3.10 APPLICATION OF COATINGS

A. Apply protective coatings to steel substrates in accordance with SSPC-PA1 - Paint Application Specification No. 1.
B. Inspect cleaned surfaces and each coat prior to succeeding coats. Schedule inspections with the Engineer in advance.

C. Paint blast-cleaned ferrous metal surfaces before rusting or other deterioration of the surface occurs. Limit blast cleaning to only those surfaces that can be coated in the same working day.

D. Apply coatings in accordance with the manufacturer’s instructions and this Section, whichever has the most stringent requirements.

E. Give special attention to edges, angles, weld seams, flanges, nuts and bolts, and other places where insufficient film thicknesses are likely to occur. Use stripe painting for these areas.

F. Give special attention to materials, which will be joined, so closely that proper surface preparation and application are not possible. Coat such contact surfaces prior to assembly or installation.

G. Apply finish coats, including touch-up and damage repair coats, in a manner which will present a uniform texture and color matched appearance.

H. Do not apply coatings under the following conditions:
   1. Temperature outside of the manufacturer’s recommended minimum and maximum range.
   2. Dust or smoke laden atmosphere.
   3. When the substrate or air temperature is less than 5 degrees F above dew point.
   4. When air temperature is expected to drop below 40 degrees F or less than 5 degrees F above the dew point within 8 hours after application of coating.
   5. When wind conditions are not calm.

I. Determine the dew point by use of a sling psychrometer in conjunction with U. S. Department of Commerce, Weather Bureau psychometric tables.

J. For steel piping which will not be buried, have the surface abrasive blast cleaned and primed before installation.

K. Apply finish coats after concrete, masonry, and equipment installation is complete and the work areas are clean and dust free.

L. Coating repairs to be made by existing system’s manufacturer’s recommendation.

3.11 CURING OF COATINGS

A. Maintain curing conditions in accordance with the recommendations of the coating material manufacturer and this Section, whichever is the most stringent. Complete curing before placing the coating systems into service.
B. In the case of enclosed areas, forced air ventilation using heated air if necessary, may be required until the coatings have fully cured.

C. Forced Air Ventilation of Enclosed Hydraulic Structures: Forced air ventilation is required for the application and curing of coatings on the interior surfaces of enclosed hydraulic structures. During application and curing periods, continuously exhaust air from the lowest level of the structure using portable ducting. After interior coating operations have been completed, provide a final curing period for a minimum of 10 days, operating the forced air ventilation system continuously.

3.12 SHOP AND FIELD INSPECTION AND TESTING

A. Give the Engineer a minimum of 3 days advance notice of the start of any field surface preparation work or coating application work, and a minimum of 7 days advance notice of the start of any shop surface preparation work.

B. Perform surface preparation and coating applications in the presence of the Engineer, unless the Engineer has granted prior approval to perform such Work in his absence.

C. Inspection by the Engineer, or the waiver of inspection of any portion of the work, does not relieve the Contractor of his responsibility to perform the Work in accordance with these Specifications.

D. Erect and move scaffolding where requested by the Engineer to facilitate inspection. Provide additional illumination to light areas to be inspected.

E. Inspection Devices: Until final acceptance of coatings, furnish inspection devices in good working condition for the detection of holidays and measurement of dry-film thicknesses of protective coatings. Make dry-film thickness gauges available for the Engineer’s use while coating is being done, until final acceptance of such coatings. Provide the services of a trained operator of the holiday detection devices until the final acceptance of such coatings. Operate holiday detection devices in the presence of the Engineer.

F. Holiday Testing: Perform holiday tests on coated ferrous surfaces inside a steel reservoir, other surfaces which will be submerged in water or other liquids, or surfaces which are enclosed in a vapor space in such structures and surfaces coated with any of the submerged and severe service coating systems. Mark and repair or recoat areas, which contain holidays in accordance with the coating manufacturer’s printed instructions and then retest.

1. Coatings with Thickness Exceeding 20 Mils: For surfaces having a total dry-film coating thickness exceeding 20 mils; use a pulse-type holiday detector such as Tinker & Rasor Model AP-W, D.E. Stearns Co. Model 14/20, or equal. Adjust the unit to operate at the voltage required to cause a spark jump across an air gap equal to twice the specified coating thickness.
For testing edges of structural members where coating thickness exceeding 20 Mils are extremely difficult to achieve use the low voltage procedure outlined in F.2, to ensure pinhole free coating on structural member edges.

2. Coatings with Thickness of 20 Mils of Less: For surfaces having a total dry-film coating thickness of 20 mils or less, use Tinker & Rasor Model M1 nondestructive-type holiday detector, K-D Bird Dog, or equal. Use a unit that operates at less than 75-volts. For thicknesses between 10 and 20 mils, add a nonsudsing-type wetting agent, such as Kodak Photo-Flo, or equal, to the water prior to wetting the detector sponge.

G. Film Thickness Testing: On ferrous metals, measure the dry-film coating thickness in accordance with the SSPC Paint Application Specification No. 2 using a magnetic-type dry-film thickness gauge such as Mikrotest Model FM, Elcometer Model 111/1EZ, or equal. Test each coat for the correct thickness. Do not take measurements until at least 8 hours after coating application. On non-ferrous metals and other substrates, measure the coating thicknesses at the time of application using a wet-film gauge.

H. Surface Preparation: Evaluation of blast-cleaned surface preparation work will be based upon comparison of the blasted surfaces with standard samples using NACE Standard TM-01-70.

I. Contractor shall provide all time and expenses associated with any shop/factory, inspection by the Engineer that requires out of town travel greater than 100 miles or include costs in bid price for qualified third-party inspection.

J. Any coating system damage by result of destructive testing deemed necessary shall be repaired by Contractor per manufacturer's recommendation at no additional cost.

3.13 PAINTING AND IDENTIFICATION OF PIPING

A. Painting and Color Coding:

1. Use colors and signs to identify all piping which is exposed to view in buildings or tunnels, above suspended ceilings, or exposed above grade, and all outdoor piping. Identify each pipe by a color complying with the following schedule of colors and by applied markers.

2. Coat pipes in the number of coats and type of material specified. Base coats for pipeline painting may be the same neutral color. Make each succeeding base coat a slightly different color. For the final coat, comply with the pipe identifying color schedule.

3. Apply pipe identification markers to exposed piping as described above, except for the following pipe at wastewater lift stations:

   a. Discharge piping for wastewater pumps.
   b. Vent piping.
   c. Any piping inside wet wells.
B. Pipe Identification Markers:

1. Identify all pipes with applied signs or markers at 15-foot centers, at both sides of penetrated walls or floors, adjacent to valves, at connected equipment, at branch fittings, and in congested pipe layouts.

   a. Apply markers consisting of signs with legends as follows:

<table>
<thead>
<tr>
<th>outside diameter of pipe or covering (inches)</th>
<th>length of color field (inches)</th>
<th>size of letters (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3/4 to 1-1/4</td>
<td>8</td>
<td>½</td>
</tr>
<tr>
<td>1-1/2 to 2-3/8</td>
<td>8</td>
<td>3/4</td>
</tr>
<tr>
<td>2-1/2 to 5-7/8</td>
<td>12</td>
<td>1-1/4</td>
</tr>
<tr>
<td>6 to 7-7/8</td>
<td>12</td>
<td>1-1/4</td>
</tr>
<tr>
<td>8 to 10</td>
<td>24</td>
<td>2-1/2</td>
</tr>
<tr>
<td>Over 10</td>
<td>32</td>
<td>3-1/2</td>
</tr>
</tbody>
</table>

   b. As pipe markers use semi-rigid outdoor grade acrylic plastic, Seton Name Plate Corp. “SetMark,” or equal. Use Type SNA for outside diameters 3/4 through 5-7/8 inches and Type STR for 6-inch outside diameter or larger. For pipes or pipe covering less than 3/4-inch in diameter, use applied marker or brass identification tags 1-1/2-inches square with depressed letters 1/4-inch high, black-filled. Apply tightly to pipeline with metal or plastic straps.

C. Pipe Identification Color Schedule:

1. For pipe coatings use the colors listed in the following pipe identification color schedule:

   **PIPE IDENTIFICATION COLOR SCHEDULE**

<table>
<thead>
<tr>
<th>Piping System</th>
<th>Color</th>
<th>Federal Std. No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fire Mains</td>
<td>Red</td>
<td>11105</td>
</tr>
<tr>
<td>Oxygen</td>
<td>Orange</td>
<td>12246</td>
</tr>
<tr>
<td>Sodium Hypochlorite</td>
<td>Yellow</td>
<td>13655</td>
</tr>
<tr>
<td>Raw Polymer</td>
<td>Pink</td>
<td>11156</td>
</tr>
<tr>
<td>Diluted Polymer</td>
<td>Purple</td>
<td>17142</td>
</tr>
<tr>
<td>Natural Gas</td>
<td>Yellow</td>
<td>13655</td>
</tr>
<tr>
<td>Heating Water</td>
<td>Pink</td>
<td>11158</td>
</tr>
<tr>
<td>Supply HWR</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Return HWR</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Domestic Hot</td>
<td>Lt. Pink</td>
<td>11668</td>
</tr>
<tr>
<td>Water Supply Dom-HWS</td>
<td>Lt. Pink</td>
<td>11668</td>
</tr>
<tr>
<td>Domestic Hot</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water Return Dom-HWS</td>
<td>Lt. Pink</td>
<td>11668</td>
</tr>
<tr>
<td>Potable Water</td>
<td>Blue</td>
<td>15102</td>
</tr>
<tr>
<td>Nonpotable Water</td>
<td>White</td>
<td>17875</td>
</tr>
<tr>
<td>Instrument Air</td>
<td>Green</td>
<td>14187</td>
</tr>
<tr>
<td>Plant Air</td>
<td>Dk. Green</td>
<td>14110</td>
</tr>
</tbody>
</table>
2. Use colors for the applied signs and markers in accordance with the color schedule, except for brass identification tags, which are colored as indicated in paragraph 3.13B.

3. For final colors used for pipe identification conform to Federal Standard 595A.

   a. For pipe identification colors not listed above, follow the American National Standard (ANSI A13.1-81) Color Schedule:

      1) Materials inherently hazardous, flammable or explosive; chemically active or toxic; extreme temperature or pressure; radioactive: Yellow field with Black letters.

      2) Material of inherently low hazard - Liquid or liquid admixture: Green field with White letters; gas or gaseous admixture: Blue field with White letters.

      3) Fire quenching materials, water, foam, carbon dioxide, Halon, etc.: Red field with White letters.
### COATING SYSTEM SCHEDULES - FERROUS METALS

**A. Coating System Schedule, Ferrous Metal - Not Galvanized:**

<table>
<thead>
<tr>
<th>SCHEDULE NO. AND APPLICATION</th>
<th>SURFACE PREPARATION</th>
<th>SYSTEM NO./ DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>FM-1: Surfaces indoors and outdoors, exposed or covered, except those listed below.</td>
<td>Near white metal blast cleaning SSPC-SP10</td>
<td>(2) Inorganic zinc/polyurethane</td>
</tr>
<tr>
<td>FM-1A: Interior surfaces exposed or covered, potable water service</td>
<td>Near white blast cleaning SSPC-SP10</td>
<td>(1-A) Hybrid Polyurethane/Polyurea</td>
</tr>
<tr>
<td>FM-2: Surfaces in chlorination room, chlorine storage room, sodium hypochlorite storage room.</td>
<td>Commercial blast cleaning SSPC-SP6</td>
<td>(100) Amine-cured epoxy</td>
</tr>
<tr>
<td>FM-3: Surfaces of pumps and equipment and other ferrous surfaces submerged or intermittently submerged in potable water, utility water, and wastewater, including surfaces lower than 2 feet above high-water level in hydraulic structures, and surfaces inside enclosed hydraulic structures, pump station wet wells, and vents (excluding shop-coated valves, couplings, and pumps).</td>
<td>White metal blast cleaning SSPC-SP5</td>
<td>(100) Amine-cured epoxy</td>
</tr>
<tr>
<td>FM-4: Surfaces exposed to high temperature between 150- and 600-degrees F.</td>
<td>Near white metal blast cleaning SSPC-SP10</td>
<td>(3) Inorganic zinc, water-based</td>
</tr>
<tr>
<td>FM-5: Surfaces exposed to high temperature between 600- and 1000-degrees F.</td>
<td>Near white metal blast cleaning SSPC-SP10</td>
<td>(9) Aluminum silicon resin</td>
</tr>
<tr>
<td>FM-6: Where indicated, ferrous surfaces in water passages of valves 4-inch size and larger, exterior surfaces of submerged valves.</td>
<td>White metal blast cleaning SPC-SP5</td>
<td>(101) Polyamide-cured epoxy</td>
</tr>
<tr>
<td>FM-7: Where indicated, ferrous surfaces in water passages of pumps which have discharge size of 4 inches or larger; exterior, submerged surfaces of pumps.</td>
<td>White metal blast cleaning SSPC-SP5</td>
<td>(100) Amine-cured epoxy</td>
</tr>
</tbody>
</table>
## SCHEDULE NO. AND APPLICATION

<table>
<thead>
<tr>
<th>SCHEDULE NO. AND APPLICATION</th>
<th>SURFACE PREPARATION</th>
<th>SYSTEM NO./DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>FM-8: Ferrous surfaces of sleeve-couplings.</td>
<td>White metal blast cleaning SSPC-SP5</td>
<td>(103) Fusion-bonded epoxy</td>
</tr>
<tr>
<td>FM-9: Ferrous surfaces of sluice gates, flap gates, and shear gates, including wall thimbles.</td>
<td>White metal blast cleaning SSPC-SP5</td>
<td>(101) Polyamide-cured epoxy</td>
</tr>
<tr>
<td>FM-10: Structural steel, miscellaneous metal work, and supports for prefabricated metal buildings, not exposed to view in finished building.</td>
<td>Commercial blast cleaning SSPC-SP6</td>
<td>(3) Inorganic zinc, water-based</td>
</tr>
<tr>
<td>FM-11: Structural steel, miscellaneous metal work, and supports for roof and facia support systems for buildings, not exposed to view in finished building.</td>
<td>Commercial blast cleaning SSPC-SP6</td>
<td>(3) Inorganic zinc, water-based</td>
</tr>
<tr>
<td>FM-12: Ferrous metal exposed to view, inside and outside of buildings.</td>
<td>Commercial blast cleaning SSPC-SP6</td>
<td>(2) Inorganic zinc/polyurethane</td>
</tr>
<tr>
<td>FM-13: Surfaces of indoor equipment, not submerged.</td>
<td>Commercial blast cleaning SSPC-SP6</td>
<td>(5) Epoxy, equipment</td>
</tr>
<tr>
<td>FM-14: Exterior (exposed) surfaces shop-coated with fusion-bonded epoxy.</td>
<td>Light sandblast to roughen surface</td>
<td>(6) Aliphatic polyurethane, fiberglass</td>
</tr>
</tbody>
</table>

### B. Coating System Schedule, Ferrous Metal - Galvanized:

Apply pretreatment coatings, barrier coatings, or washes as recommended by the coating manufacturer.

<table>
<thead>
<tr>
<th>SCHEDULE NO. AND APPLICATION</th>
<th>SURFACE PREPARATION</th>
<th>SYSTEM NO./DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>FMG-1: Exposed surfaces indoors and outdoors, except those listed below.</td>
<td>Alkaline cleaning SSPC-SP1</td>
<td>(1) Aliphatic polyurethane</td>
</tr>
<tr>
<td>FMG-2: Surfaces in chlorination room, chlorine storage room, sodium hypochlorite storage room.</td>
<td>Alkaline cleaning SSPC-SP1</td>
<td>(100) Amine-cured epoxy</td>
</tr>
<tr>
<td>FMG-3: Surfaces submerged in water or wastewater, including surfaces lower than 2 feet above high-water level and surfaces inside enclosed hydraulic structures and vents.</td>
<td>Alkaline cleaning SSPC-SP1 followed by brush-off grade blast cleaning SSPC-SP7</td>
<td>(100) Amine-cured epoxy</td>
</tr>
</tbody>
</table>
### FMG-4: Surfaces exposed to view, inside and outside of building.

<table>
<thead>
<tr>
<th>SURFACE PREPARATION</th>
<th>SYSTEM NO./ DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alkaline cleaning SSPC-SP1</td>
<td>(1) Aliphatic polyurethane</td>
</tr>
</tbody>
</table>

#### 3.15 COATING SYSTEM SCHEDULE, NONFERROUS METAL, PLASTIC, FIBERGLASS

A. Where isolated nonferrous parts are associated with equipment or piping, use the coating system for the adjacent connected surfaces. Do not coat handrails, gratings, frames, or hatches. Use primers recommended by the coating manufacturer.

<table>
<thead>
<tr>
<th>SCHEDULE NO. AND APPLICATION</th>
<th>SURFACE PREPARATION</th>
<th>SYSTEM NO./ DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>NFM-1: Exposed surfaces, indoors and outdoors, except those listed below.</td>
<td>Solvent cleaned SSPC-SP1</td>
<td>(1) Aliphatic polyurethane</td>
</tr>
<tr>
<td>NFM-2: Chlorination room, chlorine storage room, sodium hypochlorite storage room.</td>
<td>Solvent cleaned SSPC-SP1</td>
<td>(100) Amine-cured epoxy</td>
</tr>
<tr>
<td>NFM-3: Aluminum surfaces in contact with concrete, or with any other metal except galvanized ferrous metal.</td>
<td>Solvent cleaned SSPC-SP1</td>
<td>(8) Aluminum metal isolation</td>
</tr>
<tr>
<td>NFM-4: Polyvinyl chloride plastic piping, indoors and outdoors, or in structures, not submerged.</td>
<td>Solvent cleaned SSPC-SP1</td>
<td>(4) Acrylic latex</td>
</tr>
</tbody>
</table>

END OF SECTION
SECTION 11203
STAINLESS STEEL SLIDE GATES

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. The equipment provided under this section shall be fabricated, assembled, erected, and placed in proper operating condition in full conformity with the drawings, specifications, engineering data, instructions, and recommendations of the equipment manufacturer unless exceptions are noted by the engineer.

B. Gates and operators shall be furnished with all necessary parts and accessories required for a complete, properly operating installation and shall be the latest standard product of a manufacturer regularly engaged in the production of fabricated water control gates.

C. Unit Responsibility: To ensure compatibility of all components directly related to the slide gates, unit responsibility for the slide gates and accessories as describe in this section shall be the responsibility of the slide gate manufacturer, unless specified otherwise.

D. Gates furnished under this section shall be Waterman or Approved Equal.

1.02 REFERENCED

A. Except as modified or supplemented herein, all gates and operators shall conform to the applicable requirements of AWWA C501. Latest edition.

1.03 SUBMITTALS

A. Submit for approval the following:

1. Fabrication, assembly and installation diagrams.
2. Manufacturer’s literature, illustrations, specifications and engineering data.
3. Setting drawings, templates and directions for the installation of anchor bolts and other anchorages.

B. Support Design Information: Submit for record purposes only weight of each gate and expected opening and closing thrust loads on the supporting structure.

C. Shop Test Results: Submit results of the required shop tests.

D. Field Test Results: Submit a written report giving the results of the required field tests.

E. Operation and Maintenance Data:
1. Copies of all Shop Drawings, test reports, maintenance data and schedules, description of operation and spare parts information.

1.04 QUALITY CONTROL

A. Manufacturer shall have experience in production of substantially similar equipment and shall show evidence of satisfactory operation in at least 5 installations. The manufacturer’s shop welds, welding procedures and welders shall be qualified and certified in accordance with the requirements of the latest edition of ANSI/AWS D1.1 or ASME section 9.

B. The fully assembled gate shall be shop inspected, adjusted and tested for operation and leakage before shipping.

PART 2 - PRODUCTS

2.01 MATERIALS

<table>
<thead>
<tr>
<th>Component</th>
<th>Material</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wall thimble, gate frame, yoke, slide Stern guides, and reinforcing members Forcing members.</td>
<td>Stainless Steel, ASTM A-276 type 316</td>
</tr>
<tr>
<td>Seats/Seals &amp; Stem Sleeves</td>
<td>Stainless steel, ASTM A-276 type 316</td>
</tr>
<tr>
<td>Cord Seals</td>
<td>Neoprene</td>
</tr>
<tr>
<td>Flush Bottom Seals</td>
<td>Neoprene ASTM D-2000 Grade 2 BC 510</td>
</tr>
<tr>
<td>Stems</td>
<td>Stainless steel, ASTM A-276 type 316</td>
</tr>
<tr>
<td>Stem Cover</td>
<td>Clear Polycarbonate ASTM A-707</td>
</tr>
<tr>
<td>Stem Guides</td>
<td>Manganese bronze ASTM B-584 Alloy 427 B-86500</td>
</tr>
<tr>
<td>Gasket (Between frame and wall)</td>
<td>EPDM ASTM 1056</td>
</tr>
<tr>
<td>Pedestals</td>
<td>Tenzaloy Aluminum</td>
</tr>
<tr>
<td>Fasteners and Anchor Bolts</td>
<td>Bolts ASTM F593 GR2 for Type 316 Nuts ASTM F594 GR2 for Type 316</td>
</tr>
</tbody>
</table>

2.02 DESIGN CRITERIA

A. The gates shall be either self-contained or non-self-contained of the rising stem, non-rising or telescopic stem configuration as indicated on the gate schedule.

B. The gate and wall thimble shall be water and sand blasted after fabrication to remove all weld splatter and to polish scratches. Blasting shall clean the entire surface and produce an even color and sheen.
C. WALL THIMBLE: Where called out, wall thimbles shall be fabricated stainless steel and furnished by the gate manufacturer. Refer to the gate schedule for type and applicable locations.

D. FRAME AND GUIDE RAILS: The gate frame will be constructed of stainless steel guide rails with UHMW seat/seals upstream and downstream. The seat/seals shall form a tight seal between the frame and the slide (disc). The guides will be of sufficient length to support ½ the height of the slide when in full open position.

1. Yoke shall not deflect more than 1/360th of the span under full head break load.
2. Seals shall be replaceable without removing the frame from the wall. In the case of embedded gates, they shall be constructed in a manner that allows replacement of the seals without removal of the gate frame from the embedment.

E. SLIDE COVER (DISC): The slide cover (disc) shall be stainless steel plate reinforced with structural shapes welded to the plate.

1. The slide cover shall not deflect more than 1/720th of the span or 1/16” at the seated sealing surface of the gate under maximum specified head.
2. The stem to gate connection shall be either the clevis type, with structural members welded to the slide and a bolt or bolts to act as a securing method, or a threaded and bolted (or keyed) thrust nut supported in welded nut pocket.
3. The clevis, or pocket and yoke, of the gate shall be capable of taking, without damage, at least twice the rated thrust output of the operator at 40 pounds of pull on a hand wheel or hand crank.
4. The slide cover shall be constructed with vertical and horizontal reinforcement ribs.
5. All welds shall be performed by an AWS-certified welding technician.

F. SEALS: The seals shall be self-adjusting. Seals requiring periodic maintenance and adjustments to maintain specified leakage rates will not be permitted.

1. The top seal design on upward opening gates consisting of four side seals shall incorporate a self-cleaning wiping function that prevents debris from building up above the top seal and causing premature wear of the seats, seals, and gate face.
2. The UHMW seats shall impinge on the slide (disc) by way of a continuous loop cord seal. Seal designs incorporating resilient seals such as “J-bulb” or “P” seals that come in direct contact with the friction surface of the slide will not be considered.
3. The cord seal shall function as a seal between the frame and the UHMW, and as a spring force to maintain contact between the UHMW and the slide (disc).
4. The resilient bottom seal shall be set into the invert member of the frame which shall be formed in a manner to protect 3 sides of the seal only exposing the side that will come in contact with the slide. Disc-mounted invert seals exposing additional surface area will not be permitted.

5. The self-adjusting seal system shall provide an allowable leakage rate of no more than \( \frac{1}{2} \) AWWA leakage rate per minute per peripheral foot of perimeter opening for seating and unseating heads.

G. STEM AND STEM GUIDE: The stem shall be solid stainless steel of the specified grade and UHMWPE bushed.

1. Guides shall be adjustable with split stem sleeves. Guides shall be spaced per the manufacturer’s recommendations. The stem L/r ratio shall not exceed 200.
2. Stem threads shall be machine-cut 29-degree full Acme or stub Acme type.
3. Nominal diameter of the stem shall not be less than the crest of the threaded portion.

H. STEM COVER: Rising stem gates shall be provided with a clear polycarbonate stem cover. The stem cover shall have a cap and condensation vents and a clear mylar position indicating tape. The tape shall be field applied to the stem cover after the gate has been installed and positioned.

I. THRUST NUT: Each gate shall be provided with a thrust nut. For non-rising stem arrangement, the thrust nut is mounted in a pocket on the slide. The pocket shall be designed to prevent the thrust nut from turning with the stem.

1. For rising stem arrangement, the thrust nut shall be located at the operator level.
2. For telescopic arrangement, the thrust nut shall be located at the bottom end of the operating tube.

J. LIFTING MECHANISM: Manual operators of the types listed in the schedule shall be provided by the gate manufacturer.

1. All bearings and gears shall be totally enclosed in a weather tight housing. The pinion shaft of crank-operated mechanisms shall be constructed of stainless steel and supported by roller bearings or needle bearings.
2. Each manual operator shall be designed to operate the gate under the maximum specified seating and unseating heads by not more than a 40-pound (18kg) effort on the crank or handwheel and shall be able to withstand, without damage, an effort of 80 pounds (36kg). The crank shall be removable and fitted with a corrosion resistant rotating handle. The maximum crank radius shall be 15 in (380 mm) and maximum handwheel diameter shall be 24 in (600 mm).
2.03 SHOP PAINTING
A. Clean and prime coat ferrous metal surfaces of equipment in the shop in accordance with manufacturer’s recommendations.
B. Stainless steel gates do not require protective coatings.

2.04 ANCHOR BOLTS
A. Furnish anchor bolts and nuts of ample size and strength for the purpose intended, sized by the equipment manufacturer. Anchor bolt materials shall be Type 316 stainless steel and shall conform to the requirements of the manufacturer.

2.05 SPECIAL TOOLS
A. Furnish two sets of any special tools required for normal operation and maintenance.

2.06 LUBRICANTS
A. Furnish lubricant, oil and grease as required for initial operation. Products shall be as recommended by the manufacturer.

2.07 STORAGE AND HANDLING
A. Deliver materials to the site to insure uninterrupted progress of the Work. Deliver anchor bolts and anchorage devices, which are to be embedded in cast-in-place concrete in ample time not to delay that Work.
B. Handle all gates and appurtenances very carefully. Gates which are cracked, chipped, distorted or otherwise damaged or dropped, will not be acceptable. Protect all threads, seats, ends etc. from damage and corrosion.
C. Store materials to permit easy access for inspection and identification. Keep steel members off the ground using pallets, platforms and other supports. Protect equipment including packaged materials from corrosion and deterioration.

PART 3 - EXECUTION
3.01 INSPECTION
A. Inspection:
1. Inspect and verify that structures or surfaces on which the equipment will be installed have no defects, which adversely affect installation.
2. Inspect all equipment prior to installation.
3. Promptly report defects, which may affect the Work to the ENGINEER.
3.02 INSTALLATION
A. Install in a manner and to the tolerances specified by the equipment manufacturer’s written instructions.

3.03 FIELD PAINTING
A. Field painting shall conform to the requirements of the manufacturer’s recommendations and Section 09901 – Protective Coatings.

3.04 START-UP AND FIELD TEST
A. Perform operating tests to demonstrate that the equipment operates in the manner intended.
B. Make adjustments required to place equipment in proper operating condition.
C. Submit report of test results.

3.05 MANUFACTURER’S FIELD SERVICES
A. A manufacturer’s factory-trained representative shall check and approve the installation before operation. The representative shall operate and test system in the presence of ENGINEER and verify that the equipment conforms to requirements and instruct plant personnel on care and maintenance. The representative shall revisit the job site as often as necessary until all deficiencies are corrected.
B. Testing, checkout and start-up of the equipment shall be performed under the technical direction of the manufacturer’s factory-trained representative.

3.06 MANUFACTURER’S REPAIR SERVICES
A. Provide services of factory-trained representatives of the manufacturer to correct defective Work during the one-year correction period.

END OF SECTION
PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Submersible sewage pumps complete and operational with motors and accessories as shown and specified.

B. Coordination:
   1. Review installation procedures under other Sections and coordinate with the Work related to this Section.
   2. Coordinate pumps and motors with electrical work as specified in Division 16, Electrical.

1.02 MEASUREMENT AND PAYMENT

A. No separate payment will be made for work required under this section. Contractor will include all costs of the requirements of this section in the appropriate bid item(s) on the bid form.

1.03 REFERENCES

A. Reference Standards: Comply as a minimum with applicable provisions and recommendations of the following:

   1. American National Standards Institute (ANSI)
   3. Anti-Friction Bearing Manufacturers Association (AFBMA)
   5. Institute of Electrical and Electronic Engineers (IEEE)
   7. National Electrical Manufacturers Association (NEMA)
   8. Steel Structures Painting Council (SSPC)

1.04 PERFORMANCE REQUIREMENTS

A. Furnish and install the submersible, non-clog pumps capable of handling unscreened surface water with solids in accordance with these Specifications and as shown on the Drawings.

B. Number of pumps, minimum and maximum operating capacities, TDH, and other pump design data are tabulated on the Drawings.

C. Pumps shall be designed for continuous operation without cavitation within the specified operating range. The pump shall have a minimum hydraulic efficiency
of 58 percent at the rated capacity. The NPSHR at the maximum operating capacity shall not exceed 30 feet.

1.05 SUBMITTALS

A. Submit a list of not less than 5 installations where pumping equipment of the type and approximate size specified has been in successful operation for at least 5 years.

B. Submit locations of the nearest permanent service headquarters of the pump and motor manufacturer for the size of pump and motor submitted.

C. Submit descriptive literature, including a cross-sectional view of each pump and motor combination, which indicates materials of construction, weights, principal dimensions and other important details. Submit dimensioned, to-scale drawings showing placement of pumps, base ells, rail, rail mountings, and access frame and cover. Submit Shop Drawings for access frame and cover.

D. Submit certified characteristic curves showing the head-capacity relationship, brake horsepower, NPSH requirements, pump efficiency (ratio of the water horsepower to brake horsepower) and pump speed. The curves shall be complete for the entire range of operation from shutoff to minimum head conditions. Where pumps are to be used in VFD service, submit curves showing performance at 100% of rated speed and at decreasing speeds that would be expected. Label curves in terms of rpm and Hz. Indicate the minimum rpm, Hz, and gpm for the pump under the conditions shown on the drawings. Submit manufacturer's calculation of radial and thrust bearing L-10 life at the design head and flow indicated on the Drawings.

E. If the proposed pumping equipment is supplied with electrical equipment and components of larger capacity than specified or shown on the Contract Drawings, the shop drawings for the equipment listed in the following Sections shall be submitted in the same package as the shop drawings submitted for this Section.

F. Manufacturer's Certifications:

1. Submit manufacturer's certification that he has carefully examined the Contract Documents in detail, including the arrangement and conditions of proposed electrical, mechanical 3 water level settings and structural systems affecting the performance of the pumping equipment units, and the detailed requirements of manufacturing and subsequent installation of the pumping equipment units.

2. Submit manufacturer's certification that there are no omissions, ambiguities or conflicts in the Contract Documents or in the pumping station piping layout that affects the pumping unit, as shown on the Drawings, which have not already been clarified in writing.

3. Submit manufacturer's certification that the running amperes of the motor will not exceed the nameplate rating of the motor under all expected conditions.
operating conditions. Submit motor manufacturer’s maximum allowed KVAR.

4. Submit manufacturer’s certification that spare parts, seals, bearings, o-rings and power cable shall be available locally for models to be supplied.

5. Submit manufacturer’s certification that motors are explosion proof and labeled so, approved by Underwriters Laboratories (UL) or Factory Mutual (FM).

G. Factory Tests: Submit 3 copies of certified test reports to the Engineer for review.

1. The pump manufacturer shall perform the following inspections and tests on each pump before shipment:
   a. Impeller, motor rating and electrical connections shall first be checked for compliance to the customer’s purchase order.
   b. A motor and cable insulation test for moisture content or insulation defects shall be made.
   c. Prior to submergence, the pump shall be run dry to establish correct rotation and mechanical integrity.
   d. Each pump shall be run submerged in water.
   e. After running pump submerged in water, retest motor and cable insulation.

2. If tests do not meet performance specifications, Contractor shall correct deficiencies to provide the specified performance.

3. A written report stating the foregoing steps have been done must be supplied with each pump at the time of shipment. This report must be approved by the Engineer prior to payment.

H. Maximum Allowable Distance Data: Where pumps will be in VFD service (remotely located), submit maximum allowable installation distance data for motor.

1.06 QUALITY ASSURANCE

A. All materials used shall be new, of high grade, and with properties best suited to the work required.

B. Manufacturer’s Qualifications:

1. Pumping equipment provided under this Section shall be a standard product in regular production by manufacturers whose products have proven reliable in similar service for at least 5 years.

2. Manufacturer shall satisfy the Engineer that it is capable of the following:
   a. Providing factory trained personnel to service the pumps and allied equipment when needed within a 48-hour period.
   b. Providing all needed spare parts for the pumps within a 48-hour period.
3. Provide a written manufacturer's certification that spare parts, seals, bearings, O-rings and power cable shall be available locally for models to be supplied.

C. Coordination Responsibility:

1. In order to ensure equipment compatibility, one manufacturer shall be responsible for providing all submersible pumping equipment, including pump and motor, access frame and guides.

2. The Contractor shall name a pump manufacturer, who will have responsibility for the function of the complete system in accordance with the intent of these Specifications. The named manufacturer shall be experienced in similar work.

3. Contractor shall retain overall responsibility for equipment coordination, installation, testing and operation.

D. Substitution: The engineering design is based on a certain manufacturer's equipment. If the Contractor's choice of equipment is approved but requires modifications to plant, equipment or piping for installation, the Contractor is responsible for submitting revised engineering design and drawings to make the proposed equipment compatible with the project, at no additional cost to the Owner.

1.07 DELIVERY, STORAGE AND HANDLING

A. Deliver equipment to site, and store and protect off the ground in enclosed shelter.

B. The pump cable end shall be sealed with a high-quality protective covering to make it impervious to moisture or water seepage from submersion or other causes prior to electrical installation.

1.08 EVALUATION AND SELECTION

A. The Owner reserves the right to select any equipment, which is deemed to be in its best interest.

1.09 WARRANTY

A. Pump manufacturer shall furnish to the Owner a warranty written expressly from the manufacturer to the Owner, covering workmanship and material for 5 years or 10,000 hours of operation under normal use and service. The warranty shall cover 100 percent of parts and labor for at least one full year. The warranty period shall commence on the day of Final Acceptance. Warranty shall be in printed form and previously published as the manufacturer's Standard Warranty for all similar units manufactured. Pumps repaired under warranty will be returned to the job site freight pre-paid.
PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. Through shop drawing submittals, the following named manufacturers will be considered, provided the submitted equipment meets the specified requirements and system operating conditions:

1. Fairbanks-Morse
2. Ebara
3. KSB
4. Xylem
5. Flow Serve
6. Grundfos

B. Listing as an acceptable manufacturer will not relieve the manufacturer from conforming to Contract Specifications.

2.02 PUMP CONSTRUCTION

A. Casing:

1. Major pump components shall be of fine-grained gray cast iron, ASTM A48, Class 30 or better, with smooth surfaces devoid of blow holes and other irregularities. Surfaces coming into contact with water containing solids or long-fibered material, other than stainless steel shall be protected by an approved resistant coating.

2. Mating surfaces where watertight sealing is required shall be machined and fitted with nitrile rubber o-rings. Fitting shall be such that sealing is accomplished by metal-to-metal contact between machined surfaces. This will result in controlled compression of nitrile rubber o-rings without the requirement of a specific torque limit. No secondary sealing compounds, rectangular gaskets, elliptical o-rings, grease or other devices shall be used.

3. Pump suction flange shall be drilled to ANSI standard, class 125.

B. Power Cable:

1. The cable entry water seal design shall preclude specific torque requirements to ensure a watertight and submersible seal. The cable entry shall be sealed by an elastomer grommet, epoxy potting material, or a combination of both. The cable entry sealing system shall provide strain relief for the terminal connections and allow access to the terminal connections without adversely affecting the integrity or function of the seal system.

2. Cables shall be oil, grease and abrasion resistant, and meet applicable standards. The outer jacket shall be polyurethane or other material equally suitable for immersion in unclean water.
3. Cables shall be capable of operating on either 230 volt or 460-volt, 3 phase service and under continuous submergence without loss of watertight integrity to a depth of 65 feet.
4. No parallel power cables are acceptable unless they are size #1/0 or larger.
5. Motors 7.5 HP and over shall have reconnectable terminal blocks. All leads shall be numbered.

C. Submersible Motor:

1. The pump motor shall be a NEMA Design B squirrel-cage, induction, shell type design, housed in an oil-filled or air-filled watertight chamber. The stator winding and stator leads shall be insulated with moisture resistant Class F insulation which will resist a temperature of 155 degrees C (311 degrees F). The use of bolts, pins or other fastening devices requiring penetration of the stator housing shall be rejected. The rotor bars and short circuit rings shall be of aluminum. The motor shall be designed for continuous duty, capable of sustaining a minimum of 15 starts per hour, evenly spaced. The pump/motor shall be capable of operating at liquid temperature of 104 degrees F per FM requirements-without overheating or operating in the service factor. Motor shall be non-overloading over the entire range of the operating curve within the nameplate HP. A performance chart shall be provided showing curves for torque, current, a minimum service factor of 1.15, input/output kw and efficiency.
2. The motor shall be UL listed or FM approved as explosion-proof, suitable for NEC Class I, Division 1, Group C and D environments.
3. Each unit shall be provided with an adequately designed cooling system totally self-contained with no external mechanical devices. Pumps shall be designed to operate continuously with the fluid level at the top of the pump volute.
4. Maximum motor speed shall be 1200 rpm for pumps with discharge diameter greater than or equal to 6-inches.
5. For sizes 20 HP and smaller, the motor shall be equipped with dual voltage connections for 230/460 volts.
6. Thermal sensors shall be used to monitor stator temperatures. The stator shall be equipped with 3 thermal switches, embedded in the end coils of the stator winding (one switch in each stator phase). These shall be used in conjunction with and supplemental to external motor overload protection and wired to the control panel.
7. For motor sizes larger than 100 HP, an independent thermal switch shall be included to monitor the lower motor bearing temperature.
8. The pump shall be equipped with moisture sensors in the oil-filled seal chamber to indicate seal leakage. Motors larger than 20 HP shall be equipped with a leakage sensor to detect water in the stator chamber.
9. Motor shall be in VFD service and must conform to NEMA MG1, part 31 for VFD applications requiring higher peak voltage withstand.
D. Shaft: Each pump shaft shall be one piece of AISI type 420 stainless steel, or heat-treated carbon steel C 1035 protected by a stainless steel shaft sleeve. The shaft shall be of sufficient diameter to assure rigid support of the impeller and to prevent excessive vibration at all speeds.

E. Pump Seal: Each pump shall be provided with a tandem mechanical shaft seal system. The upper seal of the tandem set of seals shall operate in an oil chamber located just below the stator housing. This set shall contain one stationary tungsten-carbide ring and one positively driven rotating carbon (or better) ring, and functions as an independent secondary barrier between the pumped liquid and the stator housing. The lower seal of the tandem set of seals functions as the primary barrier between the pumped liquid and the oil housing. This set shall consist of a stationary ring and a positively driven rotating ring, both of which shall be silicon carbide or tungsten carbide. Shaft seals without positively driven rotating members or conventional double mechanical seals containing either a common single or double spring action between upper and lower seal faces shall not be acceptable.

F. Bearings: Bearings shall be permanently lubricated ball or roller type rated in accordance with AFBMA for an L-10 duty life of at least 80,000 hours at the rated capacity.

G. Impeller:

1. The impeller shall be of fine-grained cast iron, ASTM A48, Class 35, xx or better, Brinnel Hardness of 600, heat treated, dynamically or statically balanced, double shrouded non-clogging design having a long threulet without acute turns. The impeller shall be capable of handling 3-inch minimum diameter solids, fibrous materials, heavy sludge and other matter found in normal sewage application. The impeller hub shall be accurately fitted and mechanically secured to the motor shaft.

2. The volute shall be of a single piece, concentric or non-concentric design, and shall have smooth fluid passages large enough at all points to pass any size solids which can pass through the impeller. The volute bottom shall be of a suction bell design for pumps with 12-inch discharge and larger.

3. A replaceable wear ring shall be installed to provide efficient sealing between the volute and impeller. The wear rings shall consist of AISI Series 300 or better heat-treated stainless steel, Brinnel Hardness of 600. For pumps 10 HP and below the pump shall be equipped with brass or nitrite rubber volute wear ring only.

2.03 ACCESSORIES

A. Access Frames and Covers:

1. Halliday Products as shown on the Drawings, U.S. Foundry Series AHD or AHS, or Pre-Approved Equal.
2. For watertight service, Halliday Products Series H2W, U.S. Foundry Series THD or THS, or approved equal.

3. Aluminum access frames and covers shall be provided by the pump supplier. Fasteners, hinges and other hardware shall be type 316 stainless steel.

4. The frame shall be extruded aluminum with an integral seat and anchor flange. Door leaf shall be 1/4-inch thick aluminum floor plate reinforced to H-20 live load with 30 percent impact factor per AASHTO specifications.

5. The access door shall be equipped with a flush cast aluminum drop handle which does not protrude above the cover surface and an automatic hold open arm with a red vinyl release grip, that automatically holds the door in a 90 degree open position utilizing a stainless steel pin at the point where the door meets the hold open arm.

6. Hinges shall be stainless steel with stainless steel tamperproof hardware. Doors shall be equipped with a stainless steel, watertight slamlock with a threaded aluminum plug, removable outside handle and an inside release handle. The slamlock must latch onto a stainless steel catch bolted to the frame.

7. Doors shall also include a recessed padlock assembly that consists of a cast aluminum enclosure that is sized to restrict access by bolt cutters, a stainless steel staple for a padlock and a hinged stainless steel cover which does not protrude above cover surface.

8. Doors shall be equipped with stainless steel spring operators for lift assist and to retard downward motion. All parts of the spring operator shall be stainless steel or aluminum and to ensure visual inspection. Spring operators shall be open type. The spring operators shall be engineered and installed so that in the event of slamlock failure the door will remain closed. The force required to open any one door

9. The access opening shall have a permanently installed fall through protection grate system that provides continuous safety assurance in both its closed and open positions. When closed, the grate shall allow visibility for inspection and performance of limited maintenance below it. When open, the grate shall act as an additional barrier to the access door opening. The system shall be a “Hinged Hatch Safety Grate” as manufactured by U. S. F. Fabrication, Inc. or equal.

10. Apply bituminous paint on all areas that come in contact with concrete.

11. A written 10-year material and/or workmanship warranty on all components shall be provided.

B. Pump Guide System: Pump manufacturer shall provide a guide rail system complying with the following requirements:

1. Type 316 stainless steel rails, replaceable without man entry into the wet well.

2. Lower bracket integral with pump support/discharge fitting.

3. Type 316 stainless steel upper bracket bolted to access cover frame.

4. Intermediate brackets as shown on the Drawings, if required.
C. Bolts, Studs and Nuts:

1. All bolts, studs and nuts shall have American National form right-hand machine cut threads which shall be in conformity with the current ANSI B1.1, "Screw Threads", Coarse Thread Series, unless otherwise specified.
2. Bolt heads and nuts shall be semi-finished and shall be in conformity with ANSI B18.2, "Wrench-Head Bolts and Nuts and Wrench Openings", Heavy Series, unless otherwise specified. All nuts shall be hexagonal in shape.
3. Anchor bolts, flange bolts, studs and nuts shall be Type 316 stainless steel in conformity with ASTM A276.

2.04 PUMP PROTECTION SYSTEM

A. Manufacturer shall furnish a complete pump monitoring and protection system consisting of an intrinsically safe solid-state monitoring system to be installed in the motor starter cubicle, and independent probes integral to the pump/motor wired to a sealed cable entry terminal box for connection of submersible control cables.

B. Monitoring unit shall be solid state, intrinsically safe system designed for mounting within the motor starter cubicle. Monitoring system shall accept inputs from the sensors specified and shall output independent contacts which close to alarm each condition, or separate independent output terminals suitable for direct connection to interposing relays for alarm contact development. Provide a separate N.C. alarm contact, rated at 120V, 5A inductive, which opens on any failure. Monitor system shall be suitable for operation from a 24VAC unregulated, unlimited power supply. Provide any additional equipment or appurtenances required to provide current and voltage limited intrinsically safe installation as specified. The monitoring system shall accept separate isolated N.O. contacts, which close to indicate pump running and to reset after pump trip.

C. Sensors shall be independently wired to the monitoring system. Provisions for the following sensors for each pump:

1. Stator leak (one required).
2. Bearing temperature for pumps over 100 HP. (one required)
3. Stator temperature (one per phase, field test and connect to highest reading obtained)

2.05 SHOP PAINTING

A. Pump motor size up to 100 HP:

1. Pump Exterior:
   b. Primer: One coat of alkyd resin primer, 1.6 mils minimum.
c. Finish: Chloric rubber paint, 2.4 mils minimum.

2. Machine Finished Surfaces:
   a. Machined parts are cleaned to remove all dirt and grease.
   b. Cleaning is done so as not to affect primer or deteriorate adherence to finish paint.
   c. Storage and transport is carried out in such a way that rust attack on machined surfaces does not occur.
   d. At assembly, surfaces are coated with a corrosion preventive paint.

B. Pump motor size greater than 100 HP:
   1. Pump Exterior:
      a. Pre-treatment: Sandblast cleaning and removal of all oil and dust.
      b. Primer: One coat of alkyd resin primer, 1.6 mils minimum.
      c. Finish coat: Two coats of chloric rubber paint, 2.1 mils each coat.
   2. Machine finished surfaces:
      a. Machined parts are cleaned to remove all dirt and grease.
      b. Cleaning is done so as not to affect primer or deteriorate adherence to finish paint.
      c. Storage and transport are carried out in such a way that rust-attack on machined surfaces does not occur.
      d. At assembly, surfaces are coated with a corrosion preventive paint.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Installation of the pumping equipment shall conform to the manufacturer’s instructions and recommendations and reviewed shop drawings.

B. Field Tests:
   1. Each pump will be subjected to a 6-hour field operational test before acceptance as follows:
      a. The unit under test shall be properly installed in the wet well, firmly upon its discharge connection after determination of (a) proper service voltage is being supplied and (b) proper rotation of the impeller. No cooling by forced or circulated air shall be allowed.
      b. Capacity Test: On four occasions, wet well shall be filled with liquid to an elevation sufficient to allow each single pump to operate for 3 minutes, independent of the control regime. Time required to pump down known volume shall be measured as evidence of each pump’s
capacity. All portions of the force main must have been constructed and tested prior to this test.

c. Snore Tests: Snore is defined as that state when the pump is alternately pumping liquid and air and usually occurs when the pump pumps the liquid down to expose its inlet. The unit(s) under test shall be submerged with just enough liquid to accomplish "snore" and allowed to run two times for 10 minutes minimum.

C. Start-up Data: Contractor shall complete and submit the start-up records and maintenance data sheets.

END OF SECTION
PART 1 - GENERAL

1.01 SCOPE OF WORK

A. Furnish all labor, materials and equipment required to provide, install, test and make operational, a Process Instrumentation and Control System as specified herein and related specifications, and as shown on the Drawings.

B. The work shall include furnishing, installing and testing the equipment and materials detailed in each Section of Division 13 Process Control System Sections.

C. Throughout the Process Control System Sections of Division 13, the term Contractor shall refer to the General Contractor.

D. Equipment furnished as a part of other Divisions and shown on the Instrumentation and/or Electrical Drawings shall be integrated into the overall Instrumentation System under the Process Control System Sections of this Division. Instrumentation specified in other Divisions shall meet the Specification requirements of the Process Control System Sections of this Division.

E. The Contractor shall provide the services of specialized personnel that meet all of the qualifications of a Process Control Systems Integrator (PCSI) who shall perform all work necessary to select, furnish, configure, customize, debug, install, connect, calibrate, and place into operation all process control system instrumentation hardware specified within this Division. The PCSI shall coordinate with the Owner/Engineer, for all scheduling, installation, and startup services. The PCSI shall have qualifications as described herein. The personnel meeting these qualifications shall be submitted as part of the project plan submittal as described below. The personnel need not be direct employees of the contractor but shall be employed by a firm with a direct subcontract to the contractor.

G. The Contractor shall coordinate, and schedule all required testing with the General Contractor, Owner, Engineer, and PCSI.

H. The work shall include the following:

1. Make connections, including field connections and interfacing between instrumentation, controllers, control devices, control panels and instrumentation furnished under other Divisions. The Contractor shall coordinate his construction
schedule and instrumentation and control interface with the supplier of instrumentation and control equipment specified under other Divisions.

2. Make wiring terminations for all field-mounted instruments furnished and mounted under other Divisions, including process instrumentation primary elements, transmitters, local indicators and control panels. Install vendor furnished cables specified under other Divisions.

3. Auxiliary and accessory devices necessary for system operation or performance to interface with existing equipment or equipment provided by other suppliers under other Sections of these specifications, shall be included whether they are shown on the Drawings. These devices include, but are not limited to, transducers, current isolators, and signal conditioners, interposing relays or protocol converters.

4. System design shall allow removing individual devices from service without disrupting other unrelated devices in service.

5. Equipment shall be fabricated, assembled, installed, and placed in proper operating condition in full conformity with detail drawings, specifications, engineering data, instructions, and recommendations by the equipment manufacturer as approved by the Engineer.

6. Actual installation of the system need not be performed by the Contractor’s PCSI employees; however, the PCSI shall provide the on-site technical supervision of the installation.

7. The PCSI shall furnish equipment which is the product of one manufacturer to the maximum practical extent. Where this is not practical, all equipment of a given type shall be the product of one manufacturer.

8 All materials, equipment, labor, and services necessary to achieve the monitoring and control functions described herein shall be provided in a timely manner so that the monitoring and control functions are available when the equipment is ready to be placed into service.

1.02 RELATED WORK

A. Wherever references are made to Related Work in other Specification Sections of the Specifications, the Contractor is to provide such information or work as may be required in those references and include such information or work as may be specified.

B. All Instrumentation work related to Process and Mechanical Divisions equipment that is shown on the Instrumentation Drawings shall be provided under Division 13 Process Control System Sections unless otherwise explicitly shown.

C. All instrumentation Equipment and work provided under any Division of the Specifications shall fully comply with the requirements of Division 13 Instrumentations Sections.
D. No references are made to any other section which may contain work related to any
other section. The Contract Documents shall be taken as a whole with every section
related to every other section as required to meet the requirements specified. The
organization of the Contract Documents into specification divisions and sections is for
organization of the documents themselves and does not relate to the division of
suppliers or labor which the Contractor may choose to employ in the execution of the
Contract. Where references are made to other Sections and other Divisions of the
Specifications, the Contractor shall provide such information or additional work as may
be required in those references and include such information or work as may be
specified.

E. Other Divisions

1. The Contractor shall be responsible for examining all Sections of the Specifications
and Drawings and shall determine the power and wiring requirements and shall
provide appurtenances, as required to provide a fully functioning process control
system. If the equipment requires added options, due to different equipment being
supplied, the Contractor shall furnish the additional appurtenances and/or wiring,
with no change in the Contract Price, and with no increase in Contract Time.

1.03 SUBMITTALS

A. Submittal Process

1. Submit Shop Drawings, in accordance with Division 1 requirements, for equipment,
materials and all other equipment specified under each Instrumentation Section of
Division 13, except where specifically stated otherwise. An individually packaged
submittal shall be made for each Section and shall contain all of the information required
by that Section, unless specifically directed otherwise by the submittal requirements of
that section. Partial submittals will not be accepted and will be returned un-reviewed.

B. No submittals will be accepted for Section 13300, except for the qualifications of the
Contractor’s PCSI as specified herein, and the Project Plan, Schedule and Deviation List
Submittal.

C. Each Section submittal shall be complete, contain all of the items listed in the
Specification Section, and shall be clearly marked to indicate which items are applicable
on each cut sheet page. The Submittal shall list any exceptions to the Specifications and
Drawings, and the reason for such deviation. Shop drawings, not so checked and noted,
will be returned un-reviewed.

D. The Contractor shall check shop drawings for accuracy and Contract Requirements prior
to submittal to the Engineer. Errors and omissions on approved shop drawings shall not
relieve the Contractor from the responsibility of providing materials and workmanship
required by the Specifications and Drawings. Shop drawings shall be stamped with the
date checked and a Statement indicating that the shop drawings conform to
Specifications and Drawings. Only one Specification Section submittals will be allowed per transmittal unless sections are indicated for grouping in the individual sections.

E. Material shall not be ordered or shipped until the shop drawings have been approved. No material shall be ordered, or shop work started if shop drawings are marked “APPROVED AS NOTED CONFIRM”, “APPROVED AS NOTED RESUBMIT” or "NOT APPROVED".

F. Shop Drawings, O&M Manuals, and other documentation shall be submitted as listed in each of the individual Instrumentation Specification Sections.

1. Submit operations and maintenance data for equipment furnished under this Division, in accordance with Division 1. The manuals shall be prepared specifically for this installation and shall include catalog data sheets, drawings, equipment lists, descriptions, parts lists and operating and maintenance instructions.

2. Manuals shall include the following as a minimum:
   a. A comprehensive index.
   b. A complete "As-Built" set of approved shop drawings.
   c. A complete list of the equipment supplied, including serial numbers, ranges and pertinent data.
   d. A table listing of the "as left" settings for all timing relays and alarm and trip setpoints.
   e. System schematic drawings "As-Built", illustrating all components, piping and electric connections of the systems supplied under this Division.
   f. Detailed service, maintenance and operation instructions for each item supplied.
   g. Special maintenance requirements particular to this system shall be clearly defined, along with special calibration and test procedures.
   h. The operating instructions shall also incorporate a functional description of the entire system, with references to the systems schematic drawings and instructions.
   i. Complete parts list with stock numbers, including spare parts.

G. Record Drawings shall be promptly furnished when the equipment installation is complete. Payment will be withheld until Record Drawings have been furnished and approved. The PCSI shall provide markups on all Process and Instrumentation Contract Drawings.

H. At the time of delivery of the equipment, the Contractor shall have an approved shop drawing in his possession for the Owner’s Inspector and Owner’s Engineer’s verifications.

I. Project Plan, Schedule and Deviation List Submittal
1. Submit following PCSI’s receipt of Notice to Proceed, a Project Plan, Schedule and Deviation List Submittal. The Project Plan, Schedule and Deviation List Submittal shall be made and approved before any further submittals will be accepted and prior to scheduling of the first PCSI coordination meeting. The Project Plan, Schedule and Deviation List Submittal shall, as a minimum, contain the following:

   a. Overview of the Process Control System, clearly describing the PCSI’s understanding of the project work and interfaces to other systems; and including a preliminary system architecture drawing and proposed project work schedule detailing all PCSI's work activities. Description of PCSI's understanding of the work shall be an original write-up authored by the PCSI. Copying of the Scope of Work included herein or utilizing contract drawings in any form shall not be acceptable.

   b. Approach to work clearly describing how the PCSI intends to execute the work, including detailed discussion of switchover, startup, replacement of existing equipment with new, and other tasks as required by these specifications as applicable.

   c. Preliminary HMI software, PLC software, and PLC hardware list submittal information shall be included solely for determining compliance with the requirements of the Contract Documents prior to beginning development of application programming. Review and approval of software and hardware systems as part of this Project Plan stage shall not relieve the PCSI of meeting all the functional and performance requirements of the system as specified herein. Substitution of manufacturer or model of these systems after the submittal is approved shall not be permitted without prior Engineer approval.

   d. Details of personnel assigned to the project and organizational structure including the PCSI’s project manager, project engineer, and lead project technicians. Include resumes of each key individual and specify in writing their commitment to this project.

   e. Preliminary coordination meeting agendas as specified herein.

   f. Preliminary training plan

   g. Samples of shop drawings to be submitted in conformance with the requirements of the Specifications shall be submitted. At a minimum include samples of panel fabrication drawings, loop, and I/O wiring diagrams.

2. Exceptions to the Specifications or Drawings shall be clearly defined in a separate Deviation List. The Deviation List shall consist of a paragraph by paragraph review of the Specifications indicating acceptance or any proposed deviations, the reason for exception, the exact nature of the exception and the proposed substitution so that an evaluation may be made by the Engineer. The acceptability of any device or methodology submitted as an "equal" or "exception" to the specifications shall be at the sole discretion of the Engineer. If no exceptions are taken to the Specifications or Drawings, the PCSI shall make a statement indicating so. If there is no statement included by the PCSI, it shall be interpreted by the Engineer to mean that no exceptions are taken.

3. A Project Schedule shall be prepared and submitted using an ISO/IEC 26300:2006 formatted file. The schedule shall be prepared in Gantt chart format clearly showing task linkages for all tasks and identifying critical path elements. The PCSI’s schedule shall be based on and coordinated with the Contractor’s and ASP’s schedules and must meet all field installation, testing, and startup milestones in those schedules.
Updates to this schedule when approved shall be resubmitted for record before each construction milestone, or every month whichever is greater

4. The PCSI schedule shall illustrate all major project milestones including the following:

a. Schedule for all subsequent project submittals: include in the time allotment, the time required for Contractor submittal preparation, Engineer's review, and a minimum of two complete review cycles.

b. Proposed dates for all required project Coordination Meetings.

c. Hardware purchasing, fabrication, and assembly (following approval of related submittals)

d. Software purchasing and configuration (following approval of related submittals)

e. Shipment of all instrumentation and control system equipment

f. Installation of all instrumentation and control system equipment

g. Duration and dates for all required testing activities. Testing schedule shall include submittal of test procedures a minimum of 30 days prior to commencement of testing. Schedule shall also include submittal of completed documentation of testing activities for review and approval by the Engineer prior to equipment shipment, startup, or subsequent project work.

h. The PCSI shall arrange the schedule to accommodate the requirements of the ASP to develop, test, troubleshoot, and train the Owner's staff on the PLC and HMI application and systems. The timing of these coordination efforts shall be jointly determined by the ASP and PCSI; however, the PCSI shall include all necessary costs to accommodate the minimum time slots in their overall project schedule. All time allotments shall exclude any legal holidays, or days lost due to delays caused by the Contractor or PCSI.

i. Include a schedule for system cutover, startup, and/or placing in service for each major system. At a minimum, include the schedule for each process controller and HMI server/workstation provided under this Contract.

j. Schedule for all training including submittal and approval of O&M manuals, factory training, and field training

1.04 REFERENCE CODES AND STANDARDS

A. Instrumentation equipment, materials and installation shall comply with the National Electrical Code (NEC and with the latest edition of the following codes and standards:

1. National Electrical Safety Code (NESC)
2. Occupational Safety and Health Administration (OSHA)

3. National Fire Protection Association (NFPA)

4. National Electrical Manufacturers Association (NEMA)

5. American National Standards Institute (ANSI)

6. Insulated Cable Engineers Association (ICEA)

7. The International Society of Automation (ISA)

8. Underwriters Laboratories (UL)

9. UL 508, the Standard of Safety for Industrial Control Equipment

10. UL 508A, the Standard of Safety for Industrial Control Panels

11. UL 50, the Standard of Safety for Enclosures for Electrical Equipment.

12. NFPA 79, Electrical Standard for Industrial Machinery

13. Factory Mutual (FM)

14. All equipment and installations shall satisfy applicable Federal, State, and local codes.

B. Where reference is made to one of the above standards, the revision in effect at the time of bid opening shall apply.

C. All material and equipment, for which a UL standard exists, shall bear a UL label. No such material or equipment shall be brought onsite without the UL label affixed.

D. If the issue of priority is due to a conflict or discrepancy between the provisions of the Contract Documents and any referenced standard, or code of any technical society, organization or association, the provisions of the Contract Documents shall take precedence if they are more stringent or presumptively cause a higher level of performance. If there is any conflict or discrepancy between standard specifications, or codes of any technical society, organization or association, or between Laws and Regulations, the higher performance requirement shall be binding on the Contractor, unless otherwise directed by the Owner/Engineer.

E. In accordance with the intent of the Contract Documents, the Contractor accepts the fact that compliance with the priority order specified shall not justify an increase in Contract Price or an extension in Contract Time nor limit in any way, the Contractor's responsibility to comply with all Laws and Regulations at all times.
F. All control panels shall be constructed and the labeling shall be affixed in a UL 508 facility.

1.05 PROCESS CONTROL SYSTEMS INTEGRATOR (PCSI)

A. The Contractor shall provide the services of a Process Control Systems Integrator (PCSI) for all work under the instrumentation sections of this and related Divisions, as described in this section and related sections.

B. Qualifications

1. The PCSI shall be a "systems house," regularly engaged in the design and installation of control and instrumentation systems and their associated subsystems as they apply to the municipal water or wastewater industry. For the purposes of this and other applicable Divisions, a "systems house" shall be interpreted to mean an organization that complies with all of the following criteria:

2. Employs a registered professional Control Systems Engineer or Electrical Engineer in the state of Texas to supervise or perform the work required by this Specification Section.

3. Employs personnel on this project who have successfully completed a manufacturer’s training course on the hardware configuration and implementation of the specific programmable controllers, computers, and software proposed for this project.

4. Has been in the water/wastewater industry performing the type of work specified in this specification section for a minimum of five continuous years.

5. The PCSI shall maintain a fully equipped office/production facility with full-time employees capable of fabricating, configuring, installing, calibrating, troubleshooting, and testing the system specified herein. Qualified repair personnel shall be available and capable of reaching the facility within 24 hours.

6. PCSI shall have an Electrical Contractor's license in the State of Texas.

C. The PCSI shall be one of the following:

1. Prime Controls
   815 Office Park Circle
   Lewisville, Texas 75057
   Attn: Brian Poarch
   Phone: 972.221.4849

2. Richardson Logic Control
   8115 Hicks Hollow
McKinney, Texas 75071
Attn: Michel Cunningham
Phone: 972.542.7375

3. Control Panels USA
2530 Shell Road
Georgetown, TX 78628
Phone: 512.863.3224

4. WHECO Controls
8501 Jacksboro Highway
Fort Worth, TX 76135
Attn: Kent Meyerhoeffer
Phone: 817-244-6660

5. Approved Equal

E. The listing of specific PCSI organizations above does not imply acceptance of their products and capabilities that do not meet the specified ratings, features and functions. PCSI's listed above are not relieved from meeting these specifications in their entirety.

1.06 HAZARDOUS AREAS

A. Equipment, materials and installation in areas designated as hazardous on the Drawings shall comply with NEC Articles 500, 501, 502 and 503.

B. Equipment and materials installed in hazardous areas shall be UL listed for the appropriate hazardous area classification.

1.07 CODES, INSPECTION AND FEES

A. Equipment, materials and installation shall comply with the requirements of the local authority having jurisdiction.

B. Obtain all necessary permits and pay all fees required for permits and inspections.

1.08 SIZE OF EQUIPMENT

A. Investigate each space in the structure through which equipment must pass to reach its final location. Coordinate shipping splits with the manufacturer to permit safe handling and passage through restricted areas in the structure.

B. The equipment shall be kept upright at all times during storage and handling. When equipment must be tilted for passage through restricted areas, brace the equipment to ensure that the tilting does not impair the functional integrity of the equipment.
1.09 RECORD DRAWINGS

A. As the work progresses, legibly record all field changes on a set of Project Contract Drawings, hereinafter called the "Record Drawings". The Record Drawings and Specifications shall be kept up to date throughout the project.

B. Record Drawings shall accurately show the installed condition of the following items:

1. One-line Diagram(s).
2. Raceways and pull boxes.
3. Conductor sizes.
4. Panel Schedule(s).
5. Control Wiring Diagram(s) including all wire tags.
6. Process Instrumentation Diagram(s)
7. Mounting Details

C. Submit the record drawings and the schedule of control wiring raceways and wire numbers (or the point-to-point connection diagram) to the Owner/Engineer.

1.10 EQUIPMENT INTERCONNECTIONS

A. Review shop drawings of equipment furnished under other related Divisions and prepare coordinated wiring interconnection diagrams or wiring tables. Submit copies of wiring diagrams or tables with Record Drawings.

B. Furnish and install all equipment interconnections.

1.11 MATERIALS AND EQUIPMENT

A. Materials and equipment shall be new, except where specifically identified on the Drawings to be re-used.

B. The Contractor shall not bring onsite, material or equipment from a manufacturer, not submitted and approved for this project. Use of any such material or equipment, will be rejected, removed and replaced by the Contractor, with the approved material and equipment, at his own expense.

C. Material and equipment shall be UL listed, where such listing exists.
D. The Contractor shall be responsible for all material, product, equipment and workmanship being furnished by him for the duration of the project. He shall replace the equipment if it does not meet the requirements of the Contract Documents.

1.12 DELIVERY, STORAGE AND HANDLING

A. Equipment shall be handled and stored in accordance with manufacturer's instructions. Two copies of these instructions shall be included with the equipment at time of shipment and shall be made available to the Contractor and Owner.

B. Shipping groups shall be designed to be shipped by truck, rail, or ship. Indoor groups shall be bolted to skids. Accessories shall be packaged and shipped separately.

C. Equipment shall be equipped to be handled by crane. Where cranes are not available, equipment shall be suitable for skidding in place on rollers using jacks to raise and lower the groups.

D. Equipment shall be installed in its permanent, finished location shown on the Drawings within seven calendar days of arriving onsite. If the equipment cannot be installed within seven calendar days, the equipment shall not be delivered to the site, but stored offsite, at the Contractor’s expense, until such time that the site is ready for permanent installation of the equipment.

E. Where space heaters are provided in equipment or control panels, provide temporary electrical power and operate space heaters during jobsite storage and after equipment is installed in permanent location, until equipment is placed in service.

1.13 WARRANTIES

A. Manufacturer’s warranties shall be as specified in each of the Specification Sections.

1.14 EQUIPMENT IDENTIFICATION

A. Identify equipment (control panels, control stations, instruments, etc) furnished under instrumentation sections of Division 13 with the name of the equipment it serves. Control panels, Instruments, meters junction or terminal boxes, etc, shall have nameplate designations as shown on the Drawings.

B. Nameplates shall be engraved, laminated impact acrylic, black lettering on a white background, matte finish, not less than 1/16-in thick by 3/4-in by 2-1/2-in, Rowmark 322402. Nameplates shall be 316 SS screw mounted to all enclosures except for NEMA 4 and 4X. Nameplates for NEMA 4 and 4X enclosures shall be attached with double faced adhesive strips, TESA TUFF TAPE 4970, .009 X ½”, no equal. Prior to installing...
the nameplates, the metal surface shall be thoroughly cleaned, with a 70% alcohol solution, until the metal surface residue has been removed. Epoxy adhesive or foam tape is not acceptable.

PART 2 - PRODUCTS NOT USED

PART 3 - EXECUTION

3.01 INTERPRETATION OF DRAWINGS

A. Raceways and conductors for instrumentation, communications and other miscellaneous low voltage power and signal systems as specified not shown on the Drawings shall be provided as required for a complete and operating system.

B. The PCSI shall terminate all conductors of instrumentation systems to RTU and/or PLC Termination Cabinets, where designated on the Drawings. The conduit and wire, as shown on the electrical interface drawings, may not necessarily be shown on the floor plan.

C. Install conductors carrying low voltage signals (typically twisted shielded pair cables) in raceways totally separate from all other raceways containing power or 120 volt control conductors, Refer to NEC article 725. DC and AC control wiring shall be installed in separate raceways.

D. Redesign of electrical or mechanical work, which is required due to the Contractor's use of a pre-approved alternate instrumentation or control item, or arrangement of equipment and/or layout other than specified herein, shall be done by the Contractor at his/her own expense. Redesign and detailed plans shall be submitted to the Owner/Engineer for approval. No additional compensation will be provided for changes in the work, either his/her own or others, caused by such redesign.

3.02 INSTRUMENTATION EQUIPMENT PADS AND SUPPORTS

A. Equipment pads and supports, of concrete or steel including structural reinforcing and foundations, are shown on the Structural Drawings.

3.03 INSTALLATION

A. Any work not installed according to the Drawings and this Section shall be subject to change as directed by the Owner/Engineer. No extra compensation will be allowed for making these changes.
B. All dimensions shall be field verified at the job site and coordinated with the work of all other trades.

C. Equipment shall be protected at all times against mechanical injury or damage by water. Equipment shall not be stored outdoors. Equipment shall be stored in dry permanent shelters as required by each Specification Section. Do not install equipment in its permanent location until structures are weather-tight. If any apparatus has been subject to possible injury by water, Equipment shall be thoroughly dried out and tested as directed by the Owner/Engineer or shall be replaced at no additional cost at the Owner/Engineer's discretion.

D. Equipment that has been damaged shall be replaced or repaired by the equipment manufacturer, at the Owner/Engineer's discretion.

E. Repaint any damage to the factory applied paint finish using touch-up paint furnished by the equipment manufacturer. If the metallic portion of the panel or section is damaged, the entire panel or section shall be replaced, at no additional cost to the Owner.

3.04 MANUFACTURER'S SERVICE

A. Provide manufacturer's services for testing and start-up of the equipment as listed in each individual Specification Section.

B. Testing and startup shall not be combined with training. Testing and start-up time shall not be used for manufacturers warranty repairs.

C. Check interlocking, control and instrument wiring for each system and/or part of a system to prove that the system will function properly as indicated by schematics, wiring diagrams and Control Descriptions.

D. Testing shall be scheduled and coordinated with the Owner/Engineer at least two weeks in advance. Provide qualified test personnel, instruments and test equipment.

E. Refer to the individual Instrumentation Equipment Sections for additional specific testing requirements.

F. Make adjustments to the systems and instruct the Owner's personnel in the proper operation of the systems.

3.05 TESTING
A. Test systems and equipment furnished under Division 13 Process Control System Sections and repair or replace all defective work. Make adjustments to the systems and instruct the Owner’s personnel in the proper operation of the systems.

B. Make the tests and checks prior to energizing instrumentation equipment the individual Specification sections.

C. Testing shall be scheduled and coordinated with the Owner/Engineer at least two weeks in advance. Provide qualified test personnel, instruments and test equipment, including manufacturer’s services, as specified in the individual Specification sections.

D. Where test reports show unsatisfactory results, the Owner/Engineer will require the removal of all defective or suspected materials, equipment and/or apparatus, and their replacement with new items, all at no cost to the Owner. The Contractor shall bear all cost for any retesting.

3.06 TRAINING

A. The Contractor shall provide training as specified in individual specification sections.

END OF SECTION
SECTION 13310
FLOW INSTRUMENTS

PART 1 - GENERAL

1.01 SCOPE OF WORK

A. Furnish, install and test all flow measurement, flow control devices and appurtenances, as shown on the Drawings, specified in the Related Work Sections and Divisions, and as specified herein.

B. Flow equipment, specified in other Divisions, shall be manufactured in accordance with this Section and submitted as a part of the equipment specified in other Divisions.

1.02 RELATED WORK

A. No references are made to any other section which may contain work related to any other section. The Contract Documents shall be taken as a whole with every section related to every other section as required to meet the requirements specified. The organization of the Contract Documents into specification divisions and sections is for organization of the documents themselves and does not relate to the division of suppliers or labor which the Contractor may choose to employ in the execution of the Contract. Where references are made to other Sections and other Divisions of the Specifications, the Contractor shall provide such information or additional work as may be required in those references and include such information or work as may be specified.

1.03 SUBMITTALS

A. Submit catalog data for all items supplied from this specification Section as applicable. Submittal shall include catalog data, functions, ratings, inputs, outputs, displays, etc., sufficient to confirm that the meter or relay provides every specified requirement. Any options or exceptions shall be clearly indicated.

B. Submittals for equipment specified herein, for other Sections or Divisions, shall be made as a part of equipment submittals furnished under other Sections or Divisions.

C. Installation experience documentation shall be submitted for approval with the Section Equipment Submittal

D. Operation and Maintenance Manuals.
1. Operation and Maintenance manuals shall be constructed in accordance with Division 1 and shall include the following information:

   a. Manufacturer’s contact address and telephone number for parts and service.
   b. Instruction books and/or leaflets
   c. Recommended renewal parts list
   d. Record Documents for the information required by the Submittals above.

1.04 REFERENCE CODES AND STANDARDS

A. The equipment in this specification shall be designed and manufactured according to latest revision of the following standards (unless otherwise noted):

1. ISO 2975/VII liquids and BS 5857-2.4 for gases. Transit Time Meters
5. ASME PTC 19.2 Pressure Measurement
6. ANSI B88.1 Pressure Transducers Calibration
7. ISA S37.6 Strain Gage Transducers Potentiometric
8. Calibration AVS 6.2, 6.4, 6.5 Hazardous Areas
9. IEC 79-10 Intrinsically Safe Circuits
10. ANSI 913 Electrical Instruments in Hazardous Atmospheres

B. All meters, relays and associated equipment shall comply with the requirements of the National Electric Code and Underwriters Laboratories (UL) where applicable.

C. Each specified device shall also conform to the standards and codes listed in the individual device paragraphs.

1.05 QUALITY ASSURANCE
A. The manufacturer of this equipment shall have produced similar instrumentation equipment for a minimum period of five years. When requested by the Owner/Engineer, an acceptable list of installations with similar equipment shall be provided demonstrating compliance with this requirement.

B. Equipment submitted shall fit within the space or location shown on the Drawings. Equipment which does not fit within the space or location is not acceptable.

C. For the equipment specified herein, the manufacturer shall be ISO 9001 2000 certified.

1.06 WARRANTY

A. The Manufacturer shall warrant the equipment to be free from defects in material and workmanship for two years from date of acceptance of the equipment containing the items specified in this Section. Within such period of warranty, the Manufacturer shall promptly furnish all material and labor necessary to return the equipment to new operating condition. Any warranty work requiring shipping or transporting of the equipment shall be performed by the Contractor at no expense to the Owner.

PART 2 - PRODUCTS

2.01 ELECTROMAGNETIC FLOW METER

A. Subject to compliance with the Contract Documents, the following Manufacturers are acceptable:

1. Foxboro
2. Siemens
3. Endress & Hauser
4. Rosemount
5. Approved Equal

B. The listing of specific manufacturers above does not imply acceptance of their products that do not meet the specified ratings, features and functions. Manufacturers listed above are not relieved from meeting these specifications in their entirety.

C. General
1. Provide sufficient lengths of Manufacturer’s specialty cables for installation of power and signal conductors as provided with each instrument.

2. Provide a hand-held programmer, for each transmitter, where full setup is not available for the instrument directly.

D. Type

1. Microprocessor based intelligent type.

E. Function/Performance:

1. Output: 4-20 mA DC. Output shall be linear for pressure applications.

2. Accuracy: 0.5 percent of span (linear output).

3. Stability: Combined temperature effects shall be less than 0.2 percent of maximum span per 50 degrees F temperature change. Effect on accuracy, due to static pressure changes, shall be negligible.

4. RFI Protection: 0.1 percent error between 27 and 500 MHZ at 30 v/m field intensity.

5. Drift: 0.10 percent per six months for 4-20 mA output.

6. Temperature rating: Suitable for process liquid temperature up to 70 degrees C and an ambient of 65 degrees C.

7. Pressure rating: 240 PSI if 150 lb flanges are used; 700 PSI if 300 lb flanges are used.

8. Meter shall be capable of running empty indefinitely without damage to any component.

F. Physical:

1. Metering Tube
   a. Carbon steel with 304 Stainless interiors unless otherwise indicated.
   b. Electrical Classification: Rating shall be FM approved for the location shown on the Drawings
   c. Tube Flanges: Match piping AWWA rating of the pipe. Minimum AWWA 150# Flange.
   d. Tube Liner: Polyurethane or EDPM unless noted otherwise.
e. Tube Electrodes: ANSI 316 stainless steel or Hastelloy C, bullet nosed or elliptical self-cleaning type unless otherwise noted.

f. Tube Housing: Meters in below grade, vaults, basements, etc., shall be designed for accidental submergence in 30 feet of water for 24 hours. Meters above grade shall be of splash proof/drip proof design unless otherwise noted.

g. Painting: All external surfaces shall be painted with a chemical and corrosion resistant epoxy finish.

2. Transmitter

a. Transmitter Enclosure: NEMA 4X.

b. Electrical Classification: Rating shall be FM approved for the location shown on the Drawings

G. Power Requirements

1. As shown on the Drawings.

H. Options/ Accessories

1. Factory calibration: Each meter shall be factory calibrated, with a copy of the Report delivered with the device and in the O&M manual.

2. Grounding: Meter shall be grounded with rings. All materials shall be suitable and not effected by the liquid being measured. Provide 316 Stainless Steel ground rings unless otherwise recommended in writing from the meter manufacture, electrical bonding wires/straps, and gaskets, etc.

3. Provide a hand-held programmer for each transmitter, where full setup is not available from the instrument transmitter display directly.

PART 3 - EXECUTION

3.01 INSTALLER’S QUALIFICATIONS

A. Installer shall be specialized in installing this type of equipment with minimum 5 years documented experience

3.02 EXAMINATION

A. Examine installation area to assure there is enough clearance to install the equipment.
B. Verify that the equipment is ready to install.

C. Verify field measurements are as instructed by the manufacturer.

3.03 INSTALLATION

A. The Contractor shall install all equipment per the manufacturer's recommendations and Contract Drawings.

B. All process connections shall be 316 stainless steel tubing, 3/8" minimum, unless otherwise shown on the Drawings. Fittings shall be of the compression type, 316 stainless steel.

C. All conduit entries into the instruments shall use hubs of watertight, threaded aluminum, insulated throat, stainless steel grounding screw, as manufactured by T&B H150GRA Series, or equal.

D. Install stainless steel instrument labels with instrument ID, secured with safety wire.

E. All non-loop powered instrument transmitters shall have an approved disconnecting means for power mounted within reach of the transmitter.

3.04 RACEWAY SEALING

A. Where raceways enter terminal boxes, junction boxes, or instrumentation equipment, all entrances shall be sealed with 3M 1000NS Watertight Sealant, or approved equal.

3.05 FIELD QUALITY CONTROL

A. Inspect installed equipment for anchoring, alignment, grounding and physical damage.

B. Check tightness of all accessible electrical connections. Minimum acceptable values shall be specified in the manufacturer's instructions.

3.06 FIELD ADJUSTING

A. Adjust all equipment for proper range and field conditions, as described in the manufacturer's instructions.
B. Any field adjustments, required for proper system operation, shall be included in the Final O&M.

3.07 FIELD TESTING

A. Perform all electrical field tests recommended by the manufacturer.

B. Test each interlock system for proper functioning.

C. Test all control logic for proper operation.

3.08 CLEANING

A. Remove all rubbish and debris from inside and around the equipment. Remove dirt, dust, or concrete spatter from the interior and exterior of the equipment using brushes, vacuum cleaner, or clean, lint free rags. Do not use compressed air.

3.09 EQUIPMENT PROTECTION AND RESTORATION

A. Touch-up and restore damaged surfaces to factory finish, as approved by the manufacturer. If the damaged surface cannot be returned to factory specification, the surface shall be replaced.

3.10 MANUFACTURER’S CERTIFICATION

A. A qualified factory-trained and certified representative shall certify in writing that the equipment has been installed, adjusted, including all settings as defined in the Contract Documents.

B. The Contractor shall provide three copies of the representative’s certification.

3.11 TRAINING

A. Provide the representatives, services for training of Owner’s personnel in operation and maintenance of the equipment furnished under this Section.

B. The training for each type of equipment shall be for a period of not less than one eight-hour day.
C. The cost of training program to be conducted with Owner’s personnel shall be included in the Contract Price. The training and instruction, insofar as practicable, shall be directly related to the system being supplied.

D. Provide detailed O&M manuals to supplement the training course. The manuals shall include specific details of equipment supplied and operations specific to the project.

E. The training session shall be conducted by a manufacturer’s qualified representative. Training program shall include instructions on the assembly, motor starters, protective devices, metering, and other major components.

F. The Owner reserves the right to videotape the training sessions for the Owner’s use.

END OF SECTION
SECTION 13312
LEVEL INSTRUMENTS

PART 1 - GENERAL

1.01 SCOPE OF WORK

A. Furnish, install and test all level measurement, level control devices and appurtenances, as shown on the Drawings, specified in the Related Work Sections and Divisions, and as specified herein.

B. Level equipment, specified in other Divisions, shall be manufactured in accordance with this Section, and submitted as a part of the equipment specified in other Divisions.

1.02 RELATED WORK

A. No references are made to any other section which may contain work related to any other section. The Contract Documents shall be taken as a whole with every section related to every other section as required to meet the requirements specified. The organization of the Contract Documents into specification divisions and sections is for organization of the documents themselves and does not relate to the division of suppliers or labor which the Contractor may choose to employ in the execution of the Contract. Where references are made to other Sections and other Divisions of the Specifications, the Contractor shall provide such information or additional work as may be required in those references and include such information or work as may be specified.

1.03 SUBMITTALS

A. Submit catalog data for all items supplied from this specification Section as applicable. Submittal shall include catalog data, functions, ratings, inputs, outputs, displays, etc., sufficient to confirm that the meter or relay provides every specified requirement. Any options or exceptions shall be clearly indicated.

B. Submittals for equipment specified herein, for other Sections or Divisions, shall be made as a part of equipment submittals furnished under other Sections or Divisions.

C. Installation experience documentation shall be submitted for approval with the Section Equipment Submittal

D. Operation and Maintenance Manuals.
1. Operation and Maintenance manuals shall be constructed in accordance with Division 1 and shall include the following information:

   a. Manufacturer’s contact address and telephone number for parts and service.

   b. Instruction books and/or leaflets

   c. Recommended renewal parts list

   d. Record Documents for the information required by the Submittals above.

1.04 REFERENCE CODES AND STANDARDS

A. The equipment in this specification shall be designed and manufactured according to latest revision of the following standards (unless otherwise noted):

1. National Electrical Safety Code (NESC)

2. Occupational Safety and Health Administration (OSHA)

3. National Fire Protection Association (NFPA)

4. National Electrical Manufacturers Association (NEMA)

5. American National Standards Institute (ANSI)

6. Insulated Cable Engineers Association (ICEA)

7. Instrumentation Society of Automation (ISA)

8. Underwriters Laboratories (UL)

9. UL 508, the Standard of Safety for Industrial Control Equipment

10. UL 508A, the Standard of Safety for Industrial Control Panels

11. UL 50, the Standard of Safety for Enclosures for Electrical Equipment.

12. NFPA 79, Electrical Standard for Industrial Machinery

13. Factory Mutual (FM)

14. All equipment and installations shall satisfy applicable Federal, State, and local codes.

1.05 QUALITY ASSURANCE

A. The manufacturer of this equipment shall have produced similar instrumentation equipment for a minimum period of five years. When requested by the Owner/Engineer,
an acceptable list of installations with similar equipment shall be provided demonstrating compliance with this requirement.

B. Equipment submitted shall fit within the space or location shown on the Drawings. Equipment which does not fit within the space or location is not acceptable.

C. For the equipment specified herein, the manufacturer shall be ISO 9001 2000 certified.

1.06 WARRANTY

A. The Manufacturer shall warrant the equipment to be free from defects in material and workmanship for two years from date of acceptance of the equipment containing the items specified in this Section. Within such period of warranty, the Manufacturer shall promptly furnish all material and labor necessary to return the equipment to new operating condition. Any warranty work requiring shipping or transporting of the equipment shall be performed by the Contractor at no expense to the Owner.

PART 2 - PRODUCTS

2.01 ULTRASONIC LEVEL TRANSMITTERS (REMOTE TRANSMITTER)

A. Subject to compliance with the Contract Documents, the following Manufacturers are acceptable:

1. Siemens HydroRanger 200
2. Endress & Hauser
3. Approved Equal

B. The listing of specific manufacturers above does not imply acceptance of their products that do not meet the specified ratings, features and functions. Manufacturers listed above are not relieved from meeting these specifications in their entirety.

C. General

1. Provide sufficient lengths of Manufacturer’s specialty cables for installation of power and signal conductors as provided with each instrument.

D. Type:

1. Separate ultrasonic transducer
2. Dual 4-20ma outputs and 5 Form C outputs

E. Function/Performance

1. Function: Sense and transmit a variable liquid level.

2. Principle: Pulse ultrasonic signals from the transducer toward the liquid and receive an echo, measuring the time between sending and receiving the pulse signal, and proportioning that to the measured liquid depth.

3. Range Capability: 1 feet to 50 feet

4. Beam Angle: 7 degrees

5. Shall have integral temperature compensation unit.

6. Accuracy. Current output 1 percent of selected full-scale range.

8. Repeatability. 0.25 percent full scale.

F. Physical

1. Transmitter housing: shall be NEMA 4X polycarbonate enclosure. Sensor shall be completely encapsulated PVC and submersible with an aluminum outer cover, suitable for Class I Div 1 locations.

G. Power Requirements: Input Power: 100VAC-230VAC

H. Options/Accessories

1. Provide span and zero adjustment at each transmitter.

2. Provide local indication at each transmitter, either analog gauge or LCD readout. Scale shall be in engineering units.

3. Provide an integral indicator scaled in engineering units.

4. Provide hand held programmer(s) where full setup is not available for the instrument

2.02 FLOAT TYPE LEVEL SWITCHES

A. Subject to compliance with the Contract Documents, the following Manufacturers are acceptable:

1. Contegra FS-90
2. Flygt Model ENM-10.
3. Endress+Hauser FTS20
4. Approved Equal

B. The listing of specific manufacturers above does not imply acceptance of their products that do not meet the specified ratings, features and functions. Manufacturers listed above are not relieved from meeting these specifications in their entirety.

C. General

1. Provide sufficient lengths of Manufacturer’s specialty cables for installation of power and signal conductors as provided with each instrument.

D. Type:

1. The switch assembly shall be weighted and suspended on its own cable.

E. Function/Performance:

1. Temperature Rating: 0-50 degrees C.
2. Contact Rating: Up to 150V AC/DC and 1 amps AC, 1 amps DC.
3. Contact Arrangement: Form C contact which is field selectable normally open or closed.

F. Physical:

1. Contact: Sealed mercury free switch housed in a chemical-resistant polypropylene or Stainless-Steel casing.
2. Switch shall have a rating for the area in which it is installed.
3. Flexible Support Cable: Synthetic four wire cable, minimum 19 AWG wire.
4. Specific Gravity: Match to fluid being measured.

G. Power Requirements: None

H. Required Options/Accessories
1. Provide flexible support cable of sufficient length to ensure no splice or connection is required in the wet well.
2. Provide junction box rated for the area in which it is installed.
3. Provide stainless steel supports/mounting accessories as required.

I. Installation

1. Provide All Hardware from the manufacture for the installation as described and shown on the plans.
2. Provide stainless steel wire ties for all cables within the wet well area or exposed to outdoor environments.

PART 3 - EXECUTION

3.01 INSTALLER’S QUALIFICATIONS

A. Installer shall be specialized in installing this type of equipment with minimum 5 years documented experience

3.02 EXAMINATION

A. Examine installation area to assure there is enough clearance to install the equipment.
B. Verify that the equipment is ready to install.
C. Verify field measurements are as instructed by the manufacturer.

3.03 INSTALLATION

A. The Contractor shall install all equipment per the manufacturer's recommendations and Contract Drawings.
B. All process connections shall be 316 stainless steel tubing, 3/8” minimum, unless otherwise shown on the Drawings. Fittings shall be of the compression type, 316 stainless steel.
C. All conduit entries into the instruments shall use hubs of watertight, threaded aluminum, insulated throat, stainless steel grounding screw, as manufactured by T&B H150GRA Series, or equal.
D. Install stainless steel instrument labels with instrument ID, secured with safety wire.

E. All non-loop powered instrument transmitters shall have an approved disconnecting means for power mounted within reach of the transmitter.

3.04 RACEWAY SEALING

A. Where raceways enter terminal boxes, junction boxes, or instrumentation equipment, all entrances shall be sealed with 3M 1000NS Watertight Sealant or approved equal.

3.05 FIELD QUALITY CONTROL

A. Inspect installed equipment for anchoring, alignment, grounding and physical damage.

B. Check tightness of all accessible electrical connections. Minimum acceptable values shall be specified in the manufacturer's instructions.

3.06 FIELD ADJUSTING

A. Adjust all equipment for proper range and field conditions, as described in the manufacturer's instructions.

B. Any field adjustments, required for proper system operation, shall be included in the Final O&M.

3.07 FIELD TESTING

A. Perform all electrical field tests recommended by the manufacturer.

B. Test each interlock system for proper functioning.

D. Test all control logic for proper operation.

3.08 CLEANING

A. Remove all rubbish and debris from inside and around the equipment. Remove dirt, dust, or concrete spatter from the interior and exterior of the equipment using brushes, vacuum cleaner, or clean, lint free rags. Do not use compressed air.

3.09 EQUIPMENT PROTECTION AND RESTORATION
A. Touch-up and restore damaged surfaces to factory finish, as approved by the manufacturer. If the damaged surface cannot be returned to factory specification, the surface shall be replaced.

3.10 MANUFACTURER'S CERTIFICATION

A. A qualified factory-trained and certified representative shall certify in writing that the equipment has been installed, adjusted, including all settings as defined in the Contract Documents.

B. The Contractor shall provide three copies of the representative’s certification.

3.11 TRAINING

A. Provide the representatives, services for training of Owner’s personnel in operation and maintenance of the equipment furnished under this Section.

B. The training for each type of equipment shall be for a period of not less than one eight-hour day.

C. The cost of training program to be conducted with Owner's personnel shall be included in the Contract Price. The training and instruction, insofar as practicable, shall be directly related to the system being supplied.

D. Provide detailed O&M manuals to supplement the training course. The manuals shall include specific details of equipment supplied and operations specific to the project.

E. The training session shall be conducted by a manufacturer's qualified representative. Training program shall include instructions on the assembly, motor starters, protective devices, metering, and other major components.

F. The owner reserves the right to videotape the training sessions for the Owner’s use.

END OF SECTION
SECTION 13441
PUMP CONTROL SYSTEM

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Furnish programmable controllers, control switches, relays, transformers, alarm panels, terminal blocks, power supplies, air cells, and accessories, necessary to control pumping systems.

1.02 MEASUREMENT AND PAYMENT

A. No separate payment will be made for work required under this Section. Contractor will include all costs of the requirements of this Section in the appropriate bid item(s) on the Bid Form.

1.03 REFERENCES

A. National Electrical Manufacturers Association (NEMA).
   1. NEMA ICS 1 - General Standards for Industrial Control and Systems.
   2. NEMA ICS 2 - Standards for Industrial Control Devices, Controllers and Assemblies.
   3. NEMA ICS 3 - Industrial Systems.
   4. NEMA ICS 6 - Enclosures for Industrial Controls and Systems.
   5. NEMA ST 1 - Standard for Specialty Transformers (Except General Purpose Type).

B. Instrument Society of America (ISA).

C. Underwriters Laboratories, Inc. (UL).

D. Factory Mutual (FM).

E. Institute of Electrical and Electronic Engineers (IEEE).


G. Joint Industrial Council (JIC).


1.04 SUBMITTALS

A. Submit product data, shop drawings and samples, (if samples are requested by the Engineer).
1. Submit in complete packages grouped to permit review of related items as outlined in these specifications.

2. Bind submittals in three-ring binders with complete indexing and tab dividers. Completely tag and label equipment information to correspond with Drawings.

3. Review of submittals will be for conformance to Contract Documents and for application to specified functions.

B. Product Data: Submit descriptive product literature including manufacturer's specifications for each component specified.

C. Shop Drawings: Indicate layout and mounting of completed assemblies and systems, interconnecting piping and cabling, dimensions, weights, external power and communications connections.

1. Panel, Console, and Cabinet Information
   a. Layout drawings, including the following:
      1) Front, rear, end, and plan views to scale.
      2) Dimensional information.
      3) Tag numbers and functional names of components mounted in and on panels, consoles, or cabinets.
      4) Product information on panel components.
      5) Nameplate locations and legends, including text, letter sizes and colors to be used.
      6) Location of anchoring connections and holes.
      7) Location of external wiring and piping connections.
      8) Mounting and installation details.
      9) Proposed layouts and sizes of graphic display panels.

   b. Wiring and piping diagrams, including the following:
      1) Name of panel, console or cabinet.
      2) Wiring sizes and types.
      3) Piping and tubing sizes and types.
      4) Terminal strip numbers.
      5) Color coding for each wire and color-coding legend.
      6) Functional name and manufacturer's designation of components to which wiring and piping are connected.

   c. Electrical control schematics in accordance with JIC standards.
   d. Plan showing equipment layout in each area.

2. Field Wiring and Piping/Tubing Diagrams
   a. Wiring and piping/tubing sizes and types.
   b. Terminal strip, device terminal and wire numbers.
   c. Color coding.
d. Designation of conduits in which wiring is to be located.

e. Location, functional name and manufacturer's designation of items to which wiring or piping are connected.

f. Point-to-point wiring diagrams identifying every termination point and connection.

3. Instrumentation Diagrams

a. Prepare instrument loop diagrams for analog and digital displays, and control and I/O loop diagrams, using ISA standard symbols in accordance with ISA Standard S5.4. Drawing shall include the following:
   1) Instrument tag numbers.
   2) Functional name, manufacturer's name, product name and model or catalog number of each item.
   3) Location of each item.

b. Submit loop diagrams, wiring diagrams, and control schematics on USB thumb drive, formatted as AutoCAD.DWG files using the latest release of AutoCAD current and available on bid date, or any subsequent version. Identify diagrams, schematics and other files with computer-printed labels affixed to each thumb drive.

c. In addition, submit such diagrams and schematics laser-printed on 8.5-inch x 11-inch paper. Use lettering and numerals of at least 1/16-inch nominal height.

4. Programmable Controller Wiring Diagrams

a. Include the following information:
   1) Rack numbers, module types and slot numbers, module terminal point numbers, and location and identification of intermediate panel and field terminal block and strip numbers to which I/O wiring and power supply circuit numbers and ratings.
   2) Wiring sizes, types, wire numbers and color-coding.
   3) Designation of conduits in which field I/O wiring is to be run.
   4) Locations, functional names, tag numbers and manufacturer’s names and model numbers of panel and field devices and instruments to which I/O wiring is connected. Label wiring and cables at both ends and within junction and terminal boxes. Use sleeve-type plastic wire markers covered with clear heat-shrink labels, or machine-printed permanent ink heat-shrink labels by Brady or approved equal.

b. For each drawing, submit one reproducible hardcopy and one copy on USB thumb drive, formatted as AutoCAD files using the latest release of AutoCAD current and available on bid date, or any subsequent version. Identify diagrams, schematics and other files with computer-printed labels affixed to each diskette.
c. In addition, submit such diagrams and schematics laser-printed on 8.5-inch x 11-inch paper. Use lettering and numerals of at least 1/16-inch nominal height.

5. System Programming Information

a. At least six weeks prior to operational testing in site, substantial completion, submit detailed programming information consisting of ladder logic and proposed program code, complete input, output, relay, register and controller identification labels, memory allocation table, and written description of program operation.

b. Ladder logic diagrams shall contain a written descriptive note for each line of program code describing the function and logic of that line.

c. Submit documents in hard copy and as computer-readable files on USB thumb drives.

D. Quality Control Submittals

1. Factory Test Reports: If specified, submit 6 copies.

2. Testing Procedures: Submit testing procedures proposed to verify operations of the system logic. Test and verify system with external devices required to simulate field connections connected simultaneously for a full system test. Reconnecting external devices to verify portions of the systems at a time is not acceptable.

3. Certificates: Submit manufacturers’ certificates that equipment and systems meet or exceed specified requirements.

4. Instructions: Submit manufacturer’s installation instructions for each component specified.

5. Field Reports: Submit 6 copies of manufacturer’s installation inspection, field calibration and field-testing reports.

E. Operation and Maintenance (O&M) Data.

1. Information and drawings submitted must reflect the final installed condition. Revise documents requiring updates following testing and start-up.

2. Provide the following information:

a. Name, address and telephone number of the control system supplier’s local service representative.

b. Complete list of supplied system hardware parts with full model numbers referred to system part designations, including spare parts and test equipment provided.

c. Copy of approved submittal information and system shop drawings as specified in Paragraph 1.03, Submittals, with corrections made to reflect actual system as tested, delivered and installed at the site. Provide half-size blackline reproductions of all shop drawings larger than 11 inches x 17 inches.
d. Original copies of manufacturer’s hardware, installation, assembly, and operations manuals for control system components.
e. Control system description and system operation sequence instructions.
f. In separate binders, submit control and loop diagrams, electrical drawings, system description, operation instructions, and files on USB thumb drives.

F. Project Record Documents

1. Revise system shop drawings and other submittals to reflect system as installed. Accurately record locations of controller cabinets and input and output devices connected to system. Include interconnection wiring and cabling information and terminal block layouts in a suitable drawing pocket installed inside the controller cabinet door.
2. Insert half-size blackline prints of wiring diagrams applicable to each control panel in a clear plastic envelope and store in a suitable print pocket or holder inside each control panel.

1.05 QUALITY ASSURANCE

A. Manufacturer's Qualifications. Manufacturer shall be a company specializing in manufacturing products specified in this Section, having proven compatibility with the Owner's existing facilities and at least 3 years of documented experience. The company shall maintain service facilities within 100 miles of the Owner.

1.06 DELIVERY, STORAGE AND HANDLING

A. Deliver products to site in factory-sealed containers.
B. Check for damage upon receiving products on site.
C. Store products in a clean, dry area; maintain temperature in accordance with NEMA ICS-1.

1.07 ENVIRONMENTAL REQUIREMENTS

A. Maintain temperature above 32 degrees F and below 104 degrees F during and after installation of products.
B. Maintain area free of dirt and dust during and after installation of products.
C. Provide temporary heating and air conditioning units and equipment required to maintain environmental conditions specified for control and MCC panels.

1.08 MAINTENANCE SERVICE

A. Provide manufacturer's maintenance services for hardware products for one year from Date of Substantial Completion without additional cost to the Owner.
1.09 SYSTEM OPERATING REQUIREMENTS

A. The pump control system shall provide an air cell for detecting the liquid level in a wet well, sump, or basin. The liquid level shall determine the operating parameters of the pumps. At a minimum, the system shall detect the following:

1. An Extreme Low-Level condition which turns all pumps off and sends an alarm signal;
2. A Low-Level condition that turns all pumps off;
3. Intermediate Level conditions that turn pumps on and off according to the operating parameters that are set by the Operator;
4. A High-Level condition that turns all pumps on;
5. An Extreme High-Level condition that turns all pumps on and sends an alarm signal.

B. Pump Operating parameters and level settings are shown on the Drawings. The system shall meet these operating conditions and shall provide for addition of future pumps and changes in operating parameters. At a minimum, the pump control system shall provide capabilities for controlling two (2) additional pumps without adding additional control circuits or control components. The system shall permit the setting pump operating parameters in increments of three (3) inches of liquid level.

PART 2 - PRODUCTS

2.01 CONTROL SWITCHES AND INDICATOR LIGHTS

A. Manufacturers

2. Cutler Hammer.
3. Eagle Signal Company.
5. Square D Company.

B. Control Switches

1. Contacts: NEMA ICS 2; at least two Form C contact sets.
2. Contact Ratings: NEMA ICS 120 VAC, 10 ampere inductive.
3. Selector Switch Operators: NEMA ICS 2; heavy-duty oil-tight NEMA 4 multi-position rotary selector switch.
4. Push-button Operator: NEMA ICS 2; heavy-duty oil tight NEMA 4 unguarded and lockable type; black for start, red for stop.

C. Indicator Lights: Red for run, amber or yellow for alarm, green for control mode.

1. Indoor: LED, oil-tight, 120 VAC, 100,000-hour rated life expectancy.
2. Outdoor: Incandescent, oil-tight, rated voltage approximately 125 percent of nominal operating voltage.

2.02 CONTROL RELAYS
A. Contacts: NEMA ICS 2; three Form C contact sets.
B. Rating: NEMA ICS 2; 120 VAC, 10 ampere inductive.
C. Coil Voltage: 120 VAC, 60 Hz.
D. Socket: Turck S3B with coding system, label and label holder (11 pin).
E. Features: 11-pin socket relay base, external color-coded test button, mechanical and electrical status indications, impact-resistant thermoplastic case.
F. Manufacturer: Turck, Inc., or approved equal.

2.03 TIME DELAY RELAYS
A. Contacts: NEMA ICS 2; three Form C contact sets.
B. Contact Ratings: NEMA ICS 2; DPDT Class; 120 VAC 10 ampere inductive.
C. Coil Voltage: 120 VAC, 60 Hz.
D. Socket: Turck S3B with coding system, label and label holder (11-pin).
E. Description: Control relay as specified above in Paragraph 2.02, with added Time Cube Module as manufactured by Turck, Inc.; series CT3, with on or off delay, as indicated.
F. Features: DIP switch-selectable timing ranges of 0.2 to 3 seconds, 0.8 to 12 seconds, 0.1 to 1.5 minutes and 0.8 to 12 minutes; externally adjustable graduated time dial; solid-state digital timing system.

2.04 CONTROL POWER TRANSFORMERS
A. Transformer: NEMA ST 1 machine tool transformer with isolated secondary winding.
B. Power Rating: 250 VA or 200 percent power requirement, whichever is greater.

2.05 PHASE/VOLTAGE MONITOR RELAY
A. Manufacturer, Product: Diversified Electronics Inc.; Model SLM Series.
B. Description: All three phases monitored individually for preselected under and over voltage limit phase loss, phase unbalance, phase reversal, frequency shift
and phase shift. Automatic reset after adjustable release delay when line conditions return to normal.

C. Indicators: LED indicators for under and over voltage limit.

D. Output Rating: DPDT, 3 amps resistive at 600 VAC.

E. Phase Sequence: ABC.

F. Sampling Time: 2 seconds.

G. Spare Unit: In addition to the unit installed, furnish one spare phase/voltage monitor relay.

2.06 TERMINAL BLOCKS

A. Manufacturers:
   1. Bussmann.
   2. Entrelec, Inc.
   4. Phoenix Contact.
   5. Weidmuller.

B. Terminal Blocks: Provide isolated fused snap-on type terminal blocks.

C. Power Terminals: Unit construction type with closed back and tubular pressure screw connectors rated 600 volts.

D. Signal and Control Terminals: Modular construction type suitable for channel mounting with tubular pressure screw connectors; 300-volt rating.

E. Provide color-coded (green/yellow) ground bus terminal block, with each connector bonded to enclosure.

2.07 LEVEL RECORDER (If called for on Drawings)

A. Manufacturer: Foxboro Model 40, or equal.

B. Description: Large case circular pneumatic 7-day pen recorder with one-year supply of charts in 0 to 25 foot range or sized to match wet well depth if deeper than 30 feet.

2.08 PROGRAMMABLE CONTROLLER

A. Modicon “Micro 612-00” with relay output option and memory battery back-up, or approved equal.

B. Description: Programmable controller manufactured to meet NEMA ICS 3, with component circuit boards manufactured to meet NEMA ICS 2.
C. Service Conditions:
   1. Temperature: 32 to 140 degrees F.
   2. Humidity: 95 percent.
   3. Altitude: Less than 200 feet above seal level (USGS Benchmark).

D. Configuration:
   1. Processor Unit: Brick type unit with built-in I/Os, flash RAM memory and communication ports.
   2. Mounting Rack: Provide DIN EN 50 022 rail to mount PLC and necessary expansion bus.

E. Ratings:
   1. Input/Output Capacity: Expandable to 256 I/O points in any mix.
   2. Scan Rate: 2.5 milliseconds per Kword.

F. Programming Instruction Set:
   1. Language Characteristics: Ladder logic function blocks.
   2. Logic Operations: AND, OR, XOR, NOT.
   4. Bit operations: Bit modify, bit sense, bit rotate, and sequencer/drum control.
   5. Arithmetic: Double precision math (add, subtract, multiply, divide), floating point math (add, subtract, multiply, divide, square root, compare), and trigonometric (sin, cos, tan, deg-rad, and rad-deg).
   7. Programming instructions: Relay for normally open (NO), normally closed (NC) and transitional; timer (1.0, 0.1, 0.001 seconds); counter (up, down); skip; constant sweep/single sweep; interrupt.
   8. Data Transfer: Register to table, table to register, search, status, block move, first-in, first-out, table to block, and block to table.
   9. Subroutines: Instruction set capable of executing time interrupt routines.

G. Processor Unit:
   1. Memory Size: 2 Kword user logic.
   2. Storage Registers: 1820-word data.
   3. Internal Relay Equivalents: 256, retentive.
   4. Ports: Two built-in MODBUS ports and one expansion network port.

H. Input/Output Units:
   1. Spare Input/Output Capacity: At least 25 percent spare capacity of each I/O type installed.
3. Analog Input Characteristics: Built-in; 4 channels, 4 to 20 milliamperes DC.
4. Discrete/Digital Output Characteristics: Built-in; 2 channels, 4 to 20 milliamperes DC.
5. Analog Output Characteristics: Built-in; 2 channels, 4 to 20 milliamperes DC.
6. Communications Interface: Built-in; two MODBUS communication ports, independently switch-selectable from MODBUS RTU and MODBUS ASCII modes.

I. Power Supply:
1. Input voltage: 120 volt, 60 Hz single phase.
2. Output voltage: 24 VDC plus or minus 4 percent, 5 amps, less than 200 mV ripple peak to peak.
3. Rating: Minimum 200 VA or 200 percent power requirement (whichever is greater) capacity, with the demonstrated ability to drive all analog loops, all digital outputs and the central processor simultaneously without exceeding 60 percent of rated capacity.
4. Temperature: Minus 4 degrees F to 140 degrees F.

J. Programming, Software and Programming Equipment:
1. Configure system and program operation as specified in this Section. For controller programming and documentation, use Modicon “MODSOFT” software, in the latest edition.
2. Contractor shall provide necessary programming modifications and enter the required variable parameters to provide a complete functional and integrated system. The system shall be fully tested to be operational prior to substantial completion.
3. Provide a Handheld Programmer Model 520-VPU-19200 (the latest version at the time of delivery), as manufactured by AEG, including necessary cables and connectors, to program the controller via programmer.

K. Connect controller inputs/outputs, including analog inputs, through snap-on isolated fused terminal blocks.

L. Separate AC and control signals from DC and loop signals by at least 6 inches. Provide a barrier.
2.09 ACCESSORIES


B. Manufacturers:
   1. Anixter Bros., Inc.
   2. Delaware Industries, Inc.
   3. Panduit Corp.

2.10 AIR CELL SYSTEM

A. Air Cells: Fabricate and install each air cell assembly (2 required) as shown on the plans.

B. Air Supply: Each air cell shall be provided with a continuous source of air from an industrial grade air compressor. The air compressor shall be continuous running, oil less, diaphragm type and shall deliver between 0.5 and 1.0 SCFH at 9 psig. A fixed orifice shall be installed in line with the air compressor outlet to insure ripple-free air flow. A spare, back-up air compressor shall be provided that upon failure of the primary air compressor will automatically engage to maintain uninterrupted air flow and record an alarm event.

C. System Test: The liquid level indicator controller shall be equipped with manual testing capability and shall consist of a two position (normal test/blowdown) manually operated valve and test port. The test position shall seal off and prevent liquid from rising in the submersed bubble tube and shall divert bubbler air output to the test port, relieving air pressure on the indicator/controller.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install in accordance with manufacturer's instructions and Drawings. Provide enough clearance for calibration and maintenance access.

B. Do not install products until major construction is complete and building interior is enclosed and heated.

C. Connect input and output devices as shown on Drawings.

3.02 MANUFACTURER'S FIELD SERVICES

A. Prepare and start systems.

3.03 DEMONSTRATION

A. Demonstrate operation of control system. Provide 2 sessions of 1 hour of instruction each for 2 persons, to be conducted at project site with manufacturer's representative.
B. System demonstration shall include complete verification of field wiring and control system.

END OF SECTION
SECTION 13621
MAGNETIC FLOWMETER SYSTEMS

PART 1 - GENERAL

1.01 Scope
   A. Work under this section includes the furnishing and installation of magnetic
      flowmeter systems as specified, together with start-up services and training of
      plant personnel in the operation and maintenance of the equipment. Magnetic
      flowmeter systems shall be the standard product of the manufacturer and
      furnished by a single supplier.

1.02 MEASUREMENT AND PAYMENT
   A. No separate payment will be made for work required under this Section.
      Contractor will include all costs of the requirements of this Section in the
      appropriate bid item(s) on the Bid Form.

1.03 DOCUMENTATION
   A. Equipment or system documentation shall be provided for this equipment,
      including copies of manufacture’s operation and maintenance manuals covering
      the equipment in this specification.

1.04 OPERATING PRINCIPLE
   A. The magnetic flowmeters shall operate on the principle of a power generator, a
      pulsed dc voltage being induced when a conductive fluid cuts across lines of
      force in a magnetic field. The meter shall produce an output signal directly
      proportional to the rate of fluid flow.

PART 2 - PRODUCTS

2.01 FLOWTUBE
   A. The magnetic flowmeters shall be constructed so that no part of the meter will
      obstruct flow or be inserted into the flow path.
   
   B. The flowtube shall be designed to fit line sizes as shown on the Construction
      Drawings. The metering tube shall be constructed of 304 Stainless Steel with
      150 pound raised face carbon steel ANSI flanged end connections. Face-to-
      Face Dimensions Conform to ISO/DIS 13359.
   
   C. The insulating interior liner for all meters shall be of Perfluoroalkoxy (pfa),
      Polytetrafluoroethylene (ptfe), or other fluorine properly selected for the specified
      application. Liner may be reinforced with stainless steel mesh dovetailed to
      flange.
D. The flowtube shall be provided with 316L or Hasteloy C stainless steel conical electrodes.

E. Meters shall be provided with grounding rings of 316 stainless steel not less than 0.10-inch thickness.

F. Power and signal wiring connections to the flowmeter shall conform to the field wiring standards included in this specification and shall be completely moisture and watertight.

G. Power requirements: Supplied by transmitter.

H. Operating temperature range shall be from –20 to +60 deg. C.

I. The flowmeter and attached appurtenances shall be constructed to withstand accidental submergence (under water up to 30 Ft. for 24 hours) and shall be supplied with a kit for sealing the cable connections.

2.02 MAGNETIC FLOW TRANSMITTER

A. The magnetic flow transmitter shall be microprocessor-based electronics with the following features:

1. Dual compartment Enclosure Options
2. Unidirectional or Bi-directional Flow
3. Contact Inputs with Programmable Functionality for Remote Operation
4. Relay Outputs with Programmable Functionality for Alarms
5. 3-Line, 25-Character, Backlighted LCD Display designed for outdoor use and with suitable protection from sunlight to prevent fading of display
6. Pulse Output Programmable as Scaled or Frequency Pulse
7. Analog Output Programmable for Unidirectional, Bi-directional, or Multiple Input Range
8. Configurable Using, I/A Series System Workstation, HHT, PC10, or Optional Local Keypad
9. 100 to 260 V ac or 18 to 32 V dc Input Power
10. Software Configuration and Totals are Protected in Non-Volatile Memory in the Event of Power Loss

B. A keypad/display shall be provided consist of a minimum of 32 backlit alphanumeric characters. The display characters shall be a minimum ¼-inch high and shall be capable of indicating positive total, negative total, net total, net inventory total, and rate in conventional flow units. A “+” or “-” indicator shows flow direction. A minimum of eight digits shall be available to display positive total, negative total, and net total and a minimum of ten digits shall be available for net inventory total, and six digits are available to display rate. The Keypad/Display shall provide complete operation and maintenance capabilities.

1. Protection shall be provided for the display and keypad to prevent inadvertent activation of the buttons by the wash down stream
C. The transmitter shall have automatic restart in case of microprocessor lockup, and shall self-test during both power up and periodically during normal operation.

D. The transmitter shall have a built in system calibrator and loop checker plus have the capability of remote configuration using a hand held terminal. The hand held terminal shall be optional and not be required for transmitter configuration.

E. Output damping shall be filed-programmable from 0.2 to 99.9 seconds. A low flow cut-off circuit shall be provided to stop the pulse output and rate indicator when the measurement signal falls below 0.1% Ft./Sec.

F. The transmitter shall be suited for either pipe or surface mounting with a mounting kit provided for the particular configuration specified on the drawings. The transmitter housing shall be weatherproof as defined by IEC IP65, and provides the watertight protection of NEMA Type 4.

G. The transmitter shall have a fuse protected current output (4-20 madc) into 0-500 ohms minimum.

H. Pulse output shall be available, scaled proportional to flow, (0.1 to 10) pps at 100% of flow.

I. Twenty-five (25) feet of interconnecting cable shall be supplied with each transmitter.

2.03 PERFORMANCE SPECIFICATIONS

A. Accuracy

1. Pulse output: +/- 0.25% of flow rate.
2. Current output: Same as pulse output +/- 0.03%.

2.04 MODEL CODE

A. Magnetic flowmeter systems shall be a Krohne Series IFS 4000 with IFC-090, or Pre-Approved equal. As a basis for comparison of equal product, unit as delivered shall have the capability or fully employing full quantity and quality of basic functions and routines as available in published literature, whether or not actually employed in a present phase of operation.
PART 3 - EXECUTION

A. Install all equipment in accordance with system Supplier’s printed instructions and other applicable items.

B. Supplier shall provide training to operator in use of the flow meter, including instruction in programming, adjustment, and operation for this installation.

END OF SECTION
PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Basic mechanical requirements specifically applicable to all Divisions and Sections.

1.02 MEASUREMENT AND PAYMENT

A. No Separate Payment will be made for work required under this Section. Contractor shall include all costs of the requirements of this Section in the appropriate bid item(s) on the Bid Form.

1.03 REFERENCES

C. ASHRAE: American Society of Heating Refrigeration and Air Conditioning Engineers.
D. ASME: American Society for Mechanical Engineers.
G. MSS: Manufacturer's Standardization Society of the Valve and Fitting Industry.
K. UL: Underwriters' Laboratories, Inc.

1.04 SUBMITTALS

A. Submittals as specified in individual sections.

B. Submit shop drawings and product data grouped to include complete submittals of related systems, products, and accessories in a single submittal.

C. Mark dimensions and values in units to match those specified.
1.05 REGULATORY REQUIREMENTS
A. Conform to applicable Local Building Code.
C. Plumbing: Conform to National Plumbing Code.
D. Obtain permits, and request inspections from authority having jurisdiction on of this Project.

1.06 PROJECT/SITE CONDITIONS
A. Install Work in locations shown on Drawings, unless prevented by Project conditions.
B. Prepare drawings showing proposed rearrangement of Work to meet Project conditions, including changes to Work specified in other Sections. Obtain permission of Engineer before proceeding.

1.07 PIPE INSULATION - WATER SERVICE
A. Furnish and install insulation system for water piping, chemical piping, and instrument tubing containing water, and piping subject to condensation. Piping and tubing less than 4 inches in diameter to be insulated when exposed to outside temperatures. Exterior insulation piping shall be protected with weather jacket.
B. All insulation system components to be asbestos free.
C. Pipe insulation: Molded heavy density one-piece insulation made from inorganic glass fibers bonded with a thermo-setting resin. Insulation shall be Owens Corning Fiberglass, Knauf Fiber Glass, Certainteed or equal. Insulation to include an all-service jacket (ASJ) with vapor barrier, a self-sealing lap (SSL) for longitudinal joint, and similar factory-furnished butt joint sealing strip. Minimum insulation thickness to be 1 inch for pipes 2 inches and smaller, and 2 inches for lines 2 1/2 inches and larger.
D. Weather Jacket: All exterior insulation to be protected by minimum 0.016-inch-thick aluminum jacket with laminated vapor barrier of polyethylene-surlyn or polyethylene-Kraft paper thermally bonded to the inside surface. Valve fittings and flanges shall have jacketing and moisture barrier protection. Weather jacket shall be by Premeteco, Childers Product Co., or equal.
E. Sealant: Non-shrink, permanently flexible, vapor barrier sealant: Childers CP-70 or equal.
F. Strapping: Stainless steel bands, minimum 0.020-inch-thick by 3/4 inches wide with 0.034-inch-thick wing seals.
PART 2 - PRODUCTS - Not Used

PART 3 - EXECUTION - Not Used

END OF SECTION
PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Retrained joint Polyvinyl chloride pipe (PVC) for pressure-rated potable water delivery and sewer piping systems.

1.02 Materials

A. Pipe shall be made from un-plasticized PVC compound having a minimum cell classification of 12454, as defined in ASTM D 1784. The compound shall qualify for a Hydrostatic Design Basis (HDB) of 4,000 psi for water at 73.4°F in accordance with the requirements of ASTM D 2837.

<table>
<thead>
<tr>
<th>Pipe Description</th>
<th>Nominal Diameter (in)</th>
<th>DR</th>
<th>Color</th>
<th>Pressure Class (psi)</th>
<th>Required Inner Diameter (in)</th>
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<td>18</td>
<td>Green</td>
<td>235</td>
<td></td>
</tr>
<tr>
<td>Gravity Main</td>
<td>18</td>
<td>18</td>
<td>Green</td>
<td>235</td>
<td></td>
</tr>
</tbody>
</table>

B. Couplings to be filament wound glass/epoxy, with exterior surface area (excluding the ends) to be coated with Carbit Series 12 clear polyurethane coating.

1.03 REFERENCES


D. AWWA C 900 – 07 – Polyvinyl Chloride (PVC) Pressure Pipe and Fabricated Fittings, 4 Inches through 16 Inches

E. AWWA C 900 -16 - Standard for Polyvinyl Chloride (PVC) Pressure Pipe, 4 Inches Through 60 Inches for Water Distribution.


1.04 SUBMITTALS
A. Submit shop drawings showing design of new pipe and fittings indicating alignment and grade, laying dimensions, fabrication, fittings, flanges, and special details.
B. Contractor to review and submit PVC pipe manufacturers recommended installation procedures.
C. Calculations and limits of thrust restraint shall be based on AWWA M23, latest edition.

1.05 QUALITY CONTROL
A. Pipe and couplings shall be homogeneous throughout and free from voids, cracks, inclusions, and other defects, and shall be as uniform as commercially practicable in color, density, and other physical characteristics.
B. Every pipe shall pass the AWWA C900 hydrostatic integrity test requirement of two times the pressure class for five seconds.

PART 2 - PRODUCTS
2.01 MATERIAL
A. PVC Pipe:
   1. Pipe Material:
      a. DR 18: For restrained joints where shown on Drawings.
      b. DR 14: For alternate to offset pipe sections shown on Drawings. Do not use PVC for offset sections with depth of cover greater than 20 feet or less than 4 feet.
      c. Do not use PVC in potentially petroleum contaminated areas.
      d. Furnish pipe in standard laying lengths of 20 and 40 feet.
      e. Do not use PVC in areas exposed to direct sunlight.
   B. Joints:
      1. Pipe shall be joined using composite couplings to form an integral system for maximum reliability and interchangeability. High-strength, flexible thermoplastic splines shall be inserted into mating, precision machined grooves in the pipe, and coupling to provide continuous restraint with evenly distributed loading.
      2. Couplings shall be designed for use at or above the pressure class of the pipe with which they are utilized and shall incorporate twin elastomeric sealing gaskets meeting the requirements of ASTM F 477.
      3. Joints shall be designed to meet the zero leakage test requirements of ASTM D 3139 and they shall be bi-directionally restrained.
4. Joint shall not contain any metal components. Pipe shall be joined using non-metallic integral bell restrained joints to form an integral system.

C. Marking:

1. Pipe shall be legibly and permanently marked in ink with the following minimum information:
   a. Nominal Size
   b. PVC
   c. Dimension Ratio (for example, DR 18)
   d. AWWA pressure class (for example, 235 psi)
   e. AWWA designation number for this standard, which is C900-16 (or latest edition)

2. Couplings shall be legibly and permanently marked in ink with the following minimum information:
   a. Nominal Size
   b. Manufacturer’s name or trademark

2.02 Approved Manufacturers

   A. NAPCO Pipe & Fitting
   B. Approved equal

PART 3 - EXECUTION

3.01 PROTECTION

   A. Store pipe under cover out of direct sunlight and protect from excessive heat or harmful chemicals in accordance with manufacturer's recommendations.

3.02 INSTALLATION

   A. Pipe and couplings shall be homogeneous throughout and free from voids, cracks, inclusions, and other defects, and shall be as uniform as commercially practicable in color, density, and other physical characteristics.

   B. Conform to requirements of Section 02506 – Polyvinyl Chloride (PVC) Pipe, Section 02531 - Gravity Pipelines, and Section 02532 - Force Mains, as applicable.

   C. Install PVC pipe in accordance with Section 02317 - Excavation and Backfill for Utilities, ASTM D 2321 for Sewer Pipe, and manufacturer's recommendations.
D. Store PVC pipe under cover out of direct sunlight. Protect pipe from excessive heat or harmful chemicals. Prevent damage by crushing or piercing.

END OF SECTION
SECTION 15065
FUSIBLE POLYVINYLCHLORIDE PIPE

PART 1 - GENERAL

1.01 DESCRIPTION

A. SCOPE

1. This section specifies fusible polyvinylchloride pipe, including standards for dimensionality, testing, quality, acceptable fusion practice, safe handling and storage.

B. PIPE DESCRIPTION

1. Pipe supplier shall furnish fusible polyvinylchloride pipe conforming to all standards and procedures and meeting all testing and material properties as described in this specification.

2. Pipe shall conform to the following dimensionality and general characteristics table:

<table>
<thead>
<tr>
<th>Pipe Description</th>
<th>Nominal Diameter (in)</th>
<th>DR</th>
<th>Color</th>
<th>Pressure Class (psi)</th>
<th>Required Inner Diameter (in)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Force Main</td>
<td>16</td>
<td>18</td>
<td>Green</td>
<td>235</td>
<td></td>
</tr>
<tr>
<td>Gravity Main</td>
<td>18</td>
<td>18</td>
<td>Green</td>
<td>235</td>
<td></td>
</tr>
</tbody>
</table>

1.02 QUALITY ASSURANCE

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

B. Unless otherwise specified, references to documents shall mean the documents in effect at the time of design, bid, or construction, whichever is earliest. If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued.

C. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date,
regardless of whether the document has been superseded by a version with a later date, discontinued or replaced.

1.03 REFERENCES


E. AWWA C651: Standard for Disinfecting Water Mains

F. AWWA C900: Standard for Polyvinyl Chloride (PVC) Pressure Pipe and Fabricated Fittings, 4in. through 60 in. (100mm through 1500mm), for Water Distribution, latest revision.


I. ASTM D1784: Rigid Poly (Vinyl Chloride) (PVC) Compounds and Chlorinated Poly (Vinyl Chloride) (CPVC) Compounds

J. ASTM D1785: Poly (Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, 120.


L. ASTM D2241: Poly (Vinyl Chloride) (PVC) Plastic Pipe (SDR-PR)


O. ASTM F477: Elastomeric Seals (Gaskets) for Joining Plastic Pipe.


S. UNI-B-6: Recommended Practice for Low-Pressure Air Testing of Installed Sewer Pipe

T. UNI-PUB-08: Tapping Guide for PVC Pressure Pipe.


V. NSF-61: Drinking Water System Components – Health Effects

W. PPI TR-2: PVC Range Composition Listing of Qualified Ingredients

1.04 MANUFACTURER REQUIREMENTS

A. All piping shall be made from PVC compound conforming to cell classification 12454 per ASTM D1784.

1.05 FUSION TECHNICIAN REQUIREMENTS

A. Fusion Technician shall be fully qualified by the pipe supplier to install fusible polyvinylchloride pipe of the type(s) and size(s) being used. Qualification shall be current as of the actual date of fusion performance on the project.

1.06 SPECIFIED PIPE SUPPLIERS

A. Fusible polyvinylchloride pipe shall be used as manufactured under the trade names Fusible C-900®, Fusible C-905®, and FPVC®, for Underground Solutions, Inc., Poway, CA, (858) 679-9551. Fusion process shall be as patented by Underground Solutions, Inc., Poway, CA, Patent No. 6,982,051. Owner and engineer are aware of no other supplier of fusible polyvinylchloride pipe that is an equal to this specified pipe supplier and products.

1.07 WARRANTY

A. The pipe shall be warranted for one year per the pipe supplier’s standard terms. In addition to the standard pipe warranty, the fusion services shall be warranted for one year per the fusion service provider’s standard terms.

1.08 PRE-CONSTRUCTION SUBMITTALS

A. The following PRODUCT DATA is required from the pipe supplier and/or fusion provider:

1. Pipe Size
2. Dimensionality
3. Pressure Class per applicable standard
4. Color
5. Recommended Minimum Bending Radius
6. Recommended Maximum Safe Pull Force
7. Fusion technician qualification indicating conformance with this specification

1.09 POST-CONSTRUCTION SUBMITTALS

A. The following AS-RECORDED DATA is required from the contractor and/or fusion provider to the owner or pipe supplier upon request:

1. Approved datalogger device reports
2. Fusion joint documentation containing the following information:
   a. Pipe Size and Thickness
   b. Machine Size
   c. Fusion Technician Identification
   d. Job Identification
   e. Fusion Joint Number
   f. Fusion, Heating, and Drag Pressure Settings
   g. Heat Plate Temperature
   h. Time Stamp
   i. Heating and Cool Down Time of Fusion
   j. Ambient Temperature

PART 2 - PRODUCTS

2.01 FUSIBLE POLYVINYLCHLORIDE PRESSURE PIPE FOR WASTEWATER CONFORMING TO AWWA C900 DIMENSIONALITY

A. Fusible polyvinylchloride pipe shall conform to AWWA C900 standard.

B. Fusible polyvinylchloride pipe shall be extruded with plain ends. The ends shall be square to the pipe and free of any bevel or chamfer. There shall be no bell or gasket of any kind incorporated into the pipe.

C. Fusible polyvinylchloride pipe shall be manufactured in a standard 40’ nominal length, or custom lengths as specified.

D. Fusible polyvinylchloride pipe shall be green in color for wastewater use.

E. Pipe shall be marked as follows:

1. Nominal pipe size
2. PVC
3. Dimension Ratio, Standard Dimension Ratio, or Schedule
4. AWWA pressure class
5. AWWA standard designation number  
6. Extrusion production-record code  
7. Trademark or trade name  
8. Cell Classification 12454 and/or PVC material code 1120 may also be included

F. Pipe shall be homogeneous throughout and be free of visible cracks, holes, foreign material, blisters, or other visible deleterious faults.

2.02 FUSIBLE POLYVINYLCHLORIDE NON-PRESSURE PIPE FOR WASTEWATER OR SURFACE WATER

A. Fusible polyvinylchloride shall conform to AWWA C900 standard.

B. Fusible polyvinylchloride pipe shall be extruded with plain ends. The ends shall be square to the pipe and free of any bevel or chamfer. There shall be no bell or gasket of any kind incorporated into the pipe.

C. Fusible polyvinylchloride pipe shall be manufactured in a standard 40’ nominal length, or custom lengths as specified.

D. Fusible polyvinylchloride pipe shall be green in color for wastewater use. Fusible polyvinylchloride pipe shall be white in color for surface or storm water use.

E. Pipe shall be marked as follows:
   1. Nominal pipe size  
   2. PVC  
   3. Dimension Ratio, Standard Dimension Ratio, or Schedule  
   4. Pressure class or standard pressure rating  
   5. Standard designation number or pipe type  
   6. Extrusion production-record code  
   7. Trademark or trade name  
   8. Cell Classification 12454 and/or PVC material code 1120 may also be included

F. Pipe shall be homogeneous throughout and be free of visible cracks, holes, foreign material, blisters, or other visible deleterious faults.

2.03 FUSION JOINTS

A. Unless otherwise specified, fusible polyvinylchloride pipe lengths shall be assembled in the field with butt-fused joints. The Contractor shall follow the pipe supplier’s written guidelines for this procedure. All fusion joints shall be completed as described in this specification.

B. 18-inch fusible PVC Gravity Line: Internal fusion bead shall be removed.
2.04 CONNECTIONS AND FITTINGS FOR PRESSURE APPLICATIONS

A. Connections shall be defined in conjunction with the coupling of project piping, as well as the tie-ins to other piping systems.

B. DUCTILE IRON MECHANICAL AND FLANGED FITTINGS

1. Acceptable fittings for use with fusible polyvinylchloride pipe shall include standard ductile iron fittings conforming to AWWA/ANSI C110/A21.10, or AWWA/ANSI C153/A21.53 and AWWA/ANSI C111/A21.11.

2. Connections to fusible polyvinylchloride pipe may be made using a restrained or non-restrained retainer gland product for PVC pipe, as well as for MJ or flanged fittings.

3. Bends, tees and other ductile iron fittings shall be restrained with the use of thrust blocking or other means as indicated in the construction documents.

4. Ductile iron fittings and glands must be installed per the manufacturer’s guidelines.

5. If required, linings for Ductile Iron fittings shall meet the following requirements for the following service environments:

   a. Wastewater:
      1) Ceramic Epoxy shall be Tnemec Perma-Shield 431.
      2) Polyurethane shall be DuraShield 210 or 310.

   b. Potable Water:
      1) Liquid Epoxy shall be 100% solids liquid epoxy, Tnemec Epoxyline Series FC22.
      2) Polyurethane shall be DuraShield 210-61 or 310-61.

6. If required, coatings for Ductile Iron fittings shall meet the following requirements for buried and/or immersion service duty:

   a. Polyurethane shall be DuraShield 210 or 310.
   b. Liquid Epoxy shall be 100% solids liquid epoxy, Tnemec Epoxyline Series FC22.
   c. Coal tar epoxy shall be Sherwin Williams Targuard.

C. PVC GASKETED, PUSH-ON FITTINGS

1. Acceptable fittings for use with fusible polyvinylchloride pipe shall include standard PVC pressure fittings conforming to AWWA C900.

2. Acceptable fittings for use joining fusible polyvinylchloride pipe other sections of fusible polyvinylchloride pipe or other sections of PVC pipe shall include gasketed PVC, push-on type couplings and fittings, including bends, tees, and couplings as shown in the drawings.

3. Bends, tees and other PVC fittings shall be restrained with the use of thrust blocking or other restraint products as indicated in the construction documents.
4. PVC gasketed, push-on fittings and mechanical restraints, if used, must be installed per the manufacturer’s guidelines.

D. FUSIBLE POLYVINYL CHLORIDE SWEEPS OR BENDS

1. Fusible polyvinyl chloride sweeps or bends shall conform to the same sizing convention, diameter, dimensional tolerances and pressure class of the pipe being joined using the sweep or bend.

2. Fusible polyvinyl chloride sweeps or bends shall be manufactured from the same fusible polyvinyl chloride pipe being used for the installation and shall have at least 2 feet of straight section on either end of the sweep or bend to allow for fusion of the sweep to the pipe installation. There shall be no gasketed connections utilized with a fusible polyvinyl chloride sweep.

3. Standard fusible polyvinyl chloride sweeps or bend angles shall not be greater than 22.5 degrees and shall be used in nominal diameters ranging from 4-inch through 16-inch.

E. SLEEVE-TYPE COUPLINGS

1. Sleeve-type mechanical couplings shall be manufactured for use with PVC pressure pipe and may be restrained or unrestrained as indicated in the construction documents.

2. Sleeve-type couplings shall be rated at the same or greater pressure carrying capacity as the pipe itself.

F. EXPANSION AND FLEXIBLE COUPLINGS

1. Expansion-type mechanical couplings shall be manufactured for use with PVC pipe, and may be restrained or unrestrained as indicated in the construction documents.

2. Expansion-type mechanical couplings shall be rated at the same or greater pressure carrying capacity as the pipe itself.

G. CONNECTION HARDWARE

1. Bolts and nuts for buried service shall be made of non-corrosive, high-strength, low-alloy steel having the characteristics specified in ANSI/AWWA C111/A21.11, regardless of any other protective coating.

2.05 CONNECTIONS FOR GRAVITY PIPES AND NON-PRESSURE APPLICATIONS

A. The following connections are to be used in conjunction with tie-ins to other non-pressure, gravity sewer piping and/or structures, and shall be as indicated in the construction documents.

B. PVC GASKETED, PUSH-ON COUPLINGS

1. Acceptable couplings for joining fusible polyvinylchloride pipe to other sections of fusible polyvinylchloride pipe or other sections of PVC pipe shall
include gasketed PVC, push-on type couplings as indicated in the construction documents.

2. PVC gasketed, push-on fittings and/or restraint hardware must be installed per the manufacturer’s guidelines.

C. FUSIBLE POLYVINYL CHLORIDE SWEEPS OR BENDS

1. Fusible polyvinyl chloride sweeps or bends shall conform to the same sizing convention, diameter, dimensional tolerances and pressure class of the pipe being joined using the sweep or bend.

2. Fusible polyvinyl chloride sweeps or bends shall be manufactured from the same fusible polyvinyl chloride pipe being used for the installation and shall have at least 2 feet of straight section on either end of the sweep or bend to allow for fusion of the sweep to the pipe installation. There shall be no gasketed connections utilized with a fusible polyvinyl chloride sweep.

3. Standard fusible polyvinyl chloride sweeps or bend angles shall not be greater than 22.5 degrees and shall be used in nominal diameters ranging from 4 inch through 16 inches.

D. SLEEVE-TYPE COUPLINGS

1. Sleeve-type mechanical couplings shall be manufactured for use with PVC pipe, and may be restrained or unrestrained as indicated in the construction documents.

E. EXPANSION AND FLEXIBLE COUPLINGS

1. Expansion-type mechanical couplings shall be manufactured for use with PVC pipe, and may be restrained or unrestrained as indicated in the construction documents.

F. CONNECTION HARDWARE

1. Bolts and nuts for buried service shall be made of non-corrosive, high-strength, low-alloy steel having the characteristics specified in ANSI/AWWA C111/A21.11, regardless of any other protective coating.

G. CONNECTION TO CONCRETE MANHOLES AND STRUCTURES

1. Fusible polyvinylchloride pipe shall be connected to manholes and other structures to provide a leak-free, properly graded flow into or out of the manhole or structure.

2. Connections to existing manholes and structures shall be as indicated in the construction documents.

   a. For a cored or drilled opening provide a flexible, watertight connection that meets and/or exceeds ASTM C923.
b. For a knockout opening, provide a watertight connection (water stop or other method) meeting the material requirements of ASTM C923 that is securely attached to the pipe with stainless steel bands or other means.

c. Grout opening in manhole wall with non-shrink grout. Pour concrete collar around pipe and outside manhole opening. Provide flexible pipe joint or flexible connector within 2 feet of the collar.

3. Connections to a new manhole or structure shall be as indicated in the construction documents.

   a. A flexible, watertight gasket per ASTM C923 shall be cast integrally with riser section(s) for all precast manhole and structures.
   b. Drop connections shall be required where shown on drawings.
   c. Grout internal joint space with non-shrink grout.

PART 3 - EXECUTION

3.01 DELIVERY AND OFF-LOADING

   A. All pipe shall be bundled or packaged in such a manner as to provide adequate protection of the ends during transportation to the site. Any pipe damaged in shipment shall be replaced as directed by the 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 M23, and all of the pipe supplier's guidelines shall be followed.

   D. Off-loading devices such as chains, wire rope, chokers, or another 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 ensure that pipe is not dropped or damaged. Pipe should be carefully lowered, not dropped, from trucks.

3.02 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 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.

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. 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.

F. Pipe shall be stored and stacked per the pipe supplier’s guidelines.

3.03 FUSION PROCESS

A. GENERAL

1. Fusible polyvinylchloride pipe will be handled in a safe and non-destructive manner before, during, and after the fusion process and in accordance with this specification and pipe supplier’s guidelines.

2. Fusible polyvinylchloride pipe will be fused by qualified fusion technicians, as documented by the pipe supplier.

3. Each fusion joint shall be recorded and logged by an electronic monitoring device (data logger) connected to the fusion machine.

4. Only appropriately sized and outfitted fusion machines that have been approved by the pipe supplier shall be used for the fusion process. Fusion machines must incorporate the following elements:

   a. HEAT PLATE - Heat plates shall be in good condition with no deep gouges or scratches. Plates shall be clean and free of any debris or contamination. Heater controls shall function properly; cord and plug shall be in good condition. The appropriately sized heat plate shall be capable of maintaining a uniform and consistent heat profile and temperature for the size of pipe being fused, per the pipe supplier’s guidelines.

   b. CARRIAGE – Carriage shall travel smoothly with no binding at less than 50 psi. Jaws shall be in good condition with proper inserts for the
pipe size being fused. Insert pins shall be installed with no interference to carriage travel.
c. GENERAL MACHINE - Overview of machine body shall yield no obvious defects, missing parts, or potential safety issues during fusion.
d. DATA LOGGING DEVICE – An approved datalogging device with the current version of the pipe supplier’s recommended and compatible software shall be used. Datalogging device operations and maintenance manual shall be with the unit at all times. If fusing for extended periods of time, an independent 110V power source shall be available to extend battery life.

5. Other equipment specifically required for the fusion process shall include the following:
   a. Pipe rollers shall be used for support of pipe to either side of the machine
   b. A weather protection canopy that allows full machine motion of the heat plate, fusion assembly and carriage shall be provided for fusion in inclement, extreme temperatures, and /or windy weather, per the pipe supplier’s recommendations.
   c. An infrared (IR) pyrometer for checking pipe and heat plate temperatures.
   d. Fusion machine operations and maintenance manual shall be kept with the fusion machine at all times.
   e. Facing blades specifically designed for cutting fusible polyvinylchloride pipe shall be used.

B. JOINT RECORDING

1. Each fusion joint shall be recorded and logged by an electronic monitoring device (data logger) connected to the fusion machine. The fusion data logging and joint report shall be generated by software developed specifically for the butt-fusion of fusible polyvinyl chloride pipe. The software shall register and/or record the parameters required by the pipe supplier and these specifications. Data not logged by the data logger shall be logged manually and be included in the Fusion Technician’s joint report.

3.04 GENERAL INSTALLATION

A. Installation guidelines from the pipe supplier shall be followed for all installations.

B. The fusible polyvinylchloride pipe will be installed in a manner so as not to exceed the recommended bending radius.

C. Where fusible polyvinylchloride pipe is installed by pulling in tension, the recommended Safe Pulling Force established by the pipe supplier shall not be exceeded.
3.05 PREPARATION PRIOR TO MAKING CONNECTIONS INTO EXISTING PIPING SYSTEMS

A. Approximate locations for existing piping systems are shown in the construction documents. Prior to making connections into existing piping systems, the contractor shall:

1. Field verify location, size, piping material, and piping system of the existing pipe.
2. Obtain all required fittings, which may include saddles, sleeve type couplings, flanges, tees, or others as shown in the construction documents.
3. Have installed all temporary pumps and/or pipes in accordance with established connection plans.

B. Unless otherwise approved, new piping systems shall be completely assembled and successfully tested prior to making connections into existing pipe systems.

3.06 PIPE SYSTEM CONNECTIONS

A. Pipe connection shall be installed per applicable standards and regulations, as well as per the connection manufacturer’s guidelines and as indicated in the construction documents. Pipe connections to structures shall be installed per applicable standards and regulations, as well as per the connection manufacturer’s guidelines.

3.07 TESTING

A. Testing shall comply with all applicable jurisdictional building codes, statutes, standards, regulations, and laws.

B. HYDROSTATIC TESTING AND LEAKAGE TESTING FOR PRESSURE PIPING

1. Hydrostatic and leakage testing for piping systems that contain mechanical jointing as well as fused PVC jointing shall comply with AWWA C605.
2. Unless agreed to or otherwise designated by the owner or engineer, for a simultaneous hydrostatic and leakage test following installation, a pressure equal to 150% of working pressure at point of test, but not less than 125% of normal working pressure at highest elevation shall be applied. The duration of the pressure test shall be for two (2) hours.
3. If hydrostatic testing and leakage testing are performed at separate times, follow procedures as outlined in AWWA C605.
4. In preparation for pressure testing the following parameters must be followed:
   a. All air must be vented from the pipeline prior to pressurization. This may be accomplished with the use of the air relief valves or corporation stop valves, vent piping in the testing hardware or end caps, or any other method which adequately allows air to escape the pipeline at all high points. Venting may also be accomplished by ‘flushing’ the
pipeline in accordance with the parameters and procedures as described in AWWA C605.

b. The pipeline must be fully restrained prior to pressurization. This includes complete installation of all mechanical restraints per the restraint manufacturer’s guidelines, whether permanent or temporary to the final installation. This also includes the installation and curing of any and all required thrust blocking. All appurtenances included in the pressure test, including valves, blow-offs, and air-relief valves shall be checked for proper installation and restraint prior to beginning the test.

c. Temporary pipeline alignments that are being tested, such as those that are partially installed in their permanent location shall be configured to minimize the amount of potentially trapped air in the pipeline.

C. LEAKAGE TESTING FOR NON-PRESSURE PIPING

1. Gravity pipelines that contain mechanical jointing in addition to fused PVC joints may need to be tested for excessive leakage.
2. Gravity pipe leakage testing may include appropriate water or low-pressure air testing. The leakage outward or inward (exfiltration or infiltration) shall not exceed 25 gallons per inch of pipe diameter per mile per day for any section of the system. An exfiltration or infiltration test shall be performed with a minimum positive head of two feet. The air test, if used, shall be conducted in accordance with one of the following Standards:
   a. ASTM F1417
   b. UNI-B-6
3. The testing method selected shall properly consider the existing groundwater elevations during the test.

D. DEFLECTION TESTING FOR NON-PRESSURE PIPING

1. After completion of the backfill, the engineer or owner may require that a deflection test be performed.
2. Deflection tests should be conducted using a go/no-go mandrel. The mandrel’s outside dimension shall be sized to permit no more than 7.5 percent deflection. The percent deflection shall be established from the base inside diameter of the pipe. If the internal beading of the fused joints for the pipe is not required to be removed, the mandrel shall account for this clearance as well. The mandrel shall be approved by the owner or engineer prior to use. Lines that permit safe entry may allow other deflection test options, such as direct measurements.

E. PARTIAL TESTING

1. Segments of the pipe may be tested separately in accordance with standard testing procedure, as approved by the owner and engineer.
SECTION 15101
GATE VALVES

PART 1 - GENERAL

1.01 SECTION INCLUDES
A. Gate Valves and accessories for exposed, submerged and other types of piping.

1.02 MEASUREMENT AND PAYMENT
A. No separate payment will be made for work required under this section. Contractor will include all costs of the requirements of this section in the appropriate bid item(s) on the bid form.

1.03 REFERENCES
A. ANSI B 16.1 – Cast Iron Pipe Flanges and Flanged Fittings.
B. ASTM A 48 - Gray Iron Castings.
D. ASTM A 194 - Carbon and Alloy Steel Nuts for Bolts for High Pressure and High Temperature Service.
E. ASTM B 62 - Standard Specification for Composition Bronze or Ounce Metal Castings.
H. AWWA C 550 - Protective Interior Coatings for Valves and Hydrants.

1.04 QUALITY ASSURANCE
A. Manufacturer’s Qualifications:
   1. Valves and appurtenances provided under this Section shall be the standard products in regular production by manufacturers whose products have proven reliable in similar service for at least 5 years.
   2. Insofar as possible valves of the same type shall be the product of one manufacturer.

1.05 SUBMITTALS
A. Shop Drawings:
1. Submit IAW UGC, Article 6 and include detail drawings, data and descriptive literature of valves and appurtenance, including:
   a. Dimensional
   b. Size.
   c. Materials of construction.
   d. Weight.
   e. Protective coating.

B. Manufacturer’s Certification: Submit manufacturer’s certificates of compliance with ANSI, AWWA and other listed standards.

1.06 OPERATION AND MAINTENANCE DATA
A. Submit, operation and maintenance data for each type of valve and appurtenance provided under this Section.

1.07 DELIVERY, STORAGE AND HANDLING
A. Protect and store valves and appurtenances off the ground in enclosed shelter.

PART 2 - PRODUCTS

2.01 BASIC REQUIREMENTS
A. Mark and identify valves in conformance with referenced standards and these Specifications.

B. Bolts, studs, and nuts shall be Type 304 stainless steel.

C. End connections of valves shall be flanged and drilled to ANSI Class 125 unless otherwise specified.

2.02 GATE VALVES
A. Gate Valves shall be solid wedge type, with resilient nitrile rubber (Buna-N) seating surface. Provide valves that comply with AWWA C509. Acceptable manufacturers include American Darling, Clow, Kennedy, Mueller, U.S. Pipe or pre-approved equal.

B. Supply gate valves rated as 200 psi water working pressure with 400 psi hydrostatic test for structural soundness for sizes 2 inches through 12 inches.

C. Stems: Non-Rising type (NRS), 300 series stainless steel or low-zinc bronze conforming to ASTM B 62.

D. Valve Bodies: Cast iron conforming to ASTM A 126 or ASTM A 395. Internal hardware shall be 300 series stainless steel.
E. Coatings: Internal and external surfaces of the valve, except those encapsulated in resilient material, shall be coated with a fusion-bonded epoxy conforming with AWWA C 550.

F. Opening: Valves shall open counterclockwise and so indicated on hand wheel.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install valves and specialties in accordance with manufacturer’s written instructions to permit intended performance.

B. Support and anchor valves in accordance with drawings.

3.02 PAINTING

A. Paint valves and specialties in accordance with Specification 09901 – Protective Coatings.

3.03 TESTING

A. Test Valves using a hydrostatic pressure test in accordance with AWWA C 600.

B. Test Valves and specialties in place. Correct defects in valves, specialties or connections.

END OF SECTION
SECTION 15102
MISCELLANEOUS VALVES

PART 1 - GENERAL

1.01 SECTION INCLUDES
A. Valves, gates and accessories for exposed, submerged and other types of piping.

1.02 MEASUREMENT AND PAYMENT
A. No separate payment will be made for work required under this section. Contractor shall include all costs of the requirements of this section in the appropriate bid item(s) on the bid form.

1.03 REFERENCES
B. AWWA C509 - Resilient Seated Gate Valves.
C. AWWA C508 - Check Valves.
E. ASTM A395 - Ductile Iron Castings.
F. ASTM A48 - Gray Iron Castings.
G. ASTM A193 - Alloy-Steel and Stainless-Steel Bolting Materials for High Temperature Service.
H. ASTM A194 - Carbon and Alloy Steel Nuts for Bolts for High Pressure and High Temperature Service.

1.04 QUALITY ASSURANCE
A. Manufacturer's Qualifications:
   1. Valves and appurtenances provided under this Section shall be the standard product in regular production by manufacturers whose products have proven reliable in similar service for at least 5 years.
   2. Insofar as possible all valves of the same specific type shall be the product of one manufacturer.

1.05 SUBMITTALS
A. Shop Drawings: Submit for review, detailed drawings, data and descriptive literature on valves and appurtenances, including:
1. Dimensions.
2. Size.
4. Weight.
5. Protective coating.
6. Actuator weight, where applicable.
7. Calculations for actuator torque, where applicable.
8. Wiring diagram, where applicable.

B. Submit manufacturer's valve sizing calculations for verification of sizing for air release valves, air and vacuum valves, and surge relief valves.

1. Manufacturer's Certifications.

C. Submit manufacturer's certificates of compliance with ANSI, AWWA and other listed standards.

1.06 OPERATION AND MAINTENANCE DATA

A. Submit a detailed operation and maintenance manual for valves and appurtenances provided under this Section.

1.07 DELIVERY, STORAGE AND HANDLING

A. Have products delivered, stored and protected. Store valves and appurtenances off the ground in enclosed shelter.

PART 2 - PRODUCTS

2.01 BASIC REQUIREMENTS

A. Mark and identify valves in conformance with standards, these Specifications or to the manufacturer's standard.

B. Bolts, studs and nuts to be Type 316 stainless steel.

C. End connections of valves shall be flanged and drilled to ANSI Class 125 unless otherwise specified.

D. For handwheel operators on valves 4-inches or larger where located more than 5 feet above the operating floor, provide chain and chainwheel or extension operators. Use chainwheels fabricated of malleable cast iron with chain guides. Provide stainless steel chains of a length to extend to within 5 feet of the operating floor.

E. To exterior surfaces of valves, apply a shop coating in accordance with Section 09901 – Protective Coatings.
2.02 CHECK VALVES

A. Swing check valves 4-inches through 14-inches having a system pressure 30-psi or less shall be air cushioned with side mount lever and weight. The valve shaft shall extend through both sides of the body with minimum shaft diameters equal to APCO Series 6000. The cushion shall be totally enclosed, swivel mounted at the bottom, and equipped with a micrometer air control valve and air breather filters. Valves shall be APCO Series 6000, CCNE Series 9000 (Pneumatic), GA Industries 250-D, or equal.

B. Swing check valves 10-inches through 14-inches having a system pressure greater than 30 psi shall be oil cushioned with side mount lever and weight. Valves shall be similar to APCO Series 6100, CCNE Series 9000 (Oil Cushioned), or equal.

C. Swing check valves 16-inches and larger regardless of system operating pressure shall be oil cushioned with side mount lever and weight. Valves shall be similar to APCO Series 6100, CCNE Series 9000 (Oil Cushioned), GA Industries 250-DOC, or equal.

D. Check valves of special design utilizing controlled closing of the disc, such as APCO Series 6000B (Bottom-Buffer), GA Industries Fig. #25-DXH, CCNE Series 9000 (Decelerator), or equal, shall be used when specifically indicated on the Drawings. These valves are special valves used to control the surge pressure in the force main upon multiple pump shutdown during a power failure. Other surge control check valves utilizing ball or cone valve and power cylinder operator may also be used as approved by the Engineer.

E. All check valves shall have 300 series stainless steel hinge shafts, stainless steel body seats and stainless steel resilient seat retainer rings.

2.03 ECCENTRIC PLUG VALVES

A. Eccentric plug valves shall be the non-lubricated eccentric type with cast iron bodies, resilient-faced plugs or replaceable resilient seats in the bodies.

B. Operators: All valves for 4-inch and larger service shall have worm gear operators, nickel or stainless-steel seats, and ANSI 125 psi flanged ends. Operators shall clearly indicate valve position. Operators on valves in submerged or buried service shall be lubricated and sealed to prevent entry of dirt and water into the operator.

C. Resilient facing shall be suitable for the intended service.

D. All shaft bearings shall be of stainless steel, furnished with permanently lubricated bearing surfaces.
E. Valves up to and including 20 inches in size shall have an unobstructed port area of no less than 80 percent of the full pipe area, and not less than 70 percent for larger valves.

F. Eccentric plug valves shall be manufactured by Clow, De Zurik, Keystone, Val-Matic, Pratt, Milliken, or Victualic.

2.04 AIR RELEASE AND AIR AND VACUUM VALVES

A. Air Release and Air and Vacuum Valves: Provide when shown on Drawings.

B. Sewage Air Release Valve Design: Single float, single orifice, float operated with a compound lever mechanism to automatically release accumulated air and gases while the system is pressurized and operating.

C. Sewage Air and Vacuum Valve Design: Two float where the top float shuts off against the seat due to the lifting force of the bottom float as liquid enters the valve body. Once closed and pressurized the air and vacuum valve will not open to release air.

D. Fabricate valve body, cover and baffles of cast iron: Fabricate internal metal parts of stainless steel. Make valve seat of Buna-N nitrile rubber.

E. Fit valve with blow off valves, quick disconnect couplings and minimum 6-feet of hose to permit back flushing after installation with dismantling valve.

F. Provide air release valves equal to Series 400/450 SARV by APCO or Figure 925 by G.A. Industries.

G. Provide air and vacuum valves equal to Series 400 SARV by APCO. Figure 935 as manufactured by GA Industries, or Val-Matic.

2.05 SURGE RELIEF VALVES

A. Surge Relief Valves: Provide when shown on Drawings.

B. Operation: Surge relief valves shall protect piping systems from surges by opening quickly at a set pressure and throttling the flow to maintain line pressure at no more than 5 to 10 percent above the pressure setting indicated. Provide relief pressure adjustment by changing the tension on a spring holding the valve disc on its seat.

C. Valve Closing Control: By oil dashpots. Oil shall be drawn into the dashpot from a reservoir when the valve opens and return through a flow control valve when the relief valve closes.

D. Valve Construction: Fabricate valve bodies of cast iron with 300 series stainless steel seat rings. Provide seats that are renewable and resilient. Fabricate hinge shafts of stainless steel and the oil system of bronze. Unless otherwise indicated make the pressure setting 5 percent above normal line pressure.
E. Provide surge relief valves that are 90-degree elbow body configuration. Acceptable manufacturers include APCO series 3000, GA Industries 625-D, or approved equal.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install valves and specialties in accordance with manufacturer’s written instructions to permit intended performance.

B. Support and anchor valves and gates in accordance with Section 15140 - Pipe Hangars, Supports and Restraints.

C. Eccentric plug valves shall be installed according to the following:
   1. Position the valves with the stem in the horizontal direction.
   2. In horizontal pipelines, position the vales so that the plug swings upward when opening to permit flushing of solids.
   3. Orient the valves to prevent the valve bodies from filling up with solids when closed; however, orient the valves such that the pressure differential forces the plug against the seat in cases where the pressure differential across a closed valve will exceed 25 psi.

3.02 PAINTING

A. Paint valves and specialties in accordance with applicable AWWA standards and with Section 09901 - Protective Coatings.

3.03 TESTING

A. Test valves using a hydrostatic pressure test in accordance with AWWA C-600.

B. Test valves and specialties in place. Correct defects in valves, specialties or connections.

END OF SECTION
PART 1 - GENERAL

1.01 SCOPE

A. This section covers furnishing 3 inch and larger AWWA Resilient Seated Eccentric Plug Valves as required by the Work and as indicated in the AWWA Plug Valve Schedule on the Plan sheets. AWWA Resilient Seated Eccentric Plug Valves shall be furnished complete with actuators and accessories as specified herein, as indicated in the schedule, and as specified in Valve and Gate Actuators section.

1.02 GENERAL

A. Equipment provided under this section shall be fabricated and assembled in full conformity with Drawings, Specifications, engineering data, instructions, and recommendation of the equipment manufacturer, unless exceptions are noted by Engineer.

B. Valves shall be furnished with all necessary parts and accessories indicated on the Drawings, specified, otherwise required for a complete, properly operating installation and shall be the latest standard products of a manufacturer regularly engaged in the production of valves.

1. General Equipment Stipulations. The General Equipment Stipulations shall apply to all equipment furnished under this section. If requirements in this specification differ from those in the General Equipment Stipulations, the requirements specified herein shall take precedence.

2. Governing Standard. Except as modified or supplemented herein, all resilient seated eccentric plug valves and manual actuators shall conform to the applicable requirements of ANSI/AWWA C517-09.

3. Coordination. All equipment provided under this section shall be furnished by or through a single manufacturer who shall be responsible for the design, coordination, and satisfactory performance of all components over the full operating range.

4. Temporary Number Plates. Each resilient seated eccentric plug valve shall be tagged or marked in the factory with the identifying number listed in the AWWA resilient seated eccentric plug valve Schedule.

5. Identification. AWWA resilient seated eccentric plug valves shall be tagged in accordance with the Equipment and Valve Identification section.

1.03 SUBMITTALS

A. Complete drawings, details, and specifications covering the valves and their appurtenances shall be submitted in accordance with the Submittals Procedures section.
B. Drawings shall include separate wiring diagrams for each electrically operated or controlled valve and the electrical control equipment. Each drawing shall be identified with the valve number or name as specified in this section.

C. Certified copies of test results for tests described in Section 5 of the governing standard, with an affidavit of compliance as indicated in Section 6.3 of the governing standard, shall be submitted to Engineer before the valves are shipped.

PART 2 - PRODUCTS

2.01 MATERIALS

A. Except as modified or supplemented herein, materials used in the manufacture of resilient seated eccentric plug valves shall conform to ANSI/AWWA C517-09.

B. Eccentric Plug Valves shall be of the tight-closing, resilient-faced, non-lubricating variety and shall be of eccentric design such that the valve’s pressure member (plug) rises off the body seat contact area immediately upon shaft rotation during the opening movement. Valves shall be bubble-tight at the rated pressure (175 PSI through 12”, 150 PSI 14” and above) and shall be satisfactory for applications involving throttling service as well as frequent or infrequent on-off service. The valve closing member should rotate approximately 90 degrees from the full-open to full-closed position.

C. Acceptable shop coatings are listed as follows:

Epoxy

For Raw or Treated Water Service (NSF certified) PPG Amercoat "Amerlock 400 High-Solids Epoxy Coating"; Carboline "Carboguard 891", Sherwin-Williams Macropoxy 646NSF or Tnemec "Series N140 Pota-Pox plus"; immersion service.

Rust-Preventive Compound As recommended by manufacturer

2.02 VALVE CONSTRUCTION

A. Valve Body

1. The valve body shall be constructed of cast iron conforming to ASTM A126, Class B. Body ends shall be:

a. Flanged with dimensions, facing, and drilling in full conformance with ANSI B16.1, Class 125.

b. Mechanical Joint to meet the requirements of AWWA C111/ANSI A21.11.

c. Grooved ends to meet the requirements of AWWA C606.
B. Valve Port: Eccentric Plug Valves shall have a rectangular shaped port. Port areas for 3”– 20” valves shall be a minimum 80% of full pipe area. Port area for 24” valve shall be a minimum 70% of full pipe area. *

C. Valve Seat: Valve seat surface shall be welded-in overlay, cylindrically shaped of not less than 95% pure nickel. Seat area shall be raised, with raised area completely covered with weld to ensure proper seat contact. The machined seat area shall be a minimum of 0.125” thick and .0500” wide.

D. Valve Plug: The valve plug shall be constructed of cast iron conforming to ASTM A126, Class B. The plug shall have a cylindrical seating surface that is offset from the center of the plug shafts. The plug shafts shall be integral. The entire plug shall be 100% encapsulated with Buna-N rubber in all valve sizes. The rubber compound shall be approximately 70 (Shore A) durometer hardness. The rubber to metal bond must withstand 75 lbs. pull under test procedure ASTM D429-73 Method B.

E. Shaft Bearings: Shaft bearings, upper and lower, shall be sleeve-type metal bearings, sintered, oil impregnated and permanently lubricated Type 316 stainless steel conforming to ASTM A743 Grade CF-8M. Thrust bearings shall be Nylatron.

F. Valve Shaft: Plug valve shaft seals shall be of the multiple V-ring type (Chevron) and shall be adjustable. All packing shall be replaceable without moving the bonnet or actuator and while the valve is in service. Shaft seals shall be made of Buna-N.

G. Hydrostatic Test: Each valve shall be given a test against the seat at the full-rated working pressure and a hydrostatic shell test at 1.5 times the rated working pressure. Certified copies of individual tests shall be submitted when requested. Certified copies of proof-of-design tests shall be submitted upon request.

H. Actuator: Manual valves shall have lever or worm gear type actuators with handwheels, 2” square nuts, or chainwheels attached. Lever actuators shall be furnished on valves 8” and smaller where the maximum unseating pressure is 25 PSIG or less. Worm gear type actuators shall be furnished on all 4” or larger valves where the maximum unseating pressure is 25 PSIG or more.

I. Joints: All eccentric plug valves shall be Clow F-5412 (flanged), F-5413 (mechanical joint), or F-5414 (grooved) or approved equal.

J. Tolerance: Actual length of valves shall be within plus or minus 1/16 inch [1.6 mm] of the theoretical length.

K. Operating Mechanism

1. Unless otherwise specified, the basic operating mechanism for each valve shall be of the traveling-nut type and shall consist of (1) a traveling crosshead which will move transversely to the valve shaft, (2) a threaded
lead screw engaging corresponding threads in the crosshead, which will move the crosshead when turned by the valve drive unit for manual or electric motor operated valves, and a piston rod with the crosshead directly attached thereto for cylinder operated valves, and (3) a rotator lever, linked to the crosshead, which will impart a rotary motion to the valve shaft. Worm gear type operating mechanisms will be acceptable for electric motor operated valves.

2.03 VALVE ACTUATORS

A. Requirements for valve actuators shall be as specified herein, as indicated in the AWWA resilient seated eccentric plug valve Schedule, and as specified in the Valve and Gate Actuators section.

2.04 SHOP PAINTING

A. All interior and exterior ferrous metal surfaces of valves and accessories shall be shop painted for corrosion protection. The valve manufacturer’s standard coating will be acceptable, provided it is functionally equivalent to the specified coating and is compatible with the specified field painting.

B. Surfaces shall be painted as follows:

Unfinished Surfaces

<table>
<thead>
<tr>
<th>Interior Surfaces</th>
<th>Fusion Bonded Epoxy.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exterior Surfaces of Valves to be Buried or Installed in Manholes or Valve Vaults.</td>
<td>Polyurethane</td>
</tr>
<tr>
<td>Exterior Surfaces of Valves to be Submerged</td>
<td>Polyurethane</td>
</tr>
<tr>
<td>Exterior Surfaces of All Other Valves</td>
<td>Universal primer.</td>
</tr>
</tbody>
</table>

Polished or Machined Surfaces

<table>
<thead>
<tr>
<th>Flange Faces</th>
<th>Rust-preventive compound.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Other Surfaces</td>
<td>Epoxy.</td>
</tr>
</tbody>
</table>

C. Interior epoxy coatings shall comply with ANSI/AWWA C550 and shall be free of holidays. The total dry film thickness of shop-applied coatings shall be not less than:

<table>
<thead>
<tr>
<th>Type of Coating Minimum</th>
<th>Dry Film Thickness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Epoxy</td>
<td>10 mils</td>
</tr>
<tr>
<td>Universal Primer</td>
<td>3 mils</td>
</tr>
</tbody>
</table>
2.05 ACCESSORIES

A. Requirements for extension stems and stem guides; position indicators; floor boxes; and operating stands shall be as indicated in the AWWA Resilient seated eccentric plug valve Schedule and as indicated on the Drawings and as specified in the Valve and Gate Actuators section.

2.06 VALVE MANUFACTURER

A. Resilient seated eccentric plug valves specified under this section shall be as manufactured by:

1. GA Industries,
2. DeZURIK, or
3. Pratt.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Valves shall be installed in accordance with the Valve Installation section.

B. Installation Check. An experienced, competent, and authorized representative of the manufacturer shall visit the site of the Work and inspect, check, adjust if necessary, and approve the equipment installation. The representative shall be present when the equipment is placed in operation in accordance with the Startup Requirements section and shall revisit the job site as often as necessary until all trouble is corrected and the equipment installation and operation are satisfactory in the opinion of Engineer.

C. The manufacturer's representative shall furnish a written report certifying that the equipment has been properly installed and lubricated; is in accurate alignment; is free from any undue stress imposed by connecting piping or anchor bolts; and has been operated under full load conditions and that it operated satisfactorily.

D. All costs for these services shall be included in the contract price.

END OF SECTION
SECTION 15111
SWING CHECK VALVES

PART 1 - GENERAL

1.01 SECTION INCLUDES
A. Swing check valves.

1.02 MEASUREMENT AND PAYMENT
A. No separate payment will be made for work required under this section. Contractor shall include all costs of the requirements of this section in the appropriate bid item(s) on the bid form.

1.03 REFERENCES
B. AWWA C508 - Check Valves.
D. ASTM A395 - Ductile Iron Castings.
E. ASTM A48 - Gray Iron Castings.
F. ASTM A193 - Alloy-Steel and Stainless Steel Bolting Materials for High Temperature Service.

1.04 QUALITY ASSURANCE
A. Manufacturer's Qualifications:
   1. Valves and appurtenances provided under this Section shall be the standard product in regular production by manufacturers whose products have proven reliable in similar service for at least 5 years.
   2. Insofar as possible all valves of the same specific type shall be the product of one manufacturer.

1.05 SUBMITTALS
A. Submit shop drawings and product data.
   Shop Drawings: Submit for review, detailed drawings, data and descriptive literature on valves and appurtenances, including:
   1. Dimensions.
   2. Size.
4. Weight.
5. Protective coating.
6. Actuator weight, where applicable.
7. Calculations for actuator torque, where applicable.
8. Wiring diagram, where applicable.

B. Submit manufacturer’s certificates of compliance with ANSI, AWWA and other listed standards.

1.06 OPERATION AND MAINTENANCE DATA
A. Submit a detailed operation and maintenance manual for valves and appurtenances provided under this Section.

1.07 DELIVERY, STORAGE AND HANDLING
A. Have products delivered, stored and protected. Store valves and appurtenances off the ground in enclosed shelter.

PART 2 - PRODUCTS

2.01 BASIC REQUIREMENTS
A. Mark and identify valves in conformance with standards, these Specifications or to the manufacturer’s standard.
B. Bolts, studs and nuts to be Type 316 stainless steel.
C. End connections of valves shall be flanged and drilled to ANSI Class 125 unless otherwise specified.
D. To exterior surfaces of valves, apply a shop coating in accordance with Section 09901 – Protective Coatings, system 100 or 103, 12 mils DFT.

2.02 CHECK VALVES
A. Swing check valves 4-inches through 14-inches having a system pressure 30-psi or less shall be air cushioned with side mount lever and weight. The valve shaft shall extend through both sides of the body with minimum shaft diameters equal to APCO Series 6000. The cushion shall be totally enclosed, swivel mounted at the bottom, and equipped with a micrometer air control valve and air breather filters. Valves shall be APCO Series 6000, Pratt - CCNE Series 8500 (Pneumatic), GA Industries 250-D, or equal.
B. Swing check valves 10-inches through 14-inches having a system pressure greater than 30 psi shall be oil cushioned with side mount lever and weight. Valves shall be similar to APCO Series 6100, Pratt - CCNE Series 9000 (Oil Cushioned), or equal.
C. Swing check valves 16-inches and larger regardless of system operating pressure shall be oil cushioned with side mount lever and weight. Valves shall be similar to APCO Series 6100, Pratt - CCNE Series 9000 (Oil Cushioned), GA Industries 250-DOC, or equal.

D. Check valves of special design utilizing controlled closing of the disc, such as APCO Series 6000B (Bottom-Buffer), GA Industries Fig. #25-DXH, Pratt - CCNE Series 9000 (Decelerator), or equal, shall be used when specifically indicated on the Drawings. These valves are special valves used to control the surge pressure in the force main upon multiple pump shutdown during a power failure. Other surge control check valves utilizing ball or cone valve and power cylinder operator may also be used as approved by the Engineer.

E. All check valves shall have 316 series stainless steel hinge shafts, 316 stainless steel body seats and 316 stainless steel resilient seat retainer rings.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install valves and specialties in accordance with manufacturer's written instructions to permit intended performance.

B. Support and anchor valves in accordance with Section 15140 - Pipe Hangars, Supports and Restraints.

3.02 PAINTING

A. Paint valves and specialties in accordance with applicable AWWA standards and with Section 09901 - Protective Coatings, system 100 or 103, 12 mils DFT.

3.03 TESTING

A. Test valves using a hydrostatic pressure test in accordance with AWWA C-600.

B. Test valves and specialties in place. Correct defects in valves, specialties or connections.

END OF SECTION
SECTION 15140
PIPE HANGERS, SUPPORTS, AND RESTRAINTS

PART 1 - GENERAL

1.01 SECTION INCLUDES
   A. Pipe and equipment hangers, supports, and associated anchors.
   B. Equipment bases and supports.
   C. Sleeves and seals.

1.02 MEASUREMENT AND PAYMENT
   A. No Separate Payment will be made for work required under this section. Contractor shall include the cost for this work with appropriate items included in the bid form.

1.03 REFERENCES

1.04 SUBMITTALS
   A. As a minimum, submit the following items:
      1. A layout of the systems including location on fixed and movable joints.
      2. Details of design and fabrication of joints.
      3. Details of support brackets, cradles, pads, thrust resisting elements, and other supporting elements.
      4. Other pertinent elements necessary for a complete installation.
      5. Design calculations for submitted items.

PART 2 - PRODUCTS

2.01 HANGERS AND SUPPORTS
   A. For uninsulated lines 2 inches and less and for drainage and downspout lines provide hangers, which are adjustable swivel ring type fabricated of malleable iron.
   B. For uninsulated lines larger than 2 inches and for insulated lines, except drainage and downspout piping, provide adjustable clevis type hangers. Size hangers to allow insulation to extend unbroken through the hanger.
   C. Fabricate hangers installed in valve vaults, wet wells, and other below grade areas of cadmium plated or stainless steel.
2.02 INSERTS

A. Make inserts for individual hangers of galvanized malleable iron; include removable nuts held in place by V-type teeth on the insert body and nut. Make continuous-slotted channel inserts of galvanized steel with integral anchors at 6-inch centers. Provide factory finished steel Snap-On cover plates on channel inserts between support attachments.

2.03 EXPANSION BOLTS

A. Use expansion bolts for support which are stainless steel wedge type. Do not use expansion bolt anchors with lead.

2.04 PIPE SADDLES

A. Fabricate pipe saddles of hot dip galvanized steel. Saddles for supporting pipe from the floor shall be at least 9 inches in length and as wide as the outside diameter of the pipe. Make a bearing support of 120 degrees. Mount saddles on concrete pads at least 2-inches high.

2.05 FRAMING HANGERS

A. Use factory fabricated metal framing systems with factory applied primer paint as framing for wall type hangers, trapeze hangers, and tunnel stanchions. Attach supports to structures with inserts for new concrete, with surface mounting methods for masonry or existing concrete, and with welding or clamps for structural steel. Make pipe supports fabricated on the site of structural steel members with raw edges ground and dressed. Rest floor supports in areas with uncovered concrete floors on concrete pads not less than 2 inches high.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Hang piping inside structures supported from the floor or racked adjacent to walls.

B. Provide inserts cast in concrete walls or slabs for hanging and supporting pipe. If materials not galvanized or cadmium plated, paint them with primer before installation.

C. Design, fabricate, and install support components in general conformance with Sections 120 and 121 of ANSI B31.1, Power Piping, except as modified in this Section.
3.02 PIPE HANGERS AND SUPPORTS

A. Support, brace, and anchor interior piping to prevent movement in any direction because of pressure, temperature, flow, or water hammer, except at properly located expansion joints and fittings.

B. Provide two pipe guides on each side of expansion joints at which pipe movement occurs. The first guide shall be not more than 4-pipe diameters from the joint and the second not more than 14 diameters. Provide additional guides as required to maintain pipe alignment, spaced as required for the pipe size, fluid pressure and temperature inside the pipe, and as recommended by the expansion joint manufacturer or as shown.

C. Maximum support spacing and hanger rod sizes for metal pipe containing liquids are as follows:

<table>
<thead>
<tr>
<th>Nominal Pipe Size (Inches)</th>
<th>Support Spacing (Feet)</th>
<th>Rod Diameter in Inches One Rod</th>
<th>Two Rods</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 and Smaller</td>
<td>7</td>
<td>3/8</td>
<td>3/8</td>
</tr>
<tr>
<td>1-1/4 and 1-1/2</td>
<td>8</td>
<td>3/8</td>
<td>3/8</td>
</tr>
<tr>
<td>2</td>
<td>10</td>
<td>3/8</td>
<td>3/8</td>
</tr>
<tr>
<td>2-1/2</td>
<td>11</td>
<td>1/2</td>
<td>3/8</td>
</tr>
<tr>
<td>3</td>
<td>12</td>
<td>1/2</td>
<td>3/8</td>
</tr>
<tr>
<td>4 and 5</td>
<td>14</td>
<td>1/2</td>
<td>3/8</td>
</tr>
<tr>
<td>6 and 8</td>
<td>17</td>
<td>1/2</td>
<td>3/8</td>
</tr>
<tr>
<td>10</td>
<td>17</td>
<td>5/8</td>
<td>1/2</td>
</tr>
<tr>
<td>12</td>
<td>17</td>
<td>3/4</td>
<td>1/2</td>
</tr>
<tr>
<td>14</td>
<td>17</td>
<td>3/4</td>
<td>5/8</td>
</tr>
<tr>
<td>16</td>
<td>17</td>
<td>7/8</td>
<td>5/8</td>
</tr>
<tr>
<td>18 and 20</td>
<td>17</td>
<td>1-1/8</td>
<td>3/4</td>
</tr>
<tr>
<td>24</td>
<td>17</td>
<td>1-1/8</td>
<td>7/8</td>
</tr>
</tbody>
</table>

D. For valves 4 inches and larger in unburied horizontal lines support the valve on both sides when located within 18 inches of the valve or meter. Provide additional supports where required so that piping loads do not place damaging stresses on supports, valves, and equipment. Where necessary, block up pipe at supports to permit installation of insulation.

E. Support unburied horizontal runs of rubber hose and non-metallic pipe for the entire length by means of troughs consisting of structural steel channels or angles supported at not more than 10-foot intervals.

F. Support piping not included in the foregoing tabulation as indicated or in accordance with the pipe manufacturer's recommendations, if not indicated.
G. Anchor buried pressure pipe at each fitting causing a change in direction of 10 degrees or more. Concrete thrust blocks or other restraining devices in any satisfactory combination may be used. Submit the details of the method proposed for use, together with design calculations, to the Engineer before installation.

END OF SECTION
PART 1 - GENERAL

1.01 MATERIALS

A. Grooved Pipe, grooved couplings, grooved fittings, grooved valves, grooved specialties and tooling shall be coordinated by the Contractor.

1.02 SUBMITTALS

A. Grooved pipe, couplings, grooved fittings, grooved valves, and grooved specialties products shall be as shown on the Plans and product submittals and shall be specifically identified with the applicable style or series number.

1.03 REFERENCES

A. ASTM A-53 – Pipe, Steel, Black and Hot-Dipped Zinc Coated, Welded and Seamless.
B. ASTM A-183 – Carbon Steel Track Bolts and Nuts
D. ASTM A-449 – Quenched and Tempered Steel Bolts and Studs
E. ASTM A-536 – Ductile Iron Castings
F. ASTM F-1476 - Standard Specification for Performance of Gasketed Mechanical Couplings for Use in Piping Applications
G. ASME B16.9 – Factory Made Wrought Butt-Welded Fittings
H. ASME B31.1 – Chemical Plant and Petroleum Refining Piping
I. ASME B31.9 – Building Services Piping
J. AWWA C-606 – Grooved and Shouldered Joints

1.04 QUALITY ASSURANCE

A. To assure uniformity and compatibility of piping components in grooved end piping systems shall be integrated coordinated with all grooved products utilized supplied by the manufacturer of the grooved components.

PART 2 - MATERIALS

2.01 GENERAL

A. Pipe/Grooved (Standard/Light Wall): Carbon Steel, A-53B/A-106B - Roll or cut grooved-ends as appropriate to pipe material, wall thickness, pressures, size and...
method of joining. Pipe ends to be grooved in accordance with Victaulic current listed standards conforming to ANSI/AWWA C-606.

2.02 MECHANICAL COUPLINGS FOR JOINING CARBON STEEL PIPE

A. Standard Mechanical Couplings, 2 inch (DN50) through 12 inch (DN300):
Manufactured in two segments of cast ductile iron, conforming to ASTM A-536, Grade 65-45-12. Gaskets shall be pressure- responsive synthetic rubber, grade to suit the intended service, conforming to ASTM D-2000. (Gaskets used for potable water applications shall be UL classified in accordance with ANSI/NSF-61 for potable water service.) Mechanical Coupling bolts shall be zinc plated (ASTM B-633) heat treated carbon steel track head conforming to ASTM A-449 and ASTM A-183, minimum tensile strength 110,000 psi (758450 kPa).

1. Rigid Type: Coupling housings with offsetting, angle-pattern bolt pads shall be used to provide system rigidity and support and hanging in accordance with ANSI B31.1, B31.9, and NFPA 13.

   a. 2 inch (DN50) through 8 inch (DN200): Victaulic Style 107H (Quick-Vic™). Installation ready rigid coupling for direct stab installation without field disassembly. Gasket shall be Grade “EHP” EPDM compound with red color code designed for operating temperatures from -30 deg F (-34 deg C) to +250 deg F (+120 deg C).

   b. 10” (DN250) through 12” (DN300): Victaulic Style 07 (Zero- Flex®). Standard rigid coupling. Gasket shall be Grade “E” EPDM compound with green color code designed for operating temperatures from -30 deg F (-34 deg C) to +230 deg F (+110 deg C).

2. Flexible Type: Use in locations where vibration attenuation and stress relief are required. Flexible couplings may be used in lieu of flexible connectors at equipment connections. Three couplings, for each connector, shall be placed in close proximity to the vibration source.

   a. 2 inch (DN50) through 8 inch (DN200): Victaulic Style 177 (Quick-Vic™). Installation ready flexible coupling for direct stab installation without field disassembly. Gasket shall be Grade “EHP” EPDM compound with red color code designed for operating temperatures from -30 deg F (-34 deg C) to +250 deg F (+120 deg C).

   b. 10 inch (DN250) through 12 inch (DN300): Victaulic Style 75 or 77 standard flexible couplings. Gasket shall be Grade “E” EPDM compound with green color code designed for operating temperatures from -30 deg F (-34 deg C) to +230 deg F (+110 deg C).

3. Flange Adapters: For use with grooved end pipe and fittings, flat faced, for mating to ANSI Class 125 / 150 flanges use Victaulic Style 741 or approved equal. For direct connection to ANSI Class 300 flanges use Victaulic Style 743 or approved equal.

4. Grooved couplings shall meet the requirements of ASTM F-1476.

5. Gasket: Synthetic rubber conforming to steel pipe outside diameter and coupling housing, manufactured of elastomers as designated in ASTM D-2000.
a. Reference shall always be made to the latest published Selection Guide for Victaulic Gaskets or approved equal for proper gasket selection for the intended service.

6. Mechanical Couplings, 14 inch (DN350) through 24 inch (DN1500): Couplings shall consist of two ASTM A-536 ductile iron housing segments, a wide elastomer pressure responsive gasket, and zinc electroplated carbon steel track head bolts and nuts conforming to the physical and chemical requirements of ASTM A-449 and the physical requirements of ASTM A-183. Couplings consist of ductile iron housings conforming to ASTM A536, Grade 65-45-12, ASTM D2000 elastomer gasket, and ASTM A449 compliant bolts with ASTM A563 nuts. Coupling provided with AGS-grooved Vic-Rings (ASTM A105 or GB20 carbon steel) for external mounting on the pipe. Basis of Design: Victaulic Style W07 (rigid) and Style W77 (flexible) or approved equal.


8. Reference shall always be made to the latest published selection guide for gaskets for proper gasket selection for the intended service.

   a. Coupling housings designed with the wedge-shaped key profile to engage the mating pipe(s)/component(s) wedge-shaped grooves. Housings include lead-in chamfer to accommodate a wider acceptable range of initial pipe positions. Housings shall be coated with orange enamel or galvanized.

   b. Gasket: Wide width, pressure-responsive, synthetic rubber of a FlushSeal® design or equal, conforming to steel pipe outside diameter and coupling housing, manufactured of elastomers as designated in ASTM D-2000.

      1) Grade “E” EPDM with green color code designed for operating temperatures from -30 deg F (-34 deg C) to +230 deg F (+110 deg C).

      2) Grade “T” Nitrile with orange color code designed for operating temperatures from -20 deg F (-29 deg C) to +180 deg F (+82 deg C).

      3) Grade “L” Silicone with red color code designed for operating temperatures of -30 deg F (-34 deg C) to +350 deg F (+177 deg C); recommended for dry heat service (air without hydrocarbons).

      4) Reference shall always be made to the latest published Selection Guide for Victaulic Gaskets for proper gasket selection for the intended service.

   c. Coupling Types:
1) Rigid Coupling: Coupling key shall be designed to fill the wedge-shaped groove to provide a rigid joint that corresponds with support spacing as defined by ASME B31.1 and B31.9. Systems incorporating rigid couplings require the calculated thermal growth/contraction of the piping system to be fully compensated for in the design of the piping system through use of adequate flexible components. Rigid Coupling shall be Victaulic W07 AGS or equal.

2) Flexible Coupling: Coupling key shall be designed to fit into the wedge shaped AGS groove and allow for linear and angular movement, vibration attenuation, and stress relief. Support requirements defined by Victaulic Design Data Submittal 26.01. Flexible Coupling shall be Victaulic W77 AGS or equal.

3) Flange Adapter 14 inch (DN350) to 24 inch (DN600): For use with AGS grooved end pipe and fittings, flat faced, for mating to ANSI Class 125 / 150 flanges. Flange Adapter shall be Victaulic Style W741 or equal.

4) Transition from Ductile Iron Pipe to Aluminum Pipe shall be Victaulic Style 307.

5) Differential Settlement Section: Coupling key shall be designed to fit into the wedge shaped AGS groove and allow for linear and angular movement, vibration attenuation, and stress relief. Spacing requirements defined by Victaulic Design Data Submittal 09.07. Differential Settlement Section shall be Victaulic Style 257, Victaulic Design Data Submittal 23.17 Differential Settlement Section shall be Victaulic Style 257C, or equal.

2.03 GROOVED END FITTINGS

A. Standard fittings shall be cast of ductile iron conforming to ASTM A-536, Grade 65-45-12, forged steel conforming to ASTM A-234, Grade WPB 0.375-inch wall (9.53 mm wall), or fabricated from Std. Wt. Carbon Steel pipe conforming to ASTM A-53, Type F, E or S, Grade B. Fittings provided with an alkyd enamel finish or hot dip galvanized to ASTM A-153. Zinc electroplated fittings and couplings conform to ASTM B633.

B. Fittings shall be supplied with factory grooved ends, for use with couplings and flange adapter. Fittings shall be manufactured of ductile iron conforming to ASTM A-536, forged carbon steel conforming to ASTM A-234, or factory fabricated from carbon steel pipe conforming to ASTM A-53. Fittings shall be manufactured to the dimensional standards ASME B16.9. Orange enamel coated or galvanized.

C. Hole-Cut Branch Outlets:

1. Bolted Branch Outlet: Branch reductions on 2"(DN50) through 8"(DN200) header piping. Bolted branch outlets shall be manufactured from ductile iron conforming to ASTM A-536, Grade 65-45-12, with synthetic rubber gasket, and heat-treated carbon steel zinc plated bolts and nuts conforming to physical properties of ASTM A-183. Victaulic Style 920 / 920N or equal.
2. Strapless Outlet: ½-inch (DN15) or ¾-inch (DN20) NPT outlet on 4-inch (DN100) and larger header sizes rated for 300 PSI (2065 kPa). Victaulic Style 923 or equal.

3. Strapless Thermometer Outlet: To accommodate industrial glass bulb thermometers with standard 1-1/4 inch-18 NEF 2B extra fine thread and 6 inch (152mm) nominal bulb length on 4” (DN100) and larger header sizes rated for 300 PSI (2065 kPa).

2.04 GROOVED END VALVES

A. All grooved end valves shall meet the respective requirements for the type of valves as specified in the Section of these Specifications.

2.05 VICTUALIC GROOVED END SPECIALTIES

A. Expansion Joints:

1. 2-inch (DN50) through 6-inch (DN150) Sizes: Packless, gasketed, type with grooved end telescoping body, suitable for axial end movement to 3-inch, 350 psi (2410 kPa). Victaulic Style 150 Mover® or equal.

2. ¾-inch (DN20) and Larger Sizes: Expansion joint consisting of a series of grooved end nipples joined with flexible-type couplings. Joint movement and expansion capabilities determined by number of couplings / nipples used in the joint. Victaulic Style 155 or equal.

3. Dielectric Waterways: 1-inch (DN25) through 8-inch (DN200) sizes, grooved, plain end, or threaded end, ASTM A-53 carbon steel or ASTM A-536 ductile iron body, zinc electroplated, with LTHS high temperature stabilized polyolefin polymer liner. Victaulic Style 47 or equal.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Pipe ends shall be clean and free from indentations, projections and roll marks in the area from pipe end to groove for proper gasket sealing.

B. The gasket style and elastomeric material (grade) shall be verified as suitable for the intended service as specified.

C. Install the grooved piping system in accordance with the latest manufacture’s installation instructions.

D. If Victaulic AGS products are used, they shall not be installed with standard grooved end pipe or components. (Installing AGS products in combination with standard grooved end products could result in joint separation and/or leakage.)

E. Couplings installation shall be complete when visual metal-to-metal contact is reached.
3.02 TRAINING

A. A grooved coupling factory trained representative (direct employee) shall provide on-site training for contractor’s field personnel in the use of grooving tools, application of groove, and product installation.

3.03 APPLICATION

A. A grooved coupling manufacturer’s representative shall periodically visit the job site and review installation. Contractor shall remove and replace any improperly installed products.

B. Grooved mechanical pipe couplings, fittings, valves and other grooved components may be used as an option to weld, thread or flanged methods.

C. All grooved components shall conform to local code approval and/or as listed by ANSI-B-31.1, B-31.3, B-31.9, ASME, UL/ULC, FM, IAPMO or BOCA.

D. Grooved end product manufacturer to be ISO-9001 certified.

END OF SECTION
PART 1 - GENERAL

1.01 SCOPE OF WORK

A. Furnish all labor, materials and equipment required to install, test and provide an operational, electrical system as specified and as shown on the Drawings.

B. All equipment described herein shall be submitted and furnished as an integral part of equipment specified elsewhere in these Specifications.

C. All electrical work provided under any Division of the Specifications shall fully comply with the requirements of Division 16.

D. The work shall include furnishing, installing and testing the equipment and materials detailed in each Section of Division 16.

E. The work shall include furnishing and installing the following:

1. Electrical service from Southwest Rural Electric Association, Inc.

2. Provide a complete raceway system, wire and field connections for all motors, motor controllers, control devices, control panels and electrical equipment furnished under other Divisions. Coordinate construction schedule and electrical interface with the supplier of electrical equipment specified under other Divisions as required by the Contract Documents.

3. Provide a complete raceway system, wiring and terminations for all field-mounted instruments furnished and mounted under other Divisions, including process instrumentation primary elements, transmitters, local indicators and control panels. Lightning and surge protection equipment wiring at process instrumentation transmitters. Install vendor furnished cables specified under other Divisions as required by the Contract Documents.

4. Provide a complete raceway system for the Data Cables and specialty cable systems, including those furnished under other Divisions. Install the Data Cables and other specialty cable systems, in accordance with the system manufacturers' installation instructions. Review the raceway layout, prior to installation, with the Process Control System supplier and the cable manufacturer to ensure raceway compatibility with the systems and materials being furnished. Where redundant cables are furnished, install the cables in separate raceways as required by the Contract Documents.

5. Furnish and install precast electrical and instrumentation manholes, hand holes and light pole foundations as required by the Contract Documents. Pole foundations shall be designed and installed in accordance with the structural Divisions of these Specifications.

F. Provide all tools, equipment, supplies, and shall perform all labor required to install the equipment specified in the Contract Documents to install, test, and place into satisfactory
operation in the time specified for completion in the Contract Documents. Failure of any of the participants in executing the requirements of this Contract to perform the work as specified shall not constitute an acceptable reason for the Owner to grant any change in the Contract Price or additions to the Contract Time.

1.02 ELECTRICAL WORK REQUIRED IN OTHER DIVISIONS

A. No references are made to any other section which may contain work related to any other section. The Contract Documents, which is defined to include both the Drawings and the Specifications, shall be taken with every section related to every other section as required to meet the requirements specified. The organization of the Contract Documents into specification divisions and sections is for organization of the documents themselves and does not relate to the division of suppliers or labor which the Contractor may choose to employ in the execution of the Contract. Where references are made to other Sections and other Divisions of the Specifications, provide such information or additional work as may be required in those references, and include such information or work as may be specified. Examine all Sections of the Specifications and Drawings and determine the power and wiring requirements and provide external wiring and raceways, as required to provide a fully functioning power, control and process control systems. If the equipment requires more conductors and/or wiring, due to different equipment being supplied, provide the additional conductors, raceways and/or wiring, and include in the Contract Price and Schedule.

B. Process Divisions

1. Examine all Process Equipment Specifications and Drawings, determining power and wiring requirements. Provide external wiring and raceways, as required to provide a fully functioning Process Control System. If the equipment requires more conductors and/or wiring, due to different equipment being supplied, furnish the additional conductors, raceways and/or wiring, with no change in Contract Price or Schedule.

C. Mechanical Divisions

1. Examine all Mechanical Equipment Specifications and Drawings, determining power and wiring requirements. Provide external wiring and raceways, as required to provide fully functioning Mechanical Equipment Control Systems. If the equipment requires more conductors and/or wiring, due to different equipment being supplied, furnish the additional conductors, raceways and/or wiring with no change in Contract Price or Schedule.

D. Electric Valve Operator Divisions

1. Examine all Electric Valve Operator Equipment Specifications and Drawings, determining power and wiring requirements. Provide external wiring and raceways, as required to provide a fully functioning Electric Valve Operator Control System. If the equipment requires more conductors and/or wiring due to different equipment being supplied, furnish the additional conductors, raceways and/or wiring with no change in Contract Price or Schedule.

1.03 SUBMITTALS

Dundee State Fish Hatchery Water Reuse – Effluent Pump Back
TPWD No. 1110061
A. Submit Shop Drawings, in accordance with Division 1 requirements, for equipment, materials and all other items furnished under each Section of Division 16, except where specifically stated otherwise. An individually packaged submittal shall be made for each Section and shall contain all the information required by the Section. Partial submittals will not be accepted and will be returned without review.

B. Submittals will not be accepted for Section 16000.

C. Each Section submittal shall be complete, contain all the items listed in the Specification Section, and shall be clearly marked to indicate which items are applicable on each cut sheet page. The Submittal shall list any exceptions to the Specifications and Drawings, and the reason for such deviation. Shop drawings, not so checked and noted, will be returned without review.

D. Check shop drawings for accuracy and contract requirements prior to submittal to the Owner/Engineer. Errors and omissions on approved shop drawings shall not provide relief from the responsibility of providing materials and workmanship required by the Specifications and Drawings. Shop drawings shall be stamped with the date checked and a statement indicating that the shop drawings conform to Specifications and Drawings. Only one Specification Section may be made per transmittal.

E. Material shall not be ordered or shipped until the shop drawings have been approved. No material shall be ordered, or shop work started if the related shop drawings are marked "APPROVED AS NOTED CONFIRM", "APPROVED AS NOTED RESUBMIT", "REVISE AND RESUBMIT", "REJECTED", or "NOT APPROVED".

F. All approved shop drawings shall be maintained on site for the Owner’s Inspector and for the Owner’s Engineer to verify at the time of delivery of equipment to the job site.

G. Up-to-date Record Drawings shall be promptly furnished when the equipment installation is complete. Payment will be withheld until Record Drawings have been furnished and approved.

H. All shop drawing submittals and all O&M submittals shall be submitted in hard copy format and in electronic format using PDF files including a Table of Contents which is indexed on DVDs. Electronic submittals are mandatory and those which are received not indexed as specified will be returned without review. Hard copy submittals may not be required if so stipulated in the Contract Documents. No change in Contract Amount or Contract Time will be allowed for delays due to unacceptable submittals.

1.04 REFERENCE CODES AND STANDARDS

A. Electric equipment, materials and installation shall comply with the National Electrical Code (NEC) and with the latest edition of the following codes and standards:

1. National Electrical Safety Code (NESC)
2. Occupational Safety and Health Administration (OSHA)
3. National Fire Protection Association (NFPA)
4. National Electrical Manufacturers Association (NEMA)
5. American National Standards Institute (ANSI)
6. Insulated Cable Engineers Association (ICEA)
7. International Society of Automation (ISA)
8. Underwriters Laboratories (UL)
9. Factory Mutual (FM)

B. Where reference is made to one of the above standards, the revision in effect at the time of bid opening shall apply.

C. All material and equipment, for which a UL standard exists, shall bear a UL label. No such material or equipment shall be brought onsite without the UL label affixed.

D. If the issue of priority is due to a conflict or discrepancy between the provisions of the Contract Documents and any referenced standard, or code of any technical society, organization or association, the provisions of the Contract Documents will take precedence if they are more stringent. If there is any conflict or discrepancy between standard specifications, or codes of any technical society, organization or association, or between Laws and Regulations, the higher performance requirement shall be binding, unless otherwise directed by the Owner/Engineer.

E. In accordance with the intent of the Contract Documents, compliance with the priority order specified shall not justify an increase in Contract Price or an extension in Contract Time nor limit in any way, full compliance with all Laws and Regulations at all times,

1.05 SERVICE AND METERING

A. The power company serving this project is Southwest Rural Electric Association, Inc. Service shall be obtained at 480Y/277 volts, 3 phase, 4 wire, 60 Hz from an overhead line and pole mounted transformer bank furnished and installed by Southwest Rural Electric Association, Inc.

B. The power company will. be responsible for the following work:

1. Furnishing and installing the primary overhead conductors and pole line.
2. Furnishing and installing pole-mounted transformers.
3. Furnishing metering current transformers (CTs), meter and meter wiring.
4. Furnishing meter base and enclosure.
5. Furnishing overhead service lateral conductors and support messenger from utility service pole to service entrance weather-head.

C. Include the following work in the Contract Price and Schedule:

1. Furnish and install a power company approved metering current transformer enclosure.
2. Furnish and Install power company approved meter base.
3. Coordinate the electrical service installation with the Power Company.

1.06 HAZARDOUS AREAS

A. Equipment, materials and installation in areas designated as hazardous on the Drawings shall comply with NEC Articles 500, 501, 502 and 503.

B. Equipment and materials installed in hazardous areas shall be UL listed for the appropriate hazardous area classification.

1.07 CODES, INSPECTION AND FEES

A. Equipment, materials and installation shall comply with the requirements of the local authority having jurisdiction.

B. Obtain all necessary permits and pay all fees required for permits and inspections.

C. The Owner will negotiate with the electric utility for the costs of new or revised services and will include in the Contract Documents an allowance item to cover the cost. Include in the Contract Price and Schedule the time and expense to make all arrangements with the power company and coordinate with the power company to obtain electrical service. The cost of all power company charges shall be included in the Contract Price. Provide all labor and material required for electrical service.

1.08 SIZE OF EQUIPMENT

A. Investigate each space in the structure through which equipment must pass to reach its final location. Coordinate shipping splits with the manufacturer to permit safe handling and passage through restricted areas in the structure.

B. The equipment shall be kept upright at all times during storage and handling. When equipment must be tilted for passage through restricted areas, brace the equipment to ensure that the tilting does not impair the functional integrity of the equipment.

1.09 RECORD DRAWINGS

A. As the work progresses, legibly record all field changes on a set of Project Contract Drawings, hereinafter called the "Record Drawings". The Record Drawings and Specifications shall be kept up to date throughout the project.

B. The Record Drawings shall be reviewed in a meeting with the Owner/Engineer monthly.

C. Record Drawings shall accurately show the installed condition of the following items:
   1. One-line Diagram(s).
   2. Raceways and pull boxes.
   3. Conductor sizes and conduit fills.
4. Panel Schedule(s).
5. Control Wiring Diagram(s).
6. Lighting Fixture Schedule(s).
7. Lighting fixture, receptacle and switch outlet locations.
8. Underground raceway and duct bank routing. The drawings shall include the measured width and height of the ductbank and shall survey the elevation of the top of the duct bank or record its depth of burial below grade at intervals not to exceed 50 feet along the entire length. Changes in direction between termination points shall be surveyed and recorded on the record drawings.
9. Planview and locations of switchgear, distribution transformers, substations, motor control centers and panelboards.
10. Modifications to controls systems or any piece of electrical equipment including field-verified existing controls and all changes clearly identified.
11. All protective device and electrical system monitoring device settings.

D. Submit a typical example of a schedule of control wiring raceways and wire numbers, including the following information:
1. Circuit origin, destination and wire numbers.
2. Field wiring terminal strip names and numbers.

E. Submit the record drawings and the schedule of control wiring raceways and wire numbers (or the point-to-point connection diagram) to the Owner/Engineer.

F. Retainage will not be paid until the point-to-point connection diagrams have been furnished to the Owner/Engineer.

1.10 EQUIPMENT INTERCONNECTIONS

A. Review shop drawings of equipment furnished under other related Divisions and prepare coordinated wiring interconnection diagrams or wiring tables. Submit copies of wiring diagrams or tables with Record Drawings.

B. Furnish and install all equipment interconnections.

1.11 MATERIALS AND EQUIPMENT

A. Materials and equipment shall be new, except where specifically identified on the Drawings to be re-used.

B. Material or equipment from a manufacturer, not submitted and approved for this project shall not be brought on site. Use of any such material or equipment, will be rejected, and shall be removed and replaced, with the approved material and equipment, with no change allowed in the Contract Price or Schedule.

C. Material and equipment shall be UL listed, where such listing exists.
D. All material, products, equipment and workmanship being furnished for the project shall be replaced if it does not meet the requirements of Contract Documents even if installed, with no change in Contract Price or Schedule.

1.12 JOBSITE DELIVERY, STORAGE AND HANDLING

A. Prior to jobsite delivery, successfully complete all submittal requirements, and present to the Owner/Engineer upon delivery of the equipment, an approved copy of all such submittals. Delivery of incomplete constructed equipment, or equipment which failed any factory tests, will be rejected and shall be removed and replaced with no change in Contract Price or Schedule.

B. Equipment and materials shall be handled and stored in accordance with the manufacturer’s instructions, and as specified in the individual Specification Sections.

1.13 WARRANTIES

A. Manufacturer's warranties shall be provided as specified in each of the Specification Sections.

1.14 EQUIPMENT IDENTIFICATION

A. Identify all equipment (disconnect switches, separately mounted motor starters, control stations, etc.) furnished under Division 16 with the name of the equipment it serves. Motor control centers, control panels, panelboards, switchboards, switchgear, junction or terminal boxes, transfer switches, etc., shall have nameplate designations as shown on the Drawings.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION

3.01 INTERPRETATION OF DRAWINGS

A. The Drawings do not show exact locations of conduit runs. Coordinate the conduit installation with other trades and the actual supplied equipment.

B. Install each three-phase circuit in a separate conduit unless otherwise shown on the Drawings.

C. Unless otherwise approved by the Owner/Engineer, conduit shown exposed shall be installed exposed; conduit shown concealed shall be installed concealed. Submit a Request for Information for any conduit route which is not clearly identified as concealed or exposed in the Contract Documents prior to its installation.

D. Circuits are shown as "home-runs" shall be field routed. The raceway system provided shall include all necessary fittings, supports and boxes for a complete code-compliant raceway installation. Field routed raceway shall avoid blocking access to equipment either existing or spaces planned for future equipment and shall avoid blocking personnel egress through doors or access hatches.
E. Verify the exact locations and mounting heights of lighting fixtures, switches and receptacles prior to installation.

F. Except where dimensions are shown, the locations of equipment, fixtures, outlets and similar devices shown on the Drawings are approximate only. Determine exact locations and obtain approval from the Owner/Engineer during construction. Obtain information relevant to the placing of electrical work and in case of any interference with other work, proceed as directed by the Owner/Engineer and furnish all labor and materials necessary to complete the work in an approved manner.

G. Circuit layouts are not intended to show the number of fittings, or other installation details. Furnish all labor and materials necessary to install and place in satisfactory operation all power, lighting and other electrical systems shown.

H. Redesign of electrical or mechanical work, which is required due to the use of a pre-approved alternate item shall include the arrangement of equipment and/or layout other than that which is specified or shown herein. All additional work and materials required shall be provided with no change in the contract price or schedule. Redesign and detailed plans shall be submitted to the Owner/Engineer for approval.

I. Raceways and conductors for lighting, switches, receptacles and other miscellaneous low voltage power and signal systems as specified are not shown on the Drawings. Raceways and conductors shall be provided as required for a complete and operating system. Refer to riser diagrams for signal system wiring. Homeruns, as shown on the Drawings, identify raceways to be run exposed and raceways to be run concealed. Raceways installed exposed shall be near the ceiling or along walls of the areas through which they pass and shall be routed to avoid conflicts with HVAC ducts, cranes hoists, monorails, equipment hatches, doors, windows, etc. Raceways installed concealed shall be run in the center of concrete floor slabs, above suspended ceilings, or in partitions as required.

J. Provide all conduit and conductors or data highway cables to RTU and/or PLC termination cabinets, where designated on the Drawings or otherwise required by the Specifications, the manufacture of the equipment, or submitted and approved systems. The conduit and conductors or data highway cables as shown on the interface drawings may not necessarily be shown on the floor plan.

K. Install conductors carrying low voltage signals (typically twisted shielded pair cables) in raceways totally separate from all other raceways containing power or 120-Volt control conductors. Do not combine conductors carrying low voltage signals in wireways without barriers or NEC code-compliant separation for their entire length in the wire way, and/or provide separate wireways to provide separation of the conductors. Low voltage signal conductors routed through manholes or hand holes shall be bundled and separated from other conductors.

L. Raceways and conductors for thermostats controlling HVAC unit heaters, exhaust fans and similar equipment are not shown on the Drawings. Provide raceways and conductors between the thermostats, the HVAC equipment and the motor starters for a complete and operating system. All raceways and power conductors shall be in
accordance with Division 16. Raceways shall be installed concealed in all finished space and may be installed concealed or exposed in process spaces. Refer to the HVAC drawings for the locations of the thermostats and controls.

M. Raceways and conductors for the fire alarm, sound and page party systems are not shown on the Drawings. Provide raceways and conductors as required by the system manufacturer for a complete and operating system. All raceways and power conductors shall be in accordance with Division 16. Raceways shall be installed concealed in all finished spaces and may be installed exposed or concealed in process spaces.

3.02 EQUIPMENT PADS AND SUPPORTS

A. Electrical equipment pads and supports, of concrete or steel including structural reinforcing and lighting pole foundations, are shown on the Structural Drawings.

B. Electrical equipment or raceways, shall not be attached to or supported from, sheet metal walls.

C. Electrical equipment pads shall be provided for all free-standing equipment. Dimensions shall be 3-inches high. With 3-inch extension from front of equipment for equipment mounted against the wall and 3-inch extension on front and rear sections when equipment is rear accessible.

3.03 SLEEVES AND FORMS FOR OPENINGS

A. Provide and place all sleeves for conduits penetrating floors, walls, partitions, etc. Locate all necessary slots for electrical work and form before concrete is poured.

B. Unless measurements are shown on the drawings, the locations for stubbing up and terminating concealed conduits which are shown on the drawings are approximate. Exact locations are required for stubbing-up and terminating concealed conduit. Obtain shop drawings and templates from equipment vendors or other subcontractors and locate the concealed conduit before the floor slab is poured.

C. Where setting drawings are not available in time to avoid delay in scheduled floor slab pours, the Owner/Engineer may allow the installations of such conduit to be exposed. Requests for this deviation must be submitted in writing. No change in Contract Price or Schedule for such change will be allowed.

D. Seal all openings, sleeves, penetration and slots as specified in Section 16110.

3.04 CUTTING AND PATCHING

A. Coordinate with Divisions 2 and 3 for cutting and patching.

B. Core drill holes in concrete floors and walls as required. Obtain written permission from the Owner/Engineer before core drilling any holes larger than two inches.

C. Schedule the installation of work to provide the minimum amount of cutting and patching.
D. Cutting or drilling holes for the installation of raceway through joists, beams, girders, columns or any other structural members is strictly prohibited. If a structural member is cut or drilled, restore the structural member to its previous condition in complete accordance with the instructions of the Structural Engineer, with no change in contract price or schedule regardless of the extent of the repairs required to restore the member to its previous condition.

E. Cut opening only large enough to allow easy installation of the conduit.

F. Patching shall be of the same kind and quality of material as was removed.

G. The completed patching work shall restore the surface to its original appearance or better.

H. Patching of waterproofed surfaces shall render the area of the patching completely waterproofed.

I. Remove rubble and excess patching materials from the premises.

J. Existing conduits are cut at the floor line of wall line, they shall be filled with grout of suitable patching material approved by the Structural Engineer.

3.05 INSTALLATION

A. Any work not installed according to the Drawings and this Section shall be subject to change as directed by the Owner/Engineer. No change in Contract Price or Schedule will be allowed for making these changes.

B. All dimensions shall be field verified at the job site and coordinated with the work of all other trades.

C. Electrical equipment shall always be protected against mechanical or water damage. Electrical equipment shall not be stored outdoors. Electrical equipment shall be stored in dry permanent shelters as required by each Specification Section. Do not install electrical equipment in its permanent location until structures are weather-tight. If any apparatus has been subject to possible injury by water, it shall be thoroughly dried out and tested as directed by the Owner/Engineer or shall be replaced with no change in Contract Price or Schedule, at the Owner/Engineer's discretion.

D. Equipment that has been damaged shall be replaced or repaired by the equipment manufacturer, at the Owner/Engineer's discretion.

E. Repaint any damage to the factory applied paint finish using touch-up paint furnished by the equipment manufacturer. If the metallic portion of the panel or section is damaged, the entire panel or section shall be replaced, at no additional cost to the Owner.

F. NEMA 3R, 4 or 4X enclosures shall not have raceways entering from the top if the enclosure is installed in a damp or wet area. Should raceways be installed entering the top, the enclosure shall be replaced and raceways re-routed to enter the side or bottom. Conductors, if installed, shall be removed and replaced. Correction of raceways
entering the top and conductor replacement shall be provided with no change in
Contract Price or Schedule.

G. Conduits exiting tray in airconditioned indoor electrical rooms will enter the top of
electrical enclosures. The location of these conduits shall be coordinated with the HVAC
duct vents such that cold air will not blow on the conduits causing condensation which
will enter the electrical enclosures. After installation, inspect the conduits while the
HVAC system is running to insure no condensation is forming and entering any electrical
enclosure. Re-direct the air flow if possible or re-route the conduits to avoid
condensation. Conductors in re-routed conduits shall be replaced, re-terminated.
retested and the operation of the equipment retested with no change in the Contract
Price or Schedule.

3.06 PHASE BALANCING

A. The Drawings do not attempt to balance the electrical loads across the phases. Circuits
on motor control centers and panelboards shall be field connected to result in evenly
balanced loads across all phases.

B. Field balancing of circuits shall not alter the conductor color coding requirements as
specified in Section 16120.

3.07 MANUFACTURER’S SERVICE

A. Provide manufacturer’s services for testing and start-up of the equipment as listed in
each individual Specification Section. All settings, including those settings and arc flash
labels required by the Power System Study, shall be made to the equipment and
approved by the Owner/Engineer prior to energizing of the equipment.

B. Testing and startup shall not be combined with training. Testing and start-up time shall
not be used for manufacturer’s warranty repairs.

3.08 TESTS AND SETTINGS

A. Test systems and equipment furnished under Division 16 and repair or replace all
defective work. Make adjustments to the systems as specified and/or required.

B. All tests required by the individual specification Sections shall be completed prior to
ergizing electrical equipment. Submit a sample test form or procedure, and submit the
required test reports and data to the Owner/Engineer for approval at least two weeks
prior to the startup of the tested equipment. Include names of all test personnel and
initial each test.

C. Check motor nameplates for correct phase and voltage. Check bearings for proper
lubrication.

D. Check wire and cable terminations for tightness.

E. Check rotation of motors prior to energization. Disconnect driven equipment if damage
could occur due to wrong rotation. If the motor rotates in the wrong direction, the
rotation shall be immediately corrected, or tagged and locked out until rotation is corrected.

F. Verify all terminations at transformers, equipment, capacitor connections, panels, and enclosures by producing a 1 2 3 rotation on a phase sequenced motor when connected to "A", "B" and "C" phases.

G. Provide mechanical inspection, testing and setting of circuit breakers, disconnect switches, motor starters, control equipment, etc. for proper operation.

H. Check interlocking, control and instrument wiring for each system and/or part of a system to prove that the system will function properly as indicated by schematic and wiring diagrams.

I. Check the ampere rating of thermal overloads for motors and submit a typed record to the Owner/Engineer of same, including MCC cubicle location and load designation, motor service factor, horsepower, full load current and starting code letter. If inconsistencies are found, new thermal elements shall be supplied and installed.

J. Verify motor power factor capacitor ratings.

K. Testing shall be scheduled and coordinated with the Owner/Engineer at least two weeks in advance. Provide qualified test personnel, instruments and test equipment.

L. Refer to the individual equipment sections for additional specific testing requirements.

M. Make adjustments to the systems and instruct the Owner's personnel in the proper operation of the systems.

3.09 TRAINING

A. Provide manufacturer’s training as specified in each individual section of the Specifications.
PART 1 - GENERAL

1.01 SCOPE OF WORK

A. Furnish and install electrical support hardware, as shown on the Drawings and as specified herein.

B. Hardware shall include anchor systems, adhesive anchor systems, metal framing systems, and other electrical support systems, as shown on the Drawings and specified herein.

1.02 RELATED WORK

A. Refer to Division 16000 and the Contract Drawings, for related work and electrical coordination requirements.

1.03 SUBMITTALS

A. Submit to the Owner/Engineer, in accordance with Division 1, the manufacturers' names and product designation or catalog numbers for the types of materials specified or shown on the Drawings. All cut sheets shall be clearly marked to indicate which products are being submitted for use on this project. Unmarked cut sheets will cause the submittal to be rejected and returned for revision.

B. The submittal information, for anchor systems, shall contain manufacturer's specifications and technical data including:

1. Acceptable base material conditions (i.e. cracked, un-cracked concrete)

2. Acceptable drilling methods

3. Acceptable bore hole conditions (dry, water saturated, water filled, under water)

4. Manufacturer's installation instructions including bore hole cleaning procedures and adhesive injection.

5. Cure and gel time tables

6. Temperature ranges (storage, installation and in-service).
C. All shop drawing submittals and all O&M submittals shall be submitted in hard copy format and in electronic format using PDF files and shall include an indexed Table of Contents. Electronic submittals are mandatory and any submittal received not indexed as specified will be returned without review. Hard copy submittals may not be required if so stipulated in the Contract Documents. No change in Contract Price or Schedule will be allowed for delays due to unacceptable submittals.

D. Submittals shall also contain information on related equipment to be furnished under this Specification. Incomplete submittals not containing the required information on the related equipment will also be returned without review.

1.04 REFERENCE CODES AND STANDARDS

A. All products and components shown on the Drawings and listed in this specification shall be designed and manufactured according to latest revision of the following standards (unless otherwise noted):

1. NFPA 70 National Electrical Code (NEC)
2. NFPA 70E Standard for Electrical Safety in the Workplace
5. AC308; Acceptance Criteria for Post-Installed Anchors in Concrete Elements, Latest revision.
6. SAE 316 Stainless Steel Grades

B. All equipment components and completed assemblies having a UL standard specified in this Section of the Specifications shall bear the appropriate label of Underwriters Laboratories.

1.05 QUALITY ASSURANCE

A. The manufacturer of these materials shall have produced similar electrical materials and equipment for a minimum period of five years. When requested by the Owner/Engineer, a list of installations with similar equipment shall be provided demonstrating compliance with this requirement.

1.06 JOBSITE DELIVERY, STORAGE AND HANDLING
A. Prior to jobsite delivery, all submittal requirements must be complete, and an approved copy of all such submittals shall be available to the Owner/Engineer prior to delivery of the equipment. Delivery of equipment not completely constructed, onsite factory work, or failed factory tests will not be permitted.

B. Materials shall be handled and stored in accordance with manufacturer's instructions.

C. Adhesive Anchor Systems.

1. Deliver materials undamaged in Manufacturer's clearly labeled, unopened containers, identified with brand, type, and ICC-ES Evaluation Report number.

2. Coordinate delivery of materials with scheduled installation date, minimizing storage time at job-site.

3. Store materials under cover and protect from weather and damage in compliance with Manufacturer's requirements, including temperature restrictions.

4. Comply with recommended procedures, precautions or remedies described in material safety data sheets as applicable.

5. Do not use damaged or expired materials.

6. Storage restrictions (temperature range) and expiration date must be supplied with product.

D. Metal Framing Systems

1. Material shall be new and unused, with no signs of damage from handling.

1.07 WARRANTY

A. Provide warranties, including the manufacturer’s warrantee, for the equipment specified and the proper installation thereof, to be free from defects in material and workmanship for three years from date of final acceptance of the equipment and its installation. Within such period of warranty, all material and labor necessary to return the equipment to new operating condition shall be provided. Any warranty work requiring shipping or transporting of the equipment shall be provided at no expense to the Owner.

PART 2 - PRODUCTS

2.01 ANCHORING SYSTEMS

A. Acceptable Manufacturers
1. Subject to compliance with the Contract Documents, the following Manufacturers are acceptable:
   a. HILTI Kwik Bolt 3
   b. Approved equal

2. The listing of specific manufacturers above does not imply acceptance of their products that do not meet the specified ratings, features and functions. Manufacturers listed above are not relieved from meeting these specifications in their entirety.

B. Product Description

1. Torque controlled expansion anchor consisting of anchor body, expansion element (wedges), washer and nut. Anchor shall be used for anchor sizes less than 3/8 inch.

2. All parts shall be 316 stainless steel materials conforming to SAE 316.

3. UL 203 Rated.

2.02 ADHESIVE ANCHORING SYSTEMS

A. Acceptable Manufacturers

1. Subject to compliance with the Contract Documents, the following Manufacturers are acceptable:
   a. HILTI HIT-RTZ with HIT-HY 200 MAX.
   b. Approved equal

2. The listing of specific manufacturers above does not imply acceptance of their products that do not meet the specified ratings, features and functions. Manufacturers listed above are not relieved from meeting these specifications in their entirety.

B. Product Description

1. Anchor body with helical cone shaped thread on the embedded end and standard threads on the exposed end, with washer and nut, inserted into Injection adhesive. Anchor shall be used for anchor sizes 3/8 inch and larger.

2. All parts shall be 316 stainless steel materials conforming to SAE 316 standards.
A. Acceptable Manufacturers

1. Subject to compliance with the Contract Documents, the following Manufacturers are acceptable:
   a. Tyco Unistrut
   b. B-Line
   c. Super-Strut
   d. Approved equal

2. The listing of specific manufacturers above does not imply acceptance of their products that do not meet the specified ratings, features and functions. Manufacturers listed above are not relieved from meeting these specifications in their entirety.

B. Product Description

1. Metal framing system for use in the mounting or support of electrical systems, panels and enclosures, and including lighting fixture supports, trapeze hangers and conduit supports.

2. Components shall consist of telescoping channels, slotted back-to-back channels, end clamps all threads and conduit clamps.

3. Minimum sizes shall be 13/16-inch through 3-1/4 inch.

4. Components shall be assembled by means of flat plate fittings, 90-degree angle fittings, braces, clevis fittings, U-fittings, Z-fittings, Wing-fittings, Post Bases, channel nuts, washers, etc.

5. Field welding of components will not be permitted.

6. Unless otherwise specified or shown on the Drawings, all parts shall be 316 stainless steel material conforming to SAE 316.

7. Framing systems for chlorine and ammonia rooms shall be manufactured of structural fiberglass.

PART 3 - EXECUTION

3.01 GENERAL

A. Install all equipment strictly in accordance with the manufacturer's instructions and the Contract Drawings.
B. The locations of devices are shown as general on the Drawings and may be varied within reasonable limits as to avoid any piping or other obstruction without change in the Contract Price or Schedule, subject to the approval of the Owner and Engineer. Coordinate the installation of the devices for piping and equipment clearance.

C. No electrical equipment or raceways shall be attached to or supported from, sheet metal walls.

D. Install required safety labels.

E. Electrical support channel shall be used to construct support assemblies as shown on the drawings. Horizontal braces attached to concrete or CMU walls or structural building steel are permitted if the space between the back of the support structures and the attachment points are too small to permit a walk space. No attachments to sheet metal are permitted as specified above. Incorporate additional channel materials and/or provide assemblies of double channel with enough vertical and horizontal members to from a rigid structure whether or not such additional materials or the use of double channel materials are shown or specified. Support structures shall be rigid without the use of channels to from angle supports between the back or front of the assembly and the ground. Angle supports are strictly prohibited because they provide tripping hazards. Outdoor supports structures shall be able to support the equipment with the structural strength to withstand wind gusts up to 90 mph without damage.

3.02 FIELD QUALITY CONTROL

A. Inspect installed equipment for anchoring, alignment, grounding and physical damage.

B. Check tightness of all accessible electrical connections. Minimum acceptable values are specified in manufacturer's instructions.

3.03 POST INSTALLED ANCHOR SYSTEMS

A. Prior to installation of the anchor systems, the hole shall be clean and dry in accordance with the manufacturer's instructions.

3.04 CLEANING

A. Remove all rubbish and debris from inside and around the installation. Remove dirt, dust, or concrete spatter from the interior and exterior of the equipment using brushes, vacuum cleaner, or clean, lint free rags. Do not use compressed air.

END OF SECTION
PART 1 - GENERAL

1.01 SCOPE OF WORK

A. Provide a Power System Study for the electrical power system, including a Short Circuit Study, Coordination Study, Arc Flash Hazard Study, and additional studies as listed below.

B. The electrical power system shall be deemed to include the utility company’s transformer, the Owner’s entire power distribution system, all system components, including any on-site standby generation. The short circuit and coordination study reports shall provide an evaluation of the electrical power systems and the model numbers and settings of the protective relays or devices and metering or motor monitoring devices for setting by the Contractor. The Study shall include settings for all motor protective relays and electric system monitoring devices.

C. The Study shall model all electrical equipment down to and including 480-Volt utilization equipment. All motors shall be modeled individually, including disconnect switches, if present.

D. Obtain and provide all pertinent data necessary for the successful completion of the Power System Studies, including information on all new equipment and wiring pertinent to the Study. This includes all cable and raceway data, data for new motors, data from all new switchgear, motor control centers, panel boards, and separately mounted fuses, starters and circuit breakers. Obtain all new protective device information. Obtain any needed data or information from Contract Documents, various suppliers, the Electric Utility and from conducting his own field investigations. If during field investigations conflicts between the Contract Documents and the field conditions are encountered, immediately notify the Owner/Engineer for a resolution to the conflict. Copies of the data obtained, shall be organized and submitted to the Owner/Engineer at the same time of transmittal to the Study Engineer, to show that all the requested data gathering work has been completed.

1.02 RELATED WORK

A. Refer to Division 16000 and the Contract Drawings, for related work and electrical coordination requirements.

B. Provide all the information required, to the Study Engineer in a timely manner.

1.03 SUBMITTALS
A. No later than four weeks after Contract Award, provide a submittal of the name and qualifications of the Study Engineer, for approval. No submittals required under this section will be accepted until this requirement is met, and if submitted will be returned without review.

B. Provide the following additional submittals:

1. **Preliminary Study:** The first submittal shall consist only of the Short Circuit Study results and equipment evaluation, based upon sound engineering reasonable assumptions, where known values are not available. This submittal shall be used by the Study Engineer to ascertain the short circuit current rating of the related equipment. This submittal shall be made and approved prior to any shop drawing submittal being reviewed for electrical equipment for which the results of this preliminary study are required. The submittal and approval of the Preliminary Study is a critical milestone in the Construction Schedule. Failure to submit an acceptable study in a timely manner may delay the Project Schedule. No exceptions will be made for the specified sequence of the submittal of the Study prior to the submittal of shop drawings, and any delays caused by a late submittal of the Study will not be a cause for the Engineer / Owner to allow any extension of the Contract Time or Contract Price.

2. **Final Study:** The final submittal shall be the Final Study and shall include all items listed under “Scope of Work” in this Section. No electrical equipment for which the results of the final study are required, shall be energized until such results have been reviewed and approved by the Engineer / Owner, and applied to such electrical equipment, and certified as Settings Complete by the manufacturer’s field representative. This submittal is required to include a PDF of the study and a copy of the SKM raw data input files on a CD and/or a flash drive.

C. Upon completion of the studies, submit the studies for approval to the Owner/Engineer. The study submittal shall include all the input and output data files in electronic format for use directly with the specified study software. The Study shall include an actual size sample of an Arc Flash and Shock Hazard label with typical information shown. Allow not less than three calendar weeks for review of the both the Preliminary and Final Studies by the Owner/Engineer. The submittal shall not contain unresolved questions, conflicts or selective device coordination conflicts. A submittal containing such questions or conflicts will be returned unreviewed, and shall not be resubmitted until such questions or conflicts have been resolved. Delays in the Construction Schedule due to the submittal of unacceptable Power System Studies will not be a cause for the Engineer / Owner to approve any changes in the Contract Time or Contract Price.

D. The completed, sealed, and signed studies, with all known issues resolved, shall be submitted to the Owner/Engineer for approval, not less than 30 days prior to site delivery of any equipment containing protective devices requiring selections and settings for certification by the manufacturer. Final copies shall be in electronic form (Adobe PDF formatted files). SKM data files, including any custom forms, labels, formats, and
libraries, shall be provided at the same time in electronic format as specified herein. All individual arc flash labels, ready for installation, shall be provided with this submittal.

E. Submit for approval, a manufacturer’s conducted training agenda for all training specified herein. Training agenda shall not be submitted until final approval of the Operation and Maintenance Manual

1.04 REFERENCE CODES AND STANDARDS

A. The specified studies shall be in accordance with the latest versions of the following codes and standards.


2. NFPA-70E - Standard for Electrical Safety Requirements for Employee Workplaces.

3. ANSI/NFPA 70 – National Electrical Code

B. The studies shall be performed using SKM Power Tools Electrical Engineering Analysis Software for Windows.

1.05 QUALITY ASSURANCE

A. The studies shall be performed by an Electrical Engineering Services firm, who is regularly engaged in power system studies. The studies shall be performed by a Licensed Professional Electrical Engineer(PE) in the regular employment of the firm with proficiency in electrical power systems engineering and shall seal and sign the final completed power system studies. The Study Engineer shall be licensed to practice engineering in the State of Texas

B. The PE shall comply with the State PE Law in the submittal of the Preliminary and Final Studies. The Preliminary Study shall bear the name and registration number of the PE who will be sealing the work along with the statement acceptable to the State PE Board which indicates the work is “Preliminary, Not for Construction” and is “Issued for Review”. The final report shall bear the Engineer’s Seal, Registration Number, Original Signature and Date in accordance with the State PE Laws.

1.06 SCHEDULE OF WORK

A. The selection of the Study Engineer shall be submitted to the Owner/Engineer for approval in a timely manner, in accordance with the time specified. The Study shall be completed and submitted in the phases as specified above.
B. The completed studies, with all known issues resolved, shall be submitted to the Owner/Engineer for approval, as specified above.

PART 2 - STUDIES

2.01 ELECTRICAL ENGINEERING SERVICES FIRMS

A. The work experience resume of the Study Engineers who will be doing the work and the Professional Engineer who will be sealing the Final Study shall be submitted along with his / her PE registration number in the State where the equipment is to be installed. Subject to compliance with the Contract Documents, the following services firms are acceptable:

1. Cutler Hammer Engineering Services
2. General Electric Co. Engineering Services
3. Schneider Electric Engineering Services
4. Allen Bradley Co. Engineering Services
5. Approved Equal

2.02 SHORT CIRCUIT AND COORDINATION STUDY

A. Provide a complete short circuit study. Include three phase, phase-to-ground calculations and X/R ratios. Provide an equipment interrupting or withstand evaluation based on the actual equipment and model numbers provided on this project including any existing equipment modified in any way under this project. The Contractor shall field verify the name plate data of all existing transformers, protective device equipment and the size and length of any existing conductors in series with the new or modified equipment in the Contract. Conductor lengths in concealed conduit shall be estimated to the best of the Contractor’s ability from field observations and any available existing conformed to construction record drawings. Generic devices or values are not acceptable. Normal system operating method, alternate operation, and operations that could result in maximum fault conditions, shall be thoroughly addressed in the study. Provide single phase to ground and three phase to ground fault information. The study shall assume all motors are operating at rated voltage with the exception that motors, clearly identified as "standby," shall not be included. Electrical equipment bus impedances shall be assumed as zero. Short circuit momentary duties and interrupting duties shall be calculated on the basis of maximum available fault current at the switchgear busses, switchboard busses, motor control centers and panelboards. The study shall be performed using actual available short circuit currents as obtained from the Electric Utility. An assumption of infinite bus for the purposes of the Preliminary or Final study is not acceptable.
B. Provide an equipment evaluation study to determine the adequacy of the fault bracing of all bus from the panel board level up to the main switchgear or protective device. Include circuit breakers, controllers, surge arresters, busway, switches, and fuses by tabulating and comparing the short circuit ratings of these devices with the available fault currents.

C. Provide a protective device coordination study. The study shall include all electrical equipment provided under this Contract, including Control Panels containing power and protection equipment lighting panels and power panels. The Study shall include any upstream or downstream equipment that has an impact on the Coordination Study. The study shall show transformer damage curves, cable short circuit-withstand curves and motor starting curves. The phase overcurrent and ground fault protection shall be included, as well as settings for all other adjustable protective devices. All motor monitoring relays and protective or monitoring devices that are a part of a supplier's equipment, such as soft starters or adjustable frequency drives shall be included. Include the last protective device in the Electric Utilities' system feeding each facility being considered. Include all medium voltage switchgear, distribution switchboards, motor control centers and 480 Volt panelboard main circuit breakers. Complete the short circuit study down to the main breaker or largest feeder on all on all 480 Volt panelboards. Panelboard branch circuit devices need not be considered. The phase overcurrent and ground-fault protection shall be included, as well as settings for all other adjustable protective devices. All motor monitoring relays and protective or monitoring devices that are a part of a supplier's equipment, such as soft starters or adjustable frequency drives, shall be included. Include the last protective device in the Electric Utilities system feeding each facility being considered.

D. Selective device coordination is required between protective devices in equipment specified in each Section of the Electrical Specifications, and between each piece of electrical equipment supplied for this project. Include settings for the protective devices in existing equipment feeding any piece of new equipment. If the Study Engineer, during his work, determines that selective coordination cannot be obtained in or between pieces of new equipment as specified, the Owner/Engineer shall immediately be notified, Provide the supporting information to the Owner/Engineer for resolution of the problem.

E. As a minimum, each short circuit study shall include the following:

1. One-Line Diagram: The presentation of the One Line Diagram shall be on one or more 22 x 34-inch drawings with match lines if on multiple sheets, using font sizes which are easily readable. Include the following information and activities listed below:

   a. Location and function of each protective device in the system, such as relays, direct-acting trips, fuses, etc.

   b. Type designation, current rating, range or adjustment, manufacturer's style and catalog number for all protective devices.
c. Power and voltage ratings, impedance, primary and secondary connections (Delta, Wye, Grounded Wye, Zig-Zag, etc.) of all transformers. Use the ratings of the actual transformers being provided where available. The Final Study shall use the name plate information on the transformers provided. Use the actual name plate information on all existing transformers. Generic transformer data on new or existing transformers are not acceptable.

d. The type, manufacturer, and ratio of all instrument transformers energizing each relay shall be included. Field verify this information on all existing protective devices which are in series with the new equipment provided under this Contract.

e. Nameplate ratings of all motors and generators with their sub transient reactance. Field verify the name plate information of all existing generator providing power to the new equipment, and field verify the name plate motor information on all motors connected to the bus of existing equipment which is in series with the new equipment.

f. Sources of short circuit currents such as utility ties, generators, synchronous motors, and induction motors. Provide short circuit studies using each source of power separately. The study shall determine if there is sufficient short circuit current to adequately cause interruption of a protective device using the weaker power source (typically local generation), and shall determine if the equipment can safely interrupt the fault if the greater power source is connected. Additional short circuit calculations shall include emergency as well as normal switching conditions as well as normal and emergency power sources described here in.

g. All significant circuit elements such as transformers, cables, breakers, fuses, reactors, etc. shall be included.

h. The time-current setting of existing adjustable relays and direct-acting trips, if applicable. The Contractor shall field verify the information as specified herein.

i. Arrange for the shutdown of the equipment requiring field verification with the Owner. Investigations shall be done at a time, including after hours if necessary, which do not significantly interrupt the Owner’s process operations.

2. Impedance Diagram: The presentation of the Impedance Diagram shall be on one or more 22 x 34-inch drawings with match lines if on multiple sheets, using font sizes which are easily readable. Include the following:

   a. Available fault current or impedance from the utility company.

   b. Local generated capacity impedance.

   c. Transformer and/or reactor impedances.

   d. Cable impedances.

   e. System voltages.
f. Grounding scheme (resistance grounding, solid grounding, or no grounding).

3. Calculations: Include the following:
   a. Determine the paths and situations where short circuit currents are the greatest. Assume bolted faults and calculate the three-phase and line-to-ground short circuits of each case.
   b. Calculate the maximum and minimum fault currents.

F. Provide Time-Current Curves (TCC) on 8-1/2 x 11 log-log paper.

1. The Time Current Curves shall be presented in series only. Parallel branches shall not appear on the same TCC presentation.

2. Do not put more than one branch of protective devices on any one coordination curve.

3. Show a maximum of five devices in series on one TCC. Include a one-line diagram and the names of each protective device in the branch on the coordination curve drawing. Use the same color for the same protective device appearing on different TCC presentations.

4. Provide separate drawings for ground fault coordination curves.

5. Use the names designated in the Contract Documents.

6. Include motor starting curves and transformer inrush and damage curves, and cable short circuit withstand curves.

2.03 ARC FLASH HAZARD STUDY

A. The Power System Study shall include an Arc Flash Hazard Study that shall present the level of arc flash hazard for each item of electrical equipment, and the appropriate level of protection required per OSHA standards.

B. The analysis shall be performed with the aid of computer software intended for the purpose, to calculate Arc-Flash Incident Energy (AFIE) levels and flash protection boundary distances.

C. The analysis shall be performed under each possible condition and shall identify the worst-case Arc-Flash condition. The preliminary report shall describe, when applicable, how these conditions differ from worst-case bolted fault conditions.
D. The calculations shall be performed in accordance with IEEE 1584 and safe approach requirements determined in accordance with NFPA-70E. (Latest versions)

E. Results of the Analysis shall be submitted in tabular form and shall include, device or bus name, bolted fault and arcing fault current levels, flash protection boundary distances, personal-protective equipment and AFIE levels. The analysis shall be presented on paper and included with the specified electronic format files.

F. After approval of the Study, provide the Arc Flash Hazard Warning Labels. The Study Engineer shall oversee the installation of the required labels for each item of electrical equipment furnished on the project and for each item of existing equipment for which the arc flash hazard has changed. A typical warning label shall be submitted with the Study for approval, and shall include the information listed below, at minimum.

1. Flash Hazard Protection Boundary.
2. Limited Approach Boundary.
3. Restricted Boundary.
4. Incident Energy Level.
5. Required Personal Protective Equipment Rating.
6. Type of Fire Rated Clothing.

G. Labels shall be affixed to the enclosures, in a readily visible location, for all power-handling equipment as follows.

1. Switchgear
   a. One label for the line side of the main breaker
   b. One label for the load side of the main breaker (switchgear bus)
   c. One label on each vertical section, indicating the data for the switchgear bus

2. MCCs
   a. One label for the line side of the main breaker
   b. One label for the load side of the main breaker (MCC bus)
   c. One label on each vertical section, indicating the data for the MCC bus

3. Switchboards
a. One label for each switchboard operated at 480 Volts or above
b. Label to indicate data for line side of the main breaker

4. Panelboards
   a. One label for each panelboard operated at 480 Volts or above
   b. Label to indicate data for line side of the main breaker

5. Control panels, including combination starters
   a. Single label at each unit operated at 480 Volts or above.
   b. Label to indicate data for the line side of the disconnect device.

6. Disconnect switches
   a. Single label at each disconnect switch operated at 480 Volts or above.
   b. Label to indicate data for the line side of the switch

H. Size of each label shall be not less than 4 inches wide and 3 inches tall.

PART 3 - EXECUTION

3.01 FIELD SERVICES

A. Label Installation Certification

1. When the label installation is complete, the Contractor, the Contractor's Study Engineer and the Owner/Engineer shall jointly inspect each location and show to the Owner/Engineer's satisfaction that labels are installed in all the specified locations, and in any additional recommended locations indicated in the Study.

B. The cost of Field Services shall be included in the Contract Price and the schedule for training shall be included in the Contract Schedule.
PART 1 - GENERAL

1.01 SCOPE OF WORK

A. Furnish and install complete raceway systems as shown on the Drawings and as specified herein. A raceway system shall consist of materials designed expressly for containing wires and cables, including but not limited to, conduit, device bodies, conduit bodies, raceway boxes, enclosures containing electrical devices, controls and related materials.

1.02 RELATED WORK

A. Refer to Division 16000 and the Contract Drawings, for related work and electrical coordination requirements.

1.03 SUBMITTALS

A. Submit to the Owner/Engineer, in accordance with Division 1, the manufacturers' names and product designation or catalog numbers of all materials specified.

1. Cut sheets for each individual item shall be submitted.

2. Each cut sheet shall be clearly marked to indicate the item submitted and/or mark out items which are not being submitted for approval. Submittals not clearly marked will be returned with the indication REVISE AND RESUBMIT as a minimum or other indication per the specifications as warranted.

B. Submit to the Owner/Engineer, certification that the electricians installing the PVC coated conduit have a five-year minimum experience, in the installation of the product.

C. All shop drawing submittals and all O&M submittals shall be submitted in hard copy format and in electronic format using PDF files [and shall include an indexed Table of Contents. Electronic submittals are mandatory, and any submittal received not indexed as specified will be returned without review. Hard copy submittals may not be required if so stipulated in the Contract Documents. No change in Contract Price or Schedule will be allowed for delays due to unacceptable submittals.
D. Submittals shall also contain information on related equipment to be furnished under this Specification. Incomplete submittals not containing the required information on the related equipment will also be returned without review.

1.04 REFERENCE CODES AND STANDARDS

A. All products and components shown on the Drawings and listed in this specification shall be designed and manufactured according to latest revision of the following standards (unless otherwise noted):

1. NFPA 70 – National Electrical Code (NEC)
2. NFPA 70E – Standard For Electrical Safety in the Workplace
3. UL 6A – Electrical Rigid Metal Conduit
4. ANSI C80.5 – Electrical Rigid Aluminum Conduit
5. UL 514B – Outlet Bodies

B. All equipment components and completed assemblies specified in this Section of the Specifications shall bear the appropriate label of Underwriters Laboratories.

1.05 QUALITY ASSURANCE

A. The manufacturer of these materials shall have produced similar electrical materials and equipment for a minimum period of five years. When requested by the Owner/Engineer, an acceptable list of installations with similar equipment shall be provided demonstrating compliance with this requirement.

B. The manufacturer of the assembly shall be the manufacturer of the major components within the assembly. All assemblies shall be of the same manufacturer.

C. The installer of materials specified herein, shall have a minimum of five years’ experience in the installation of each type of material. Proof of experience shall be submitted, upon request of the Owner/Engineer, prior to installation.

D. Used materials are unacceptable, will be rejected and shall be removed from the job site. Used materials, if installed, shall be removed and replaced with new materials. If new materials are installed with used materials, and the removal of the used materials renders the new materials in an unacceptable condition, such as new conductors installed in used raceway components, (determined by the Engineer/Owner alone) then the new materials shall be removed along with the used materials and replaced. No increase in the Contract Price nor in Contract Schedule will be allowed.

Dundee State Fish Hatchery Water Reuse – Effluent Pump Back
TPWD No. 1110061
1.06 JOBSITE DELIVERY, STORAGE AND HANDLING

A. Prior to jobsite delivery, complete all submittal requirements, and present to the Owner/Engineer prior to delivery of the equipment, an approved copy of all such submittals. Delivery of incomplete constructed equipment, or equipment which failed any factory tests, will not be permitted.

B. Materials shall be handled and stored in accordance with manufacturer’s instructions.

C. Materials shall not be stored exposed to sunlight. Such materials shall be completely covered.

D. Materials showing signs of previous use, jobsite storage at another location, or exposure to the elements or other damage will be rejected.

1.07 WARRANTY

A. Provide warranties, including the manufacturer’s warrantee, for the equipment specified and the proper installation thereof, to be free from defects in material and workmanship for three years from date of final acceptance of the equipment and its installation. Within such period of warranty, all material and labor necessary to return the equipment to new operating condition shall be provided. Any warranty work requiring shipping or transporting of the equipment shall be provided at no expense to the Owner.

PART 2 - PRODUCTS

2.01 GENERAL

A. Raceways and fittings shall be as shown on the Drawings, with a minimum 3/4-inch trade size.

B. Device entries less than 3/4 inch shall be provided with an adaptor to connect ¾-inch or larger conduit. The following adaptors are acceptable:

1. REA12SA, Cooper Crouse Hinds or equal, for aluminum
2. ADAPT ADU302930, REDAPT or equal, for 316 stainless.
3. Approved equal

2.02 CONDUIT RACEWAY
A. PVC Coated Rigid Aluminum Conduit (CRMC)

1. PVC coated rigid aluminum conduit shall have a minimum 0.040-inch thick, polyvinyl chloride coating permanently bonded to rigid aluminum conduit and an internal chemically cured urethane or enamel coating.

2. Rigid Aluminum conduit shall be extruded from AA 6063 alloy in temper designation T-1 and shall conform to FED Spec WW-C-540C, ANSI C80.5 and UL 6A.

3. The ends of all couplings, fittings, etc. shall have a minimum of one pipe diameter in length of PVC overlap.

4. Manufacturers for PVC coated conduit and fittings
   a. Perma-Cote
   b. Robroy Industries
   c. O’Kote, Inc.
   d. Calbond
   e. Ocal.
   f. Approved equal

5. Elbows and couplings shall be PVC coated by the same manufacturer supplying the conduit PVC coating system. Elbows and couplings used with PVC coated conduit shall be furnished with a PVC coating bonded to the aluminum, the same thickness as used on the coated aluminum conduit.

B. Liquid tight Aluminum Flexible Metal Conduit (LFMC)

1. Liquid tight aluminum flexible metal conduit shall have an interlocked aluminum core, PVC jacket rated for 60 degrees C., and meeting NEC Article 351.

2. Manufacturers
   a. Anaconda Metal Hose Div.
   b. Southwire
   c. Anaconda American Brass Co.
   d. American Flexible Conduit Co., Inc.
   e. Universal Metal Hose Co.
C. Aluminum Flexible Metal Conduit (FMC)

1. Aluminum flexible metal conduit shall have an interlocked aluminum core, meeting NEC Article 348, UL 1 and Federal Specification WW-C-566C.

2. Manufacturers
   a. Anaconda Metal Hose Div.
   b. Southwire
   c. Anaconda American Brass Co.
   d. American Flexible Conduit Co., Inc.
   e. Universal Metal Hose Co.
   f. Approved equal

3. Fittings used with aluminum flexible metal conduit shall be copper-free aluminum and shall conform to FEDSPEC AA50552.

D. Rigid Aluminum Conduit (RMC)

1. Rigid Aluminum conduit shall be extruded from AA 6063 alloy in temper designation T-1 and shall conform to FED Spec WW-C-540C, ANSI C80.5 and UL 6A.

2. Manufacturer for rigid aluminum conduit and fittings
   a. Wheatland Tube Company
   b. Allied
   c. American Conduit
   d. Patriot Industries
   e. Approved equal

E. Liquid tight Steel Flexible Metal Conduit (LFMC)
1. Liquid tight steel flexible metal conduit shall have an interlocked steel core, PVC jacket rated for 80°C., and meeting NEC Article 350.

2. Manufacturers
   a. Ultratite AEF by Southwire
   b. Anaconda Metal Hose Div.
   c. Anaconda American Brass Co.
   d. American Flexible Conduit Co., Inc.
   e. Universal Metal Hose Co.
   f. ALFLEX
   g. Approved equal

3. Fittings used with liquid tight flexible metal conduit shall conform to ANSI C80.1, and UL-6.

F. Steel Flexible Metal Conduit (LMC)

1. Flexible metal conduit shall have an interlocked steel core, meeting NEC Article 348

2. Manufacturers
   a. Southwire
   b. Anaconda Metal Hose Div.
   c. Anaconda American Brass Co.
   d. American Flexible Conduit Co., Inc.
   e. Universal Metal Hose Co.
   f. Approved equal

3. Fittings used with steel flexible metal conduit shall conform to FEDSPEC WW-C-581 ANSI C80.1, and UL-6.

G. Rigid PVC Schedule 40 Conduit (RNC)

1. Schedule 40 PVC Rigid Nonmetallic Conduit (RNC) shall be designed for use underground as described in the NEC, resistant to sunlight. The conduits and fittings shall be manufactured to NEMA TC-2, Federal Specification WC1094A and UL 651
specifications. Fittings shall be manufactured to NEMA TC-3, Federal Specification WC1094A and UL 514B. Conduit shall have a UL Label.

2. Manufacturers
   a. Rocky Mountain Colby
   b. Carlon
   c. Kraloy
   d. Approved equal

2.03 WIREWAYS

A. All wireways shall be NEMA 4X 316 stainless steel, with gasketed hinged covers and stainless steel quick-release type latches. Wireway shall have two Breather/Drains for each ten feet of wireway. Breather/Drain shall be in the bottom, near the ends of the wireway. Wireways shall have integral welded mounting lugs. Bolted-on mounting lugs are unacceptable. Provide stainless steel internal barriers to isolate signal cables from power conductors and multiconductor digital control cables.

B. Manufacturers
   1. Industrial Enclosure Corporation
   2. Cooper B Line
   3. Approved equal

C. Breather/Drains
   1. Eaton Crouse-Hinds 316 stainless steel
   2. Approved equal

2.04 RACEWAY BOXES AND EQUIPMENT ENCLOSURES

A. The term box and enclosure are synonymous for this specification. Boxes and enclosures specified herein, include terminal boxes, junction boxes pull boxes, and boxes for switch, receptacles and lighting. Enclosures used for electrical and instrumentation equipment, other than terminal boxes, shall be provided as described in this section with references to this specification in other specification sections. All raceway boxes and equipment enclosures shall be provided with a common ground point and shall be UL rated.
B. NEMA Type 4X boxes shall be 316 stainless steel or aluminum only as otherwise specified or shown with mounting lugs or brackets welded on the box, suitable for wall mounting, or have mounting feet where self-standing. Boxes for wall-mounting shall have integral welded-on mounting lugs. Enclosures with mounting feet shall have the mounting feet brackets for the attachment of mounting feet welded on. Boxes manufactured with holes intended for mounting using bolted-on mounting lugs or feet are not acceptable. Drilling through the back of the box to mount is strictly prohibited. Drilled boxes shall be removed and replaced. All boxes shall have continuously welded seams ground smooth, and shall have continuous hinged, gasketed doors. Box bodies shall not be less than 16 gauge. Boxes larger than 24 inches X 20 inches shall have a three-point type latch with handle. Boxes 24 inches X 20 inches or smaller shall have 316 stainless steel luggage type quick release latches, or three-point latch system with all components 316 stainless steel. Latch systems requiring tools to open or close are unacceptable.

C. NEMA 4X 316 Stainless Steel enclosures

1. Use for all locations unless otherwise shown or specified
2. Type 316 stainless steel, body and door
3. Stainless steel continuous hinge
4. Foam in-place gasket
5. Single point quarter turn latches (20-inch X 24-inch and smaller). All others shall have three-point
6. Manufacturers
   a. Enclosures housing electrical equipment may be constructed by the manufacturer of that equipment but shall meet all the physical requirements specified herein.
   b. Eaton Crouse Hinds
   c. Hoffman
   d. Appleton Electric
   e. EMF Company
   f. NEMA Enclosures Company
   g. Cooper B Line
   h. Rittal
   i. Approved equal
D. NEMA 4X Aluminum boxes shall be constructed as follows:

1. Type 5052 aluminum, body and door
2. Stainless steel continuous hinge
3. Foam in-place gasket
4. Single point quarter turn latches (20-inch X 24-inch and below). All others three-point latch
5. Manufacturers
   a. Enclosures housing electrical equipment may be constructed by the manufacturer of that equipment but shall meet the all the physical requirements specified herein.
   b. Hoffman
   c. EMF Company
   d. NEMA Enclosures Company
   e. Cooper B Line
   f. Approved equal

E. Chemical Rooms: NEMA 4X nonmetallic boxes shall be constructed as follows:

1. PVC or Fiberglass reinforced polyester body and door.
2. UV inhibitors
3. UL Listed
4. RoHS compliant
5. Formed in place polyurethane gasket in continuous channel.
6. 316 Stainless steel quick release latches.
7. Manufacturers
   a. Enclosures housing electrical equipment may be constructed by the manufacturer of that equipment but shall meet the all the physical requirements specified herein.
   b. Allied Molded Products, Inc.
c. Cantex
d. Cooper
e. Hoffman
f. Hubbell-Wiegmann Non-Metallic
g. Approved equal

F. Classified Areas, NEMA 7/4X boxes (Class 1, Division 1, Groups A, B, C, and D, or as defined in NFPA 70) shall be constructed as follows:

1. Copper free cast aluminum body and cover
2. Stainless steel hinges
3. Watertight neoprene gasket
5. Manufacturers
   a. Enclosures housing electrical equipment may be constructed by the manufacturer of that equipment but shall meet the all the physical requirements specified herein.
   b. Eaton Crouse-Hinds
c. Appleton Electric
d. Approved equal

G. NEMA 12 boxes shall be constructed as follows:

1. Type 5052 aluminum, body and door
2. Stainless steel continuous hinge
3. Foam in-place gasket
4. Single point quarter turn latches (20-inch X 24-inch and below). All others three-point latch
5. Manufacturers
a. Enclosures housing electrical equipment may be constructed by the manufacturer of that equipment but shall meet all the physical requirements specified herein.

b. Hoffman
c. EMF Company
d. NEMA Enclosures Company
e. Cooper

H. NEMA 1 or NEMA 1A boxes shall not be used.

I. Malleable iron boxes shall not be used.

2.05 DEVICE BOXES

A. Device boxes installed in aluminum raceway systems for switches and receptacle, etc., shall be copper free cast aluminum, and shall have tapered, threaded, hubs, with integral bushings. Boxes shall have internal grounding screw, and a minimum of two mounting feet. Boxes shall be type FD.

B. Manufacturers

1. Eaton Crouse-Hinds
2. Appleton
3. Approved equal

2.06 CONDUIT OUTLET BODIES

A. Conduit outlet bodies and covers shall be Form 7, copper-free aluminum, with captive screw-clamp cover, neoprene gasket and stainless-steel screws and clamps for conduits up to and including 2-1/2 inches.

B. Manufacturers

1. Eaton Crouse-Hinds Form 7 with Mark 7 wedge-nut cover
2. Appleton
3. Approved equal
C. Provide junction boxes for conduits larger than 2-1/2 inches.

D. All outlet boxes and covers for Class 1 Division 2 areas shall be rated NEMA 4X.
   1. Manufacturers
      a. Eaton Crouse-Hinds EA Series
      b. Approved equal

2.07 CONDUIT HUBS

A. Conduit hubs for use on raceway system pull and junction boxes shall be watertight, threaded aluminum, insulated throat, stainless steel grounding screw

B. Manufacturers
   1. T&B H150GRA Series
   2. Approved equal

2.08 GROUNDING BUSHINGS

A. Grounding bushings shall be insulated lay-in lug grounding bushings with tin-plated copper grounding path. Bushings shall have integrally molded noncombustible phenolic insulated surfaces rated 150°C. Each bushing shall be furnished with a plastic insert cap. The size of the lug shall be sufficient to accommodate the maximum ground wire size required by the NEC for the application.

B. Manufacturers
   1. O-Z/Gedney Type ABLG
   2. Approved equal

2.09 RACEWAY SEALANT

A. Raceway sealant for use in the sealing of raceway hubs, entering or terminating in boxes or enclosures where such sealing is shown or specified, shall be 3M 1000NS Watertight Sealant, or approved equal.

2.10 CONDUIT PENETRATION SEALS
A. Conduit wall and floor seals

1. O.Z./Gedney Co. Series CSM
   a. Type CSML-XXXP shall be used for all applications that do not require a recessed sealing bushing.
   b. Type CSMI-XXXP shall be used for all applications that require a recessed sealing bushing.

2. Approved equal

2.11 EXPANSION-DEFLECTION COUPLING

A. Combination expansion-deflection fittings with 3/4-inch axial expansion and contraction movement, 3/4-inch parallel misalignment movement, and up to 30 degrees of angular movement in any direction. It shall be copper-free aluminum, with exterior tinned copper braid bonding jumper and 316 stainless grounding straps

B. Manufacturers

1. Eaton Crouse-Hinds Model XD
2. Approved equal

C. Provide an aluminum cover over the fitting to protect the rubber portions from exposure to direct sunlight. Secure the aluminum sun shield with a minimum of two stainless steel tie wraps.

D. Nylon tie wraps are not acceptable.

2.12 EXPANSION FITTINGS

A. Expansion fittings shall provide eight-inch movement, shall be made of copper-free aluminum, with exterior tinned copper braid bonding jumper and 316 stainless grounding straps. Provide internal grounding. Nylon tie wraps are not acceptable.

B. Manufacturers

1. Eaton Crouse-Hinds Co. Type XJGSA
2. Approved equal

2.13 EXPLOSION-PROOF SEALS, BREATHERS AND DRAINS
A. Explosion proof fittings shall be designed for Class 1 Division 1, Group D, hazardous locations. Fittings shall be copper-free aluminum, with seals, breathers and drains. Provide type ED, or as required for the application.

B. Manufacturers

2. Appleton Electric Co.
3. O.Z./Gedney Co.
4. Approved equal

2.14 KELLEMS GRIPS

A. Kellems grips cables supports shall be 316 stainless steel.

2.15 CONDUIT MOUNTING EQUIPMENT

A. Pull and junction box supports, spacers, conduit support rods, clamps, hangers, channel, nut, bolts, washers, etc. and shall be 316 stainless steel. Nylon tie wraps are not acceptable.

2.16 CONDUIT IDENTIFICATION TAGGING

A. Tag all underground conduits at all locations exiting and entering from underground, including manholes and handholes.

B. Use the tagging formats for conduits as shown on the Drawings.

C. Conduit identification plates shall be embossed stainless steel with stainless steel band, permanently secured to the conduit without screws. Nylon tie wraps are not acceptable.

D. Identification plates shall be as manufactured by the Panduit Corp. or equal.

PART 3 - EXECUTION

3.01 RACEWAY APPLICATIONS
A. Unless exact locations are shown on the Drawings, coordinate the placement of raceway systems and related components with other trades and existing installations.

B. Raceway Systems for the installation of Fiber Optic Cables shall not contain conduit bodies, device boxes, or raceway boxes containing less than twelve inches of bend radius.

C. Unless shown on the Drawings or specified otherwise, the raceway type installed with respect to the location shall be as follows, including all materials:

<table>
<thead>
<tr>
<th>Raceway System</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. PVC Coated Aluminum (CRMC) Type</td>
<td>All embedded raceway bends, underground duct bank bends of more than 20 degrees, and all raceway stub-ups to a minimum of six inches above finished floor or grade and in Chlorine and Caustic rooms.</td>
</tr>
<tr>
<td>2. Liquidtight Flexible Aluminum (LFMC) Type</td>
<td>Raceway connection to vibrating equipment, and as shown on the Drawings in all areas.</td>
</tr>
<tr>
<td>3. Rigid Non-metallic, Schedule 40 PVC (RNC) Type</td>
<td>Underground encased in red dyed reinforced concrete.</td>
</tr>
<tr>
<td>4. Rigid Non-metallic, Schedule 80 PVC (RNC) Type</td>
<td>For use only in Chlorine and Caustic Rooms.</td>
</tr>
<tr>
<td>5. Flexible Aluminum (FMC) Type</td>
<td>Fixture whip connection to lighting fixtures in NEMA 12 areas (maximum 3-feet). BX or AC type prefabricated cables are not permitted.</td>
</tr>
<tr>
<td>6. Aluminum Rigid Metal (RMC) Type</td>
<td>All above grade areas, except for concrete embedded and those areas described in Locations 2 through 6 above.</td>
</tr>
<tr>
<td>7. Liquidtight Steel Flexible Metal Conduit (LFMC) Type</td>
<td>Raceway connection to vibrating equipment, and as shown on the Drawings in all areas.</td>
</tr>
<tr>
<td>8. Rigid Non-metallic, Schedule 40 PVC (RNC) Type</td>
<td>Underground encased in red dyed reinforced concrete.</td>
</tr>
</tbody>
</table>

D. All conduit of a given type shall be the product of one manufacturer.
3.02 BOX APPLICATIONS

A. All raceway junction pull and terminal boxes and electrical equipment enclosures shall have NEMA ratings for the location in which they are installed, and as specified herein.

B. The distance between each raceway entry inside the box and the opposite wall of the box shall not be less than eight times the metric designator (trade size) of the largest raceway in a row. This distance shall be increased for additional entries by the amount of the sum of the diameters of all other raceway entries in the same row on the same wall of the box. Each row shall be calculated individually, and the single row that provides the maximum distance shall be used.

C. Provide cast aluminum conduit fittings for exposed switch, receptacle and lighting outlet boxes.

D. All raceway boxes and wall–mounted electrical equipment enclosures shall be provided with factory mounting integral welded mounting lugs. Bolt-on gasketed mounting lugs attached through factory-drilled holes are not acceptable for any raceway box or electrical equipment enclosure. Drilling through the back of any box or enclosure is prohibited, and if so installed, shall be removed and replaced, with no increase in the Contract Price or Construction Schedule.

E. No penetrations shall be made in the top of boxes or electrical equipment enclosures in wet locations.

3.03 DEVICE BOX APPLICATIONS

A. Device boxes shall be used for mounting wiring devices such as receptacles, switches, thermostats, lighting and other permanently mounted devices. All device boxes shall be installed with a minimum of 1/4-inch air space between the back of the box and the wall or back panel on which it is installed. The space may be created with enough 316 stainless steel washers to provide the required air space or may be mounted using 316 stainless steel slotted channel.

3.04 CONDUIT OUTLET BODIES APPLICATIONS

A. Conduit outlet bodies may be used on conduits up to and including 2-1/2 inches, except where junction boxes are shown or otherwise specified. For conduits larger than 2-1/2 inches, junction boxes shall be provided.

3.05 CONDUIT HUB APPLICATIONS
A. Unless specifically stated herein or described on the Drawings, all raceways shall terminate at an outlet with a conduit hub. Locknut or double locknut terminations will not be permitted.

B. When conduits contain equipment grounding conductors the wire shall be grounded to the hub(s) associated with that grounding conductor.

3.06 INSULATED GROUNDING BUSHING APPLICATIONS

A. Insulated grounding bushings shall be provided and used to terminate raceways where the raceways enter pad-mounted electrical equipment or switchgear from the bottom where there is no wall or floor pan on which to anchor or terminate the raceway.

B. All other raceways shall terminate on enclosures with a conduit hub, except for NEMA 7/4X areas.

C. Grounding bushing caps shall remain on the bushing until the wire is ready to be pulled.

3.07 CONDUIT FITTINGS APPLICATIONS

A. Combination expansion-deflection fittings shall be installed where conduits cross structure expansion joints, and where installed in exposed conduit runs such that the distance between expansion-deflection fittings does not exceed 150 feet of conduit run. Expansion-deflection fittings are acceptable in indoor locations out of exposure to direct sunlight or other outdoor locations which are shaded.

B. Expansion-deflection fittings are not acceptable for use outdoors unless approved in writing on a case-by-case basis from the Engineer/Owner. Where combination expansion-deflection fittings with exposed non-metallic sections, are approved by the Engineer/Owner for use where exposed to sunlight or other outdoor locations which are shaded, an aluminum wrap shall be installed loosely over the non-metallic portion, extending at least two inches beyond the ends. The wrap shall be loosely secured, to permit movement, with at least two 316 SS fasteners. Nylon tie-wraps are not acceptable.

C. Provide an expansion fitting with a minimum of six inches available movement shall be installed on the exposed side of under to above grade conduit transitions. Expansion-deflection fittings shall not be provided unless approved and protected as specified above.

3.08 CONDUIT PENETRATION SEALS APPLICATIONS
A. Conduit wall seals shall be used where underground conduits penetrate walls or at other locations shown on the Drawings.

B. Conduit sealing bushings shall be used to seal conduit ends exposed to the weather and at other locations shown on the Drawings.

3.09 EXPLOSION-PROOF SEALS, BREATHERS AND DRAINS APPLICATIONS

A. Fittings consisting of sealing fittings, breathers, drains, with sealing compound and fiber, as specified herein, shall be used as required to meet all the requirements of the National Electrical Code.

3.10 CONDUIT TAG APPLICATIONS

A. All conduits shall be tagged within one foot of the entry of equipment, and wall and floor penetrations.

B. Tag all underground conduits and ducts at all locations, exiting and entering from underground, including manholes and handholes.

3.11 RACEWAY SEALING

A. All raceways entering junction boxes, terminal junction boxes, electrical equipment enclosures or control panels containing electrical or instrumentation equipment shall be connected to the box, enclosure or panel using conduit hubs and shall be sealed with Raceway Sealant, as specified herein.

3.12 PVC RACEWAY TO PVC COATED ALUMINUM RACEWAY TRANSITIONS IN CONCRETE ENCASEMENT

A. Transitions from PVC raceway to PVC coated aluminum raceway in concrete encasements shall be made as follows:

   1. Terminate the PVC conduit in a threaded PVC female adapter.
   2. Terminate the PVC coated aluminum conduit in a threaded male adaptor.
   3. Thread the male PVC-coated aluminum conduit adaptor into the female threaded PVC adapter.

B. Tighten the joint securely, then double layer wrap the joint with two-inch vinyl electrical tape for a distance of two inches each side of the threaded joint to prevent any contact between any exposed aluminum threads and concrete.
3.13 RACEWAY INSTALLATION

A. Do not install pull wires and conductors until the raceway system is in place. No wire shall be installed between outlet points, junction points or splicing points, until all raceway sections are complete, and all raceway covers are installed for protection of conductors from damage or exposure to the elements. Conductors installed into incomplete raceway systems are considered improperly installed and are in violation of the NEC. The occurrence of wire installed in an incomplete installation, shall require the removal of such conductors from the project site, and replacement of the conductors at with no increase in Contract Price or Schedule. The raceway system shall be completed and inspected by the Engineer/Owner, before new conductors are installed.

B. No conduit smaller than 3/4-inch electrical trade size, shall be used, nor shall any have more than the equivalent of three 90-degree bends in any one run. Pull boxes shall be provided as necessary. Conduit reducers which are the same type of the raceway shall be installed where manufacturer-provided enclosures are not available with conduit hubs larger than 1/2-inch at the enclosure to terminate 3/4-inch conduit. The raceway fill shall be adjusted to accommodate the smaller opening in the manufacturer-provided enclosure. Notify the Engineer/Owner prior to the installation of the raceway into enclosures with openings smaller than the specified minimum. Raceways installed without notice are considered unacceptable and may be required to be removed at the Engineer's/Owner’s discretion with no increase in the Contract Price or Schedule allowed.

C. All raceways, installed underground, shall be installed in accordance with Section Underground System, and be a minimum size of two-inch trade size.

D. Raceways entering or leaving the raceway system, which could be subjected to the entry of moisture, rain or liquid of any type, shall be tightly sealed, using 3M 1000NS Watertight Sealant, or approved equal at any possible moisture entry point both before and after the installation of cables to prevent the entry of water or moisture to the Raceway System at any time. Any damage to new or existing equipment, due to the entrance of moisture from unsealed raceways, shall be corrected by complete replacement of such equipment. No increase in the Contract Price or Schedule will be allowed. Cleaning or drying of such damaged equipment will not be acceptable.

E. Conduit supports, other than for underground raceways, shall be spaced at intervals of eight feet or less, as required by the NEC and as required to obtain rigid construction. Conduits shall be supported near the entry into any enclosure in accordance with the NEC. Conduits shall not be used to support other conduits, nor shall conduits be supported from cable tray.

F. Single conduits shall be supported by means of one-hole pipe clamps in combination with one-screw back plates, to raise conduits from the surface.
G. Multiple runs of conduits shall be supported on trapeze type hangers with horizontal members and threaded hanger rods. The rods shall be not less than 3/8-inch diameter. Multiple conduits mounted on walls shall be supported using strut and 316 stainless steel conduit clamps, screws, nuts and washers.

H. Surface mounted panel boxes, junction boxes, conduit, etc. shall be supported as specified herein.

I. Conduit hangers shall be attached to structural steel by means of beam or channel clamps. Where attached to concrete surfaces, anchors shall be as specified in Section Electrical Support Hardware.

J. No electrical equipment enclosures, boxes, terminal junction boxes or raceways shall be attached to or supported from, sheet metal walls.

K. All conduits on exposed work shall be run at right angles to and parallel with the surrounding wall and shall conform to the form of the ceiling. No diagonal runs will be allowed. Bends in parallel conduit runs shall be concentric. Offsets in conduit runs shall all be done at the same point and shall all be the same angle, so the entire installation appears to be parallel or concentric at every point. All conduits shall be run perfectly straight and true.

L. Conduits terminated into enclosures shall be perpendicular to the walls where flexible liquid tight or rigid conduits are required. The use of short seal tight elbow fittings for such terminations will not be permitted, except for connections to instrumentation transmitters, where multiple penetrations are required.

M. Conduits containing equipment grounding conductors and terminating in boxes shall have insulated throat grounding bushings. The grounding conductor shall be grounded to the box.

N. Conduits shall be installed using threaded fittings. Running threads will not be permitted.

O. Provide glued type conduit fittings on PVC conduit.

P. Conduits installed which are not in compliance with these requirements shall be removed and reinstalled at the Engineer’s/Owner’s discretion. If conductors are installed when the improper installation is discovered, the conductors shall be removed from the raceway, discarded and removed them from the job site, replaced, re-terminated, retagged, and retested in accordance with the specifications. The function of the system
shall be retested in its entirety. No increase in Contract Time or Schedule will be allowed.

Q. Liquid tight flexible metallic conduit shall be used for the primary and secondary of transformers, generator terminations and other equipment where vibration is present. Use in other locations is not permitted, except for connections to instrumentation transmitters, where multiple penetrations are required. Liquid tight flexible metallic conduit shall have a maximum length not greater than that of a factory manufactured elbow of the conduit size being used. The maximum bending radius shall not be less than that shown in the NEC Chapter 9, Table 2, “Other Bends”. BX or AC type prefabricated cables will not be permitted.

R. Seal the remaining openings or spaces of conduits passing through openings in walls or floor slabs to prevent the passage of flame or smoke where additional openings or space around the conduits are present.

S. Conduit ends exposed to the weather or corrosive gases shall be sealed with conduit sealing bushings.

T. Raceways terminating in Control Panels or enclosures outdoors or any wet or damp location or any location where plant process equipment is located, or any location not otherwise specifically designated as a dry electrical room, control room or office space, which contain electrical equipment or terminal blocks, shall not enter from the top of the enclosure. The raceways shall be sealed with a watertight sealant as specified herein. Enclosures entered from the top where top entry is prohibited, will be rejected and shall be removed and replaced regardless of the Division which contains the specification for the enclosure. The use of UL Listed conduit closures to restore the NEMA rating of the enclosure will not be accepted. Conduit entering the top of the enclosures shall be removed and re-routed to enter the enclosure from the side or bottom. Conductors installed in top entering conduits shall be pulled back to the nearest conduit body or junction box and re-routed with the conduit, provided the conductors are long enough to be re-terminated. Conductors found to be insufficient in length to be re-terminated shall be completely removed and replaced, re-tested, re-tagged, re-tested and the control function of the panel shall be re-tested. If the enclosure is provided by an OEM, the enclosure and its contents shall be returned to the OEM for a new enclosure. No increase in Contract Price nor increase in Contract Time will be allowed the Contractor for making these corrections.

U. All conduits from external sources entering or leaving a multiple compartment enclosure shall be stubbed up into the bottom horizontal wire way or other manufacturer designated area, directly below the vertical section in which the conductors are to be terminated. Conduits entering from cable tray shall be stubbed into the upper section.
V. Conduit sealing and drain fittings shall be installed in areas designated as NEMA 4X or 7.

W. A conduit identification plate shall be installed on all power, instrumentation, alarm and control conduits at each end of the run and at intermediate junction boxes, manholes, etc. Conduit plates shall be installed before conductors are pulled into conduits. Exact identification plate location shall be coordinated with the Owner/Engineer at the time of installation to provide uniformity of placement and ease of reading. Conduit numbers shall be exactly as shown on the Drawings.

X. Mandrels shall be pulled through all existing conduits that will be reused and through all new conduits two inches in diameter and larger prior to installing conductors.

Y. 3/16-inch polypropylene pull lines shall be installed in all new conduits noted as spares or designated for future equipment.

Z. All conduit that may under any circumstance contain liquids such as water, condensation, liquid chemicals, etc. shall be arranged to drain away from the equipment served. If conduit drainage is not possible, conduit seals shall be used to plug the conduits at the point of attachment to the equipment.

AA. Conduits shall not cross pipe shafts, access hatches or vent duct openings. They shall be routed to avoid such present or future openings in floor or ceiling construction.

BB. The use of running threads is prohibited. Where such threads are necessary, a three-piece union shall be used.

CC. Conduits passing from heated to unheated spaces, exterior spaces, refrigerated spaces, cold air plenums, etc. shall be sealed with Watertight Sealant as specified herein.

DD. Conduits shall be located a minimum of three inches from steam or hot water piping. Where crossings are unavoidable, the conduit shall be kept at least one inch from the covering of the pipe crossed.

EE. Conduits terminating at a cable tray shall be supported independently from the cable tray. Provide a conduit support within one foot of the cable tray. The weight of the conduit shall not bear on the cable tray.

FF. Conduits entering the top of electrical equipment enclosures from cable tray or otherwise routed from above the equipment in airconditioned dry indoor spaces shall coordinate
their placement with the HVAC duct vents such that cold air from the HVAC system will not blow directly on the vertical conduits causing condensation. Conduits which cannot be located away from direct exposure to cold air from the HVAC system shall be insulated to prevent condensation from forming inside the conduits or shall be re-routed. In all cases, condensation caused by cold air from the HVAC system shall be prevented from entering electrical enclosures. Equipment damaged by water from condensation shall be removed, replaced, conductors re-terminated, and its operation retested with no change in the contract price or schedule.

GG. All changes of direction on PVC coated steel conduit greater than 20 degrees shall be accomplished using long radius bends. Any field bends shall be made using equipment designed to prevent damage to the PVC coating.
PART 1 - GENERAL

1.01 SCOPE OF WORK

A. Furnish, install and test all wire, cable and appurtenances as shown on the Drawings and as specified herein.

1.02 RELATED WORK

A. Refer to Division 16000 and the Contract Drawings, for related work and electrical coordination requirements.

1.03 SUBMITTALS

A. Shop Drawings

1. Submit catalog data of all wire and cable, connectors and accessories, specified under this Section with all selections, options and exceptions clearly indicated. All cut sheets shall be clearly marked to indicate which products are being submitted for use on this project. Unmarked cut sheets will be cause to reject the submittal and return it for revision.

B. Certified Tests

1. Submit a test report of all installed wire insulation tests.

1.04 REFERENCE CODES AND STANDARDS

A. The equipment in this specification shall be designed and manufactured according to latest revision of the following standards (unless otherwise noted):

1. NFPA 70 – National Electrical Code (NEC)
2. NEMA WC-5 – Thermoplastic-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy
3. ANSI/TIA/EIA 606A – Standard for telecommunications Infrastructure

1.05 QUALITY ASSURANCE
A. The general construction of the wire, cables and the insulation material used shall be similar to that used for cable of the same size and rating in continuous production for at least 15 years and successfully operating in the field in substantial quantities.

B. Wire and cable with a manufacture date of greater than 12 months previous will not be acceptable.

C. Wire and cable shall be in new condition, with the manufacturer’s packaging intact, stored indoors since manufacture, and shall not have been subjected to the weather. Date of manufacture shall be clearly visible on each reel.

D. The manufacturer of these materials shall have produced similar electrical materials for a minimum period of five years. When requested by the Owner/Engineer, an acceptable list of installations with similar equipment shall be provided demonstrating compliance with this requirement.

1.06 JOBSITE DELIVERY, STORAGE AND HANDLING

A. Prior to jobsite delivery, complete all submittal requirements, and present to the Owner/Engineer prior to delivery of the equipment, an approved copy of all such submittals. Delivery of incomplete constructed equipment, or equipment which failed any factory tests, will not be permitted.

B. Check for reels not completely restrained, reels with interlocking flanges or broken flanges, damaged reel covering or any other indication of damage. Do not drop reels from any height.

C. Unload reels using a sling and spreader bar. Roll reels in the direction of the arrows shown on the reel and on surfaces free of obstructions that could damage the wire and cable.

D. Store cable on a solid, well drained location. Cover cable reels with plastic sheeting or tarpaulin. Do not lay reels flat.

1.07 WARRANTY

A. Provide warranties, including the manufacturer’s warrantee, for the equipment specified and the proper installation thereof, to be free from defects in material and workmanship for three years from date of final acceptance of the equipment and its installation. Within such period of warranty, all material and labor necessary to return the equipment to new operating condition shall be provided. Any warranty work requiring shipping or transporting of the equipment shall be provided at no expense to the Owner.
PART 2 - PRODUCTS

2.01 GENERAL

A. Wires and cables shall be annealed, 98% conductivity, soft drawn copper.

B. All conductors shall be Class B stranded.

C. Except for control, signal and instrumentation circuits, wire smaller than #12 AWG shall not be used.

2.02 POWER & BUILDING WIRE

A. All building wire shall be stranded copper conductors, Type XHHW-2

B. Manufacturers

1. Southwire
2. General Cable
3. Okonite
4. RSCC Wire & Cable
5. Encore Wire
6. Approved equal

2.03 VARIABLE FREQUENCY DRIVE CABLE

A. Cable for use with VFDs shall be symmetrical design, three stranded Class D, tinned copper, circuit conductors with XLPE insulation, three bare copper grounds, 100% shields with 50% overlap, and overall PVC jacket. Cable shall be 2000 volt, UL 1277 Type TC, XHHW-2 rated, 90°C., IEEE 1202/383.

B. Manufacturers

1. Belden
2. General Cable
3. Southwire
4. Okonite
5. RSCC Wire & Cable
6. Encore Wire
7. Approved equal

2.04 TRAY CABLE

A. Cable for tray use shall be stranded copper conductors, Type XHHW-2 insulation, rated as UL Type TC cable. Cable shall be sunlight resistant and approved for direct burial.

B. Manufacturers
   1. Southwire
   2. General Cable
   3. Okonite
   4. RSCC Wire & Cable
   5. Encore Wire
   6. Approved equal

2.05 GROUNDING ELECTRODE CONDUCTOR

A. Grounding electrode conductor shall be stranded copper conductor, Type XHHW-2 with green insulation.

B. Manufacturers
   1. Southwire
   2. General Cable
   3. Okonite
   4. RSCC Wire & Cable
   5. Encore Wire
   6. Approved equal
2.06  BONDING JUMPER

A. Bonding Jumper shall be bare tinned stranded copper conductor.

B. Manufacturers
   1. Southwire
   2. General Cable
   3. Okonite
   4. RSCC Wire & Cable
   5. Encore Wire
   6. Approved equal

2.07  CONTROL WIRE AND CABLE

A. Control wire shall be NEC Type XHHW-2.

B. Multi-conductor control cable, shall be stranded, #14 AWG 600-volt, XHHW-2, insulated, PVC outer jacket overall, Type TC, UL rated for underground wet location.

C. Manufacturers
   1. Southwire
   2. Okonite
   3. General Cable
   4. RSCC Wire & Cable
   5. Encore Wire
   6. Approved equal

2.08  INSTRUMENTATION CABLE

A. Cables for 4-20 ma, RTD, potentiometer and similar signals shall be PLTC rated and shall be:
1. Single pair cable:
   a. Conductors: Two #16 AWG stranded, tinned and twisted on two-inch lay
   b. Insulation: PVC with 600-volt, 90°C rating
   c. Shield: 100% Mylar tape with drain wire
   d. Jacket: PVC with manufacturer’s identification
   e. UL1685 listed for underground wet location use
   f. Manufacturers
      1) Okonite
      2) Belden
      3) Approved equal

2. Three conductor (triad) cable:
   a. Conductors: Three #16 AWG stranded, tinned and twisted on two-inch lay
   b. Insulation: PVC with 600-volt, 90°C rating
   c. Shield: 100% Mylar tape with drain wire
   d. Jacket: PVC with manufacturer’s identification
   e. UL1685 listed for underground wet location use
   f. Manufacturers:
      1) Okonite
      2) Belden
      3) Approved equal

3. Multiple pair cables (where shown on the Drawings):
   a. Conductor: Multiple pairs, #16 AWG stranded, tinned and twisted on a two-inch lay
   b. Insulation: PVC with 600-volt, 90°C rating
   c. Shield: Individual pairs shielded with 100% Mylar tape and drain wire
   d. Jacket: PVC with manufacturer’s identification
e. UL1685 listed for underground wet location use

f. Manufacturers:
   1) Okonite
   2) Belden
   3) Approved equal

2.09 COMMUNICATION CABLES

A. Cables for Ethernet and RS485 shall be rated and shall be:

1. Category 5e above Grade shielded Cable
   a. Conductors: Four bonded pair #24 AWG Bare Copper
   b. Insulation: Polyolefin
   c. Shield: 100% aluminum foil polyester tape with drain wire
   d. Jacket: PVC with 600-volt rated and manufacturer’s identification
   e. UL21047 and UL1666 listed for indoor and dry locations use
   f. Manufacturers
      1) Belden 7957A
      2) Approved equal

2. Category 5e above Grade un-shielded Cable
   a. Conductors: Four bonded pair #24 AWG Bare Copper
   b. Insulation: Polyolefin
   c. Jacket: PVC with 300-volt rated and manufacturer’s identification
   d. NEC CMR
   e. UL1666 listed for indoor and dry locations use
   f. Manufacturers
      1) Belden 7923A
      2) Approved equal
3. Category 6 above Grade shielded Cable
   a. Conductors: Four bonded pair #23 AWG Bare Copper
   b. Insulation: Polypropylene
   c. Shield: 100% aluminum foil polyester tape with drain wire
   d. Jacket: PVC with 600-volt rated and manufacturer’s identification
   e. Transmission Standards: Category 6 - TIA 568.C.2
   f. NEC CMR
   g. Flame Test Method: UL1666 Vertical Riser listed for indoor and dry locations use
   h. Manufacturers
      1) Belden 7953A
      2) Approved equal

4. Category 6 above Grade un-shielded Cable
   a. Conductors: Four bonded pair #23 AWG Bare Copper
   b. Insulation: Polyolefin
   c. Jacket: PVC with 300-volt rated and manufacturer’s identification
   d. Transmission Standards: Category 6 - TIA 568.C.2
   e. Nominal Velocity of Propagation: 72%
   f. Flame Test Method: UL1666 Vertical Riser listed for indoor and dry locations use
   g. Manufacturers
      1) Belden 7940A
      2) Approved equal

5. Category 5e below Grade shielded Cable
   a. Conductors: Four pair #24 AWG Bare Copper
   b. Insulation: Polyolefin
   c. Shield: 100% aluminum foil polyester tape with drain wire
d. Jacket: LLPE (Linear Low Density Polyethylene) with 300-volt rated and manufacturer’s identification

e. Misc.: NEMA WC-63.1, listed for outdoor and wet locations use

f. Water Blocking compound and listed for direct bury applications.

g. Manufacturers
   1) Belden 7937A
   2) Black Box
   3) Approved equal

6. Category 5e below Grade unshielded Cable

   a. Conductors: Four pair #24 AWG Bare Copper

   b. Insulation: Polyolefin

   c. Jacket: LLPE (Linear Low-Density Polyethylene) with 300-volt rated and manufacturer’s identification

   d. Misc.: NEMA WC-63.1, listed for outdoor and wet locations use.

   e. TIA-568-C.2 Category 5e compliance

   f. Water Blocking compound and listed for direct bury applications.

   g. Manufacturers
      1) Belden 7934A
      2) CommScope Ultra II 5NF4
      3) Approved equal

7. Category 6 below Grade Cable

   a. Conductors: 4 pair 23AWG Bare Copper

   b. Insulation: Polyolefin

   c. Shield: 100 percent aluminum foil polyester tape with drain wire

   d. Jacket: Polyethylene with 300 volts rated and manufacturer’s identification

   e. Misc.: Gel filled and NEMA WC-63.1, listed for outdoor and wet locations use
f. Manufacturers:

1) CommScope SYSTIMAX GigaSPEED X10D 1571

2) Approved equal

8. 485 Communications Cable

a. Conductors: One pair #24 AWG Tinned Copper

b. Insulation: Polyethylene

c. Shield: 100% aluminum foil polyester tape with tinned copper drain wire

d. Jacket: PVC with 300-volt rated and manufacturer's identification

e. Misc.: UL2919 listed for indoor and dry locations use

f. Manufacturers

1) Belden 9841

2) Approved equal

2.10 TERMINATION MATERIALS

A. Power Conductors: Termination materials, of conductors at equipment, shall be as specified in the relevant equipment Section.

B. Control and Instrumentation Conductors (including graphic panel, alarm, low- and high-level signals): Termination connectors shall be DIN-rail-mounted one-piece molded plastic blocks with tubular-clamp-screw type, with end barriers, dual side terminal block numbers and terminal group identifiers. Terminals to be UL Listed for stranded conductor terminations. Rated for a maximum of 2 #14 stranded conductors. Color of terminals to comply with NFPA 79.

C. Manufacturers

1. Phoenix Contact

2. Entrelec

3. Weidmuller

4. Allen Bradley

5. Approved equal
D. Motor Conductors: Motor connections with conductors #12 AWG up to #6 AWG shall be ring type compression terminations on the motor leads and secured with bolt, nut and spring washer. Connections shall be -30°C rubber insulated, half lap, and two layers minimum of Scotch 33 or equal vinyl tape. Motor terminations for conductors #8 AWG and larger shall be in accordance with paragraph “Lugs and Connectors” below. Motors provided on this project per specification 16150 and / or 16151 shall have motor terminals enclosures with bus and NEMA one-hole or two-hole pads to accommodate the conductor terminals specified herein.

E. Lugs and Connectors

1. All lugs and connectors shall be tin plated copper and shall be crimped type, installed with standard industry tooling. Lugs and connectors shall match the wire size where used, and shall be clearly identified and color coded on the connector. All connections shall be made for stranded wire and shall be made electrically and mechanically secured. The lugs and connectors shall have a current carrying capacity equal to the conductors for which they are rated and meet UL 486 requirements for 75°C. Lugs for #12 AWG up to #6 AWG shall be ring terminals. Conductors #4 AWG and larger shall be two-hole long barrel lugs with NEMA spacing. All lugs shall be the closed end construction to exclude moisture migration into the cable conductor.

2.11 SPLICE MATERIALS

A. Power Conductors: Circuits shall be pulled from terminal to terminal, without splicing, except where splicing is shown on the Drawings. No other splicing will be permitted. For wires sizes #8 AWG and smaller, provide color coded wire nuts, with metal inserts, 3M or Ideal, rubber insulated with half lap and two layers minimum of Scotch 33 tape. For wires greater than #8 AWG, provide a heat shrink insulated, color-coded, die-crimped splice lug, T&B 54XXX, or equal, rubber insulated, with half lap and two layers minimum of Scotch 33 tape.

B. Control and Instrumentation Conductors (including graphic panel, alarm, low and high level signals): No splicing of control and instrumentation conductors will be permitted.

2.12 WALL AND FLOOR SLAB OPENING SEALS

A. Wall and floor slab openings shall be sealed with “FLAME-SAFE” as manufactured by the Thomas & Betts Corp. or equal.

2.13 WIRE AND CABLE TAGS

A. Use the tagging formats for wire and cable as shown on the Drawings. Where modifications or additions are made to existing wire and cable runs, replace existing tags with new modified tags.
B. Wire tags for wire sizes, #2 AWG and smaller, shall be heat shrink type Raychem TMS-SCE, or approved equal with the tag numbers typed with an indelible marking process. Character size shall be a minimum of 1/8-inch in height. Hand written tags shall not be acceptable. Where ends are not available, attach cable tags with nylon tie cord.

C. Tags for wires larger than #2 AWG and all cables shall be thermally printed polyethylene type, Brady TLS 2200 or approved equal, nylon zip tied in accordance with the manufacturer’s instructions.

D. Tags relying on adhesives or taped-on markers are not acceptable.

E. Tagging shall be done in accordance with the execution portion of these Specifications.

2.14 WIRE COLOR CODE

A. All wire shall be color coded or coded using electrical tape in sizes #8 or greater, where colored insulation is not available. Where tape is used as the identification system, it shall be applied in all junction boxes, manholes and other accessible intermediate locations as well as at each termination.

B. The following coding shall be used:

<table>
<thead>
<tr>
<th>System</th>
<th>Wire</th>
<th>Color</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-Phase, 3 Wire</td>
<td>Phase A</td>
<td>Black</td>
</tr>
<tr>
<td></td>
<td>Phase B</td>
<td>Blue</td>
</tr>
<tr>
<td></td>
<td>Neutral</td>
<td>White</td>
</tr>
<tr>
<td>208Y/120, Volts 3-Phase, 4 Wire</td>
<td>Phase A</td>
<td>Black</td>
</tr>
<tr>
<td></td>
<td>Phase B</td>
<td>Red</td>
</tr>
<tr>
<td></td>
<td>Phase C</td>
<td>Blue</td>
</tr>
<tr>
<td></td>
<td>Neutral</td>
<td>White</td>
</tr>
<tr>
<td>480/277, Volts 3-Phase, 4 Wire</td>
<td>Phase A</td>
<td>Brown</td>
</tr>
<tr>
<td></td>
<td>Phase B</td>
<td>Orange</td>
</tr>
<tr>
<td></td>
<td>Phase C</td>
<td>Yellow</td>
</tr>
<tr>
<td></td>
<td>Neutral</td>
<td>Gray/White with one or more colored stripes</td>
</tr>
</tbody>
</table>

2.15 CABLE TAG COLOR CODE

A. All cable tags shall be white in color with black printing.
PART 3 - EXECUTION

3.01 GENERAL

A. Do not install conductors until the raceway system is in place. No conductor shall be installed between outlet points, junction points or splicing points, until raceway sections have been completed, and raceway covers are installed for protection of conductors from damage or exposure to the elements. Any conductor installed in an incomplete raceway system shall be removed from the raceway system and from project site. A complete inspection of such raceway sections shall be completed, before new conductors are installed.

B. Installed unapproved wire shall be removed and replaced at no additional cost to the Owner.

C. Completely swab raceway system before installing conductors. Do not use cleaning agents and lubricants which have a deleterious effect on the conductors or their insulation.

D. Pull all conductors into a raceway at one time, using wire pulling lubricant as needed to protect the wire.

E. Except for hand-pulled conductors into raceways, all wire and cable installation shall be installed with tension-monitoring equipment. Conductors which are found to have been installed without tension-monitoring shall be immediately removed from the raceways, permanently identified as rejected material, and removed from the jobsite. New conductors and cables shall be reinstalled, tagged and raceways resealed, with no change in the Contract Price or Schedule allowed.

F. Do not exceed cable manufacturer’s recommendations for maximum pulling tensions and minimum bending radii. Where pulling compound is used, use only UL listed compound compatible with the cable outer jacket and with the raceway involved.

G. Tighten all screws and terminal bolts using torque type wrenches and/or drivers to tighten to the inch-pound requirements of the NEC and UL.

H. Single conductors and cables in manholes, hand holes, vaults, cable trays, and other indicated locations are not wrapped together by some other means such as arc and fireproofing tapes, shall be bundled throughout their exposed length with nylon, self-locking, releasable, cable ties placed at intervals not exceeding four inches on centers.
I. All wire and cable installed in cable trays shall be UL Listed as Type TC, for cable tray use.

3.02 CONDUCTORS 1000 VOLTS AND BELOW

A. Provide conductor sizes indicated on Drawings, as a minimum.

B. Use crimp connectors on all stranded conductors.

C. Soldered mechanical joints insulated with tape will not be acceptable.

D. Arrange wiring in cabinets and panels neatly cut to proper length. Surplus wire shall be removed unless noted otherwise. Conductors shall be bridled or bundled and secured in an acceptable manner. Identify all circuits entering motor control centers and all other control enclosures in accordance with the conductor identification system specified herein.

E. Terminate control and instrumentation wiring with methods consistent with terminals provided, and in accordance with terminal manufacturer's instructions.

F. Attach compression lugs, larger than #6 AWG, with a tool specifically designed for that purpose which provides a complete, controlled crimp where the tool will not release until the crimp is complete. Use of plier type crimpers is not acceptable.

G. Cap spare conductors and conductors not terminated with the UL listed end caps.

H. Remove all burrs, chamfer all edges, and install bushings and protective strips of insulating material to protect the conductors passing through holes or over edges in sheet metal enclosures.

I. Provide at least 6 feet spare conductors in freestanding panels and at least two feet spare in other assemblies for all conductors which are to be terminated by others. Provide additional conductor length in any assembly where it is obvious that more conductor will be needed to reach the termination point.

J. Do not combine power conductors in the same raceway unless shown on Drawings. Do not run signal conductors carrying voltages less than 120 volts AC in the same raceway as conductors carrying higher voltages regardless of the insulation rating of the conductors. Do not share neutrals on branch circuits.
3.03 GROUNDING

A. Conduits and other raceways shall contain an equipment grounding conductor whether the raceway is metallic or not. Conduits, motors, cabinets, outlets and other equipment shall be properly grounded in accordance with NEC requirements and specification 16660 26 05 26. Ground wires exposed to mechanical damage shall be installed in rigid aluminum conduit. Make connections to equipment with solderless connections. Connections to ground rods shall be of the fused type equal to the Cadweld process.

3.04 TERMINATIONS AND SPLICES

A. No splices of wire and cable will be permitted, except where specifically permitted by the Owner/Engineer in writing, or as shown on the Drawings.

B. Power conductors: Terminations shall be made with connectors as specified. Splices, where specifically allowed as stated above, shall be made in a Termination Cabinet (TC).

C. Control Conductors: Splices of control conductors will not be permitted between terminal points. Terminations shall be made with approved terminals as specified.

D. Instrumentation Signal Conductors (including graphic panel, alarm, low and high level signals): Splices of Instrumentation conductors will not be permitted between terminal points. Terminations shall be made with connectors as specified. The shield of pair shielded and triad shielded shall be terminated on terminal strips. Provide dedicated terminal block to every conductor including shields. Double lugging terminations is not acceptable.

3.05 INSTRUMENTATION CABLES

A. Instrumentation cables shall be installed in raceways as specified. Unless specifically shown on the Drawings, all instrumentation circuits shall be installed as single shielded twisted pair cables or single shielded twisted triads. In no case shall a circuit be made up using conductors from different pairs or triads. Triads shall be used wherever three wire circuits are required.

B. Terminal blocks shall be provided at all instrument cable junction boxes, and all circuits shall be identified at such junctions.

C. Shielded instrumentation wire, coaxial cable, data highway cable, discrete I/O, multiple conductor cable, and fiber optic cables shall be run without splices between instruments, terminal boxes, or panels. The shield shall be continuous for the entire run.
D. Shields shall be grounded at the PLC/RTU. Terminal blocks shall be provided for inter-connecting shield drain wires at all junction boxes. Individual circuit shielding shall be provided with its own block.

E. Shield wire shall be wrapped and taped at the transmitter end of the signal run. Before termination, peel back the outer sheath, leaving the shield intact. Wrap the drain wire around the conductors, leaving approximately two inches exposed. Wrap the drain wire with two layers of Scotch 33 tape.

3.06 WIRE TAGGING

A. All wiring shall be tagged at all termination points and at all major access points in the electrical raceways. A termination point is defined as any point or junction where a wire or cable is physically connected. This includes terminal blocks and device terminals. A major access point to a raceway is defined as any enclosure; box or space designed for wire or cable pulling or inspection and includes pull boxes, manholes, and junction boxes.

B. Wire tags shall show both origination and destination information to allow for a wire or cable to be traced from point in the field. Information regarding its origination shall be shown in parenthesis.

C. For multiconductor cables, both the individual conductors and the overall cable shall be tagged. Conductors that are part of a multiconductor cable shall reference the cable identification number that they are a part of, as well as a unique conductor number within the cable.

3.07 CABLE TAGGING

A. All cables shall be tagged at all termination points and at all major access points in the electrical raceways as defined in the wire tag section of this Specification.

B. The cable tag shall be installed where the cable enters and leaves each access point (e.g., junction box, manhole, etc.). In cases of limited access space, a single tag may be used that shows both equipment tag origination and destination. In the case where the jacket is stripped for terminations, the tag shall be installed at the end of the jacket.

3.08 RACEWAY SEALING

A. Raceways entering junction boxes or control panels containing electrical or instrumentation equipment shall be sealed with 3M 1000NS Watertight Sealant or approved equal.
B. This requirement shall apply to all raceways in the conduit system.

3.09 FIELD TESTS

A. Conductors under 600 volts

1. Perform insulation resistance testing of all power circuits below 1000 volts with a 1000-volt megger, in accordance with the recommendations of the wire manufacturer.

2. Prepare a written test report of the results and submit to the Owner/Engineer prior to final inspection.

3. Minimum acceptable value for insulation resistance is 100 megohms. Lower values shall be acceptable only by the Owner/Engineer’s specific written approval.

4. Disconnect equipment that might be damaged by this test. Perform tests with all other equipment connected to the circuit.

B. Tests: After instrumentation cable installation and conductor termination by the instrumentation and control supplier, perform tests to ensure that instrumentation cable shields are isolated from ground, except at the grounding point in the instrumentation control panel. Remove all improper grounds.
END OF SECTION
PART 1 - GENERAL

1.01 SCOPE OF WORK

A. Furnish all labor, materials, equipment, and install wiring devices as shown on the Drawings and as specified herein.

B. Provide all interconnecting conduit and branch circuit wiring for receptacle circuits in accordance with the NEC.

1.02 RELATED WORK

1.03 Refer to Division 16000 and the Contract Drawings, for related work and electrical coordination requirements.

1.04 SUBMITTALS

A. Shop Drawings

1. Submit catalog data of all switches, receptacles and other specified items under this Section, with all options, application locations and exceptions clearly indicated. All cut sheets shall be clearly marked to indicate which products are being submitted for use on this project. Unmarked cut sheets will be cause to reject the submittal and return it for revision.

1.05REFERENCE STANDARDS

A. Wiring devices shall comply with the requirements of the National Electrical Code (NEC) and shall be Underwriters Laboratories (UL) labeled.

1.06 QUALITY ASSURANCE

A. The manufacturer of these materials shall have produced similar electrical materials and equipment for a minimum period of five years. When requested by the Owner/Engineer, an acceptable list of installations with similar equipment shall be provided demonstrating compliance with this requirement.
B. The manufacturer of the assembly shall be the manufacturer of the major components within the assembly. All assemblies shall be of the same manufacturer.

1.07 JOBSITE DELIVERY, STORAGE AND HANDLING

A. Prior to jobsite delivery, the Contractor shall have successfully completed all submittal requirements, and present to the Owner/Engineer upon delivery of the equipment, an approved copy of all such submittals. Delivery of incomplete constructed equipment, or equipment which failed any factory tests, will not be permitted.

B. Equipment shall be handled and stored in accordance with manufacturer's instructions.

C. Equipment shall be stored indoors and protected from moisture, dust and other contaminants.

D. Equipment shall not be installed until the location is finished and protected from the elements.

1.08 WARRANTY

A. The Manufacturer shall warrant the equipment to be free from defects in material and workmanship for one year from date of final acceptance of the equipment. Within such period of warranty, the Manufacturer shall promptly furnish all material and labor necessary to return the equipment to new operating condition.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Subject to compliance with the Contract Documents, the Manufacturers listed in each product category are acceptable.

B. The listing of specific manufacturers does not imply acceptance of their products that do not meet the specified ratings, features and functions. Manufacturers listed are not relieved from meeting these specifications in their entirety.

2.02 RATINGS

A. The service voltage, shall be as shown on the Drawings. The overall short circuit withstand and interrupting rating of the equipment and devices shall be equal to or
greater than the overall short circuit withstand and interrupting rating of the feeder device immediately upstream of the equipment.

2.03 MATERIALS

A. Wall switches shall be heavy duty, industrial specification grade, toggle action, flush mounting quiet type. All switches shall conform to the latest revision of Federal Specification WS 896.

1. Manufacturer
   a. Cooper (catalog number as listed)
   b. Hubbell, Inc.
   c. Pass & Seymour, Inc.
   d. Approved equal

2. Single pole, 20 Amp, 120/277 Volt – (Cooper 2221V)
3. Double pole, 20 Amp, 120/277 Volt – (Cooper 2222V)
4. Three way, 20 Amp, 120/277 Volt – (Cooper 2223V)
5. Four way, 20 Amp, 120/277 Volt – (Cooper 2224V)
6. Single pole, 20 Amp, 120/277 Volt - key operated - (Cooper AH1191N)
7. Single pole, 20 Amp, 120 Volt - red pilot-lighted handle – (Cooper 2221PL)
8. Single pole, 20 Amp, 120 Volt, clear lighted handle – (Cooper 2221LTV)
9. Momentary contact, three position, 2 circuit, center off – (Cooper 1995V)

B. Fluorescent wall box dimmer switch for 120/277 Volt control of rapid start fluorescent lamps with a dimming range of 100% to 0.5% light for 120-volt and 100% to 1% light for 277-volt.

1. Manufacturers
   a. Lutron Electronics Co., Inc.
   b. Lithonia Control Systems
   c. Valmont Electric, Inc.
   d. Approved equal.
C. Explosion-proof single pole factory sealed switches shall be for 20 Amps, 120/277 volts, mounted in copper free aluminum boxes.

1. Manufacturers
   a. Crouse-Hinds EDS Series
   b. Appleton Electric Co.
   c. Killark
   d. Approved equal.

D. Receptacles shall be heavy duty, corrosion resistant, specification grade of the following types and manufacturer or equal. Receptacles shall conform to Fed Spec WC596.

1. Manufacturers
   a. Cooper (catalog numbers as listed)
   b. Hubbell, Inc.
   c. Pass & Seymour, Inc.
   d. Approved equal

2. Duplex, 20 Amp, 125 Volt, 2 Pole, 3 Wire Grounding, high impact, arc and moisture resistant yellow nylon construction, heavy nickel plating on metal parts; (Cooper 5362CRY)

3. Single, 20 Amp, 250 Volt, 2 Pole, 3 Wire; (Cooper 5461GY)

E. Weatherproof covers

1. Die cast aluminum. Plastic or other non-metallic in-use covers are not acceptable.

2. Weatherproof while-in-use rating

3. Manufacturers
   a. Eaton Catalog No. WIUMH/V
   b. Thomas & Betts
   c. Approved equal

F. Special purpose
1. Manufacturers
   a. Cooper (catalog number as listed)
   b. Hubbell
   c. Pass & Seymour
   d. Approved equal

2. Clock hanger single, 15 Amp, 125 Volt, 2 Pole, 3 Wire, with hanging hook on device plate. (Cooper 452)

3. Single, corrosion resistant locking, 20 Amp, 125 Volt, 2 Pole, 3 Wire; Cooper, Catalog No. CRL520R and plug (Cooper CRL520P)

4. Single twist-lock, 30 Amp, 125 Volt, 1 Phase, 3 Wire; Cooper, Catalog No. CRL530R; plug. (Cooper CRL530P)

5. Single twist-lock, 20 Amp, 250 Volt, 1 Phase, 3 Wire; Cooper, Catalog No. CRL620R; plug. (Cooper CRL620P) similar by Hubbell, Inc.; Pass & Seymour, Inc. or equal.

6. Single twist-lock, 30 Amp, 250 Volt, 1 Phase, 3 Wire; Cooper, Catalog No. CRL630R; plug. (Cooper CRL630P)

G. Explosion-proof receptacles and plugs

1. Manufacturers
   a. Appleton Electric (Catalog number as listed)
   b. Crouse-Hinds
   c. Hubbell Inc.
   d. Approved equal.

2. Single, 20 Amp, 125 Volt, 1 Phase, 3 Wire. (Appleton EFSC175-2023 and plug ECP-2023)

3. Duplex, 20 Amp, 125 Volt, 1 Phase, 3 Wire. (Appleton EFSC275-2023 and plug, ECP-2023)

4. Single, 20 Amp, 250 Volt, 1 Phase, 3 Wire. (Appleton EFSC175-20232 and plug ECP-20232)

5. Duplex, 20 Amp, 250 Volt, 1 Phase, 3 Wire. (Appleton EFSC275-20232 and plug ECP-20232)
H. Device Plates

1. Plates for indoor flush mounted devices shall be of the required number of gangs for the application involved and shall be as follows:
   
a. Administration type buildings: Smooth, high impact nylon of the same manufacturer and color as the device. Final color to be as selected by the Architect.
   
b. Where permitted in other areas of the plant, flush mounted devices in cement block construction shall be Type 302 high nickel (18-8) stainless steel of the same manufacturer as the devices.

2. Plates for indoor surface mounted device boxes shall be cast metal of the same material as the box, Crouse-Hinds No. DS23G and DS32G, or equal.

3. Oversized plates shall be installed where standard plates do not fully cover the wall opening.

4. Device plates for switches mounted outdoors or indicated as weatherproof shall be gasketed, cast aluminum with provisions for padlocking switches "On" and "Off", Crouse Hinds No. DS185, or equal.

5. Multiple surface mounted devices shall be ganged in a single, common box and provided with an adapter, if necessary, to allow mounting of single gang device plates on multi-gang cast boxes.

6. Engraved device plates shall be provided where required.

7. Weatherproof, gasketed cover for GFI receptacle mounted in a FS/FD box
   
a. Manufacturers
      
1) Cooper, Catalog No. 4501-FS
   
2) Hubbell, Inc.

3) Pass & Seymour, Inc.

4) Approved equal.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Switches and receptacles shall be installed flush with the finished wall surfaces in areas with stud frame and gypsum board construction, in dry areas with cement block construction or when raceways are shown as concealed on the Drawings.
B. Do not install flush mounted devices in areas designated DAMP, WET or WET/CORROSIVE on the Drawings. Provide surface mounted devices in these areas.

C. Provide weatherproof devices covers in areas designated WET or WET/CORROSIVE on the Drawings.

D. Unless otherwise shown on the Drawings, wall switches and other wall mounted controls shall be installed at 54 inches AFF.

E. Convenience receptacles shall be 36 inches above the floor unless otherwise shown.

F. Convenience receptacles installed outdoors and in rooms where equipment may be hosed down shall be 36 inches above floor or grade. Switches shall be ganged together under one cover plate.

G. The location of all devices is shown, in general, on the Drawings and may be varied within reasonable limits so as to avoid any piping or other obstruction without extra cost, subject to the approval of the Owner. Coordinate the installation of the devices for piping and equipment clearance.

H. Convenience receptacles and light switches shall be connected using stranded pig tails and spring fork insulated lugs. Feed-through wiring of receptacles is prohibited.

3.02 FIELD QUALITY CONTROL

A. Test wiring devices to ensure electrical continuity of grounding. Energize the circuit to demonstrate compliance with the requirements.
PART 1 - GENERAL

1.01 SCOPE OF WORK

A. This Section of the Specifications describes the requirements for power metering and protective relays to be furnished under other Sections of the Specifications to which reference is made in the Related Work paragraph of this Section.

B. All equipment described herein shall be submitted and furnished as an integral part of equipment specified elsewhere in these Specifications.

1.02 RELATED WORK

A. Refer to Division 16000 and the Contract Drawings, for related work and electrical coordination requirements.

1.03 SUBMITTALS

A. Refer to Division 16000 for media and format for shop drawing submittals.

B. All cut sheets shall be clearly marked to indicate which products are being submitted for use on this project. Unmarked cut sheets will cause the submittal to be rejected and returned for revision.

C. Submittals shall also contain information on related equipment to be furnished under this Specification. Incomplete submittals not containing the required information on the related equipment will also be returned without review.

D. Submit catalog data for all items supplied from this specification Section as applicable. Submittal shall include catalog data, functions, ratings, inputs, outputs, displays, etc., enough to confirm that the meter or relay provides every specified requirement. Any options or exceptions shall be clearly indicated.

E. Operation and Maintenance Manuals.

1. Operation and Maintenance manuals shall include the following information:
a. Manufacturer’s contact address and telephone number for parts and service.
b. Instruction books and/or leaflets
c. Recommended renewal parts list
d. Record Documents for the information required by the Submittals above.

1.04 REFERENCE CODES AND STANDARDS

A. The equipment in this specification shall be designed and manufactured according to latest revision of the following standards (unless otherwise noted):

1. NEMA/ISCI – 109 Transient Overvoltage Withstand Test
2. IEEE Std. 472/ANSI C37.90A Surge Withstand Capability Tests
3. IEC 255.4 Surge Withstand Capability Tests

B. All meters, relays and associated equipment shall comply with the requirements of the National Electric Code and Underwriters Laboratories (UL) where applicable.

C. Each specified device shall also conform to the standards and codes listed in the individual device paragraphs.

1.05 QUALITY ASSURANCE

A. The manufacturer of this equipment shall have produced similar electrical equipment for a minimum period of five years. When requested by the Owner/Engineer, an acceptable list of installations with similar equipment shall be provided demonstrating compliance with this requirement.

B. Equipment submitted shall fit within the space or location shown on the Drawings. Equipment which does not fit within the space or location is not acceptable.

C. For the equipment specified herein, the manufacturer shall be ISO 9001 2000 certified.

1.06 WARRANTY

A. Provide warranties, including the manufacturer’s warrantee, for the equipment specified and the proper installation thereof, to be free from defects in material and workmanship for three years from date of final acceptance of the equipment and its installation. Within such period of warranty, all material and labor necessary to return the equipment to new
operating condition shall be provided. Any warranty work requiring shipping or transporting of the equipment shall be provided at no expense to the Owner.

PART 2 - PRODUCTS

2.01 GENERAL

A. Metering and Protective Relay Enclosures

1. Enclosures for meters and protective relays located within the associated equipment shall have the same Enclosure Types as specified for the associated equipment.

B. Settings

1. Refer to Section 16105 Power System Study for relay settings.

2.02 FEEDER PROTECTION SYSTEM (FP1)

A. Subject to compliance with the Contract Documents, the following Manufacturers are acceptable:

1. Multilin Model 850
2. Schweitzer Engineering Laboratories Model SEL-751
3. Basler Electric Model BE1-11f
4. Approved equal

B. The listing of specific manufacturers above does not imply acceptance of their products that do not meet the specified ratings, features and functions. Manufacturers listed above are not relieved from meeting these specifications in their entirety.

C. General

1. The relay shall have a common hardware and firmware platform that shall support feeder, motor, transformer and generator applications.

2. The unit shall be equipped with separate processors for protection and for communication related functions. The relay shall provide protection, control, and monitoring functions with both local and remote human interfaces.

3. The relay shall be of draw out construction.
4. All circuit boards shall have a harsh environment conformal coating to resist H2S gas and other corrosive agents, including humidity.

5. All components, except terminating hardware, shall be mounted inside the relay.

6. The unit shall be suitable for semi-flush mounting in a panel.

7. It shall be equipped with a front panel display and keypad for programming and monitoring.

8. The relay shall comply with surge withstand capability standards ANSI C37.90 and IEC 255.4.

D. Protection: The relay shall provide analog input systems that can reproduce up to 46 times CT rating RMS symmetrical. The relay shall execute protection related main algorithms at 8 times per power system cycle.

1. The relay shall have the protective functions as show on the drawings: Settings for selected functions are as follows.

<table>
<thead>
<tr>
<th>ANSI Function</th>
<th>Description</th>
<th>Setting</th>
</tr>
</thead>
<tbody>
<tr>
<td>27</td>
<td>Phase under voltage</td>
<td>&lt;85%</td>
</tr>
<tr>
<td>50</td>
<td>Instantaneous overcurrent</td>
<td>According to protective device coordination study</td>
</tr>
<tr>
<td>50G</td>
<td>Ground instantaneous overcurrent</td>
<td>According to protective device coordination study</td>
</tr>
<tr>
<td>51</td>
<td>Time overcurrent</td>
<td>According to protective device coordination study</td>
</tr>
<tr>
<td>51G</td>
<td>Ground time overcurrent</td>
<td>According to protective device coordination study</td>
</tr>
<tr>
<td>59</td>
<td>Phase over voltage</td>
<td>&gt;115%</td>
</tr>
<tr>
<td>81O</td>
<td>Over Frequency</td>
<td>&gt;60.5 Hz</td>
</tr>
<tr>
<td>81U</td>
<td>Under Frequency</td>
<td>&lt;59.5 Hz</td>
</tr>
</tbody>
</table>

2. The phase time overcurrent can be selected to operate either on RMS or Fundamental value.

3. The relay shall have the ability to build trip and alarm matrices and directly assign corresponding output relay without using programmable logic.
4. The relay shall have 6 switchable setting groups for dynamic reconfiguration of the protection elements due to changed conditions such as system configuration changes, or seasonal requirements.

5. The relay shall support 8 flex elements that can use any available/calculated analog parameters within the relay (e.g. comparator, inverter, over/under, etc).

6. The relay shall support 16 digital counters.

E. Programmable Logic:

1. The relay shall support 1024 lines of user defined logic to build control schemes supporting logic gates, timers, nonvolatile latches.

2. The programmable logic in the relay shall be executed at 8 times per power system cycle.

3. The relay configuration tool shall have embedded graphical user interface to build programmable logic.

F. Communications:

1. The relay shall support the following communication protocols:
   a. Modbus RTU
   b. Modbus TCP/IP

2. The relay shall have support multiple time synchronization sources such as IRIG-B, IEEE 1588 and SNTP with the ability to configure priority for the time sources and dynamically switch based on availability of each source.

3. The relay shall provide two fiber optic Ethernet ports with two modes of operation – fail over mode or independent mode.

4. The relay shall have an option for Wi-Fi (IEEE 802.11 b/g/n) connectivity to configure settings and retrieve operational records.

5. The relay shall have a front panel USB port that shall provide connectivity to configure settings and retrieve operational records.

6. The relay shall provide a user definable memory map.

7. The protocol interface shall implement Modbus TCP Protocol with the following as minimum capabilities:
   a. All data shall be available and/or mirrored within the Modbus 4x or "Holding Register" memory area.
b. Register 4x00001 shall exist and be readable to allow simple, predictable "com tests".

c. Software tools shall function properly with slaves’ only supporting Modbus functions 3, 4 and 16. Requiring support of diagnostic function 8 is not acceptable.

d. Software tools shall be configurable to write a single register as either function 6 or 16.

e. Software tools shall allow setting the Modbus/TCP "Unit Id" to be a value other than zero. This is required for Ethernet-to-Serial bridging.

8. The media protocol converter shall meet the following criteria:

a. The converter shall support 10/100Base-T Ethernet. The serial port speed (baud rate) shall support 230kbps. The protocol shall support Modbus TCP, Ethernet IP, DF1, and Modbus RTU/ASCII. Protocol shall be Web Browser configurable.

b. Operating limits shall be 0-60°C, with humidity range minimum of 5-90%. Shock capability on the serial port shall be ESD +15 kV air GAP meeting IEC 1000-4-2. Power requirements shall be 9-30VDC at 0.5A minimum.

c. The converter shall have LED status for serial, signals, power, and Ethernet.

d. The converter housing shall be UL 1604, Class 1 Div 2, DIN Rail mountable. The converter shall have DB-9M port connection, with screw terminals, to the input.

e. Converter shall be Digi One IAP, or approved equal.

G. Relay Configuration / Setting File Management

1. Entire relay setting from only single setting file shall be supported:

2. Entire relay settings (not only communication related but also protection and control functional settings) shall be part of the same single setting file.

3. There shall be only single relay setting (i.e. CID based KML format) file which can be directly uploaded into the device. No intermediate conversion of any proprietary setting file formats which requires to manage multiple settings files for just one relay.

4. The relay shall be able to receive this single configuration / setting file from any third party tool (not only vendor specific proprietary relay configuration tool).

H. Front-Panel Visualization

1. User interface shall provide a large color LCD front panel display, and navigation keys.
2. Front panel color LCD to display single line diagram (SLD) of the generator with online metering and status information.

3. The front panel shall be capable of displaying measured values, calculated values, I/O status, device status, target messages, events, motor learner data and configured relay settings.

4. The front panel shall have user-programmable LEDs and pushbuttons.

I. Metering and Digital Fault Recording.

1. The relay shall record its exposure to temperature, humidity and surge and a report shall be retrievable via the communication ports on the min / max average of those recorded values.

2. The relay shall provide up to 64 digital channels and up to 40 analog channels of oscillography at a sampling rate of 128 samples per cycle.

3. The relay shall provide a fault report with option for fault locator.

4. The relay shall provide event records – with a record of the last 1024 events, time tagged with a resolution of 1ms.

5. The relay shall store all its recorded data in nonvolatile memory.

6. The relay shall provide data logger function which shall record a maximum of 16 analog channels.

7. The current metering accuracy shall be at +/- .25% of the reading for up to 2 times rated secondary current and +/- 1% above them.

8. The voltage metering accuracy shall be at +/- 0.5% of the reading from 15 to 208 volts.

9. The power metering accuracy shall be at +/- 1% of the reading.

10. The frequency metering accuracy shall be typically 1 milliHertz accuracy level.

J. Hardware

1. Relay shall have conformal coated electronic board assemblies for harsh environment deployment.

3. The relay shall have draw-out construction to facilitate testing, maintenance and interchange flexibility.

4. The relay shall not use electrolytic capacitors as any component or sub-component.

5. The relay shall provide a field swappable power supply module.

6. The relay shall have a scan rate of 128 samples per power system cycle for digital inputs and provide less than 1 msec time stamp resolution for state changes.

7. The relay shall provide an operating temperature range of -40 to 60°C.

8. The relay shall support a minimum of 10 digital outputs and 14 digital inputs.

9. The relay shall provide a field swappable power supply module.

10. The relay contacts shall be rated for a minimum of 10A continuous.

K. Security

1. The relay shall provide RBAC (Role Based Access Control) with three roles such as Observer, for accessing operational data, Operator for start-stop of the motor, Administrator for configuring.

2. The relay shall provide option for password complexity.

3. The relay shall provide option for local device level authentication and for remote server authentication using RADIUS.

4. The relay shall provide support for SYSLOG to publish security related events.

5. The relay shall support secure file transfer protocol SFTP.

6. Security setting reports must include the following events with time stamp:
   a. Failed Authentication
   b. User Lock out
   c. Setting changes
   d. Log in
   e. Log out
   f. RADIUS server unreachable
g. Clear Event / Transient / Fault records

2.03 MOTOR PROTECTION SYSTEM (MP4)

A. Subject to compliance with the Contract Documents, the following Manufacturers are acceptable:

1. Multilin 469
2. Schweitzer Engineering Laboratories Model SEL-710
3. Approved equal

B. The listing of specific manufacturers above does not imply acceptance of their products that do not meet the specified ratings, features and functions. Manufacturers listed above are not relieved from meeting these specifications in their entirety.

C. Minimum ANSI Functions

<table>
<thead>
<tr>
<th>ANSI Function</th>
<th>Description</th>
<th>Setting</th>
</tr>
</thead>
<tbody>
<tr>
<td>27</td>
<td>Under voltage</td>
<td>&lt;85%</td>
</tr>
<tr>
<td>37</td>
<td>Undercurrent/Under voltage</td>
<td>Per motor vendor recommendation</td>
</tr>
<tr>
<td>38</td>
<td>Bearing Temperature</td>
<td>Enabled</td>
</tr>
<tr>
<td>46</td>
<td>Current Unbalance</td>
<td>Enabled</td>
</tr>
<tr>
<td>47</td>
<td>Voltage Unbalance / Phase Reversal / Phase Failure</td>
<td>Enabled</td>
</tr>
<tr>
<td>49</td>
<td>Stator Temperature</td>
<td>Enabled</td>
</tr>
<tr>
<td>50</td>
<td>Instantaneous Current</td>
<td>According to protective device coordination study</td>
</tr>
<tr>
<td>50G</td>
<td>Instantaneous Ground Current</td>
<td>According to protective device coordination study</td>
</tr>
<tr>
<td>51</td>
<td>Overcurrent</td>
<td>According to protective device coordination study</td>
</tr>
<tr>
<td>51G</td>
<td>Ground Overcurrent</td>
<td>According to protective device coordination study</td>
</tr>
</tbody>
</table>
### ANSI Function Description Setting

<table>
<thead>
<tr>
<th>ANSI Function</th>
<th>Description</th>
<th>Setting</th>
</tr>
</thead>
<tbody>
<tr>
<td>59</td>
<td>Overvoltage</td>
<td>&gt;115%</td>
</tr>
<tr>
<td>66</td>
<td>Starts per Hour</td>
<td>Set in field per manufacturer requirements</td>
</tr>
<tr>
<td>81</td>
<td>Frequency</td>
<td>&lt;59.5 Hz; &gt;60.5 Hz</td>
</tr>
<tr>
<td>86</td>
<td>Overcurrent Lockout</td>
<td>Enabled</td>
</tr>
</tbody>
</table>

D. General: All circuit boards shall have a harsh environment conformal coating to resist H2S gas and other corrosive agents, including humidity.

E. Protection and Control

1. Thermal model biased with RTD and negative sequence current feedback

2. Start supervision and inhibit

3. Locked rotor / mechanical jam: The relay shall protect the rotor during stall and acceleration. The stall/acceleration curve shall be voltage compensated and a speed switch input shall be available. The stator protective thermal model shall combine inputs from positive and negative sequence currents and RTD winding feedback. The model shall be dynamic in nature in order to follow the loading and temperature of the motor.

4. Voltage compensated acceleration

5. Under voltage, overvoltage

6. Under frequency

7. Stator differential protection: Differential protection using CT inputs (6) from both sides of the machine winding Voltage transformer inputs shall be used to provide over voltage, under voltage, voltage phase reversal, over frequency and under frequency functions.

8. Thermal overload

9. Over temperature 12 RTD’s

10. Phase and ground overcurrent

11. Current unbalance
12. Power Elements
   a. Power factor
   b. Reactive power
   c. Under power
   d. Reverse active power
   e. Over torque

13. Torque protection

14. Reduced voltage starting control

F. Monitoring and Metering

1. Metering Functions
   a. A, V, W, Var, VA, PF, Hz, kWh, VARh, and kW demand
   b. The system shall include complete power metering. An event record shall store
      the last 40 events. Sixteen cycles of waveform data shall be stored each time a
      trip occurs. A simulation feature shall be available for testing the function.

2. Torque, temperature

3. Event recorder

4. Oscillography and data logger

5. Statistical information and learned motor data

6. Motor starting reports

G. Inputs and Outputs

1. 12 RTDs, programmable

2. Five predefined and four assignable digital inputs

3. Six output relays

4. Four analog inputs

5. Four programmable analog outputs
H. Memory

1. Memory shall be non-volatile and programming shall remain intact upon power failure.

2. Interface software shall be provided in a Windows® format.

I. User Interface: A 40-character LCD display and associated keypad to provide access to actual values and set points.

J. Control Power:


2. LO Range: DC: 20-60 VDC; AC: 20-48 VAC, 48 to 62 Hz.

K. Communication

1. For remote monitoring, the following communication ports shall be provided:
   a. One Industry Standard port for meter and relay programming using a laptop computer.
   b. One RS-485 port.
   c. One integral 10/100BaseT Ethernet port. The connection shall support Modbus TCP, Ethernet IP and SNMP. Where an integral port is not available, provide a media protocol converter as specified herein.
   d. The manufacturer shall factory enter the proper IP Address for such connection. Upon request by the Contractor, the Owner/Engineer will provide the proper Internet Protocol Address (IP Address), to be configured by the equipment manufacturer.

2. The protocol interface shall implement Modbus TCP Protocol with the following as minimum capabilities:
   a. All data shall be available and/or mirrored within the Modbus 4x or "Holding Register" memory area.
   b. Register 4x00001 shall exist and be readable to allow simple, predictable "comm tests".
   c. Software tools shall function properly with slaves’ only supporting Modbus functions 3, 4 and 16. Requiring support of diagnostic function 8 is not acceptable.
d. Software tools shall be configurable to write a single register as either function 6 or 16.

e. Software tools shall allow setting the Modbus/TCP "Unit Id" to be a value other than zero. This is required for Ethernet-to-Serial bridging.

3. The media protocol converter shall meet the following criteria:

a. The converter shall support 10/100Base-T Ethernet. The serial port speed (baud rate) shall support 230kbps. The protocol shall support Modbus TCP, Ethernet IP, DF1, and Modbus RTU/ASCII. Protocol shall be Web Browser configurable.

b. Operating limits shall be 0-60°C, with humidity range minimum of 5-90%. Shock capability on the serial port shall be ESD +15 kV air GAP meeting IEC 1000-4-2. Power requirements shall be 9-30VDC at 0.5A minimum.

c. The converter shall have LED status for serial, signals, power, and Ethernet.

d. The converter housing shall be UL 1604, Class 1 Div 2, DIN Rail mountable. The converter shall have DB-9M port connection, with screw terminals, to the input.

e. Converter shall be Digi One IAP, or approved equal.

2.04 POWER QUALITY METER (PM1)

A. Subject to compliance with the Contract Documents, the following Manufacturers are acceptable:

1. GE Multilin PQMII Power Quality Meter

2. Schweitzer Engineering Laboratories Model SEL-735

3. Approved equal

B. The listing of specific manufacturers above does not imply acceptance of their products that do not meet the specified ratings, features and functions. Manufacturers listed above are not relieved from meeting these specifications in their entirety.

C. General

1. All circuit boards shall have a harsh environment conformal coating to resist H2S gas and other corrosive agents, including humidity.

D. Monitoring and Metering

1. Metering Functions with accuracy of 0.2% for A & V and 0.4% for power parameters
a. A, V, VA, W, VAR, KWH, KVARH, KVAH, PF, Hz
b. W, VAR, A, VA Demand
c. A, V Unbalance

2. Power Analysis Functions.
   a. Total Harmonic Distortion
   b. Individual harmonics
   c. Waveform capture
   d. Historical data
   e. Minimum and maximum metered values complete with time and date
   f. Record of last 40 events
   g. Two independent data logs

E. User Interface and Programming

1. Integrated keypad to access actual values and set points.
   a. 2 - line, 40 character illuminated display for use with keypad. The display shall have:
      1) Variable scrolling rates.
      2) Front mounted LEDs to display alarms, communication status, relay status, simulation mode, self-test failure, and set point access status.
      3) Relay reset button to clear alarm and auxiliary conditions.

2. The meter shall have one alarm output relay with Form C contacts.

3. Relay output shall be through alarm, auxiliary and pulse output functions.

4. The meter shall provide a user configurable pulse output based on KWH, KVARH or KVAH.

5. The meter shall provide a pulse input for demand synchronization.

6. The meter shall include a simulation mode capability for testing the functionality and meter response to programmed conditions without the need for external inputs.
7. The relay shall include a power systems option consisting of harmonic analysis, triggered trace memory waveform capture, event record and data logger functions.

F. Control Power:

2. LO Range: DC: 20-60 VDC; AC: 20-48 VAC, 48 to 62 Hz.

G. Communication

1. For remote monitoring, the following communication ports shall be provided:
   a. One Industry Standard port for meter and relay programming using a laptop computer.
   b. One RS-485 port.
   c. One integral 10/100BaseT Ethernet port. The connection shall support Modbus TCP, Ethernet IP and SNMP. Where an integral port is not available, provide a media protocol converter as specified herein.
   d. The manufacturer shall factory enter the proper IP Address for such connection. Upon request by the Contractor, the Owner/Engineer will provide the proper Internet Protocol Address (IP Address), to be configured by the equipment manufacturer.

2. The protocol interface shall implement ModbusTCP Protocol with the following as minimum capabilities:
   a. All data shall be available and/or mirrored within the Modbus 4x or "Holding Register" memory area.
   b. Register 4x00001 shall exist and be readable to allow simple, predictable "comm tests".
   c. Software tools shall function properly with slaves' only supporting Modbus functions 3, 4 and 16. Requiring support of diagnostic function 8 is not acceptable.
   d. Software tools shall be configurable to write a single register as either function 6 or 16.
   e. Software tools shall allow setting the Modbus/TCP "Unit Id" to be a value other than zero. This is required for Ethernet-to-Serial bridging.

3. The media protocol converter shall meet the following criteria:
a. The converter shall support 10/100Base-T Ethernet. The serial port speed (baud rate) shall support 230kbps. The protocol shall support Modbus TCP, Ethernet IP, DF1, and Modbus RTU/ASCII. Protocol shall be Web Browser configurable.

b. Operating limits shall be 0-60°C, with humidity range minimum of 5-90%. Shock capability on the serial port shall be ESD +15 kV air GAP meeting IEC 1000-4-2. Power requirements shall be 9-30VDC at 0.5A minimum.

c. The converter shall have LED status for serial, signals, power, and Ethernet.

d. The converter housing shall be UL 1604, Class 1 Div 2, DIN Rail mountable. The converter shall have DB-9M port connection, with screw terminals, to the input.

e. Converter shall be Digi One IAP, or approved equal.

2.05 PHASE FAILURE RELAY (PFR)

A. Subject to compliance with the Contract Documents, the following Manufacturers are acceptable:

1. Taylor Phase-Guard Model P
2. Approved equal

B. The listing of specific manufacturers above does not imply acceptance of their products that do not meet the specified ratings, features and functions. Manufacturers listed above are not relieved from meeting these specifications in their entirety.

C. Protection

1. Indicators - LED
   b. Phase loss or Low Voltage – Yellow.
   c. Reverse Phase – Red.

2. Enclosure: As required in accordance with the Area Classification and Enclosure Types specified herein.

3. Functions.
   a. Automatic Reset
   b. Phase Loss.
1) 12% or more.
2) Delay 1-1/2 seconds.

c. Low Voltage Protection
   1) Drop at 70% of normal
   2) Reset at 90% of normal

d. Time Delays: Adjustable

e. Over Voltage Protection
   1) Greater than 15%
   2) Reset at 5% greater than normal

2.06 HOURMETER (ETM)

A. Subject to compliance with the Contract Documents, the following Manufacturers are acceptable:

   1. Veeder-Root Model 779536-201
   2. Approved equal

B. The listing of specific manufacturers above does not imply acceptance of their products that do not meet the specified ratings, features and functions. Manufacturers listed above are not relieved from meeting these specifications in their entirety.

C. Indicator: 6 Digit Electromechanical

D. Input 120 VAC (Range ±10%), 60Hz

E. Resolution: One-tenth hour

F. Accuracy: 0.02%

G. Capacity: Up to 9999.9 Hours, automatic recycle at zero.

H. Operating Temperature: -40° to +185°F
I. Rectangular 0.95" x 1.45", screw terminals

2.07 ACCESSORIES

A. Furnish nameplates for each device as indicated on drawings. Color schemes shall be as indicated on Drawings.

PART 3 - EXECUTION

3.01 INSTALLATION

A. All equipment specified herein shall be factory installed, field adjusted, tested and cleaned as an integral part of equipment specified elsewhere in these Specifications.

B. Enclosure Mounting Requirements:

1. Mount all wall-mounted enclosures with an air gap between the enclosure and wall or mounting plate. Create the air space with slotted channel or several stainless steel washers which together will make at least a ¼-inch space.

2. Provide mounting feet for floor mounted enclosures.

3. Mount all enclosures with integral welded-on mounting lugs. Drilling through the back of any enclosure to provide a mounting means is prohibited. Any enclosure drilled to provide a mounting means will be rejected and shall be replaced with no change in Contract Time or Price even if the enclosure installation is complete with raceway attached and conductors installed.

4. Penetrations in any enclosures with a NEMA 3R, 4 or 4X rating which is located in any wet or damp area or in any process area whether it appears to be dry or not shall be in the sides or bottom only. Top penetrations in any enclosure located as described herein shall not be done for any reason, including raceway entries or equipment mounting. Top penetrations by the Contractor or by the original equipment manufacturer in the factory are all prohibited. Any enclosure with a top penetration located in the areas specified will be rejected and shall be removed and replaced, even if it requires a return to the factory. Raceway penetrating the top shall be re-routed and re-installed. All installed conductors in re-routed raceway shall be removed and re-routed in the re-routed raceway. Conductors found to be too short to be re-terminated shall be removed back to their source or load as the case may be, and shall be replaced. Splicing is prohibited and unacceptable. All specified corrective measures shall be provided with no change in Contract Time or Price.
END OF SECTION
SECTION 16196
LOW VOLTAGE AC SURGE PROTECTIVE DEVICES (SPDs)

PART 1 - GENERAL

1.01 SCOPE OF WORK

A. This Section of the Specifications describes the requirements for low voltage AC surge protective devices (SPDs 1kV and less), to be furnished under other Sections of the Specifications.

B. All equipment described herein shall be submitted, and factory installed, as an integral part of equipment specified elsewhere in these Specifications.

1.02 RELATED WORK

A. Refer to Division 16000 for related work and electrical coordination requirements.

1.03 SUBMITTALS

A. Submittals for equipment specified herein shall be made as a part of equipment furnished under other Sections. Individual submittals for equipment specified herein will not be accepted and will be returned unreviewed. Unmarked cut sheets will cause rejection of the submittal and its return for revision.

B. Submittals shall also contain information on related equipment to be furnished under this Specification but described in the related sections to which reference is made in the Related Work paragraph above. Incomplete submittals not containing the required information on the related equipment will be returned unreviewed.

C. Submit catalog data for all items supplied from this specification Section as applicable. Submittal shall include catalog data, functions, ratings, inputs, outputs, displays, etc., enough to confirm that the SPD provides every specified requirement. Any options or exceptions shall be clearly indicated, with the reason for such deviations. Acceptance of any deviation will be at the sole discretion of the Owner/Engineer. Shop drawings, not so checked and noted, will be returned unreviewed.

D. The submittals shall include:

1. Dimensional drawing of each SPD type.
2. UL 1449 Third Edition Listing, Standard for Safety, Surge Protective Devices, documentation. Provide verification that the SPD complies with the required ANSI/UL 1449 3rd Edition listing by Underwriters Laboratories (UL) or other Nationally Recognized Testing Laboratory (NRTL).

3. UL 1283 Listing, Electromagnetic Interference Filters, documentation.

4. ANSI/IEEE C6241 and C6245, Category C3 (20kV-1.2/50, 10kA-8/20µs waveform) clamping voltage test results.

E. Operation and Maintenance Manuals.

1. Operation and Maintenance manuals shall include the following information:
   a. Manufacturer’s contact address and telephone number for parts and service.
   b. Instruction books and/or leaflets
   c. Recommended renewal parts list
   d. Record Documents for the information required by the Submittals above.

1.04 REFERENCE CODES AND STANDARDS

A. The equipment in this specification shall be designed and manufactured according to latest revision of the following standards (unless otherwise noted):

1. UL 1449 Third Edition – Surge Protective Devices
2. UL 1283 Electromagnetic Interference Filters
5. NEC Article 285 - Surge Protective Devices
6. NEMA/ISCI – 109 Transient Overvoltage Withstand Test
7. IEEE Std. 472/ANSI C37.90A Surge Withstand Capability Tests
8. IEC 255.4 Surge Withstand Capability Tests

B. All SPDs and their installation shall comply with the requirements of the National Electric Code and Underwriters Laboratories (UL) where applicable.
LOW VOLTAGE AC SURGE PROTECTIVE DEVICES (SPDs)

C. Each specified device shall also conform to the standards and codes listed in the individual device paragraphs.

1.05 QUALITY ASSURANCE

A. The manufacturer of this equipment shall have produced similar electrical equipment for a minimum period of five years. When requested by the Owner/Engineer, an acceptable list of installations with similar equipment shall be provided demonstrating compliance with this requirement.

B. The manufacturer of the SPD shall be the same as the manufacturer of the service entrance and distribution equipment in which the devices are installed and shipped. The protected electrical equipment, after installation of the SPD, shall be fully tested and certified to the following UL standards:

1. UL 67 - Panelboards.
2. UL 845 - Motor Control Centers.
3. UL 891 - Switchboards.
4. UL 1558 - Low Voltage Switchgear.

C. For the equipment specified herein, the manufacturer shall be ISO 9001 or 9002 certified.

1.06 WARRANTY

A. Provide warranties, including the manufacturer’s warrantee, for the equipment specified and the proper installation thereof, to be free from defects in material and workmanship for three years from date of final acceptance of the equipment and its installation. Within such period of warranty, all material and labor necessary to return the equipment to new operating condition shall be provided. Any warranty work requiring shipping or transporting of the equipment shall be provided at no expense to the Owner.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Subject to compliance with the Contract Documents, the following Manufacturers are acceptable (Type 1 and Type 2):

1. Eaton
2. General Electric Co./ABB
3. Square D
4. Allen-Bradley
5. Approved equal.

B. Subject to compliance with the Contract Documents, the following Manufacturers are acceptable (Type 3):

1. Edco SLAC Series
2. Phoenix Contact
3. Brick Wall Model PWOM20
4. Approved equal.

2.02 SERVICE ENTRANCE AND DISTRIBUTION EQUIPMENT

A. General

1. All SPDs shall be internal to the equipment being protected. Externally housed SPDs will not be acceptable.

2. All SPDs shall be marked with a short-circuit current rating and shall meet or exceed the available fault current at the connection point.

3. UL 1449 Usage Classifications.
   a. Type 1 – Permanently connected SPDs intended for installation between the secondary of the service transformer and the line side of the service equipment overcurrent device, and intended to be installed without an external overcurrent protective device.
   b. Type 2 – Permanently connected SPDs intended for installation on the load side of service equipment overcurrent device; including SPDs located at the branch panel.
   c. Type 3 – Point of utilization SPDs, installed at a minimum conductor length of 10 meters (30 feet) from the electrical service panel to the point of utilization, for example cord connected, direct plug-in, receptacle type and SPDs installed at the utilization equipment being protected. The distance (10 meters) is exclusive of conductors provided with or used to attach SPDs.

4. Construction of Type 1 and Type 2.
a. Fully Integrated Component Design: All of the SPD’s components and diagnostics shall be contained within one discrete assembly. SPDs or individual SPD modules that must be ganged together in order to achieve higher surge current ratings or other functionality will not be accepted.

b. Overcurrent Protection: The unit shall contain thermally protected MOVs. The thermally protected MOVs shall have a thermal protection element packaged together with the MOV in order to achieve overcurrent protection of the MOV. The thermal protection element shall disconnect the MOV(s) from the system in a fail-safe manner should a condition occur that would cause them to enter a thermal runaway condition.

c. Maintenance Free Design: The SPD shall be maintenance free and shall not require any user intervention throughout its life. SPDs containing items such as replaceable modules, replaceable fuses, or replaceable batteries are not acceptable. SPDs requiring any maintenance of any sort such as periodic tightening of connections are not acceptable.

d. Balanced Suppression Platform: The surge current shall be equally distributed to all MOV components to ensure equal stressing and maximum performance. The surge suppression platform must provide equal impedance paths to each matched MOV. Designs incorporating replaceable SPD modules are not acceptable.

e. Electrical Noise Filter: Each unit shall include a high-performance EMI/RFI noise rejection filter. Noise attenuation for electric line noise shall be up to 50 dB from 10 kHz to 100 MHz using the MIL-STD-220A insertion loss test method.

f. Internal Connections: No plug-in component modules or printed circuit boards shall be used as surge current conductors. All internal components shall be soldered, hardwired with connections utilizing low impedance conductors.

g. Power and ground connections shall be prewired within the protected equipment.

h. Local Monitoring: Visible indication of proper SPD connection and operation shall be provided. The indicator lights shall indicate which phase as well as which module is fully operable. The status of each SPD module shall be monitored on the front cover of the enclosure as well as on the module. A push-to-test button shall be provided to test each phase indicator. Push-to-test button shall activate a state change of dry contacts for testing purposes.

i. Surge Counter: The SPD shall indicate user how many surges have occurred at the location. The surge counter shall trigger each time a surge event with a peak current magnitude of a minimum of 50 ± 20A occurs. A reset pushbutton shall also be standard, allowing the surge counter to be zeroed. The reset button shall contain a mechanism to prevent accidental resetting of the counter via a single, short-duration button press. To prevent accidental resetting, the surge counter reset button shall be depressed for a minimum of two seconds in order to clear.
the surge count total. The ongoing surge count shall be stored in non-volatile memory or UPS backup.

j. Remote Monitoring: For remote monitoring, the SPDs shall provide the same discrete and analog signal and control functions as specified for local monitoring and the surge counter, to a terminal strip for outgoing connection to a PLC as shown on the Drawings. The functions shall be converted as specified for interface to the monitored equipment.

k. The voltage surge suppression system shall incorporate thermally protected metal-oxide varistors (MOVs) as the core surge suppression component for the service entrance and all other distribution levels. The system shall not utilize silicon avalanche diodes, selenium cells, air gaps, or other components that may crowbar the system voltage leading to system upset or create any environmental hazards.

l. SPD shall be Listed in accordance with UL 1449 Third Edition and UL 1283, Electromagnetic Interference Filters.

m. Integrated surge protective devices (SPD) shall be Component Recognized in accordance with UL 1449 Third Edition, Section 37.3.2 and 37.4 at the standard’s highest short circuit current rating (SCCR) of 200 kA, including intermediate level of fault current testing.

n. SPD shall be tested with the ANSI/IEEE Category C High exposure waveform (20kV-1.2/50µs, 10kA-8/20µs).

o. SPD shall provide suppression for all modes of protection: L-N, L-G, and N-G in WYE systems (7 Mode).

5. Construction of Type 3.

a. Fully Integrated Component Design: All of the SPD’s components and diagnostics shall be contained within one discrete assembly. SPDs or individual SPD modules that must be ganged together in order to achieve higher surge current ratings or other functionality will not be accepted.

b. Maintenance Free Design: The SPD shall be maintenance free and shall not require any user intervention throughout its life. SPDs containing items such as replaceable modules, replaceable fuses, or replaceable batteries are not acceptable. SPDs requiring any maintenance of any sort such as periodic tightening of connections are not acceptable.

c. Electrical Noise Filter: Each unit shall include a high-performance EMI/RFI noise rejection filter. Noise attenuation for electric line noise shall be up to 50 dB from 10 kHz to 100 MHz using the MIL-STD-220A insertion loss test method.
d. Internal Connections: No plug-in component modules or printed circuit boards shall be used as surge current conductors. All internal components shall be soldered, hardwired with connections utilizing low impedance conductors.

e. Power and ground connections shall be prewired within the protected equipment.

f. Local Monitoring: Visible indication of proper SPD connection and operation shall be provided. The indicator light shall indicate that the module is fully operable. The status of each SPD module shall be monitored on the front cover of the module.

g. SPD shall be Listed in accordance with UL 1449 Third Edition and UL 1283, Electromagnetic Interference Filters.

h. SPD shall be tested with the ANSI/IEEE Category C High exposure waveform (20kV-1.2/50µs, 10kA-8/20µs).

B. Applications.

1. Service Entrance Rated Equipment (Type 1).

   a. This applies to switchgear, switchboards, panelboards, motor control centers, and other devices installed as service entrance equipment where the SPD is to be permanently connected between the secondary of the service transformer and the line side of the service equipment overcurrent device.

   b. Service entrance located SPDs shall be tested and demonstrate suitability for application within ANSI/IEEE C62.41 Category C environments.

   c. The SPD shall be of the same manufacturer as the equipment

   d. The SPD shall be factory installed inside the equipment, at the assembly point, by the original equipment manufacturer

   e. Locate the SPD on the load side of the main disconnect device, as close as possible to the phase conductors and the ground/neutral bars.

   f. The SPD shall be connected through a UL approved disconnecting means. The disconnect shall be located in immediate proximity to the SPD. Connection shall be made via bus, conductors, or other connections originating in the SPD and shall be kept as short as possible.

   g. The SPD shall be integral to the equipment as a factory standardized design.

   h. All monitoring and diagnostic features shall be visible from the front of the equipment.

2. Distribution Equipment Applications (Type 2).
a. This applies to switchgear, switchboards, panelboards, motor control centers, and other non-service entrance equipment where the SPD is to be permanently connected on the load side of the equipment overcurrent device.

b. The SPD shall be of the same manufacturer as the equipment.

c. The SPD shall be included and mounted within the equipment by the manufacturer.

d. The manufacturer shall size and provide the overcurrent and disconnecting means for the SPD.

e. The SPD units shall be tested and demonstrate suitability for application within ANSI/IEEE C62.41 Category B environments.

f. The SPD shall be located within the panelboard, unless otherwise shown on the Drawings. SPDs shall be installed 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.

g. The SPD shall not limit the use of through-feed lugs, sub-feed lugs, and sub-feed breaker options.

h. All monitoring and diagnostic features shall be visible from the front of the equipment.

3. Individual Control Panel and Related Equipment Protection (Type 3).

a. Locate the SPD on the load side of the ground and neutral connections.

b. The SPD shall be connected through a disconnect circuit breaker or fuse as shown on the drawings. The disconnecting means shall be located in immediate proximity to the SPD. Connection shall be made via bus, conductors, or other connections originating in the SPD and shall be kept as short as possible.

c. All monitoring and diagnostic features shall be visible from the front of the equipment.

4. Mechanical Equipment Manufacturer’s Provided Control Panels (MEMs) and Electrical Manufacturer’s Provided Control Panels (OEMs) Applications (Type 1, Type 2, and Type 3)

a. Where any such panel is installed as service entrance equipment, a Type 1 SPD shall be installed.

1) The same requirements for other service entrance equipment listed above apply to this application except for the requirement that the Type 1 SPD shall not be required to be of the same manufacturer as the panel.
b. Where any such panel is installed as non-service entrance equipment, but within 50’ of wire length of the incoming power line when that line is overhead.

1) The same requirements for other non-service entrance equipment listed above apply to this application except for the requirement that the Type 2 SPD shall not be required to be of the same manufacturer as the panel.

2) Where a Type 1 SPD is installed, a Type 2 SPD is not required on the same panel unless otherwise specifically shown on the drawings.

c. Where any such panel includes a PLC, a Type 3 SPD shall be installed.

1) The same requirements for other individual control panel and related equipment listed above apply to this application.

2) The SPD shall be integral to the MEM or OEM panel, as a factory standardized design.

C. Ratings

1. Unit Operating Voltage: Refer to drawings for operating voltage and unit configuration.

2. SPD shall be designed to withstand a maximum continuous operating voltage (MCOV) of not less than 115% of nominal RMS voltage.

3. Minimum surge current rating shall be 240 kA per phase (120 kA per mode) for service entrance and 120 kA per phase (60 kA per mode) for distribution applications.

4. UL 1449 clamping voltage must not exceed the following: Voltage Protection Rating (VPR)

<table>
<thead>
<tr>
<th>Voltage</th>
<th>L-N</th>
<th>L-G</th>
<th>N-G</th>
</tr>
</thead>
<tbody>
<tr>
<td>240/120</td>
<td>1200/800V</td>
<td>800V</td>
<td>800V</td>
</tr>
<tr>
<td>208Y/120</td>
<td>800V</td>
<td>800V</td>
<td>800V</td>
</tr>
<tr>
<td>480Y.277</td>
<td>1200V</td>
<td>1200V</td>
<td>1200V</td>
</tr>
<tr>
<td>600Y/347</td>
<td>1500V</td>
<td>1500V</td>
<td>1500V</td>
</tr>
</tbody>
</table>

5. Pulse life test: Capable of protecting against and surviving 5000 ANSI/IEEE Category C High transients without failure or degradation of clamping voltage by more than 10%.

6. Minimum UL 1449 3rd edition withstand Nominal Discharge Current (In) rating to be 20kA per mode
2.03 ACCESSORIES

A. Furnish nameplates for each device as indicated on drawings. Color schemes shall be as indicated on Drawings.

PART 3 - EXECUTION

3.01 INSTALLATION

A. All equipment specified herein shall be factory installed, field adjusted, tested and cleaned as an integral part of equipment specified elsewhere in the individual equipment Specification.

B. Types 1 and 2 shall be grounded and bonded as a part of the individual equipment as specified in the individual equipment Section. Type 3 shall be grounded and bonded in accordance with the SPD manufacturer’s instructions.

END OF SECTION
PART 1 - GENERAL

1.01 SCOPE OF WORK

A. Furnish and install single-phase and three-phase general purpose individually mounted dry-type transformers of the two-windings type, self-cooled as specified herein, and as shown on the Drawings.

B. The provisions of this Section shall apply to all dry-type distribution transformers, except as indicated otherwise.

1.02 RELATED WORK

A. No references are made to any other section which may contain work related to any other section. The Contract Documents shall be taken as a whole with every section related to every other section as required to meet the requirements specified. The organization of the Contract Documents into specification divisions and sections is for organization of the documents themselves and does not relate to the division of suppliers or labor which the Contractor may choose to employ in the execution of the Contract. Where references are made to other Sections and other Divisions of the Specifications, the Contractor shall provide such information or additional work as may be required in those references, and include such information or work as may be specified.

B. Other Divisions

1. The Contractor shall be responsible for examining all Sections of the Specifications and Drawings, and shall determine the power and wiring requirements and shall provide external wiring and raceways, as required to provide a fully functioning power, control and process control systems. If the equipment requires more conductors and/or wiring, due to different equipment being supplied, the Contractor shall furnish the additional conductors, raceways and/or wiring, with no change in the Contract Price, and with no increase in Contract Time.

1.03 SUBMITTALS

A. Submittals shall be made in accordance with the requirements of Division 1, Section 16000 and as specified herein.
B. Submittals for equipment and materials, furnished under this Section of the Specifications, will not be accepted prior to approval of the Power System Study specified under Section 16105. Submittals made prior to such approval will be returned without review. All cut sheets shall be clearly marked to indicate which products are being submitted for use on this project. Unmarked cut sheets will be cause to reject the submittal and return it for revision without review.

C. Submittals shall also contain information on related equipment to be furnished under this Specification but described in the related sections listed in the Related Work paragraph above. Incomplete submittals not containing the required information on the related equipment will also be returned without review.

D. All equipment supplied under this Section of the Specifications shall be products of the same Manufacturer, and shall be contained in one single submittal. Partial submittals will be returned without review. Submittals shall also contain information on related equipment to be furnished under this Specification but described in the related sections listed in the Related Work paragraph above. Incomplete submittals not containing the required information on the related equipment will also be returned without review.

E. Equipment specified in Process Equipment and Mechanical Equipment Divisions, and supplied as an integral part of a process equipment manufacturer’s package, but referred to this Section for component details, shall be submitted with the manufacturer’s package in those Divisions.

F. Shop Drawings and Product Data. For each transformer specified under this Section, submit the following information:

1. Outline dimensions and weights
2. Typical/Design test data
3. Transformer ratings including:
   a. kVA
   b. Primary and secondary voltage
   c. Taps
   d. Basic impulse level (BIL) for equipment over 600 volts
   e. Design impedance
   f. Insulation class and temperature rise
DISTRIBUTION DRY-TYPE TRANSFORMERS

4. Product data sheets
5. Connection diagrams
6. Installation information
7. Date of manufacture for each transformer

G. Operation and Maintenance Manuals.

1. Operation and Maintenance Manuals shall include the following information:
   a. Manufacturer's contact address and telephone number for parts and service.
   b. Instruction books and/or leaflets
   c. Recommended renewal parts list
   d. Record Drawings of information required by the Submittals part of this Section.
   e. Project record drawings clearly indicating operating features and including as-built shop drawings, outline drawings, and schematic and wiring diagrams.

1.04 REFERENCE STANDARDS

A. The dry-type transformer(s) and all components shall be designed, manufactured and tested in accordance with the latest applicable NEMA and ANSI standards as follows;

1. DOE 2016 Energy Efficiency Standards, 10 CFR Part 431
2. ANSI C57.96 2004 Guide for Loading Dry-Type Distribution and Power Transformers
4. NEMA ST20
5. UL 1561
6. IEEE-519
7. IEEE-597
8. NFPA 70 – National Electrical Code

1.05 QUALITY ASSURANCE
A. The manufacturer of this equipment shall have produced similar equipment for a minimum period of ten years. When requested by the Engineer, an acceptable list of installations with similar equipment shall be provided demonstrating compliance with this requirement.

B. The manufacturer of the assembly shall be the manufacturer of the major components within the assembly. All assemblies shall be of the same manufacturer. Equipment that is manufactured by a third party and “brand labeled” shall not be acceptable.

C. All components and material shall be new and of the latest field proven design and in current production. Obsolete components or components scheduled for immediate discontinuation shall not be used.

D. Equipment submitted shall fit within the space shown on the Drawings. Equipment which does not fit within the space is not acceptable.

E. For the equipment specified herein, the manufacturer shall be ISO 9001 2000 certified.

F. Transformers manufactured more than 24 months prior to the date of this Contract will not be acceptable.


1.06 JOBSITE DELIVERY, STORAGE AND HANDLING

A. Prior to jobsite delivery, the Contractor shall have successfully completed all submittal requirements, and present to the Owner/Engineer upon delivery of the equipment, an approved copy of all such submittals. Delivery of incomplete constructed equipment, or equipment which failed any factory tests, will not be permitted.

B. Equipment shall be handled and stored in accordance with manufacturer's instructions. Two copies of these instructions shall be included with the equipment at time of shipment, and shall be made available to the Contractor and Owner/Engineer

C. Shipping groups shall be designed to be shipped by truck, rail, or ship. Indoor groups shall be bolted to skids. Breakers and accessories shall be packaged and shipped separately.

D. Equipment shall be equipped to be handled by crane. Where cranes are not available, equipment shall be suitable for skidding in place on rollers using jacks to raise and lower the groups.
E. Equipment shall be installed in its permanent finished location shown on the Drawings within seven calendar days of arriving onsite. If the equipment cannot be installed within seven calendar days, the equipment shall not be delivered to the site, but stored offsite, at the Contractor’s expense, until such time that the site is ready for permanent installation of the equipment.

F. Where space heaters are provided in equipment, provide temporary electrical power and operate space heaters during jobsite storage, and after equipment is installed in permanent location, until equipment is placed in service.

1.07 WARRANTY

A. The Manufacturer shall warrant the equipment to be free from defects in material and workmanship for one year from date of final acceptance of the equipment. Within such period of warranty, the Manufacturer shall promptly furnish all material and labor necessary to return the equipment to new operating condition. Any warranty work requiring shipping or transporting of the equipment shall be performed by the Contractor at no expense to the Owner.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Subject to compliance with the Contract Documents, the following Manufacturers are acceptable:

1. General Electric/ABB
2. Eaton
3. Square D
4. Approved equal

B. The listing of specific manufacturers above does not imply acceptance of their products that do not meet the specified ratings, features and functions. Manufacturers listed above are not relieved from meeting these specifications in their entirety.

2.02 RATINGS

A. The ratings of the transformer shall be as follows:

1. kVA Rating: As shown on the Drawings.
2. Impedance: ANSI Standard Tolerance

3. HV: As shown on the Drawings.

4. LV: As shown on the Drawings.

5. LV: As shown on the Drawings.

2.03 CONSTRUCTION

A. Insulation Systems

1. Transformer insulation system shall be as follows:

   a. Up to 15kVA, three-phase and single-phase: UL recognized 180°C rated insulation system, encapsulated with 115°C rise.

   b. 15kVA, and above, three-phase and single-phase: UL recognized 200°C rated insulation system, ventilated, with 115°C rise.

2. Required performance shall be obtained without exceeding the above indicated temperature rise in a 40°C maximum ambient, and a 24-hour average ambient of 30°C.

3. All insulation materials shall be flame-retardant and shall not support combustion as defined in ASTM Standard Test Method D635.

4. Windings shall have a BIL of 10kV minimum.

B. Core and Coil Assemblies

1. Transformer core shall be constructed with high-grade, non-aging, silicon steel with high magnetic permeability, and low hysteresis and eddy current losses. Maximum magnetic flux densities shall be substantially below the saturation point. The transformer core volume shall allow efficient transformer operation at 10% above the nominal tap voltage. The core laminations shall be tightly clamped and compressed. Coils shall be wound of electrical grade copper with continuous wound construction.

2. Transformer coil assembly shall be impregnated with non-hygroscopic, thermosetting varnish and cured to reduce hot spots and seal out moisture; the core shall be coated with HAPs (Hazardous Air Pollutants) free water reducible electrical varnish to give good corrosion resistance. The assembly shall be installed on vibration-absorbing pads.

3. On single and three-phase units rated 15kVA and below, the core and coil assembly shall encapsulation system shall minimize the sound level. Enclosure construction shall be encapsulated, non-ventilated enclosure, with lifting eyes.
4. On single and three-phase units, rated above 15kVA, the core and coil assembly shall be ventilated, weatherproof enclosure. All ventilation openings shall be protected against falling dirt. The assembly shall be installed on vibration-absorbing pads.

5. Terminals shall be welded to the leads of the coils for better conductivity, less maintenance and lower risk of hot spots. Terminals shall not be spot welded or bolted to the coil leads.

6. The neutral bus shall be configured to accommodate 200% of the rated current.

C. Taps

1. Three-phase transformers rated 15 through 500 kVA shall be provided with six 2-1/2% taps, two above and four below rated primary voltage

2. All single-phase transformers, and three-phase transformers rated below 15 kVA and above 500 kVA, shall be provided with the manufacturer’s standard tap configuration.

D. Isolation Pad

1. Each transformer, pad-mounted, bracket-mounted, or suspended, shall utilize double deflecting neoprene mounting vibration isolators as manufactured by Mason Industries Type ND, sized according to rated capacities.

E. Finish

1. Enclosures, other than stainless steel, shall be finished with ANSI Gray color, weather-resistant enamel.

F. Accessories

1. On ventilated outdoor units provide suitable weather shields over ventilation openings.

2. Lug kits shall be provided by the Manufacturer of the transformer.

2.04 FACTORY TESTING

A. The following standard factory tests shall be performed on the equipment provided under this section. All tests shall be in accordance with the latest applicable ANSI and NEMA standards.

1. Ratio tests at the rated voltage connection and at all tap connections
2. Polarity and phase relation tests on the rated voltage connection
3. Applied potential tests
4. Induced potential test
5. No-load and excitation current at rated voltage on the rated voltage connection

PART 3 - EXECUTION

3.01 INSTALLATION
A. The Contractors shall install all equipment per the manufacturer’s recommendations and the contract drawings.
B. Securely connect all neutrals and transformer enclosures to ground.

3.02 FIELD ADJUSTMENTS
A. Adjust taps to deliver appropriate secondary voltage.

3.03 FIELD TESTING
A. Measure primary and secondary voltages for proper tap settings.

END OF SECTION
SECTION 16470
PANELBOARDS

PART 1 - GENERAL

1.01 SCOPE OF WORK
A. Furnish and install panelboard(s) as specified herein and as shown on the Drawings.
B. The provisions of this Section shall apply to all panelboards, except as indicated otherwise.

1.02 RELATED WORK
A. No references are made to any other section which may contain work related to any other section. The Contract Documents shall be taken as a whole with every section related to every other section as required to meet the requirements specified. The organization of the Contract Documents into specification divisions and sections is for organization of the documents themselves and does not relate to the division of suppliers or labor which the Contractor may choose to employ in the execution of the Contract. Where references are made to other Sections and other Divisions of the Specifications, the Contractor shall provide such information or additional work as may be required in those references, and include such information or work as may be specified.

B. Other Divisions

1. The Contractor shall be responsible for examining all Sections of the Specifications and Drawings, and shall determine the power and wiring requirements and shall provide external wiring and raceways, as required to provide a fully functioning power, control and process control systems. If the equipment requires more conductors and/or wiring, due to different equipment being supplied, the Contractor shall furnish the additional conductors, raceways and/or wiring, with no change in the Contract Price, and with no increase in Contract Time.

1.03 SUBMITTALS
A. Submittals shall be made in accordance with the requirements of Division 1, Section 16000 and as specified herein.
B. Provide systems engineering to produce coordination curves, showing coordination between breakers and/or fuses submitted, such that protective device coordination is accomplished. Such curves and settings shall be included as a part of these submittals.

C. Submittals shall also contain information on related equipment to be furnished under this Specification but described in the related Sections listed in the Related Work paragraph above. Incomplete submittals not containing the required information on the related equipment will also be returned without review. All cut sheets shall be clearly marked to indicate which products are being submitted for use on this project. Unmarked cut sheets will be cause to reject the submittal and return it for revision without review.

D. Shop Drawings and Product Data. The following information shall be submitted to the Engineer:

1. Master drawing index
2. Front view elevation
3. Top view
4. Nameplate schedule
5. UL Listing of the completed assembly
6. Conduit entry/exit locations
7. Assembly ratings including:
   a. Short-circuit rating
   b. Voltage
   c. Continuous current
8. Major component ratings including:
   a. Voltage
   b. Continuous current
   c. Interrupting ratings
9. Descriptive bulletins
11. Cable terminal sizes.
E. Operation and Maintenance Manuals shall include the following information.

1. Manufacturer’s contact address and telephone number for parts and service.

2. Instruction books and/or leaflets

3. Recommended renewal parts list

4. Record Documents for the information required by the Submittals paragraph above.

1.04 REFERENCE CODES AND STANDARDS

A. The low voltage panelboard assembly and all components in this specification shall be designed and manufactured according to latest revision of the following standards (unless otherwise noted):

1. UL 67 - Panelboards

2. UL 50 - Cabinets and Boxes

3. NEMA PB-1 2006 - Panelboards


1.05 QUALITY ASSURANCE

A. The manufacturer of this equipment shall have produced similar equipment for a minimum period of ten years. When requested by the Engineer, an acceptable list of installations with similar equipment shall be provided demonstrating compliance with this requirement.

B. The manufacturer of the assembly shall be the manufacturer of the major components within the assembly. All assemblies shall be of the same manufacturer. Equipment that is manufactured by a third party and “brand labeled” shall not be acceptable.

C. All components and material shall be new and of the latest field proven design and in current production. Obsolete components or components scheduled for immediate discontinuation shall not be used.

D. For the equipment specified herein, the manufacturer shall be ISO 9001 2000 certified.

E. Equipment submitted shall fit within the space shown on the Drawings. Equipment which does not fit within the space is not acceptable.
1.06 JOBSITE DELIVERY, STORAGE AND HANDLING

A. Prior to jobsite delivery, the Contractor shall have successfully completed all submittal requirements, and present to the Owner/Engineer upon delivery of the equipment, an approved copy of all such submittals. Delivery of incomplete constructed equipment, onsite factory work, or failed factory tests will not be permitted.

B. Equipment shall be handled and stored in accordance with manufacturer's instructions. Two copies of these instructions shall be included with the equipment at time of shipment, and shall be made available to the Contractor and Owner. The instructions shall include detailed assembly instructions including but not limited to wiring interconnection diagrams, rigging for lifting, skidding, jacking and moving using rolling equipment to place the equipment, bolt torquing requirements for bus and all other components which require the installation of bolted connections, and instructions for storing the equipment prior to energizing.

C. Equipment shall be stored indoors and protected from moisture, dust and other contaminants.

D. Equipment shall not be installed until the location is finished and protected from the elements.

1.07 WARRANTY

A. The Manufacturer shall warrant the equipment to be free from defects in material and workmanship for one year from date of final acceptance of the equipment. Within such period of warranty the Manufacturer shall promptly furnish all material and labor necessary to return the equipment to new operating condition. Any warranty work requiring shipping or transporting of the equipment shall be performed by the Contractor at no expense to the Owner.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Subject to compliance with the Contract Documents, the following Manufacturers are acceptable.

1. General Electric/ABB
2. Eaton
3. Square D
4. Approved equal

B. The listing of specific manufacturers above does not imply acceptance of their products that do not meet the specified ratings, features and functions. Manufacturers listed above are not relieved from meeting these specifications in their entirety.

2.02 RATINGS

A. The service voltage, overall short circuit withstand and interrupting rating of the equipment and components shall be as shown on the Drawings, except that the minimum interrupting rating shall be 22,000 amperes RMS symmetrical for 240/120 volt single-phase or 208Y/120 volt three-phase. The minimum interrupting for 480Y/277 volt three-phase shall be 65,000 amperes RMS symmetrical. Panelboards employing series connected ratings for main, feeder and branch devices are not acceptable and shall not be provided.

B. Panelboards shall be UL listed and labeled as suitable for use as service equipment.

C. Where the panelboard is shown or specified to contain a surge protective device (SPD), the complete panelboard, including the SPD, shall be UL67 listed.

D. Panelboards shall be designed for continuous operation, at rated current, in a 40°C ambient.

E. For additional ratings and construction notes, refer to the Drawings.

2.03 CONSTRUCTION

A. General

1. Refer to the Drawings for actual layout and location of equipment and components, and other required details.

2. A nameplate shall be provided listing manufacturer's name, panel type and rating. Nameplates shall be engraved, laminated impact acrylic, matte finish, not less than 1/16-inch thick by 3/4-inch by 2-1/2-inch, Rowmark 322402, or equal. Nameplates shall be 316 SS screw mounted to all enclosures except for NEMA 4 and 4X. Nameplates for NEMA 4 and 4X enclosures shall be attached with double faced adhesive strips, TESA TUFF TAPE 4970, .009 X 1/2 inch, or equal. Prior to installing the nameplates, the metal surface shall be thoroughly cleaned with 70% alcohol until all residues has been removed. Epoxy adhesive or foam tape is not acceptable.
B. Enclosures

1. General
   a. Each enclosure shall be provided with a legend pocket on the inner door.
   b. Enclosures shall not have holes or knockouts.

2. NON METALLIC
   a. Chemical Rooms. NEMA 4X constructed as follows:
      1) PVC or Fiberglass reinforced polyester body and door.
      2) UV inhibitors
      3) Luggage type quick release latches
      4) Foam-in-place gasketed doors

3. NEMA 4X ALUMINUM
   a. Type 5052 aluminum, body and door
   b. Stainless steel hinge pins
   c. Foam in-place gasket

4. NEMA 12 Steel
   a. Mild Steel body and door
   b. Stainless steel hinge Pins

5. Where an enclosure is not otherwise defined or shown on the Drawing
   a. NEMA 4X Stainless Steel
   b. Type 316 stainless steel, body and door
   c. Stainless steel hinges
   d. Foam in-place gasket

6. NEMA 1 or NEMA 1A boxes shall not be used.

C. Surge Protective Devices (SPDs)
1. Where panelboards are shown or specified to include an SPD, the panelboard manufacturer shall be the manufacturer of the Type 2 SPD, and the SPD shall be located within the panelboard, unless otherwise shown on the Drawings. Refer to Section 16196 for specifications of the SPDs, and the required submittals to be included under this Section. Submittals not containing the required information in Section 16196 will be returned un-reviewed.

2. The SPD shall be installed 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. The SPD shall be interfaced to the panelboard via a direct bus bar connection. The SPD shall not limit the use of through-feed lugs, sub-feed lugs, and sub-feed breaker options. See Section 16196 for additional requirements.

D. Exteriors

1. Unless otherwise noted, all panels shall be designed for surface mounting.

2. Hinged doors covering all circuit breaker handles shall be provided on all panels.

3. Doors shall have semi flush type cylinder lock and catch, except that doors over 48 inches in height shall have a vault handle and three-point latch, complete with lock, arranged to fasten door at top, bottom and center. Door hinges shall be concealed. Furnish two keys for each lock. All locks shall be keyed alike; directory frame and card having a transparent cover shall be furnished on each door.

E. Interiors

1. At least four studs for mounting the panelboard interior shall be furnished.

2. Interiors shall be so designed that circuit breakers can be replaced without disturbing adjacent units and without removing the main bus connectors and shall be so designed that circuits may be changed without machining, drilling or tapping.

3. All interiors shall be completely factory assembled with circuit breakers, wire connectors, etc. All wire connectors, except screw terminals, shall be of the anti-turn solderless type and all shall be suitable for copper wire of the sizes indicated.

F. Busses

1. All busses, including neutral busses and ground bars, shall be of tin plated copper. Neutral busses shall be full size. Phase bussing shall be full height without reduction. Cross connectors shall be tin plated copper.

2. Neutral bussing shall have a suitable lug for each outgoing feeder requiring a neutral connection.
3. Spaces for future circuit breakers shall be bussed for the maximum device that can be fitted into them.

4. Equipment ground bars, of tin-plated copper, shall be furnished.

5. Branch circuits shall be arranged using double row construction except when narrow column panels are indicated. Branch circuits shall be numbered by the manufacturer.

2.04 CIRCUIT BREAKERS

A. Panelboards shall be equipped with circuit breakers with frame size and trip settings as shown on the Drawings.

B. Circuit breakers shall be molded case, bolt-on type.

C. Each circuit breaker used in 208Y/120 volt, three phase, or 120/240 volt single phase, panelboards shall have an interrupting capacity of not less than 22,000 amperes, RMS symmetrical.

D. Each circuit breaker used in 480Y/277 volt and 480 volt panelboards shall have an interrupting capacity of not less than 65,000 amperes, RMS symmetrical.

E. Circuit breakers shall be as manufactured by the panelboard manufacturer.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Mount boxes for surface mounted panelboards so there is at least 1/2-inch air space between the box and the wall.

B. Connect panelboard branch circuit loads so that the load is distributed as equally as possible between the phase busses.

C. Type circuit directories giving location and nature of load served. Install circuit directories in each panelboard.

END OF SECTION
PART 1 - GENERAL

1.01 SCOPE OF WORK

A. The Contractor shall furnish and install low voltage enclosed circuit breakers and disconnect switches, together with appurtenances, complete and operable, as specified herein and as shown on the Contract Drawings.

B. All equipment specified in this Section of the Specifications shall be the product of one manufacturer and shall be factory constructed and assembled by that manufacturer.

1.02 RELATED WORK

A. No references are made to any other section which may contain work related to any other section. The Contract Documents shall be taken as a whole with every section related to every other section as required to meet the requirements specified. The organization of the Contract Documents into specification divisions and sections is for organization of the documents themselves and does not relate to the division of suppliers or labor which the Contractor may choose to employ in the execution of the Contract. Where references are made to other Sections and other Divisions of the Specifications, the Contractor shall provide such information or additional work as may be required in those references, and include such information or work as may be specified.

B. Other Divisions

1. The Contractor shall be responsible for examining all Sections of the Specifications and Drawings, and shall determine the power and wiring requirements and shall provide external wiring and raceways, as required to provide a fully functioning power, control and process control systems. If the equipment requires more conductors and/or wiring, due to different equipment being supplied, the Contractor shall furnish the additional conductors, raceways and/or wiring, with no change in the Contract Price, and with no increase in Contract Time.

1.03 SUBMITTALS

A. Submittals shall be made in accordance with the requirements of Division 1, Section 16000 and as specified herein.
B. Submittals for equipment and materials, furnished under this Section of the Specifications, will not be accepted prior to approval of the Power System Study specified under Section 16105. Submittals made prior to such approval will be returned unreviewed.

C. Submittals shall also contain information on related equipment to be furnished under this Specification but described in the related Sections listed in the Related Work paragraph above. Incomplete submittals not containing the required information on the related equipment will also be returned without review. All cut sheets shall be clearly marked to indicate which products are being submitted for use on this project. Unmarked cut sheets will be cause to reject the submittal and return it for revision without review.

D. The original equipment manufacturer shall create all equipment shop drawings, including all wiring diagrams, in the manufacturer’s Engineering department. All equipment shop drawings shall bear the original equipment manufacturer’s logo, drawing file numbers, and shall be maintained on file in the original equipment manufacturer’s archive file system. Photocopies of the Engineer’s ladder schematics are unacceptable as shop drawings.

E. Submit to the Owner/Engineer, shop drawings and product data, for the following:

1. Product data sheets and catalog numbers for overcurrent protective trip devices on circuit breakers and switches, relaying, meters, pilot lights, etc. The manufacturer’s name shall be clearly visible on each cut sheet submitted. List all options, trip adjustments and accessories furnished specifically for this project.

2. Provide control systems engineering to produce custom unit elementary drawings showing interwiring and interlocking between components and to remotely mounted devices. Include and identify all connecting equipment and remote devices on the schematics. The notation “Remote Device” will not be acceptable. Show wire and terminal numbers. Indicate special identifications for electrical devices per the Drawings.

3. Provide plan and elevation drawings of each controller or enclosure, with dimensions, exterior and interior views, showing component layouts, controls, terminal blocks, etc.

4. Schematic diagram

5. Nameplate schedule

6. UL Listing of the completed assembly.

7. Component list with detailed component information, including original manufacturer’s part number.
8. Conduit entry/exit locations

9. Assembly ratings including:
   a. Short-circuit rating
   b. Voltage
   c. Continuous current

10. Major component ratings including:
    a. Voltage
    b. Continuous current
    c. Interrupting ratings

11. Number and size of cables per phase, neutral if present, ground and all cable terminal sizes.

12. Instruction and renewal parts books.

F. Factory Tests. Submittals shall be made for factory tests specified herein.

G. Field Test Reports. Submittals shall be made for field tests specified herein.

H. Operation and Maintenance Manuals.

1. Operation and maintenance manuals shall include the following information:
   a. Manufacturer’s contact address and telephone number for parts and service.
   b. Instruction books and/or leaflets
   c. Recommended renewal parts list
   d. Record Documents for the information required by the Submittals paragraph above.

I. The manufacturer shall submit for approval, a training agenda for all training specified herein. Training agenda shall not be submitted until final approval of the Operation and Maintenance Manual.

1.04 REFERENCE CODES AND STANDARDS
A. All products and components shown on the Drawings and listed in this specification shall be designed and manufactured according to latest revision of the following standards (unless otherwise noted):

1. NEMA Standard AB1 – Molded Case Circuit Breakers, Molded Case Switches and Circuit Breaker Enclosures
2. NFPA 70 – National Electrical Code (NEC)
3. NFPA 70E – Standard For Electrical Safety in the Workplace
4. IEEE 242 – Protection and Coordination of Industrial and Commercial Power Systems
5. IEEE 399 – Power Systems Analysis
6. UL 489 – Molded Case Circuit Breakers and Circuit Breaker Enclosures
7. UL 1066 – Low Voltage AC and DC Power Circuit Breakers Used in Enclosures.

B. All equipment components and completed assemblies specified in this Section of the Specifications shall bear the appropriate label of Underwriters Laboratories.

1.05 QUALITY ASSURANCE

A. The manufacturer of this equipment shall have produced similar equipment for a minimum period of ten years. When requested by the Engineer, an acceptable list of installations with similar equipment shall be provided demonstrating compliance with this requirement.

B. The manufacturer of the assembly shall be the manufacturer of the major components within the assembly. All assemblies shall be of the same manufacturer. Equipment that is manufactured by a third party and “brand labeled” shall not be acceptable.

C. All components and material shall be new and of the latest field proven design and in current production. Obsolete components or components scheduled for immediate discontinuation shall not be used.

D. For the equipment specified herein, the manufacturer shall be ISO 9001 2000 certified.

E. Equipment submitted shall fit within the space shown on the Drawings. Equipment which does not fit within the space is not acceptable.
1.06 JOBSITE DELIVERY, STORAGE AND HANDLING

A. Prior to jobsite delivery, the Contractor shall have successfully completed all submittal requirements, and present to the Owner/Engineer upon delivery of the equipment, an approved copy of all such submittals. Delivery of incomplete constructed equipment, or equipment which failed any factory tests, will not be permitted.

B. Equipment shall be handled and stored in accordance with manufacturer's instructions. Two copies of these instructions shall be included with the equipment at time of shipment, and shall be made available to the Contractor and Owner. The instructions shall include detailed assembly instructions including but not limited to wiring interconnection diagrams, rigging for lifting, skidding, jacking and moving using rolling equipment to place the equipment, bolt torqueing requirements for bus and all other components which require the installation of bolted connections, and instructions for storing the equipment prior to energizing.

C. Equipment shall be stored indoors and protected from moisture, dust and other contaminants.

D. Equipment shall not be installed until the location is finished and protected from the elements.

1.07 WARRANTY

A. The Manufacturer shall warrant the equipment to be free from defects in material and workmanship for one year from date of final acceptance of the equipment. Within such period of warranty the Manufacturer shall promptly furnish all material and labor necessary to return the equipment to new operating condition. Any warranty work requiring shipping or transporting of the equipment or components shall be performed by the Contractor at no expense to the Owner.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Subject to compliance with the Contract Documents, the following Manufacturers are acceptable:

1. Eaton
2. General Electric Co./ABB
3. Square D
4. Approved equal

B. The listing of specific manufacturers above does not imply acceptance of their products that do not meet the specified ratings, features and functions. Manufacturers listed above are not relieved from meeting these specifications in their entirety.

C. All equipment furnished under this Section shall be of the same manufacturer.

2.02 RATINGS

A. The service voltage, shall be as shown on the Drawings. The overall short circuit withstand and interrupting rating of the equipment and devices shall be equal to or greater than the overall short circuit withstand and interrupting rating of the feeder device immediately upstream of the circuit breaker or switch. Systems employing series connected ratings for main and feeder devices shall not be used.

B. Circuit breakers, safety switches and associated devices shall be designed for continuous operation at rated current in a 40°C ambient temperature.

C. Furnish heavy duty Mill rated devices.

D. For additional ratings and construction notes, refer to the Drawings.

2.03 CONSTRUCTION

A. General

1. Refer to Drawings for: actual layout and location of equipment and components; current ratings of devices, components; protective relays, voltage ratings of devices, components and assemblies; and other required details.

2. Furnish lugs for incoming wiring, sizes as shown on the Drawings. Allow adequate clearance for bending and terminating of cable size and type specified. Lugs for #12 AWG up to #6 AWG shall be ring terminals. Conductors #4 AWG and larger shall be two-hole long barrel lugs with NEMA spacing. All lugs shall be the closed end construction to exclude moisture migration into the cable conductor. See also Section 16120 Wires and Cables (1000 Volt Maximum) for additional requirements.

3. Built in control stations and indicating lights shall be furnished where shown on the Drawings.

4. Furnish nameplates for each device as indicated in Drawings. Nameplates shall be engraved, laminated impact acrylic, matte finish, not less than 1/16-inch thick by
3/4-inch by 2-1/2-inch, Rowmark 322402. Nameplates shall be 316 SS screw mounted to all enclosures except for NEMA 4 and 4X. Nameplates for NEMA 4 and 4X enclosures shall be attached with double faced adhesive strips, TESA TUFF TAPE 4970, .009 X 1/2 inch, or equal. Prior to installing the nameplates, the metal surface shall be thoroughly cleaned with 70% alcohol until all residue has been removed. Epoxy adhesive or foam tape is not acceptable.

B. Enclosures

1. General
   a. Provide 316 SS hardware for all enclosures.
   b. All enclosure doors shall have bonding studs. The enclosure interior shall have a bonding stud.
   c. Enclosures shall not have holes or knockouts for conduit entry.
   d. All panels installed outdoors shall have a factory applied, suitable primer and final coat of weatherproof white paint.
   e. All enclosures shall be provisioned with hardware for a padlock.
   f. All enclosures shall have integral welded mounting lugs.
   g. See Section 16110 Raceways, Boxes and Fittings for additional requirements.

2. NON METALLIC
   a. Chemical Rooms. NEMA 4X constructed as follows:
      1) PVC or Fiberglass reinforced polyester body and door.
      2) UV inhibitors
      3) Luggage type quick release latches
      4) Foam-in-place gasketed doors

3. NEMA 4X ALUMINUM
   a. Type 5052 aluminum, body and door
   b. Stainless steel hinge
   c. Foam in-place gasket
   d. Single point quarter turn latches
4. **NEMA 12 Steel**
   a. Mild steel body and door
   b. Stainless steel hinges
   c. Foam in-place gasket
   d. Single point quarter turn latches

5. **NEMA 4X Stainless Steel where an enclosure is not otherwise defined or shown on the Drawing**
   a. NEMA 4X Stainless Steel
   b. Type 316 stainless steel, body and door
   c. Stainless steel hinge
   d. Foam in-place gasket
   e. Single point quarter turn latches

6. **NEMA 1 or NEMA 1A boxes shall not be used.**

7. **Malleable iron boxes shall not be used.**

8. **Provide a flange mounted, or through the door, disconnect operating handle with mechanical interlock having a bypass that will allow the enclosure door to open only when the circuit breaker or switch is in the OFF position. The circuit breaker or switch shall have the capability of being bypassed after the door has been opened.**

C. **Internal Wiring**

1. **Wiring:** Stranded copper, minimum size No. 14 AWG, with 600 Volt, 90°C, flame retardant, Type MTW thermoplastic 600-volt insulation, NEMA Class II, Type B wiring. Line side power wiring shall be sized for the full rating or frame size of the connected device.

2. All wiring shall be tagged and coded with an identification number as shown on the Drawings. Coding shall be typed on a heat shrinkable tube applied to each end showing origination and destination of each wire. The marking shall be permanent, non-smearing, solvent-resistant type similar to Raychem TMS-SCE, or equal. Wire tags shall be machine-printed. Wire tags relying on adhesives of any type are unacceptable.

3. All wiring shall be neatly bundled with tie wraps and supported to wire way supports. Control wiring shall be bundled separately from power wiring. In addition, low signal
wiring (millivolt and milliamp) shall be bundle separately from the rest of the control wiring.

D. Field Installed Internal Wiring

1. Field installed interior wiring shall be neatly grouped by circuit and bound by plastic tie wraps. Circuit groups shall be supported so that circuit terminations are not stressed. In addition, low signal wiring (millivolt and milliamp) shall be bundle separately from the rest of the control wiring. Wiring shall not be supported using adhesive supports. Adhesive wire supports are unacceptable, and if installed shall be removed and replaced with a non-adhesive support with no increase in Contract Price or Time.

2. All field wiring shall be tagged and coded with an identification number. Coding shall be typed on a heat shrinkable tube applied to each end of the wire. The marking shall be a permanent, non-smearing, solvent-resistant type similar to Raychem TMS-SCE, or equal. Wire tags shall be machine-printed. Wire tags relying on adhesives of any type are unacceptable.

3. In general, all conduit entering or leaving equipment shall be stubbed up into the bottom of the enclosure directly below the area in which the conductors are to be terminated, or from the top if shown on the Drawings and not located in a wet, damp or any process area. Conduits shall not enter the side unless approved in writing by the Owner/Engineer.

2.04 CIRCUIT BREAKERS

A. Insulated Case Circuit Breakers (ICCBs)

1. Unless otherwise shown on the Drawings, circuit breakers, larger than a 1200 ampere rating, shall be insulated case (ICCB), three-olé, 600 volt, fixed type, with stored energy closing mechanism.

2. Breakers shall be manually operated unless indicated as electrically operated (EO) on the Drawings.

3. All insulated case circuit breakers shall have a minimum symmetrical interrupting capacity of 65,000 amperes, with individual interrupting capacity as shown on the Drawings. Insulated case circuit breakers without an instantaneous trip element adjustment shall be equipped with a fixed internal instantaneous override set at the upper limit.

4. All insulated case circuit breakers shall be constructed and tested in accordance with UL 489. The circuit breakers shall carry a UL label.

5. All insulated case circuit breakers shall have an adjustable long time pickup, and delay; adjustable short time pickup and delay; short time i²t switch; high range instantaneous (fixed at the breaker’s short-time withstand rating), adjustable ground.
fault pickup and delay; ground fault delay and pickup trips for selective tripping, overload, short circuit, and ground fault indicator lights.

B. Molded Case Circuit Breakers (MCCB’s)

1. Unless otherwise shown on the Drawings, circuit breakers 225 ampere frame rating and larger, shall be molded case (MCCB), three-Pole, 600-volt, fixed type, with stored energy closing mechanism. Breakers shall be manually operated unless indicated as electrically operated (EO) on the Drawings. Trip device shall be solid state with adjustable long time pickup, and delay; adjustable short time pickup and delay; short time i2t switch; adjustable instantaneous pickup, adjustable ground fault pickup and delay, and ground fault delay and pickup trips for selective tripping.

2. Unless otherwise shown on the Drawings, circuit breakers less than 225 ampere frame rating shall be molded case, three-Pole, 600-volt, fixed type, manually operated with stored energy closing mechanism. Circuit breakers shall have inverse time and instantaneous tripping characteristics.

2.05 DISCONNECT SWITCHES

A. Disconnect switches shall be heavy duty, quick make, quick break, visible blades, 600-volt, three-pole with full cover interlock, interlock defeat and flange mounted operating handle.

2.06 FUSED DISCONNECT SWITCHES

A. Fused disconnect switches shall be heavy duty, quick make, quick break, visible blades, 600 volt, three-pole with full cover interlock, interlock defeat and flange mounted operating handle.

B. Fuses shall be rejection type, 600 volts, 200,000 A.I.C., dual element, time delay, Bussman Fusetron, Class RK 5 or equal.

2.07 MOTOR ISOLATION SWITCHES

A. For motors up to and including 100 horsepower, the isolating switch shall be a horsepower rated, quick make, quick break, visible blades, 600 volt, three pole motor circuit switch, in an enclosure as listed above and sized for the motor as shown on the Drawings. The switch shall be plainly marked “Do not operate under load”.

B. Where a switch status auxiliary contact is shown on the Drawings, the auxiliary contact shall be early break (opens before the switch is opened) and early make (closes before the switch is closed). The auxiliary contact shall be rated 5 amperes at 480 volts.
2.08 Double Throw Manual Transfer Switch

A. Manual transfer switches shall be heavy duty, quick make, quick break, visible blades, 600-volt, three-ole, fused or non-fused as shown on the Contract Documents, with flange mounted operating handle.

2.09 SPARE PARTS

A. Provide the following spare parts:

1. Three – Fuses of each type used.

B. Spare parts shall be boxed or packaged for long term storage and clearly identified on the exterior of package. Identify each item with manufacturers name, description and part number.

2.10 FACTORY TESTING

A. The circuit breakers and disconnects shall be completely assembled, wired, and adjusted at the factory and shall be given the manufacturer’s routine shop tests and any other additional operational test to insure the workability and reliable operation of the equipment.

B. Factory test equipment and test methods shall conform with the latest applicable requirements of ANSI, IEEE, UL, and NEMA standards, and shall be subject to the Owner/Engineer’s approval.

PART 3 - EXECUTION

3.01 INSTALLER’S QUALIFICATIONS

A. Installer shall be specialized in installing low voltage circuit breakers and disconnect switches with minimum five years documented experience. Experience documentation shall be submitted for approval prior to beginning work on this project.

3.02 EXAMINATION

A. Examine installation area to assure there is enough clearance to install the equipment.

B. Verify that the equipment is ready to install.
C. Verify field measurements are as instructed by manufacturer.

3.03 INSTALLATION

A. The Contractor shall install all equipment per the manufacturer's recommendations and Contract Drawings.

B. Install required safety labels.

C. Conduit entry into the top of any NEMA 4/4X rated enclosure in any outdoor, damp, wet or process area is strictly prohibited. Any enclosure entered from the top will be removed, the conduit and conductors re-routed, or conductors replaced if too short. No increase in Contract Price or Contract Time will be allowed.

3.04 FIELD QUALITY CONTROL

A. Inspect installed equipment for anchoring, alignment, grounding and physical damage.

B. Check tightness of all accessible electrical connections. Minimum acceptable values are specified in manufacturer's instructions.

3.05 FIELD ADJUSTING

A. Adjust all circuit breakers, switches, access doors, operating handles for free mechanical and electrical operation as described in manufacturer's instructions.

B. The Power Monitoring and Protective Devices shall be set in the field by a qualified representative of the manufacturer, retained by the Contractor, in accordance with settings designated in a coordinated study of the system as required in Section 16105 Power System Study. All such settings, including the application of arc flash labels, shall have been made and Approved by the Owner/Engineer, prior to energizing of the equipment.

3.06 FIELD TESTING

A. Perform all electrical field tests recommended by the manufacturer. Disconnect all connections to solid-state equipment prior to testing.

B. Megger and record phase to phase and phase to ground insulation resistance. Megger, for one minute, at minimum voltage of 1000 volts DC. Measured Insulation resistance
shall be at least 100 megohms. In no case shall the manufacturer’s maximum test voltages be exceeded.

C. Test the ground fault protection system using a high current injection method.

D. Test the rating plug for correct rating.

3.07 CLEANING

A. Remove all rubbish and debris from inside and around the equipment. Remove dirt, dust, or concrete spatter from the interior and exterior of the equipment using brushes, vacuum cleaner, or clean, lint free rags. Do not use compressed air.

3.08 EQUIPMENT PROTECTION AND RESTORATION

A. Touch-up and restore damaged surfaces to factory finish, as approved by the manufacturer. If the damaged surface cannot be returned to factory specification, the surface shall be replaced.
PART 1 - GENERAL

1.01 SCOPE OF WORK

A. Furnish and install assemblies of low voltage motor control centers (MCCs), together with appurtenances, complete and operable, as specified herein and as shown on the Contract Drawings.

B. Automatic transfer switches, automatic transfer schemes, variable frequency drives, SPDs and programmable controllers shall be factory installed by the motor control center manufacturer as shown on the Drawings.

C. Motor control centers shall be sized to include all equipment, spares and spaces shown on the Drawings.

1.02 RELATED WORK

A. Refer to Division 16000 for related work and electrical coordination requirements.

1.03 SUBMITTALS

A. Submittals shall be made in accordance with the requirements of Division 1, Section 16000 and as specified herein.

B. All shop drawing submittals and all O&M submittals shall be submitted in hard copy format and in electronic format using PDF files including a Table of Contents which is indexed on DVDs. Electronic submittals are mandatory and those which are received not indexed as specified will be returned without review. Hard copy submittals may not be required if so stipulated in the Contract Documents. No change in Contract Amount or Contract Time will be allowed for delays due to unacceptable submittals.

C. Provide systems engineering to produce coordination curves, showing coordination between breakers and/or fuses submitted, such that protective device coordination is accomplished. Such curves and settings shall be included as a part of these submittals.

D. Submittals shall also contain information on related equipment to be furnished under this Specification but described in the related sections to which reference is made in the
Related Work paragraph above. Incomplete submittals not containing the required information on the related equipment will be returned unreviewed.

E. Provide original equipment manufacturer (OEM) created equipment shop drawings, including all wiring diagrams, created in the manufacturer's Engineering department. All equipment shop drawings shall bear the original equipment manufacturer's logo, drawing file numbers, and shall be maintained on file in the OEM's archive file system. Photocopies of the Engineer's ladder schematics are unacceptable as shop drawings.

F. Submit to the Owner/Engineer, shop drawings and product data, for the following:

1. Equipment outline drawings showing elevation and plan views, dimensions, weight, shipping splits and metering layouts. Indicate all options, special features, ratings and deviations from the Specifications.

2. Conduit entrance drawings, including floor penetrations.


4. Unit summary tables showing detailed equipment description and nameplate data for each compartment.

5. Product data sheets and catalog numbers for overcurrent protective devices, motor starters, control relays, control stations, meters, pilot lights, etc. List all options, trip adjustments and accessories furnished specifically for this project. Clearly mark each sheet to indicate which items apply and/or those items that do not apply. Unmarked cut sheets will cause rejection of the submittal and its return for revision.

6. Provide control systems engineering to produce custom unit elementary drawings showing interwiring and interlocking between units and to remotely mounted devices. Show wire and terminal numbers. Indicate special identifications for electrical devices per the Drawings.

7. Master drawing index

8. Front view elevation

9. Floor plan

10. Top view

11. Single line

12. Schematic diagram, including manufacturer’s selections of component ratings, and CT and PT ratios.

13. Nameplate schedule
14. UL Listing of the completed assembly.

15. Component list with detailed component information, including original manufacturer’s part number.

16. Conduit entry/exit locations

17. Assembly ratings including:
   a. Short-circuit rating
   b. Voltage
   c. Continuous current

18. Major component ratings including:
   a. Voltage
   b. Continuous current
   c. Interrupting ratings

19. Descriptive bulletins

20. Product data sheets.

21. Number and size of cables per phase, neutral if present, ground and all cable terminal sizes.

22. Instruction and renewal parts books.

23. Itemized list of spare parts furnished specifically for this project, including quantities, description and part numbers.

G. Factory Tests. Submittals shall be made for factory tests specified herein.

H. Field Test Reports. Submittals shall be made for field tests specified herein.

I. Operation and Maintenance Manuals.

1. Operation and maintenance manuals shall include the following information:
   a. Manufacturer’s contact address and telephone number for parts and service.
   b. Instruction books and/or leaflets
c. Recommended renewal parts list

d. Record Documents for the information required by the Submittals paragraph above.

J. Submit for approval, a manufacturer’s conducted training agenda for all training specified herein. Training agenda shall not be submitted until final approval of the Operation and Maintenance Manual.

1.04 REFERENCE CODES AND STANDARDS

A. The low voltage motor control centers and all components in this specification shall be designed and manufactured according to latest revision of the following standards (unless otherwise noted):

1. NEMA Standard ICS 2 – 2000 Industrial Control and Systems
2. UL 845 – Electric Motor Control Centers
3. NEMA Standard SG-3 – Low Voltage Power Circuit Breakers
4. NFPA 70 – National Electrical Code (NEC)
5. NFPA 70E – Standard For Electrical Safety in the Workplace

B. All equipment components and completed assemblies specified in this Section of the Specifications shall bear the appropriate label of Underwriters Laboratories.

1.05 QUALITY ASSURANCE

A. The manufacturer of the equipment provided shall have produced similar equipment for a minimum period of ten years. When requested by the Engineer, an acceptable list of installations with similar equipment shall be provided demonstrating compliance with this requirement.

B. The manufacturer of the assembly provided shall be the manufacturer of the major components within the assembly. All assemblies provided shall be manufactured by the same manufacturer. Equipment that is manufactured by a third party and “brand labeled” will not be acceptable.

C. All components and material shall be new and of the latest field proven design and in current production. Obsolete components or components scheduled for immediate discontinuation shall not be used.
D. Equipment submitted shall fit within the space shown on the Drawings. Equipment which does not fit within the space is not acceptable.

E. For the equipment specified herein, the manufacturer shall be ISO 9001 2000 certified.

1.06 JOBSITE DELIVERY, STORAGE AND HANDLING

A. Prior to jobsite delivery, complete all submittal requirements, and present to the Owner/Engineer upon delivery of the equipment, an approved copy of all such submittals. Delivery of incomplete constructed equipment, onsite factory work, or failed factory tests will not be permitted.

B. Equipment shall be handled and stored in accordance with manufacturer's instructions. Two copies of these instructions shall be included with the equipment at time of shipment, and shall be made available to the Contractor and Owner/Engineer.

C. Shipping groups shall be designed to be shipped by truck, rail, or ship. Indoor groups shall be bolted to skids. Breakers and accessories shall be packaged and shipped separately.

D. Equipment shall be equipped to be handled by crane. Where cranes are not available, equipment shall be suitable for skidding in place on rollers using jacks to raise and lower the groups.

E. Equipment shall be installed in its permanent finished location shown on the Drawings within seven calendar days of arriving onsite. If the equipment cannot be installed within seven calendar days, the equipment shall not be delivered to the site, but stored offsite, until such time that the site is ready for permanent installation of the equipment with no change in Contract Price or Schedule.

F. Space heaters provided in equipment shall be provided with temporary electrical power to operate during jobsite storage and after equipment is installed in permanent location. Space heater operation shall be continuous until equipment is powered and placed in service.

1.07 WARRANTY

A. Provide warranties, including the manufacturer’s warrantee, for the equipment specified and the proper installation thereof, to be free from defects in material and workmanship for three years from date of final acceptance of the equipment and its installation. Within such period of warranty, all material and labor necessary to return the equipment to new
operating condition shall be provided. Any warranty work requiring shipping or transporting of the equipment shall be provided at no expense to the Owner.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Subject to compliance with the Contract Documents, the following Manufacturers are acceptable:

1. Eaton
2. General Electric/ABB
3. Allen-Bradley
4. Square D
5. Approved equal

B. The listing of specific manufacturers above does not imply acceptance of their products that do not meet the specified ratings, features and functions. Manufacturers listed above are not relieved from meeting these specifications in their entirety.

2.02 RATINGS

A. The service voltage, overall short circuit withstand and interrupting rating of the equipment and devices shall be as shown on the Drawings. Main and feeder circuit protective devices shall be fully rated for the specified short circuit duty. Systems employing series connected ratings for main and feeder devices shall not be used. Motor starter units shall be tested and UL labeled for the specified short circuit duty in combination with the motor branch circuit protective device.

B. The continuous current rating of the main horizontal bus shall be as shown on the Drawings. Vertical busses shall be sized for the structure load and shall have a minimum rating of 300 amperes.

C. Motor control centers, including devices, shall be designed for continuous operation at rated current in a 40°C ambient temperature.

D. For additional ratings and construction notes, refer to the Drawings.

2.03 CONSTRUCTION
A. General

1. Refer to Drawings for: actual layout and location of equipment and components; current ratings of devices, bus bars, components; protective relays, voltage ratings of devices, components and assemblies; and other required details.

2. Control units shall be arranged as shown on the Drawings.

3. Provide a factory-installed dedicated Point of Utilization Device (SPD) specified in Section 16196, Individual Control Panel and Related Equipment Protection (Type 3), and Section 16195, Power Metering and Protective Relays when the equipment contains a programmable logic controller (PLC) or a uninterruptible power supply (UPS) or Protective Relay devices, or is otherwise indicated on the drawings.

4. Nameplates
   a. External
      1) Furnish nameplates for each device as specified herein and as indicated on the Drawings. All nameplates shall be laminated plastic, black lettering on a white background, attached with stainless steel screws. There shall be a master nameplate that indicates equipment ratings, manufacturer’s name, shop order number and general information. Cubicle nameplates shall be mounted on the front face. Nameplates shall be engraved, laminated impact acrylic, matte finish, not less than 1/16-inch thick by 3/4-inch by 2-1/2-inch, Rowmark 322402. Nameplates shall be 316 SS screw mounted to all enclosures except for NEMA 4 and 4X. Nameplates for NEMA 4 and 4X enclosures shall be attached with double faced adhesive strips, TESA TUFF TAPE 4970, .009 X 1/2 inch, or equal. Prior to installing the nameplates, the metal surface shall be thoroughly cleaned with 70% alcohol until all residue has been removed. Epoxy adhesive or foam tape is not acceptable.

   b. Internal
      1) Control components mounted within the assembly, such as fuse blocks, relays, pushbuttons, switches, etc., shall be suitably marked for identification, corresponding to appropriate designations on manufacturer’s wiring diagrams.

   c. Special
      1) Identification nameplates shall be white with black letters, caution nameplates shall be yellow with black letters, and warning nameplates shall be red with white letters.

5. Control Devices and Indicators
   a. All operating control devices, indicators, and instruments shall be securely mounted on the panel door. All controls and indicators shall be 30-millimeter, corrosion resistant, NEMA 4X/13, anodized aluminum or reinforced plastic. Booted control devices are not acceptable. Auxiliary contacts shall be provided for remote run indication and indication of each status and alarm condition.
Additional controls shall be provided as specified herein and as required by the detailed mechanical and electrical equipment requirements.

b. Indicator lamps shall be LED type. For all control applications, indicator lamps shall incorporate a push-to-test feature. Lens colors shall be as follows:

1) Red for ON, Valve OPEN, and Breaker CLOSED.
2) Green for OFF, Valve CLOSED and Breaker OPEN.
3) Amber for FAIL.
4) Blue for READY
5) White for POWER ON.

c. Mode selector switches (HAND-OFF-AUTO, LOCAL-OFF-REMOTE, etc.) shall be as shown on the Drawings. Units shall have the number of positions and contact arrangements, as required. Each switch shall have an extra dry contact for remote monitoring.

d. Pushbuttons, shall be as follows:

1) Red for STOP, Valve OPEN, Breaker OPEN and mushroom Red for EMERGENCY STOP.
2) Green for START, Valve CLOSE and Breaker CLOSE.
3) Black for RESET.

e. Furnish nameplates for each device. All nameplates shall be laminated plastic, black lettering on a white background, attached with stainless steel screws. Device mounted nameplates are not acceptable.

f. The manufacturer shall not remove, reuse, alter, or replace original equipment nameplates or equipment tags associated with equipment or components supplied by the manufacturer’s suppliers and sub-suppliers.

6. Control and Instrument Power Transformers

a. Control power transformers, encapsulated, shall be provided where shown on the Drawings. Transformer shall be sized for the entire load, including space heaters, plus 25% spare capacity, and shall be not less than 100 VA. Provide a load calculation showing the sizing of the control power transformer complies with this requirement.

b. Control power transformers shall be 120 volts grounded secondary. Primary side of the transformer shall be fused in both legs. One leg of the transformer secondary shall be solidly grounded while the other leg shall be fused.
B. Enclosures

1. Structures shall be NEMA Type 1A unless noted otherwise on the Drawings.

2. Motor control centers shall consist of a series of metal enclosed, free standing, dead front vertical sections bolted together to form double wall construction between sections. Individual vertical sections shall be nominally 90 inches high, 20 inches wide and 20 inches deep unless otherwise shown on the Drawings. Vertical sections shall be mounted on steel channel sills. Bottom channel sills shall be mounted front and rear of the vertical sections extending the full width of each shipping split. Top of each section shall have removable plates with lifting angle. MCCs shall be constructed to allow field installation of additional sections to each end and shall be provided with full depth cover plates (rodent barriers) at each end of the motor control center channel sills.

3. Provide continuous top and bottom horizontal wireways extending the full width of the lineup, isolated from the horizontal bus. Provide a four-inch wide, full height, vertical wire way in each section, equipped with a hinged door and cable supports. Vertical wire way shall be isolated from the bus and device compartments. Wireways or other metal member’s openings shall have rolled edges or protective grommets.

4. All cables shall enter and exit underground from the bottom of the structure, unless otherwise shown on the Drawings.

5. Provide individual, flange formed, pan type door with concealed hinges and quarter turn latches for each device compartment and future space. Doors shall be removable. Door removal shall not be required to withdraw starter units or feeder tap devices.

6. Motor control centers shall be designed for mounting against the wall or back-to-back with another MCC. All wiring, bus joints and other mechanical parts requiring tightening or other maintenance shall be accessible from the front or top.

7. Each vertical section shall be divided into no more than six compartments which shall contain a feeder breaker, combination motor control unit, or other control assemblies connected to a common vertical power bus.

8. Vertical sections shall contain horizontal wire ways at top and bottom of the structure. The design shall be such to permit a continuous wiring trough from end to end of the entire width of the motor control center. End vertical sections shall have cover plates, which can be easily removed to allow continuation of wire ways and horizontal bus extensions for future addition of vertical sections.

9. The vertical section shall also have a continuous vertical raceway extending the full height of the structure and shall intersect with the horizontal raceways. This wire way shall be provided with barriers which completely isolate the wire way from the bus compartments, the controller compartment, and the adjacent vertical units. The wire way shall have its own separate hinged door.
10. Combination motor control units (Size 5 and smaller), as well as other electrical assemblies, including feeder tap units (225 ampere and smaller), shall be provided with appropriately rated stab assemblies for draw out (plug-in) type construction.

11. Plug in provisions shall include a positive guide rail system and stab shrouds to insure alignment of stabs with the vertical bus. The stab shall be designed to increase bus contact pressure during a fault. The stab design shall assure a consistent low-resistance contact with the vertical bus, even after repeated insertions and removals. The unit shall be equipped with a lockout mechanism to lock the drawer in an extended or stabbed position for maintenance and testing. Each draw out compartment shall have a separate hinged removable door.

12. Each unit compartment shall be provided with an individual front hinged door. Motor control and feeder units shall be interlocked mechanically with a unit disconnect device to prevent unintentional opening of the door while unit is energized. An interlock between the unit disconnect and the structure shall prevent the removal or reinsertion of the unit when the unit is in the "ON" position. Means shall be provided for releasing the interlock for intentional access and/or application of power. Pad locking arrangements shall permit locking the disconnect device in the "OFF" position.

13. The MCC shall be furnished as a completely factory assembled unit where transportation facilities and installation requirements permit. Minimize shipping splits if required.

14. All painted steel work shall be treated with a primer coat and a finish coat, or bonderized and finished with a coat of baked enamel at the factory, such that no field painting will be required except for "touching up" of damaged areas. Color shall be manufacturer's standard.

15. Furnish documentation with the equipment as follows: Compartments containing panel boards shall have a card holder on the inside of the door with the branch circuits clearly identified. Compartments containing motor starters shall each have an overload heater section table posted inside the door. All control compartments shall have a pocket on the inside of the door with a copy of the appropriate schematic and wiring diagram.

16. Where the motor control center is shown outdoors the construction shall be NEMA 3R and shall be as follows:

   a. The MCC shall be non-walk-in weatherproof construction of basic indoor equipment enclosed in a weatherproof enclosure. Gasket all covers, provide filters for ventilation louvers and a sloped roof.

   b. The MCC shall be supported on a heavy gauge, welded steel channel base extending around all four sides, constructed to exclude rodents, vermin, and dust.
c. All non-current carrying metal parts of the control center assembly shall be cleaned of all weld spatter and other foreign material and given a heat cured, phosphatized chemical pretreatment to inhibit rust.

d. Roof structure shall be watertight with a continuous drip edge channel on the front. Roof shall slope to the rear for water drainage. Holes for lifting eyes shall be blind tapped.

e. Provide tamper resistant, pad lockable, weathertight, gasketed cubicle doors and switch handle covers, with stainless steel hinge pins.

f. Each vertical section shall have heavy duty, 240 volts AC, space heaters, thermostat controlled, of sufficient capacity to prevent condensation with the equipment de-energized, while operating at half their rated voltage. Heaters shall be provided with perforated metal guards and a circuit breaker disconnect. 120-volt AC control power shall be provided from the MCC.

C. Construction

1. Provide individual compartments for each removable combination starter and feeder tap device unit. Each vertical section shall accommodate a maximum of six compartments. Steel barriers shall isolate the top, bottom and sides of each compartment from adjacent units and wireways. Removable units shall connect to the vertical bus in each section with tin plated, self-aligning, pressure type copper plug connectors. Size 6 and larger starter units may be wired directly to the bus. Removable units shall be aligned in the structure on guide rails or shelves and secured with a cam latch mechanism or racking screw.

2. Provide individual, isolated compartments for fixed mounted devices such as circuit breakers, cable lugs, metering, relaying and control devices. Main and bus tie circuit breakers shall be wired directly to the main horizontal bus. All bus connections shall be fully rated.

3. Provide the following features:

   a. Provision to padlock removable units in a partially withdrawn TEST position, with the bus stabs disengaged.

   b. Provision to padlock unit disconnect handles in the OFF position with up to three padlocks.

   c. Mechanical interlock with bypass to prevent opening unit door with disconnect in the ON position, or moving disconnect to the ON position while the unit door is open.

   d. Mechanical split type terminal blocks for disconnecting external control wiring.

   e. Auxiliary contact on unit disconnect to isolate control power when fed from an external source.
f. Disconnect operating handles and control devices.

D. Bus Systems

1. The bus support system shall be high dielectric strength, low moisture absorbing high impact material.

2. Bus bracing shall be minimum 65,000 amperes RMS symmetrical, and be equal to or exceed the value shown on the Drawings.

3. Busses shall have uniform cross-sectional area throughout their length. Tapered bus will not be acceptable.

4. All bolted bus mating surfaces and splicing material shall be the same plated material as the bus.

5. The main horizontal bus shall extend the entire length of the motor control center. The main bus bars shall be rated as shown on the Contract Drawings but shall not be less than 600 amperes.

6. Main horizontal bus: Tin plated copper, bolted joints, accessible from the front of the structure, fully rated throughout the lineup.

7. Vertical section bus: Tin plated copper, full height, totally insulated and isolated by labyrinth design barrier of glass-reinforced polyester, or sandwich insulated/isolated busses, with shutters to cover stab openings when units are withdrawn. Provide fish tape barriers to isolate bottom wireways from lower ends of vertical bus. Bus shall be provided in each vertical draw out section.

8. Vertical busses used for a tie circuit breaker or tie feeder lugs shall be rated for a continuous capacity equivalent to the main horizontal bus rating.

9. Horizontal ground bus: Provide a 300A minimum, continuous tin-plated copper ground bus in each section equipped with lugs for termination of feeder and branch circuit ground conductors. Connect to ground bus in adjacent sections with splice plates. Provide ground bolted connectors for 2/0 AWG minimum wire at each end of the bus.

E. Wiring

1. Wiring: Stranded copper, minimum size #14 AWG, with 600 volt, 90°C, flame retardant, Type MTW thermoplastic insulation, NEMA Class II, Type B. Line side power wiring shall be sized for the full rating or frame size of the connected device. All conductors #1/0 AWG and larger shall be terminated with long barrel NEMA two-hole lugs.
2. Identification: Numbered sleeve type wire markers at each termination point, color coding per NEMA standards and the NEC. Foreign voltage control wiring shall be yellow.

3. All control wiring to draw out units shall be run through split type terminal blocks (draw out) which can be split to allow easy unit removal. Motor “T” leads shall bolt directly to starter or overloads and shall not utilize split type terminal blocks. Terminal blocks shall be of the fully shielded, tubular screw clamp type, resilient collar design to eliminate loose connections. Terminal blocks shall be nickel or tin plated and have exposed wire numbering corresponding to the connected wires. Terminals shall have a maximum of two wires per terminal.

4. All wiring shall be neatly bundled with ty-raps and supported to wire way supports. Control wiring shall be bundled separately from power wiring. In addition, low signal wiring (millivolt and milliamp) shall be bundle separately from the rest of the control wiring.

5. Where “shipping splits” are required between the control compartments and the starter cubicles, interconnecting jumper wires shall be provided for field re-connection.

6. Field installed interior wiring shall be neatly grouped by circuit and bound by plastic tie wraps. Circuit groups shall be supported so that circuit terminations are not stressed. In addition, low signal wiring (millivolt and milliamp) shall be bundle separately from the rest of the control wiring.

7. In general, all conduit entering or leaving a motor control center shall be stubbed up into the bottom horizontal wire way directly below the vertical section in which the conductors are to be terminated or shall enter the motor control center from the top. Conduits shall not enter the motor control center from the side unless approved in writing by the Owner/Engineer.

8. All field wiring and all field-installed internal wiring shall be tagged and coded with an identification number as shown on the Drawings. Coding shall be typed on a heat shrinkable tube applied to each end showing origination and destination of each wire. The marking shall be permanent, non-smearing, solvent-resistant type similar to Raychem TMS-SCE, or equal.

F. Main Section

1. The MCC main sections shall include the main and tie breakers, metering and power feeder entrance to the MCC. Where a power feeder entrance is shown on the Drawings, the power feeder entrance section shall be provided. Provide bus extensions and compression lugs for number and size of incoming cables as shown on the Drawings. Where main and tie breakers are shown to be key interlocked, interlocks shall be Kirk-Key type.
2. Where Kirk-Key arrangements are used, the Kirk keyed interlocks shall be Kirk HD Series (Heavy Duty) 316 Series of 316 stainless steel or approved equal.

G. Surge Protective Devices

1. Furnish where shown on the Drawings, or specified herein, a manufacturer provided and installed, Low Voltage Surge Protective Devices (SPD) (Type 2), as specified in Section 16196 of these Specifications. Connection to the MCC shall be with a surge rated disconnect, mounted integral to the MCC.

H. Main Circuit Protective Devices

1. Unless otherwise shown on the Drawings, single main or main-tie-main, or main-tie-main circuit breakers, with a frame rating larger than 1200, shall be insulated case (ICCB), 3 Pole, 600 Volt, draw out type, manually operated, with stored energy closing mechanism. Breakers shall be electrically operated where shown as (EO) on the Drawings. Trip device shall be solid state with adjustable long time, short time with short time i2t switch, adjustable instantaneous settings, and adjustable ground fault settings with i2t switch. Provide overload, short circuit, and ground fault indicator lights. A remote energy-reduction maintenance switch with local indication connected to the instantaneous setting shall be provided to reduce the setting to minimum to reduce arc flash during equipment maintenance.

2. Unless otherwise shown on the Drawings, single main or main-tie-main circuit breakers, with a frame rating of 1200 amperes or less, shall be molded case (MCCB), three-pole, 600 volt, fixed type, manually operated with stored energy closing mechanism. Trip device shall be solid state with adjustable long time, short time with short time i2t switch, adjustable instantaneous settings, and adjustable ground fault settings with i2t switch. A remote energy-reduction maintenance switch with local indication connected to the instantaneous setting shall be provided to reduce the setting to minimum to reduce arc flash during equipment maintenance.

3. Insulated case and molded breakers shall have a UL 489 listing.

I. Feeder Protective Devices (Non-Motor Loads)

1. Unless otherwise shown on the Drawings, feeder circuit breakers, 1200 ampere down to 250-ampere, shall be molded case, three-pole, 600-volt, fixed type, manually operated with stored energy closing mechanism. Trip device shall be solid state with adjustable long time pickup, adjustable instantaneous, adjustable ground fault pickup and delay; ground fault delay and pickup trips for selective tripping, and overload, short circuit and ground fault indicator lights. On breakers rated 1200 amperes, provide a remote energy-reduction maintenance switch with local indication connected to the instantaneous setting shall be provided to reduce the setting to minimum to reduce arc flash during equipment maintenance.
2. Unless otherwise shown on the Drawings, feeder circuit breakers, less than 250 amperes-frame, shall be molded case, three-pole, 600-volt, fixed type, manually operated with over-center toggle mechanism.

3. All circuit breakers shall have trip units of the modular type for easy changing of trip range.

4. All Main and Feeder circuit breakers shall have provision for padlocking in the OFF position.

J. Interlocks

1. Electrical, mechanical and Kirk-Key interlocks shall be provided on breakers where shown on the Drawings.

2. Where Kirk-Key arrangements are used, the Kirk keyed interlocks shall be Kirk HD Series (Heavy Duty) 316 Series of 316 stainless steel or approved equal.

K. Control and Instrument Power Transformers.

1. Control power transformers shall be provided where shown on the Drawings. Transformer shall be sized for the entire load, including space heaters, plus 25% spare capacity. Provide a load calculation showing that the sizing of the control power transformer complies with this requirement.

2. Control power transformers shall be 120-volt grounded secondary. Primary side of the transformer shall be fused in both legs. One leg of the transformer secondary shall be solidly grounded while the other leg shall be fused.

L. Furnish lugs for incoming line feeders, sizes as shown on the Drawings. Allow adequate clearance for bending and terminating of cable size and type specified.

2.04 MOTOR CONTROLLERS

A. General

1. The Drawings indicate the approximate horsepower and intended control scheme of the motor driven equipment. Provide the NEMA size starter, circuit breaker trip ratings, control power transformers and thermal overload heater element ratings matched to the motors and control equipment supplied, in compliance with the NEC and the manufacturer’s heater selection tables. All variations necessary to accommodate the motors and controls as actually furnished shall be made without extra cost to the Owner.

2. Motor starters shall be as shown on the Drawings. All motor starters shall be combination units, full voltage non-reversing (FVNR), with adjustable instantaneous
trip magnetic only circuit breakers, or motor circuit protectors (MCP), unless otherwise specified or shown on the Drawings. NEMA starter sizes and breaker trip ratings shall be as required for the horsepower indicated but shall be in no case less than NEMA Size 1. If the manufacturer of the equipment utilizing the motor, supplies a motor horsepower larger than that shown on the Drawings, the Contractor shall supply a motor starter sufficient in size to control the motor supplied. International (IEC) starters shall not be acceptable.

3. Each motor starter shall have a 120-volt operating coil unless otherwise noted.

4. NEMA Size 5 and smaller shall be draw out design with stab-on connectors engaging the vertical buses. Larger units shall be of the fixed (bolt-in) design.

5. Overload relays shall be standard Class 20, ambient compensated, manually reset by pushbutton located on front of the compartment door. A normally closed contact shall be directly used in the start circuit and a normally open contact shall be wire to a terminal board for overload alarm.

6. Control power transformers shall be 120-volt grounded secondary. Primary shall be fused with slow blow fuses in each phase. One leg of the transformer secondary shall be solidly grounded while the other leg shall be fused. The transformer shall be oversized for auxiliary loads as indicated on drawings, but in no case be smaller than 100 VA.

7. Combination starters shall include a motor circuit protector (MCP) in series with a motor controller and an overload protective device. The MCP shall have an adjustable magnetic trip range in percent of rated continuous current and a trip test feature. MCP’s shall be labeled in accordance with UL489.

B. Magnetic Motor Starters

1. Motor starters shall be two or three pole, single or three-phase as required, 60 Hertz, 600 volt, magnetically operated, full voltage non reversing except as shown on the Drawings. NEMA sizes shall be as required for the horsepower shown on the Drawings. IEC rated starters are unacceptable.

2. Each motor starter shall have a 120-volt operating coil, and control power transformer. Starters shall have motor overload protection in each phase. Auxiliary contacts shall be provided as shown on the Drawings. A minimum of one normally open and one normally closed auxiliary contacts shall be provided in addition to the contacts shown on the Drawings.

3. Overload relays shall be adjustable, ambient compensated and manually reset.

4. Control power transformers shall be sized for additional load of 100 VA or an additional 10% whichever is larger. Transformer primary shall be equipped with slow blow fuses. Control power transformers shall not be located behind other...
components and shall be accessible for removal or replacement without removing any other component.

5. Built in control stations and indicating lights shall be furnished where shown on the Drawings.

6. All wires shall be terminated on terminal blocks and shall be tagged.

7. The control compartment shall have a copy of the appropriate schematic and wiring diagram.

C. Combination Magnetic Motor Starters

1. Motor starters shall be a combination motor circuit protector and contactor, two or three pole, single or three-phase as required, 60 Hertz, 600 volt, magnetically operated, full voltage non reversing unless otherwise shown on the Drawings. NEMA starter sizes shall be as shown on the Drawings. If the motor supplied by the equipment supplier is larger than that shown on the Drawings, supply a larger starter size corresponding to the motor supplied. Motor circuit protectors shall be molded case with adjustable magnetic trip only. They shall be specifically designed for use with magnetic motor starters. Motor circuit protectors shall be current limiting type, with additional current limiters if required. IEC rated starters are unacceptable.

2. Each motor starter shall have a 120-volt operating coil, and control power transformer. Starters shall have motor overload protection in each phase. Auxiliary contacts shall be provided as shown on the Drawings. A minimum of one normally open and one normally closed auxiliary contacts shall be provided in addition to the contacts shown on the Drawings.

3. Overload relays shall be adjustable, ambient compensated and manually reset.

4. Control power transformers shall be sized for additional load of 100 VA or an additional 10% whichever is larger. Transformer primary shall be equipped with time delay fuses.

5. Built in control stations and indicating lights shall be furnished where shown on the Drawings.

6. All wires shall be terminated on terminal blocks and shall be tagged.

7. The control compartment shall have a copy of the appropriate schematic and wiring diagram.

2.05 METERING AND PROTECTIVE RELAYS

A. Where an elapsed time meter is specified or shown on the Drawings, a six digit, non-resettable elapsed time meter shall be installed on the face of each motor starter. Meter shall be as specified in Section 16195.
B. Furnish where shown on the Drawings, a Phase Protective Relay (PPR), as shown on the Drawings, and as specified in Section 16195 Power Metering and Protective Relays.

C. Furnish where shown on the Drawings, a Motor Protection System (MP4), as shown on the Drawings, and as specified in Section 16195 Power Metering and Protective Relays.

D. Furnish where shown on the Drawings, a Power Quality Meter (PM1), for each Main or Feeder Breaker, as shown on the Drawings and as specified in Section 16195 Power Metering and Protective Relays.

2.06 ACCESSORIES

A. Provide the following accessories.

1. Furnish and install a non-conducting switchboard floor mat, minimum 3/8-inch-thick by 3 feet wide, meeting ANSI/ASTM D-178-01 Type 2 Class 3, Wearwell 702 or equal, and extending the full length of the equipment lineup.

2.07 SPARE PARTS

A. Provide the following spare parts:

1. Three – Control fuses of type used.

2. One dozen each of cover bolts, spring nuts and door fasteners.

3. One quart or 12 aerosol cans of touch-up paint.

B. Spare parts shall be boxed or packaged for long term storage and clearly identified on the exterior of package. Identify each item with manufacturers name, description and part number.

2.08 FACTORY TESTING

A. The Motor Control Center shall be completely assembled, wired, and adjusted at the factory and shall be given the manufacturer’s routine shop tests and any other additional operational test to insure the workability and reliable operation of the equipment.

B. Prior to factory testing, the manufacturer shall check to see that all selections and settings required by the Power System Study Engineer have been performed.
C. Factory test equipment and test methods shall conform with the latest applicable requirements of ANSI, IEEE, UL, and NEMA standards.

D. The operational test shall include the proper connection of supply and control voltage and, as far as practical, a mockup of simulated control signals and control devices shall be fed into the boards to check for proper operation.

E. The manufacturer shall provide three certified copies of factory test reports as specified in Paragraph 1.03F.

PART 3 - EXECUTION

3.01 MANUFACTURER’S REPRESENTATIVE

A. Provide the services of a qualified factory-trained manufacturer’s field engineer to assist in installation and start-up of the equipment specified under this Section for a period of not less than two working days, with not less than one working day per motor control center. The manufacturer's field engineer shall provide technical direction and assistance in general assembly of the equipment, connections and adjustments, and testing of the assembly and components contained therein.

B. Provide three copies of the manufacturer's field-testing report.

3.02 INSTALLER’S QUALIFICATIONS

A. Provide an installer who shall be specialized in installing low voltage motor control centers with minimum five years documented experience. Experience documentation shall be submitted for approval prior to beginning work on this project.

3.03 EXAMINATION

A. Examine installation area to assure there is enough clearance to install the equipment.

B. Housekeeping pads shall be included for the motor control centers as detailed on the Drawings except for motor control centers which are to be installed adjacent to an existing unit. Housekeeping pads for these (if used) shall match the existing installation.

C. Check concrete pads and baseplates for uniformity and level surface.

D. Verify that the equipment is ready to install.
E. Verify field measurements are as instructed by manufacturer.

3.04 INSTALLATION

A. Install all equipment per the manufacturer's recommendations and Contract Drawings.

B. Install required safety labels.

3.05 FIELD QUALITY CONTROL

A. Inspect installed equipment for anchoring, alignment, grounding and physical damage.

B. Check tightness of all accessible electrical connections. Minimum acceptable values are specified in manufacturer's instructions.

3.06 FIELD ADJUSTING

A. Adjust all circuit breakers, switches, access doors, operating handles for free mechanical and electrical operation as described in manufacturer's instructions.

B. The Power Monitoring and Protective Relays shall be set in the field by a qualified representative of the manufacturer, in accordance with settings designated in a coordinated study of the system as required in Section 16105 Power System Study. All such settings, including the application of arc flash labels, shall have been made and Approved by the Owner/Engineer, prior to energizing of the equipment.

3.07 FIELD TESTING

A. Provide a manufacturer's field engineer who shall make all electrical field tests recommended by the manufacturer. Disconnect all connections to solid-state equipment prior to testing.

B. Megger and record phase to phase and phase to ground insulation resistance of each bus section. Megger, for one minute, at minimum voltage of 1000 volts DC. Measured Insulation resistance shall be at least 100 megohms. In no case shall the manufacturer's maximum test voltages be exceeded.

C. Complete the following test forms:

1. Motor Control Center Test Report: Before energizing the motor control center, perform megohm meter tests. The measurements shall be made on all phase
busing and the data checked for conformance with typical manufacturer’s data. The tests shall adhere to manufacturer’s testing recommendations for the proper testing methods and test voltage levels for each piece of equipment. Readings that fall below manufacturer’s recommended values will not be acceptable. Provide any necessary remedial action before the busing is energized. A data sheet and test report shall be submitted to the Owner/Engineer for each MCC and shall be reviewed and approved prior to energization of the MCC. The test report shall include the following equipment information:

a. MCC (SB or PNL) Name and number:

b. MCC (SB or PNL) manufacturer

c. MCC (SB or PNL) Nameplate data:
   1) Volts:
   2) Horizontal bus amps:
   3) Main breaker amps:

d. Insulation test (measured):
   1) Phase A-B:
   2) Phase B-C:
   3) Phase C-A:
   4) Phase A-G:
   5) Phase B-G:
   6) Phase C-G:

e. Equipment disconnected during test:

f. Date of test:

g. Tested by:

D. Test reports showing unsatisfactory results may require the removal of all defective or suspected materials, equipment and/or apparatus, and their replacement with new items as determined by the Owner/Engineer with no change in the Contract Price or Schedule allowed. Retesting, if required by the Owner/Engineer shall be done with no change in Contract Price or Schedule.

3.08 CLEANING
A. Remove all rubbish and debris from inside and around the equipment. Remove dirt, dust, or concrete spatter from the interior and exterior of the equipment using brushes, vacuum cleaner, or clean, lint free rags. Do not use compressed air.

3.09 EQUIPMENT PROTECTION AND RESTORATION

A. Touch-up and restore damaged surfaces to factory finish, as approved by the manufacturer. If the damaged surface cannot be returned to factory specification, the surface shall be replaced.

3.10 MANUFACTURER’S CERTIFICATION

A. Provide a qualified factory-trained manufacturer's representative who shall personally inspect the equipment at the jobsite and shall certify in writing that the equipment has been installed, adjusted, and tested, in accordance with the manufacturer's recommendations, including all settings designated in the Power System Study.

B. Provide three copies of the manufacturer's representative's certification.

3.11 TRAINING

A. Provide manufacturer's services for training of plant personnel in operation and maintenance of the equipment furnished under this Section.

B. The training shall be for a period of not less than one eight-hour day.

C. The cost of training program to be conducted with Owner's personnel shall be included in the Contract Price. The training and instruction, insofar as practicable, shall be directly related to the system being supplied.

D. Provide detailed O&M manuals to supplement the training course. The manuals shall include specific details of equipment supplied and operations specific to the project.

E. The training session shall be conducted by a manufacturer's qualified representative. Training program shall include instructions on the assembly, motor starters, protective devices, metering, and other major components.

F. The Owner reserves the right to videotape the training sessions for the Owner's use.
END OF SECTION
SECTION 16600
UNDERGROUND SYSTEM

PART 1 - GENERAL

1.01 SCOPE OF WORK

A. Furnish and install a complete underground system of raceways, manholes and handholes as shown on the Drawings and as specified herein.

B. Raceways for use in structural concrete is specified in Section 16110 Raceways, Boxes and Fittings.

1.02 RELATED WORK

A. No references are made to any other section which may contain work related to any other section. The Contract Documents shall be taken as a whole with every section related to every other section as required to meet the requirements specified. The organization of the Contract Documents into specification divisions and sections is for organization of the documents themselves and does not relate to the division of suppliers or labor which the Contractor may choose to employ in the execution of the Contract. Where references are made to other Sections and other Divisions of the Specifications, the Contractor shall provide such information or additional work as may be required in those references, and include such information or work as may be specified.

B. Other Divisions

1. The Contractor shall be responsible for examining all Sections of the Specifications and Drawings, and shall determine the power and wiring requirements and shall provide external wiring and raceways, as required to provide a fully functioning power, control and process control systems. If the equipment requires more conductors and/or wiring, due to different equipment being supplied, the Contractor shall furnish the additional conductors, raceways and/or wiring, with no change in the Contract Price, and with no increase in Contract Time.

1.03 SUBMITTALS

A. Submit to the Engineer, in accordance with Division 1 and Section 16000, shop drawings and product data, for the following:

1. Manholes, handholes and associated hardware.
2. Plastic duct spacers

B. Submittals shall also contain information on related equipment to be furnished under this Specification but described in the related Sections listed in the Related Work paragraph above. Incomplete submittals not containing the required information on the related equipment will be returned unreviewed.
1.04 REFERENCE CODES AND STANDARDS

A. All products and components shown on the Drawings and listed in this specification shall be designed and manufactured according to latest revision of the following standards (unless otherwise noted):

1. NFPA 70 – National Electrical Code (NEC)
2. NFPA 70E – Standard For Electrical Safety in the Workplace
3. ASTM A615/A615M-06a – Standard Specification for Deformed and Plain Carbon-Steel Bars for concrete Reinforcement
5. ASTM A536 - Standard Specification for Ductile Iron Castings
6. AASHTO M306-04/ ASTM A48 – Drainage Structure Castings, Section 7.0 Proof Load Testing
7. ASTM C-850- Specifications for underground precast concrete utility structures

B. All excavation, trenching, and related sheeting, bracing, etc., as shown on the Drawings and listed in these Specifications, shall comply with the following standards (unless otherwise noted):

1. Occupational Safety and Health Administration (OSHA)
   a. ASTM D 698a – Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft³ (600kN-m/m³)).

C. All equipment components and completed assemblies specified in this Section of the Specifications shall bear the appropriate label of Underwriters Laboratories.

1.05 QUALITY ASSURANCE

A. The manufacturer of these materials shall have produced similar electrical materials and equipment for a minimum period of five years. When requested by the Owner/Engineer, an acceptable list of installations with similar equipment shall be provided demonstrating compliance with this requirement.

B. The precast manholes shall be manufactured in a NPCA (National Precast Concrete Association) Certified Plant.

1.06 JOBSITE DELIVERY, STORAGE AND HANDLING

A. Prior to jobsite delivery, the Contractor shall have successfully completed all submittal requirements, and present to the Owner/Engineer upon delivery of the equipment, an approved copy of all such submittals. Delivery of incomplete constructed equipment, onsite factory work, or failed factory tests will not be permitted.

B. Materials shall be handled and stored in accordance with manufacturer's instructions.
C. Materials shall not be stored exposed to sunlight. Such materials shall be completely covered.

D. Materials showing signs of previous or jobsite exposure will be rejected.

1.07 WARRANTY

A. The Manufacturer shall warrant the equipment to be free from defects in material and workmanship for one year from date of final acceptance of the equipment. Within such period of warranty, the Manufacturer shall promptly furnish all material and labor necessary to return the equipment to new operating condition. Any warranty work requiring shipping or transporting of the equipment, or materials shall be performed by the Contractor at no expense to the Owner.

PART 2 - PRODUCTS

2.01 MATERIALS

A. Raceway System

1. Raceway system shall be Schedule 40 PVC Rigid Nonmetallic Conduit (RNC), designed for use aboveground and underground as described in the NEC, resistant to sunlight. The conduits and fittings shall be manufactured to NEMA TC-2, Federal Specification WC1094A and UL 651 specifications. Minimum raceway size shall be 2 inch. Fittings shall be manufactured to NEMA TC-3, Federal Specification WC1094A and UL 514B. Conduit shall have a UL Label. Conduit shall be Carlon, Kraloy, or approved equal.

2. PVC coated rigid aluminum conduit shall have a minimum 0.040-inch thick, polyvinyl chloride coating permanently bonded to rigid aluminum conduit and an internal chemically cured urethane or enamel coating. The ends of all couplings, fittings, etc. shall have a minimum of one pipe diameter in length of PVC overlap. PVC coated conduit and fittings shall be as manufactured by Perma-Cote, Robroy Industries, Calbond or Ocal. Any field bends shall be made using equipment designed to prevent damage to the PVC coating.

3. All underground raceways of the underground system, terminating in manholes or handholes shall use terminators of the same size and type as the raceway

4. Blank Duct Plugs shall be sized for the duct installed on, and shall be TYCO Type JM-BLAXDXXXCR, with rubber gasket, or approved equal.

5. Duct spacers shall be as manufactured by Carlon or equal.

6. Where raceways terminate into existing and new manholes, handholes or structures, the duct bank steel shall be anchored into the manhole, handhole or structure with a Hilti HIT 150 MAX epoxy anchoring system. The termination of the duct bank steel shall utilize a minimum 24-inch length of reinforcing bar anchored not less than four inches into the manhole, handhole or structure wall, and lapped into each reinforcing bar in the duct bank.

7. Concrete encasement for raceways and duct banks shall be normal weight concrete weighing not more than 145 pounds per cubic foot with compressive strength, a minimum of 3000 pounds per square inch, or greater if required by other Divisions of the Specifications, at 28 days. Concrete shall have crushed aggregate with a maximum size of 3/4-inch, a slump of four to six inches and flow freely without the use of vibrators. Install red dye of 40 pounds per 10 cubic yards. of concrete, installed in the truck at the concrete plant.
8. Reinforcing steel shall comply with ASTM A615 Grade 60 and of a size and installation as shown on the Drawings.

B. Manholes and Handholes

1. General
   a. Manholes and handholes shall be of the precast concrete type, designed for a Class H20 load with sizes as shown on the Drawings, and as manufactured by Oldcastle Precast, Mansfield, TX, or approved equal.

2. Construction
   a. Concrete for manholes and handholes shall have a 28-day compressive strength of 5000 PSI. Cement shall be Type I or III. Reinforcing steel shall be Grade 60 with minimum yield strength of 60,000 PSI. Design loadings shall be H-20-44 w/impact.
   b. The top of all manholes shall be field removable and have stainless steel lifting eyes.
   c. Duct bank entries into the manhole or handhole shall be centered on the entering wall, and shall contain the appropriate number and size of duct terminators to match the corresponding duct bank.
   d. Each manhole and handhole shall have a minimum size of 1 inches by 12 inches by 2 inches deep concrete sump in the middle of the floor of the manhole or handhole, or as shown on the Drawings.

3. Manhole Covers
   a. Unless otherwise shown on the Drawings, manhole and handhole covers shall be heavy duty 36-inch machined gray iron, and AASHTO M306-04/ ASTM A48 CL35B Minimum, 40,000-pound proof load value (Class H20 X 2.5) “True Traffic” load covers, complete with frame, and “Electric” or “Communication” raised lettering recessed flush, as required, on the cover. Covers shall be V-1600-5, with drop handles as manufactured by East Jordan Iron Works, Ardmore, OK.
   b. All castings shall be made in the USA, cast with the foundry’s name, part number, “Made in USA”, and production date (example: mm/dd/yy). Castings without proper markings will be rejected. Manufacturer shall certify that all castings conform to the ASTM and AASHTO Designations as specified herein. All casting shall be true to pattern in form and dimension, free from pouring faults, sponginess, cracks, blow holes and other defects in positions affecting strength and value for the service intended. Angles shall be filleted, and arises shall be sharp and true.

4. Hardware
   a. Cable racks shall be of the heavy duty non-metallic type with arm lengths of 8 inches, 14 inches, and 20 inches, each supporting a load of not less than 250 pounds at the outer end. Racks shall be molded in one piece of U.L. listed glass reinforced nylon, Catalog CR36N with RA08N, RA14N and RA20N arms as manufactured by Underground Devices Inc. Northbrook, IL. Cable racks shall be secured to the manhole and walls by drilled, Hilti HIT-HY 150 MAX epoxy anchoring system, with Hilti 316 stainless steel bolts. Arms for racks shall be vertically spaced not greater than 24 inches on centers.
   b. Pulling irons shall be of copolymer polypropylene coated 1/2-inch diameter cable, with a rated pulling strength of 7500 pounds and a polyethylene pulling iron pocket, all recessed in the manhole wall opposite each duct entry. Pulling irons for handholes shall have the pulling iron located in the floor of the handhole near the center of the handhole opposite the duct entry. Pulling irons shall be as manufactured by M.A. Industries, Inc. Peachtree, GA. or Bowco Industries, Portland OR.
c. Manhole and handhole ladders shall be constructed of fiberglass reinforced plastic, safety yellow, 18-inch rung width with 12-inch rung spacing, Safrail as manufactured by Strongwell Corp., Bristol, VA. Furnish a total of two ladders, each of a length four feet greater than the deepest manhole in the underground system.

C. Polyethylene Warning Tape

1. Subject to compliance with the Contract Documents, the following Manufacturers are acceptable:
   a. Brady Detectable Identoline
   b. Approved Equal

2. The listing of specific manufacturers above does not imply acceptance of their products that do not meet the specified ratings, features and functions. Manufacturers listed above are not relieved from meeting these specifications in their entirety.

3. Warning tape shall be metal detectable polyester with subsurface graphics, black letters on red tape. The tape shall meet the OSHA 1926.956(c)(1), two-inch minimum width, for location tracing.

PART 3 - EXECUTION

3.01 GENERAL

A. The Contractor shall field verify the routing of all underground duct banks before placement. He shall modify the routing as necessary to avoid underground utilities or above ground objects. Modification or rerouting for the convenience of the Contractor, or to reduce the length of duct run as designed, will not be permitted. The Contractor shall provide any alternate routing of the duct banks to the Owner/Engineer and, after approval, shall proceed with the installation.

B. All changes of direction, less than 20 degrees, shall be made using a hotbox, strictly in conformance with the conduit manufacturer’s instructions. Changes of direction greater than 20 degrees shall be accomplished using long radius bends of PVC coated rigid aluminum conduit.

C. The Contractor shall saw cut and repair existing pavements above new and modified existing duct banks. The Contractor shall provide the alternate routing of the duct banks to the Owner/Engineer and after approval shall proceed with the installation.

D. Install raceways to drain away from buildings. Raceways between manholes or handholes shall drain toward the manholes or handholes. Raceway slopes shall not be less than 3 inches per 100 feet.

E. Reinforce raceway banks as shown on the Drawings.

F. A #4/0 stranded bare tinned copper ground conductor shall be installed along the top of the rebar cage, as shown on the Drawings, for the full length of each duct run between manholes and handholes, and bonded to a ground rod in the vicinity of each manhole and handhole.
G. Lay raceway lines in trenches on compacted earth as specified herein.

H. Use plastic spacers located not more than four feet apart to hold raceways in place. Spacers shall provide not less than two-inch clearance between raceways.

I. The minimum cover for raceway banks shall be 24 inches unless otherwise permitted by the Owner/Engineer.

J. Raceway terminations at all manholes, existing and new, shall be with terminator for PVC conduit.

K. Blank duct plugs shall be used to seal the ends of all unused ducts in the duct system. Plugs shall be installed at all locations where the ducts enter and leave the manholes or handholes, and all entrances and exits to the underground system.

L. Where raceways enter or exit the Underground System, and the raceways rise to a higher elevation upon entering or leaving the System, such raceways shall be tightly sealed at the higher elevation, both before and after the installation of cables, such that there shall be no entry of water or moisture to the Underground System at any time. Raceways shall be sealed with 3M 1000NS Watertight Sealant, or approved equal.

M. No wire shall be pulled until the duct system has been completed in every detail.

N. Swab all raceways clean before installing cable.

O. Train cables in manholes and handholes and support and restrain them on cable racks. All cables passing manhole duct entrances in the manhole or handhole shall pass above all duct entrances. No cable shall pass in front of or below duct bank entrances.

P. Polyethylene Warning Tape shall be installed in the trench above each raceway or duct bank and located at the elevations shown on the Drawings.

Q. The Contractor shall tag all underground conduits at all locations, exiting and entering from underground, including manholes and handholes.

R. The minimum raceway size shall be 2-inch.

3.02 TRENCH EXCAVATION
A. The excavation shall extend to the width and depth as shown on the Drawings, or as specified, and shall provide suitable room for installing manholes, handholes, ducts and appurtenances.

B. Furnish and place all sheeting, bracing and supports.

C. Excavation shall include material of every description and of whatever substance encountered, regardless of the methods or equipment required to remove the material. Pavement shall be cut with a saw, wheel or pneumatic chisel along straight lines before excavating.

D. The Contractor shall strip and stockpile topsoil from grassed areas crossed by trenches. At the Contractor’s option, topsoil may be otherwise disposed of and replaced, when required, with approved topsoil of equal quality.

E. While excavating and backfilling is in progress, traffic shall be maintained, and all utilities and other property protected, as provided for in the Contract Documents.

F. Materials shall be excavated to the depth indicated on the Drawings and in widths sufficient for installing manholes and laying the ducts. Coordinate the trench width the Details shown on the Drawings. The bottom of the excavations shall be firm and dry in all respects acceptable to the Owner/Engineer. Trench width shall be a practical minimum, but not less than 6 inches greater on each side, than the total duct section arrangement, including reinforcing steel.

G. Excavation and dewatering shall be accomplished by methods which preserve the undisturbed state of subgrade soils. The trench may be excavated by machinery to, or just below, the designated subgrade, provided that material remaining in the bottom of the trench is no more than slightly disturbed. Subgrade soils which become soft, loose or otherwise unsatisfactory as a result of inadequate excavation, dewatering or other construction methods, shall be removed and replaced by gravel fill, of aggregate as specified herein, as required by the Owner/Engineer at the Contractor’s expense.

3.03 EXCAVATION BELOW GRADE AND REFILL

A. Regardless of the nature of unstable material encountered, or the groundwater conditions, trench and excavation drainage shall be complete and effective.

B. If deemed necessary by the Owner/Engineer, or as shown on the Drawings, the Contractor shall be required to deposit pea gravel for duct bedding or gravel refill for excavation below grade, directly on the bottom of the trench immediately after excavation has reached the proper depth and before the bottom of the trench has become softened or disturbed by any cause whatsoever. All excavation shall be made in open trenches. Gravel used for this purpose, shall be aggregate, as specified that is no larger than one-half the minimum clear spacing between electrical ducts, and a maximum coarse aggregate size of 3/4-inch.
3.04 BACKFILLING

A. Remove from the excavation all materials which the Owner/Engineer may deem unsuitable for backfilling.

B. Backfilling shall not commence until, not less than 48 hours after placing of any concrete embedment, have lapsed.

C. Where the duct banks are laid in the yard, the remainder of the trench, after concrete encasement, shall be filled with common fill material, void of rock or other non-porous material, in layers not to exceed eight inches in loose measure and compacted to 90% standard Proctor density at optimum moisture content of +/- 4%. The backfill shall be mounded six inches above the existing grade or as directed by the Owner/Engineer. Where a grass, loam or gravel surface exists prior to excavations in the yard, it shall be removed, conserved and replaced to the full original depth as part of the work under the duct items. In some areas, it may be necessary to remove excess material during the cleanup process, so that the ground may be restored to its original level and condition.

D. Where the duct banks are laid in paved areas or designated future paved areas, existing or designated future structures, or other existing or future utilities, the remainder of the trench above the encasement, shall be backfilled with select common fill or select fill material in layers not to exceed eight inches loose measure and compacted at optimum moisture content (+/- 3%) to 95% standard Proctor density.

E. Compaction shall be by use of hand or pneumatic tamping with tools weighing at least 20 pounds. The material being spread and compacted shall be placed in layers not over eight inches loose thick. If necessary, sprinkling shall be employed in conjunction with rolling or ramming.

F. Bituminous paving shall not be placed in backfill.

G. Water jetting will not be accepted as a means of consolidating or compacting backfill.

H. All road surfaces shall be broomed and hose-cleaned immediately after backfilling. Dust control measures shall be employed at all times.

3.05 RESTORING TRENCH AND ADJACENT SURFACES

A. In paved areas, the edge of the existing pavement to be removed shall be cut along straight lines, and the pavement replaced with the same type and quality of the existing paving.
B. In sections where the duct bank passes through grassed areas, the Contractor shall, at his own expense, remove and replace the sod, or shall loam and reseed the surface to the satisfaction of the Owner/Engineer.

3.06 CLEANING

A. Remove all rubbish and debris from inside and around the underground system. Remove dirt, dust, or concrete spatter from the interior and exterior of manholes, handholes and structures, using brushes, vacuum cleaner, or clean, lint free rags. Do not use compressed air.

END OF SECTION
SECTION 16660
GROUNDING AND BONDING SYSTEM

PART 1 - GENERAL

1.01 SCOPE OF WORK

A. Furnish all labor, materials, equipment and incidentals required to install a complete Grounding and Bonding System, in strict accordance with Article 250 of the National Electrical Code (NEC), and as shown on the Drawings and specified herein.

B. The system shall include ground wires, ground rods, exothermic connections, mechanical connectors, structural steel connections, all as shown on the Drawings, and as specified herein, to provide a bonding to earth ground of all metallic materials likely to become energized.

1.02 RELATED WORK

A. Refer to Division 16000 and the Contract Drawings, for related work and electrical coordination requirements.

1.03 SUBMITTALS

A. Submit to the Engineer, in accordance with Division 1 and Section 16000, shop drawings and product data, for the following:

1. Ground rods.
2. Grounding conduit hubs.
3. Waterpipe ground clamps.
4. Buried grounding connections.
5. Compression lugs.
6. Exothermic bonding system.

B. All shop drawing submittals and all O&M submittals shall be submitted in hard copy format and in electronic format using PDF files [on a CD and/or a flash drive] [on a flash drive] and shall include an indexed Table of Contents. Electronic submittals are mandatory, and any submittal received not indexed as specified will be returned without review. Hard copy submittals may not be required if so stipulated in the Contract.
Documents. No change in Contract Price or Schedule will be allowed for delays due to unacceptable submittals.

C. All cut sheets shall be clearly marked to indicate which products are being submitted for use on this project. Unmarked cut sheets will cause the submittal to be rejected and returned for revision.

1.04 REFERENCE CODES AND STANDARDS

A. All products and components shown on the Drawings and listed in this specification shall be designed and manufactured according to latest revision of the following standards (unless otherwise noted):

1. NFPA 70 – National Electrical Code (NEC)
2. UL 467-2007 --Grounding and Bonding Equipment
3. NFPA 70E – Standard for Electrical Safety in the Workplace

B. All equipment components and completed assemblies specified in this Section of the Specifications shall bear the appropriate label of Underwriters Laboratories.

1.05 QUALITY ASSURANCE

A. The manufacturer of these materials shall have produced similar electrical materials and equipment for a minimum period of five years. When requested by the Owner/Engineer, an acceptable list of installations with similar equipment shall be provided demonstrating compliance with this requirement.

1.06 JOBSITE DELIVERY, STORAGE AND HANDLING

A. Prior to jobsite delivery, complete all submittal requirements, and present to the Owner/Engineer prior to delivery of the equipment, an approved copy of all such submittals. Delivery of incomplete constructed equipment, onsite factory work, or failed factory tests will not be permitted.

B. Protect equipment during shipment, handling, and storage by suitable complete enclosures. Protect equipment from exposure to the elements and keep thoroughly dry.

1.07 WARRANTY

A. Provide warranties, including the manufacturer’s warrantee, for the equipment specified and the proper installation thereof, to be free from defects in material and workmanship.
for three years from date of final acceptance of the equipment and its installation. Within such period of warranty, all material and labor necessary to return the equipment to new operating condition shall be provided. Any warranty work requiring shipping or transporting of the equipment shall be provided at no expense to the Owner.

PART 2 - PRODUCTS

2.01 RACEWAYS

A. Conduit shall be as specified under Section 16110.

B. All raceways, conduits and ducts shall contain equipment grounding conductors sized in accordance with the NEC. Minimum sizes shall be #12 AWG unless otherwise indicated on the drawings.

2.02 CONDUCTORS

A. Conductors shall be as specified under Section 16120.

B. Equipment grounding conductors shall be insulated XHHW-2 conductors. Conductors shall be green where available from the wire manufacturers or marked with green tape as specified under 16120.

C. Grounding electrode conductors shall be bare tinned copper where direct buried, or encased in concrete. Bare grounding electrode conductors or lightning protection conductors where exposed to damage shall be installed in conduit. Grounding electrode conductors or lightning protection down lead conductors shown, specified or required to be installed in conduit per the NEC with no other conductors shall be bare tinned copper. Bare conductors installed in metallic conduits shall be bonded to the metallic conduit at both ends.

D. Grounding electrode conductors routed between concealed grounding electrodes or interconnecting grounding electrode counterpoise loop conductors to exposed (IE “Pigtails”) shall be bare copper.

2.03 GROUNDING ELECTRODES

A. Ground rods shall be 3/4-inch by 10-foot copper clad steel and constructed in accordance with UL 467. The minimum copper thickness shall be 10 mils.

B. Manufacturers for ground rods
1. ERICO
2. Copperweld
3. Approved equal.

2.04 CONNECTORS AND CONNECTIONS

A. Waterpipe ground clamps shall be cast bronze

1. Manufacturers
   a. Thomas & Betts Co. Cat. JPT
   b. Burndy
   c. O.Z. Gedney Co.
   d. Cooper Power Systems
   e. Erico
   f. Harger
   g. Approved equal
   h. Provide the correct size for the pipe.

B. Other grounding system clamps, where specified or shown shall be cast bronze

1. Manufacturers
   a. Thomas & Betts Co.
   b. Burndy
   c. O.Z. Gedney Co.
   d. Cooper Power Systems
   e. Erico
   f. Harger
   g. Approved equal.

C. All concealed grounding system or lightning protection system connections shall be by an exothermic weld process
1. Manufacturers
   a. T&B Furseweld SCR1
   b. Burndy Thermoweld
   c. Cadweld
   d. Approved equal.

2. Exothermic welded connections shall be used in exposed locations as specified herein.

D. Provide a Burndy Hyground Irreversible Compression System or equal in areas where the Owner’s operations prevent the use of an exothermic welded connection. The use of a compression system ground connection is otherwise prohibited without written approval on a case-by-case basis from the Owner or Engineer. Permission shall be submitted through the RFI process. Compression connectors installed without permission shall be removed and replaced with exothermic weld connections with no change in the Contract Price or change in the Contract Schedule allowed.

E. All grounding connections which would require exothermic welding in a Class 1 Division 1 Area as determined by NFPA 820, or the Engineer, or the NEC Authority Having Jurisdiction shall use a Burndy Hyground Irreversible Compression System, or equal.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Route exposed grounding electrode conductors in rigid aluminum conduits to protect the conductors from damage. The rigid conduits shall be aluminum or PVC-coated aluminum conduits as specified in 16110. Bond the protecting conduits to the grounding electrode conductors at both ends. Water pipe grounding connections shall not be painted. Painted connections shall be disassembled, replaced and reconnected.

B. Install equipment grounding conductors in all raceways for the power, control and instrumentation systems. Grounding conductors shall be independent conductors and shall be separate from all shield drain wires.

C. Conduits and other raceways shall contain an equipment grounding conductor whether the raceway is metallic or not. Conduits, motors, cabinets, outlets and other equipment shall be properly bonded in accordance with NEC requirements. Where ground wire is exposed to mechanical damage, install wire in rigid metallic conduit.
D. In NEC classified areas, connection of grounding electrode connections to structural steel columns shall be made with long barrel type one-hole heavy duty copper compression lugs, bolted through 1/2-inch maximum diameter holes drilled in the column web, with stainless steel hex head cap screws and nuts.

E. In new construction, bond each building column to the grounding electrode counterpoise system whether nor not specifically shown on the Drawings using grounding electrode conductors. Grounding electrode conductors rising from the counterpoise to bond to a column shall be made using an insulated conductor the same size as the conductors used to form the counterpoise. Exposed grounding electrode conductors shall be routed in rigid conduit. Bond metallic conduits as specified. Grounding electrode conductor connections to structural steel columns shall be made with as permitted by the Structural Engineer.

F. Metal conduits stubbed into a motor control center shall be terminated with insulated grounding bushings and connected to the motor control center ground bus. Bond boxes mounted below motor control centers to the motor control center ground bus. Size the grounding wire in accordance with NEC Table 250.122, except that a minimum #12 AWG shall be used.

G. Liquid tight flexible metal conduit in sizes 1-1/2-inch and larger shall have bonding jumpers. Bonding jumpers shall be external, run parallel (not spiraled) and fastened with plastic tie wraps.

H. Ground transformer neutrals to the nearest available grounding electrode with a conductor sized as shown with a minimum size in accordance with NEC Article 250.66.

I. Provide power system grounding electrodes (ground rods) no closer than twice the length of the ground rod. Where a lightning protection is specified to be provided, the Contractor shall provide a dedicated lightning protection system grounding electrode (ground rod) at the end of every down lead if no counterpoise is present or shall connect directly to the power system counterpoise without driving a separate ground rod. Refer to Section 16670 for lightning protection system specifications.

J. Provide a #1/0 AWG bare tinned grounding conductor the full length of each cable tray system, bond each section and tray fitting to the tray grounding conductor. Route the tray grounding conductor along the outside of the cable tray. Install no grounding clamps on the inside of the tray to avoid damage to tray conductors. Bond the tray grounding conductor to the power system counterpoise grounding electrode system at the end of the tray, or for tray systems installed in a loop configuration, bond in at least two locations at opposite sides of the tray loop. Bond every enclosure to which tray conductors are routed to the tray grounding conductor. Bond every conduit or raceway...
routing tray conductors away from or to the tray system to the cable tray and to the cable tray grounding conductor.

K. All equipment enclosures, motor and transformer frames, conduits systems, cable tray, cable armor, exposed structural steel and all other equipment and materials required by the NEC to be grounded, shall be grounded and bonded in accordance with the NEC.

L. Seal exposed connections between different metals with no-oxide paint, Grade A or equal.

M. Lay all underground grounding conductors' slack and, where exposed to mechanical injury, protect by pipes or other substantial guards. If guards are iron pipe, or other magnetic material, electrically connect conductors to both ends of the guard. Make connections as specified herein.

N. Care shall be taken to ensure good ground continuity, between the conduit system and equipment frames and enclosures. Where necessary, bonding jumper conductors shall be provided.

O. Ground all grounding type receptacles to the outlet boxes with a minimum, #12 AWG XHHW-2 stranded green conductor, connected to the ground terminal of the receptacle and bonded to the outlet box by means of a grounding screw.

3.02 INSPECTION AND TESTING

A. Inspect the grounding and bonding system conductors and connections for tightness and proper installation.

B. Use Biddle Direct Reading Earth Resistance Tester or equivalent test instrument to measure resistance to ground of the system. Perform testing in accordance with test instrument manufacturer's recommendations using the fall-of-potential method.

C. All test equipment shall be provided under this Section and approved by the Owner/Engineer.

D. Resistance to ground testing shall be preceded by no precipitation for a minimum of five days. Submit test results in the form of a graph showing the number of points measured (12 minimum) and the numerical resistance to ground.

E. Testing shall be performed before energizing the electrical distribution system.
F. A separate test shall be conducted for each building or system.

G. Notify the Engineer immediately if the resistance to ground for any building or system is greater than five ohms.

END OF SECTION