CLEAN WATER SERVICES

TIGARD, OREGON

BIDDING REQUIREMENTS
AND
CONTRACT DOCUMENTS

for the construction of the

DURHAM WATER RESOURCE RECOVERY FACILITY
ODOR CONTROL PHASE 3 HEADWORKS

VOLUME 2

SPECIFICATIONS
DIVISION 13 THROUGH DIVISION 17

PROJECT NO. 7202

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JACOBS

Corvallis, Oregon

February 2026

CLEAN WATER SERVICES

TIGARD, OREGON

BIDDING REQUIREMENTS
AND
CONTRACT SPECIFICATIONS

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DURHAM WATER RESOURCE RECOVERY FACILITY
ODOR CONTROL PHASE 3 HEADWORKS

PROFESSIONAL OF RECORD CERTIFICATION(S):

 EXP. 6-30-27 Kenneth J. Galardi	Signing as the Professional of Record for the Sections listed below: Sections: 01012, 01110, 01140, 01292, 01320, 01324, 01329, 01330, 01350, 01352, 01410, 01424, 01450, 01455, 01500, 01505, 01530, 01532, 01555, 01560, 01570, 01600, 01612, 01640, 01645, 01732, 01738, 01756, 01770, 01782, 09900, 10400, 13222, 15060, 15080, 15200, 15200.10, 15200.13, 15202, 15205, 15812, 15835, 15850, 15892, 15950, 15955

 Daniel J. Peterson	Signing as the Professional of Record for the Sections listed below: Sections: 02200, 02240, 02260, 02315, 02316, 02319, 02320, 02370, 02600, 02631, 02705, 02710, 02751, 02771

 EXP. 12-31-24 Kristina Milaj	Signing as the Professional of Record for the Sections listed below: Sections: 03100, 03210, 03215, 03251, 03300, 03370, 03600, 03640, 03722, 03740, 05020, 05050, 05500, 05516

 EXP. 06-30-25 Ryan S. Harbert	Signing as the Professional of Record for the Sections listed below: Sections: 16050, 16052, 16055, 16060, 16070, 16075, 16123, 16130, 16134, 16140, 16150, 16222, 16411, 16444, 16510, 16950

 EXP. 12/31/25 David Matthew Dutcher	Signing as the Professional of Record for the Sections listed below: Sections: 17050, 17101, 17402, 17403, 17404, 17405, 17710, 17901, 17903

END OF SECTION

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SECTION 13222
BIOFILTER ODOR CONTROL SYSTEM

EQUIPMENT AND COMPONENT NUMBER(S)

200OS4114: Headworks Biofilter.
200PCP4610: Water Panel.
200SV4613: Irrigation Control Valve.
200SV4614: Irrigation Control Valve.

PART 1 GENERAL

1.01 WORK OF THIS SECTION

A. This section covers the work necessary to provide biofilter engineered media, baseplate air distribution plenum, geomembrane HDPE liner, humidification system, irrigation system and control valves, drain system, instrumentation, startup, functional and performance testing, and all necessary appurtenances for a complete and properly functioning biofilter odor control system. Odor control exhaust fans are specified in Section 15835, Odor Control Fans.

B. The scope of supply associated with the Work, in addition to equipment and material supply, shall include the following services: HDPE liner manufacturer's certification and field services, laboratory analysis of air samples and functional testing of the completed installation.

1.02 RELATED SECTIONS

A. Related sections include the following:

1. Section 01756, Testing and Facility Startup.
2. Section 15200, Process Piping—General.
3. Section 15202, Process Valves and Operators.
4. Section 15835, Odor Control Fans.
5. Section 15892, Foul Air Ductwork and Accessories.
6. Section 15950, Testing, Adjusting and Balancing for HVAC
7. Section 16050, Common Work Results for Electrical.
8. Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.
9. Section 17710, Control Systems Panels, Enclosures, and Panel Components.

1.03 GENERAL

A. Like items of equipment specified hereunder shall be the end product of one Supplier in order to achieve standardization for operation, maintenance, spare parts, and Supplier's services.

1.04 SERVICE CONDITIONS

A. The biofilter odor control system shall be installed as generally shown on the Drawings. This arrangement is intended to represent the minimum standard of quality and treatment capacity.

B. The biofilter system shall incorporate components and provisions to meet the following service conditions:

1. Environment: Pacific Northwest with moderate summers and cool wet winters.
2. Ambient Temperature Range: Plus 15 degrees F to plus 100 degrees F.
3. Precipitation: Greater than 30 inches per year.
4. Altitude: Approximately 200 feet above mean sea level (msl).
5. Odor Loadings: Depending on season and diurnal variations, the expected inlet odor concentrations are as follows.
    a. Hydrogen Sulfide: Average ranging from 2 ppmV to 3 ppmV with peaks to 10 ppmV (peak).
    b. Total Odor: Average 4,500 DT with peaks to 9,000 DT.
6. Temperature of Influent Odorous Air to the Biofilter: 35 degrees F to 85 degrees F.
7. Seismic, Wind, and Snow Loads: As described on General Structural Note Sheets on the Drawings.

C. The biofilter system shall treat 29,000 cfm of continuously exhausted odorous air from the Headworks Facility sources. This system is designed to eliminate odorous compounds from the airstream typical of a municipal wastewater treatment application. These compounds shall include, but not be limited to, hydrogen sulfide, mercaptans, reduced sulfur compounds, ammonia, and volatile organic compounds typical of this type of application.

D. Specific Design Criteria:

1. Number of Cells: One.
2. Nominal Total Area: 2,900 square feet.
3. Media Depth, After Placement and Initial Irrigation: 6 feet.
4. Empty Bed Residence Time: Minimum of 35 seconds.
5. Maximum Pressure Drop through Biofilter System: 4 inch WC.

E. All electrical and control components located within 3 feet of odorous air leakage sources shall be UL listed for use in Class 1, Division 2, Group D hazardous area and shall be installed in compliance with NEC 500, 501.

1. See Area Classification limits shown on the Drawings.

F. All mechanical components shall be designed and constructed in accordance with the latest edition and revision of all applicable codes and regulations, including the following:

1. NIST.
2. ASTM.
3. ANSI.
4. ASME.

G. Equipment Materials:

1. All components of the biofilter system shall be compatible with the conditions and chemicals to which they will be subjected to during normal operation.
2. Compounds with which the materials of construction must be compatible include, but are not limited to:
   a. Hydrogen sulfide (H2S).
   b. Sulfuric acid caused by the presence of H2S.

1.05 PERFORMANCE CRITERIA

A. Guaranteed Removal Efficiency:

1. Hydrogen Sulfide: 99 percent removal for concentrations above 10 ppm. 100 ppbV maximum discharge concentration at inlet concentrations less than 10 ppmV.
2. Total Odor: Odor removal for inlet detection threshold (DT) concentrations greater than or equal to 3,000 odor units (OU), 90 percent removal; for inlet odor DT concentration less than 3,000 OU, outlet DT concentration less than 300 OU. (Odor DT concentrations to be determined using ASTM E679 with a 20 liter per minute odor panel presentation rate).
3. A performance test as described herein shall be means for demonstrating actual biofilter performance.

1.06 DEFINITIONS

A. Boot: Watertight collar fabricated from geomembrane sheet for sealing geomembrane to pipes and other objects that penetrate geomembrane.

B. EBRT: Empty bed residence time equals volume that media occupies/air flow.

C. Film Tearing Bond: A failure in the ductile mode of one of the bonded sheets by testing prior to complete separation of the bonded area.

D. Geomembrane: An essentially impermeable geosynthetic composed of one or more layers of polyolefin materials fusion bonded into single ply integral sheet.

E. H2S: Hydrogen sulfide.

F. HDPE: High density polyethylene.

G. Panel: Piece of geomembrane composed of two or more sheets seamed together.

H. Sheet: Seamless piece of geomembrane.

I. Watertight: Geomembrane installation free of flaws and defects that will ensure containment of water and gases, liquids, and solids under anticipated service conditions.

1.07 REFERENCES

A. The following is a list of standards referenced in this section:

1. American National Standards Institute (ANSI).
2. American Society of Mechanical Engineers (ASME).
3. National Electrical Manufacturers Association (NEMA): 250-2014, Enclosures for Electrical Equipment (1,000 volts, maximum).
4. National Fire Protection Association (NFPA):
   a. 70, National Electrical Code (NEC).
   b. 820, Fire Protection in Wastewater Treatment and Collection Systems.
5. National Institute of Standards and Technology (NIST).
6. Occupational Safety and Health Act (OSHA).
7. UL: 508a, Industrial Control Panels.

1.08 SUBMITTALS

A. Submittals shall be made as required in Section 01330, Submittal Procedures, of Division 01, General Requirements. The following specific information shall be provided:

1. Action Submittal:
   a. Shop Drawings:
      1) Shop Fabricated Piping: Detailed pipe fabrication or spool drawings showing special fittings and bends, dimensions, coating, field connection details, and other pertinent information.
      2) Product literature to provide a complete description of the equipment and system components specified in this section.
      3) Drawings, catalog information and cut sheets, and performance data.
      4) Irrigation spray nozzle layout drawing.
      5) Approximate shipping weight of the equipment and, if shipped unassembled, the number of components and approximate weight of each.
      6) Shipping method.
      7) Recommended handling methods.
      8) Requirements for storage and protection prior to installation.
      9) Manufacturer’s Information on the Biofilter Media:
         a) Media data sheet.
         b) Pressure drop data through media(s).
         c) Biofilter Media Physical Characteristics, Including:
            (1) Media weight, volume, and density.
            (2) Media depth.
            (3) Empty Bed Residence Time.
      10) Information on expected settling rates of the media per year.
      11) Manufacturer’s information on the Baseplate Engineered Plenum/Media support, including:
         a) Material of construction.
         b) Load capacity.
         c) Pressure loss vs air flow curve.
   b. Samples:
      1) Submit a 0.5 cubic foot material sample of the biofilter media.
      2) Submit a 1 square foot material sample for the geomembrane barrier.

2. Informational Submittals:
   a. Supplier's Certificate of Compliance.
   b. Statement of Qualifications.
   c. Supplier's Certificate of Proper Installation.
3. Functional Testing Submittals:
   a. Submit a Detailed Functional Testing Plan for approval prior to conducting testing which includes:
      1) Test equipment and apparatus.
      2) The specific testing methodology to be used.
      3) The sampling and analysis procedures.
   b. Submit a final report that provides a narrative of the testing activities, tabular summary of all data collected, and conclusions of these results.
4. Performance Demonstration Submittals:
   a. Detailed Acclimation Plan for biofilter to ensure system is gradually ramped up to prevent offsite odor impacts during acclimation and made ready to be performance tested. Plan shall comply with Section 01140, Work Restrictions.
   b. Submit a Detailed Performance Demonstration Plan for approval prior to conducting demonstration which includes:
      1) Test equipment and apparatus.
      2) The specific testing methodology to be used.
      3) The sampling and analysis procedures.
   c. Submit a final report that provides a narrative of the testing activities, photographs showing the activities, tabular summary of all data collected, and conclusions of these results.
5. Operation and Maintenance Data:
   a. Operations and Maintenance (O&M) Manuals: Content format, and schedule for providing as specified in Section 01782, Operation and Maintenance Data.
   b. Data Sheet Forms: As specified in Section 01782, Operation and Maintenance Data.
6. HDPE Liner:
   a. Installer: Certification and approval of welders to be used on this Project. Include experience record with references for previous HDPE liner system installation to concrete structures of similar design and complexity.
   b. Field installation report including welding log and diagram, list any deficiencies and recommended action, and statement certifying the components are properly installed and fully operational (aside from any noted deficiencies).

1.09 EXTRA MATERIALS

A. Provide a list of spare parts recommended by the manufacturer including part numbers, current price list, and purchasing contact.

B. Tools and Accessories: Provide manufacturer's recommended special tools and accessories required to assemble and disassemble the equipment furnished under this section.

1.10 DELIVERY, STORAGE, AND HANDLING

A. In accordance with Section 01600, Product Requirements, and:

1. Individually package each sheet of geomembrane and protect from damage during shipment. Mark each package with identification of material type, size, and weight.
2. Biofilter media shall be protected using a tarp if stored on site prior to installation.
3. Responsibility for shipping damage: Be responsible for the condition of biofilter components delivered to the jobsite. Any damage suffered during transportation or unloading shall be repaired or replaced at no cost to Owner.
4. Crate materials whenever practical prior to shipment.

1.11 SAFETY REQUIREMENTS

A. All equipment furnished shall be designed and manufactured with due regard to safety of operation, accessibility, and durability of parts, and shall comply with all applicable Occupational Health and Safety Act, federal, state, and local safety regulations.

1.12 QUALITY ASSURANCE

A. Perform smoke tests on the installed biofilter system to ensure uniform air distribution at design flow rate using suitably sized smoke emitters. All tests shall be conducted in the presence of Owner's representative. Provide Owner and Engineer a minimum of 14 days notice prior to testing. Biofilter media shall be removed, topped-off, or replaced as required by Engineer to achieve proper airflow distribution. Following any system improvements resulting from smoke test findings, smoke testing shall be repeated until results are considered acceptable to Engineer.

B. HDPE Geomembrane Liner Manufacturer's Certification:

1. Review Project requirements and certify application of proposed product.
2. Approve installer, materials, welding procedures and welder qualifications.
3. Inspect installed liner system and certify installation is complete and free from defects. Provide field installation report.

1.13 SPECIAL GUARANTEE

A. Supplier shall warrant the biofilter media for a period of 10 years from the date of Substantial Completion. This warranty shall be issued to the Owner. In addition:

1. The media shall not shrink or compact by more than 10 percent of the original bed depth, as indicated in differential pressure drops exceeding maximum limits stated herein at design airflow rates.
2. The media shall not degrade or decompose during the warranty period.
3. The biofilter shall meet the performance criteria specified herein throughout the warranty period.
4. If the media degrades or is shown to be defective in material or workmanship or performance criteria is exceeded, upon examination by the media supplier, the media supplier shall either:
   a. Repair or replace any part of the defective media at no cost to the Owner.
   b. Replace the entire media bed at no cost to the Owner.

B. Warranty shall be contingent on the following conditions:

1. The Owner must ensure that the biofilter system is operated and maintained in accordance with the Supplier's written recommendations contained in the operation and maintenance manual.
2. The Owner must seek written authorization from the Supplier prior to undertaking any service, modifications or the addition of any substance(s) to the media.

C. HDPE Geomembrane Liner Warranty:

1. Material manufacturer shall warrant the liner system (products and labor) for a period of 3 years from the date of Substantial Completion under normal operating conditions as specified. This warranty shall not cover wear and tear such as abrasion resistance or mechanical abuse.

2. The Manufacturer shall warrant to repair or replace, without cost or undue hardship to the Owner, manufacturer's work that is found to be defective, that is not in accordance with the Contract Documents, that fails to perform as represented by the Manufacturer's published product information, or that does not meet generally recognized standards of quality or performance for such work, whichever is greater.
3. Warranty shall include the repair or removal and replacement, without cost or undue hardship to the Owner, of other Work which is damaged as a result of removal or replacement of the Manufacturer's work which is defective or nonconforming, as set forth above.

PART 2 PRODUCTS

2.01 BIOFILTER ODOR CONTROL

A. Engineered Biofilter Media:

1. Media must be resistant to degradation and compaction. Media is not to settle by more than 5 percent of its original depth within 6 months after installation. Media shall not shrink or swell with varying moisture contents.
2. All media surfaces shall be 100 percent coated. Plain, uncoated media shall not be acceptable.
3. Biofilter media shall be formulated with the proper nutrients and buffering agents for intended operation.
4. Provide sufficient depth for a minimum empty bed retention time as stated herein.
5. Manufacturers and Products:
   a. Biorem; XLD or Biosorbens Media.
   b. ECS BioPure.
   c. Global Environmental Solutions; Enhanced CellMax.
   d. No "or-equal."

B. Cover Material:

1. Gradation: ASTM C136.

Sieve Size	Percent Passing By Weight
2 inch	100
1-1/2 inch	90 - 100
3/4 inch	0 – 15
1/2 inch	0 - 2

2. Material shall be smooth and rounded such as river rock and free from bark, wood, or other extraneous or objectionable material. Material shall be washed to remove excess dirt and silt.
3. Provide material depth as indicated on the Drawings.

2.02 HDPE GEOMEMBRANE LINER

A. Provide geomembrane liner to protect interior concrete surfaces within the biofilter, including walls, floor, and air inlet plenum. Extend liner to limits shown on the Drawings. Attach liner to biofilter walls as shown on the Drawings.

1. Composition:
   a. High density polyethylene (HDPE) containing no plasticizers, fillers, extenders, reclaimed polymers, or chemical additives, except following:
      1) Approximately 3 percent by weight of carbon black to resin for ultraviolet resistance.
      2) Antioxidants and heat stabilizers, not to exceed 1.5 percent total by weight, may be added as required for manufacturing.
2. Furnish in rolled single-ply continuous sheet of longest manageable length to reduce field seams.
3. Meet manufacturer's most recent published specifications and required minimum values in this table:

Property	Required Value	Test Method
Specific Gravity	0.940 to 0.936 g/cc; not more than 15% greater than base resin density	ASTM D792, Method A-1 or ASTM D1505
Smooth-Surface, Minimum Properties, Each Direction		
Tensile Strength at Yield	2.1 lb/in-width/mil thickness	ASTM D638
Elongation to Yield	12% minimum	ASTM D638
Thickness, Nominal, plus or minus 5%	60-mil (average)	ASTM D5199
Puncture Resistance	120 lbs	ASTM D4833
Tear Resistance	0.70 lb/mil thickness	ASTM D1004, Die C
Modulus of Elasticity	80,000 lb/sq in	ASTM D882, Method A or ASTM D638

Property	Required Value	Test Method
Bonded Seam Strength in Shear	2 lb/in-width/mil thickness, min. and FTB	ASTM D6392
Bonded Seam Strength in Peel	1.2 lb/in-width/mil thickness, min. and FTB	ASTM D6392

B. Extrudate for Fusion Welding of HDPE Geomembranes:

1. Liner shall be extrusion welded in the field. Qualified welders shall be authorized by the liner manufacturer.
2. Formulated from same HDPE resin as geomembrane and shall meet applicable physical property requirements.
3. Field welds shall be tested in accordance with manufacturer's recommendations.
4. Welds shall be free from bubbles, cracks, and holes.

C. Boots:

1. At pipe penetration locations shown on the Drawings.
2. Fabricated of same material as geomembrane sheets to fit around penetrations, i.e., pipe, without folds, stretching, or unsupported areas.
3. Flanges: Angle shall match the angle of the slope or bottom where the penetration passes through the liner, width shall be minimum 2 feet plus diameter of penetration.
4. Stainless Steel Bands: As manufactured by Breeze Clamp Products, Saltsburg, PA.
5. Neoprene Rubber Pad:
   a. 50 durometer to 60 durometer, in accordance with ASTM D2240 hardness.
   b. Manufacturer: Aero Rubber Co., Inc., Bridgeview, IL.

D. Sealant Caulking:

1. Two-component sealant formulated of 100 percent polyurethane elastomer.
2. Manufacturer and Product: United Coatings, Industrial Coatings Division, Greenacres, WA; ELASTUFF 120 Mastic.

E. Quality Control:

1. Independent Testing Agency certified in the State of Oregon and 5 years' experience in field of geomembrane testing.
2. Test geomembrane actually used as evidence of compliance with specifications herein.

F. Manufacturers:

1. GSE Environmental.
2. AEG, A Tetra Tech Company.
3. JH Walters Inc.
4. "Or-equal."

2.03 BASEPLATE AIR DISTRIBUTION PLENUM

A. The air plenum of the biofilter shall consist of a modular, self-contained HDPE or HDPE/PP perforated floor system installed over a reinforced concrete slab as indicated on the Drawings. The perforated floor system shall conform to the following requirements:

1. Airflow through the floor system openings shall be sized to provide the required airflow to the biofilter bed as defined herein.
2. The baseplate floor system shall be capable of being accessed by and support material handling equipment with weight of 3 metric tons using an eight-leg support system.
3. The baseplate floor system shall have the ability to be trimmed without reduction in structural integrity.
4. The floor system shall allow for biofilter drainage. Legs shall be such that biofilter leachate can flow freely along the floor surface and around the support legs.
5. Support legs shall be of sufficient height as shown on the Drawings. Support legs length shall be adjustable by cutting to fit at the factory or at the site.
6. Baseplates shall be constructed and installed in a manner that allows the expansion and contraction of each individual module to occur without creating a gross expansion or contraction of the entire floor system over the temperature range of the biofilter operation.
7. Contractor to provide a concrete ledge of sufficient width and height around the perimeter to maximize the use of whole modules if shown on the Drawings.

8. The floor system shall be as manufactured by Hahn Plastics, “or-equal.” Basis of design indicated on the Drawings is Hahn Plastics Hanit grating system. If Contractor opts for a manufacturer other than the Hahn Plastics system used for the basis of design, Contractor shall be responsible for all associated costs due to any redesign or changes.

B. Mesh Liner:

1. A mesh liner shall be placed over the baseplate to prevent biofilter media from falling through the baseplate openings, if required by the biofilter media supplier for the selected flooring system.
2. High Performance tri-planar geonet consisting of thick supporting ribs with diagonally placed top and bottom ribs.
3. Material of Construction: Extrusion of high-density polyethylene resin and carbon black. Inert to chemical and biological attack and stabilized against UV degradation.
4. Structure:
   a. Geonet Cross-Rib Spacing: 0.4 inch.
   b. Geonet Main-Rob Spacing: 0.5 inch.
   c. Unsupported Aperture Area: 0.3 square inches.
   d. Thickness: 0.275 inch (ASTM D5199).
   e. Tensile Strength: 1,000 pounds per foot (ASTM D7179).
5. Manufacturer and Product:
   a. Syntec Geosynthetics Evolved; Tendrain BF.
   b. “Or-equal.”

C. Plenum Floor Perimeter Seal: Provide solid end plate for sealing the perimeter edge of floor system. End plate shall be 12 inches wide, manufactured of HDPE or HDPE/PP or Type 316 stainless steel and shall be bolted to the concrete wall or curb to provide proper anchorage. All hardware to be Type 316 stainless steel.

2.04 HUMIDIFICATION SYSTEM

A. The biofilter system shall include primary humidifier for primary moisture control of the biofilter media using non-potable water (NPW). The primary humidification system shall operate continuously and shall include in-duct humidification nozzle assembly.

B. Primary Humidification Spray Nozzle Assembly: Spray system shall distribute water evenly across the cross-section of the duct as shown on the Drawings. Spray assembly shall include spray nozzles, piping, pressure indicator, pressure regulator, strainer, valve, and flow indicator. All humidification valves and flowmeter shall be installed in the water panel as shown on the Drawings. The exposed piping shall be provided with heat tracing and/or insulation as indicated on the Drawings. Spray nozzles shall be easily removable from the duct for inspection and maintenance without disassembly of the piping system and without requiring shutdown of the foul air treatment system. Oversized nozzles and unions shall be provided as necessary as shown on the Drawings.

1. Humidification Spray Nozzles: Each spray nozzle shall provide fine spray atomization in a 90-degree full cone pattern using hydraulic pressure alone. Each nozzle shall be constructed of Type 316 stainless steel.
   a. Flow Rate: 0.34 gallon per minute per nozzle.
   b. Number of Nozzles per Assembly: Two.
   c. Water Pressure: 60 psig.
   d. Manufacturer and Product: Bete Fog Nozzle Inc.; Model PJ40, “or-equal.”
2. Flow Element, Rotameter (200FI4612):
   a. Polysulfone meter body with PTFE float and PVC ends.
   b. Rated 150 psi with 1/2-inch NPT screwed ends.
   c. Direct-reading scale with range of 0.1 gpm to 5 gpm.
   d. Manufacturer and Product: Blue-White Industries; F-460 Series, “or-equal.”

C. Humidifier Access Port: Port shall be 8-inches diameter and configured to allow access into the duct for humidifier nozzles, as shown on the Drawings.

1. Port Cover Retainers: Stainless steel captured tee-bolts formed directly into the FRP duct flange and configured to allow a minimum of 90-degree rotation outward from the retention position without requiring the full removal of retention hardware from tee-bolt. Retention hardware shall be wing-nut or thumb-screw style and shall be sized to allow tightening and removal without hand tools. Sufficient number of retainers shall be provided to assure a tight seal of the port cover to flange.
2. Gasket: Provide continuous ring gasket between port cover and flange. Gasket material shall match duct gasket material.
3. Port Cover: Acrylic or polycarbonate clear plastic, minimum 1/2-inch thick, with retention bolt holes slotted radially to the cover edge to allow cover retainer tee-bolts to swing clear of cover.

4. Port Cover Sun Shade: Provide a removable flexible plastic or vinyl cover over the port cover to protect the clear plastic from UV degradation and prevent interior biological growth.

D. Air Plenum Access Port: Access to the air inlet plenum shall be provided using two 36-inch diameter access ports as shown on the Drawings.

1. Gasket: Provide continuous flat gasket between port cover and flange. Gasket material shall match duct gasket material.
2. Port Cover: FRP cover with drilling pattern to match flange. Cover thickness shall be a minimum of 5/8-inch and include stiffeners if required for supporting a load of 300 pounds per foot.

E. Pipe: PVC pipe conforming to Section 15200, Process Piping—General. PVC valves conforming to Section 15202, Process Valves and Operators.

2.05 IRRIGATION SYSTEM

A. The biofilter system shall include an irrigation system for secondary moisture control of the biofilter media using nonpotable water (NPW). Each irrigation system shall include sprinklers, piping, pressure regulator, and automatic control valves. All irrigation control valves, isolation valves, and accessories shall be installed in the water panel as shown on the Drawings.

B. The general layout of the irrigation system, and the number of irrigation system zones are shown on the Drawings. Provide submittal data to verify the type and layout for irrigation sprinkler nozzles meets biofilter media supplier requirements. The irrigation system shall incorporate provisions for cold weather operation as outlined in Article Service Conditions. All irrigation piping shall be sloped back to a system drain valve as shown on the Drawings.

C. Sprinkler Heads: Adjustable arc, popup rotor style sprinkler heads. All sprinklers to have purple “Nonpotable Water” markings.

1. Placement: As indicated on the Drawings.
2. Nozzle Trajectory: Standard 25-degree angle with a minimum 25 percent adjustment.
3. Arc: Adjustable from 0 degrees to 360 degrees.
4. Nozzle Size: As required to achieve irrigation rate indicated herein and radius indicated on the Drawings.
5. Irrigation Rate: 0.6 inch per hour.
6. Water Pressure: 45 psig.
7. Manufacturer and Product:
   a. Rain Bird; R-VAN 24-360.
   b. “Or-equal.”

D. Pipe: PVC pipe conforming to Section 15200, Process Piping—General. PVC valves conforming to Section 15202, Process Valves and Operators.

2.06 WATER PANEL (200PCP4610)

A. The water panel shall house the humidification and irrigation components as described herein.

1. Control Valves (200SV4613, 200SV4614):
   a. Provide electric solenoid type irrigation control valve meeting the following requirements:
      1) Brass: 120V ac actuator, actuator enclosure suitable for outdoor application, fail CLOSED.
      2) Manufacturer and Product:
         a) ASCO.
         b) "Or-equal."
2. Panel Heater: Thermostatically controlled, 120V ac, single-phase, minimum of 200W enclosure heater mounted near the bottom of the panel interior to prevent freezing of panel components.
3. Pressure regulators (200PRV4612, 200PRV4613) and upstream and downstream pressure indicators (200PI4611, 200PI4612). Supply pressure up to 80 psig.
4. Flow transmitter for irrigation pipe (200FIT4611). Flow transmitter shall be an electromagnetic flowmeter, with loop power and 4mA to 20mA HART output.
   a. Manufacturer: Endress Hauser.
   b. Model: Promag P200.
5. Flow indicator (rotameter) for humidification flow indication (200FI4612), as specified herein.
6. Y-strainer with 20-mesh stainless steel screen element and blowdown valve.
7. PVC isolation, drain, bypass and flow regulation valves as shown on the Drawings.
8. Connections for compressed air to blow out piping for winterization, as shown on the Drawings.

B. Type 316 stainless steel, NEMA 4X construction.

C. Panel location and configuration as indicated on the Drawings. Locate panel outside of hazardous area envelope.

2.07 INSTRUMENTATION AND CONTROL

A. General:

1. Control of the Biofilter Odor Control System shall be provided by the plant control system.
2. The minimum functional requirements of the control system are specified herein. Provide additional instrumentation as required to provide a safe and operable system.
3. Control narratives for biofilter odor control system provided in Section 17101, Control Loop Descriptions, Supplement Loop Specifications. As part of submittal requirements, verify the narrative meets media supplier's requirements for proper operation and performance.

B. Instrument Components: As described in Section 17050, Basic Measurement and Control Instrumentation.

PART 3 EXECUTION

3.01 EXCAVATION AND SUBGRADE PREPARATION

A. Excavate to lines, grades and dimensions as specified in Section 02315, Excavation.

B. Prepare subgrade as specified in Section 02319, Subgrade Preparation.

3.02 HDPE GEOMEMBRANE LINER

A. Geomembrane Inspection: During unwrapping visually inspect, mark each imperfection for repair.

B. Complete Installer's Certification of Subgrade Acceptability prior to installation per Supplement.

C. Protection:

1. Do not use geomembrane surfaces as work area for preparing patches, storing tools and supplies, or other uses. Use protective cover as work surface, if necessary.

2. Instruct workers about requirements for protection of geomembrane such as handling geomembrane material in high winds, handling of equipment, and walking on geomembrane surfaces. Shoes of personnel walking on geomembrane shall be smooth bonded sole or be covered with smooth type of overboot. Prohibit smoking, eating, or drinking in vicinity of geomembrane, placing heated equipment directly on geomembrane, or other activities that may damage geomembrane.
3. Do not operate equipment without spark arrestors in vicinity of geomembrane material nor place generators or containers of flammable liquid on geomembranes.
4. Protect from vehicle traffic and other hazards.
5. Keep clean and free of debris during placement.
6. Prevent uplift, displacement, and damage by wind.

D. Installation Quality Assurance:

1. Installed by qualified HDPE liner installer and using certified welder(s) for all seams field welds.
2. Install according to manufacturer’s written instructions.
3. Fasten to biofilter walls as shown on the Drawings.

E. Inspection and Certification:

1. Manufacturer’s certification and approval of installer.
2. Manufacturer’s inspection of installed liner and installation report.

F. General:

1. Each miscellaneous product required for completion of geomembrane installation shall be of types, sizes, and installed in strict accordance with this specification and the geomembrane manufacturer’s recommendations.
2. Reduce field seaming to minimum. Horizontal seams on slopes will not be acceptable. Seams parallel to toe shall be at least 5 feet from toe. Align rough-sided sheets in manner that maximizes their frictional capabilities along slope.
3. Prevent wrinkles, folds, or other distress that can result in damage or prevent satisfactory alignment or seaming. Provide for factors such as expansion, contraction, overlap at seams, anchorage requirements, seaming progress, and drainage.
4. Temporarily weight sheets with sandbags as necessary to anchor or hold them in position during installation. Use continuous holddowns along edges to prevent wind flow under sheet.

5. Anchor perimeter of geomembrane as shown on the Drawings.
6. Place overlying cover materials immediately following completion of geomembrane installation and field testing as acceptable to Engineer.

G. Field Seams:

1. General:
   a. Wipe sheet contact surfaces clean to remove dirt, dust, moisture, and other foreign materials and prepare contact surfaces in accordance with seaming method accepted by Engineer.
   b. Lap sheet edges to form seams to seam geomembrane sheets together. Adjust edges to be seamed and temporarily anchor to prevent wrinkling and shrinkage.
   c. Seams shall not go through a boot. Locate seams a minimum of 2 feet from boot.
   d. Avoid seam intersections involving more than three thicknesses of geomembrane material. Offset seam intersections at least 2 feet. Extend seams through anchor trench to sheet edges.
   e. Seal seam “T” intersections by removing excess material and extrusion welding lap joint.
2. HDPE:
   a. For boots and seams that cannot be otherwise tested, insert copper wire for spark test at edge of overlapping sheet in extrudate of weld prior to filet welding. Position to within 1/8-inch of sheet edge.
   b. Seam sheets together, using fusion-extrusion or hot-wedge welding system, equipment, and techniques.

H. Boot Seals:

1. Preparation: Thoroughly clean contact surfaces.
2. Place boot around penetrations so flange is supported everywhere in full contact with the subgrade, and is free of wrinkles.
3. Seal boot to surrounding geomembrane as specified for field seams using extrusion welding methods.
4. Tighten steel clamping bands until neoprene rubber pads are compressed 12 percent to 15 percent of total pad thickness.

I. Short Circuit Barrier:

1. Provide a geomembrane sheet welded to the geomembrane liner that extends a minimum of 12 inches into the biofilter media, measured from the face of the wall, to prevent short circuiting of air along the perimeter of the biofilter, as shown on the Drawings.

J. Geomembrane Anchor Plate:

1. Provide 2-inch wide by 1/4-inch thick Type 316 stainless steel batten plate for anchoring geomembrane liner to the structural wall.
2. Batten bar shall be continuous with a gap between sections of not more than 1/4 inch.
3. Provide 3/8-inch diameter Type 316 stainless steel concrete anchor bolts 12 inches on center. Install anchor bolts with a minimum of 4-inch embedment with a minimum of 4-inch edge distance.
4. Provide 2-inch wide by 1/4-inch thick neoprene rubber pad between geomembrane and structural wall. Apply a bead of sealant along the top edge between the batten bar and structural wall, fully covering the exposed edge of the geomembrane and neoprene rubber pad.
5. Install at elevation as indicated on the Drawings.

K. In-Place Observation and Testing:

1. Visually inspect geomembrane sheets, seams, anchors, seals, and repairs for defects as installation progresses and again on completion.
2. Test each seam and repair using vacuum testing device and/or air channel pressure test for double wedge welded seams.
3. Clearly mark defective and questionable areas, and repair them to Engineer’s satisfaction.
4. Each area showing injury due to scuffing, penetration by foreign objects, or distress from rough subsurface shall be replaced or covered with an additional layer of geomembrane material.
5. Perform testing in presence of Engineer.
6. Conform to ASTM D6392 and this specification for vacuum box testing and air channel pressure testing.
7. Vacuum Box Testing of Geomembrane Welds:
    a. Vacuum Box Test Each of These Types of Welds: Fillet, extrusion lap, and single hot-wedge fusion lap.
    b. Testing Procedures: Conforming to ASTM D5641.
8. Air Channel Pressure Testing of Double Hot-Wedge Seam:
    a. Insert a needle with gauge in air space between welds. Pump air into space to 30 psi and hold for 5 minutes.
    b. At end of 5 minutes, depressurize seam by placing needle hole in air space between welds at opposite end of seam and observe gauge.
    c. Seam is acceptable if seam maintains a minimum of 27 psi. If pressure drops below 27 psi during test period, or does not drop during 30-second depressurization period, repair needle holes and retest seam by same procedure or vacuum box test along entire length of seam.

d. Vacuum box test entire length of seam if second air pressure test fails.
    1) If no bubbles appear in vacuum box, lower weld will be considered defective and upper seam is acceptable.
    2) If bubbles appear in vacuum box, repair each defective area by extrusion welding and test again by vacuum box.
e. As alternative to vacuum box testing, apply soap solution to exposed seam edge while maintaining required air channel test pressure.
    1) If bubbles appear, mark, trim unbonded edge, and extrusion weld defective areas.
    2) If no bubbles appear and test pressure cannot be maintained, leak is judged to be in bottom or second seam.
f. Mark and repair needle holes.

L. Repairing Geomembrane:

1. Repair damage or rejected seams with pieces of flat and unwrinkled geomembrane material free from defects and seams. Patches shall be tightly bonded on completion of repair Work.
2. Patch shall be neat in appearance and of size 6 inches larger in all directions than areas to be repaired. Round corners of each patch to minimum 1-inch radius.
3. Prepare contact surfaces and seam patch in accordance with Paragraph Field Seams.
    a. Pull and hold flat receiving surface in area to be patched.
    b. Seal each patch by extrusion welding continuous bead along edge, with no free edge remaining.

M. Placing Products Over Geomembrane:

1. Prior to placing material over geomembrane, notify Engineer’s representative. Do not cover installed geomembrane until after Engineer provides authorization to proceed.
2. Place biofilter plenum flooring over geomembrane in accordance with manufacturer’s instructions.
3. If tears, punctures, or other geomembrane damage occurs during placement of overlying products, remove overlying products as necessary to expose damaged geomembrane, and repair damage as specified in Paragraph Repairing Geomembrane.
4. Geomembrane installer shall remain available during placement of overlying products to repair geomembrane if damaged.

3.03 BASEPLATE AIR DISTRIBUTION PLENUM

A. Install according to manufacturer's written instructions.

B. Install plumb and straight, parallel to existing walls. Place flooring on sloped foundation allowing the top of flooring to maintain the same slope.

C. Install plenum floor perimeter seal as specified between baseplate floor system and concrete wall perimeter.

D. Entire plenum floor system shall be installed as a modular system for ease of removal and replacement. No welding or other permanent means of connections shall be utilized, except perimeter sealing as specified.

E. Baseplate air distribution plenum system indicated on the Drawings is basis of design and requires modifying length or width of floor modules for proper fit.

1. Floor system provided other than basis of design may require modifying of floor modules and shall be the responsibility of the Contractor to ensure proper installation of modified modules.
2. Provide a 1/2-inch clearance between the walls and last row and column of baseplates to account for expansion and contraction. Floor modules shall be able to be removed without binding.
3. Install mesh liner over the baseplate to prevent media from falling through. Mesh liner shall extend a minimum of 18 inches above the floor modules up against the biofilter wall. Overlap sequential rows of mesh by 24 inches.

3.04 BIOFILTER MEDIA INSTALLATION

A. Delivery:

1. Load and deliver the materials to the site and at the specific location as directed by Engineer or directly into biofilter from truck. Do not stockpile more than what will fit in the available stockpile footprint onsite.
2. If stockpiling materials, prevent contamination by raising off ground and covering with a tarp until it is installed in the biofilter.

B. Installation:

1. Place media in biofilter as loosely as possible and in a consistent manner preventing damage to baseplate and mesh material.

2. Finished surface of media made level and smooth. No equipment is allowed on top of placed media at any time and foot traffic shall be limited to boards placed on media.

3.05 IRRIGATION SYSTEM AND HUMIDIFIER SYSTEM INSTALLATION

A. All valves, fittings, and hoses shall be installed as shown and all connections made to permit the irrigation and humidifier system to function properly.

B. All materials and equipment shall be installed in strict accordance with the manufacturer's written instructions and recommendations.

C. Humidifier spray nozzles shall be adjusted to provide specified moisture addition.

D. Irrigation system sprinklers shall be adjusted to achieve maximum coverage while also confining the irrigation spray coverage to within the perimeter walls of the biofilter cells.

E. Irrigation system shall be flow tested to verify that each zone performs at specified application rates at specified pressures. Duration of test shall not be less than 1 hour.

3.06 DRAINS

A. Install drains on low points of pipelines.

B. Drains at low points in piping required for completed system may or may not be shown on the Drawings.

3.07 FIELD QUALITY CONTROL

A. Functional Tests:

1. Notify Engineer in writing at least 14 days prior to scheduled date of functional testing.
2. Field test and calibrate equipment and demonstrate that all equipment will satisfactorily perform the functions intended.
3. Provide all test apparatus required.
4. Perform functional test on associated odor control exhaust fans. See Section 15835, Odor Control Fans.
5. Air Balancing: See Section 15950, Testing, Adjusting, and Balancing for HVAC.

6. Biofilter System:
   a. Test all system components for proper adjustment and operation in both the manual and automatic operating modes.
   b. Demonstrate to Engineer that fan speed control operates properly and will maintain required flows and pressures.
   c. Humidifier and Irrigation Systems:
      1) Allow the biofilter to operate for a 24-hour period with control systems in the AUTO mode.
      2) Monitor proper humidifier and irrigation system operation; make adjustments as necessary.
7. Smoke Testing:
   a. The Contractor shall perform a smoke test on the biofilter system after the placement of biofilter media in accordance with the approved testing plan.
   b. All other functional testing including fan testing, air balancing, humidification system testing, and irrigation system testing shall be completed prior to the smoke test.
   c. The Contractor shall provide smoke generation equipment with enough materials to run the test for a minimum duration of 5 minutes at the biofilter design flow rate.
   d. The Contractor shall make all necessary safety precautions and notifications to plant personnel and local fire departments prior to using smoke generating equipment to conduct smoke test.
   e. The smoke test shall consist of generating smoke and injecting it into one of the foul air system connections to verify proper air distribution throughout the media.

B. Performance Test:

1. General:
   a. The Contractor shall conduct a performance test in accordance with an approved protocol. The performance test shall not commence until a test plan has been received and approved, and the functional testing has been completed.
   b. The Contractor shall provide, install, and maintain, if required, all temporary metering or analytical equipment necessary to measure the various performance parameters.
   c. Before the performance test begins, the Owner, Engineer and the Contractor shall meet and agree upon the procedures to be used. Such agreements shall be included in the written test plan submittal.

d. The Contractor shall inform the Owner and Engineer at least 14 days prior to the start of any performance testing. The Owner and Engineer shall have the right to observe, sample, and make any parallel determinations during the performance test.
e. Within 30 days after the conclusion of the test period, the Contractor shall submit a Performance Test Report, including all laboratory and field test data, stating the conclusions of the test with regard to the performance of the biofilter system.

2. Test Conditions:
   a. The performance test shall be conducted after all odorous connections are complete and the biofilter has been fully functional and receiving odorous air from operative facilities for a minimum of 30 consecutive days prior to commencing the test.
   b. All testing, adjusting, and balancing of the odor control and any associated HVAC systems, including exhaust fans, shall have been completed and approved.
   c. The test shall be conducted over an 8-hour period with sampling and data measurements being evenly distributed over that time period.
   d. The actual sample day shall be chosen for low wind speeds and no rain.
3. Sampling and Data Measurement:
   a. During the test period, as a minimum, the following data and measurements shall be taken at each cell and at the frequency indicated:
      1) Biofilter Cell Airflow Rate: Near the start and near the end of test period. Measurement shall be performed using an approved thermal anemometer instrument.
      2) Biofilter Cell Inlet Pressure in Inches of WC: Every 2 hours.
      3) A photographic record of the sampling technique and bed sampling location will be completed for each type of sampling.
      4) Sampling Log:
         a) A sampling log shall be maintained that will include:
            (1) A hand drawn map showing the approximate locations of all bed sampling locations.
            (2) Date, time, location, sampler, and results of each sample.
            (3) A description of each photograph taken.
            (4) Weather conditions for the sampling day.
            (5) A qualitative description of the operation of the treatment processes.
            (6) A description of any exceptions or deviations from the sampling plan.

5) Hydrogen Sulfide Sampling:
   a) Hydrogen Sulfide Concentrations (ppm) at the inlet to each Biofilter Cell: Every 2 hours.
   b) Hydrogen Sulfide Concentrations (ppb) at Two Locations (one near perimeter and one near the center) on each Biofilter Cell Bed Using a Flux Chamber: Every 2 hours.
   c) The results will then be calculated by: Percent Removal equals (Average Inlet - Average Outlet)/Average Inlet.
   d) Hydrogen sulfide sampling shall be completed using a Jerome Analyzer with a detection limit of 1 ppbv. The analyzer shall be operated in compliance with the manufacturer's instructions. The results of the hydrogen sulfide sampling shall be recorded in the sampling log.
6) Gas Sampling:
   a) Samples shall be collected in Tedlar bags, using the sampling procedure described in EPA Method 18 with either a vacuum chamber or vacuum pump.
   b) Gas Sampling at the inlet to each Biofilter Cell: Two sets of two samples to be collected; one at the beginning of the 2-hour time mark, the second at the beginning of the 6-hour time mark.
   c) Gas Sampling at the outlet of each Biofilter Cell: Two sets of two samples (one located near perimeter and one located near the center) will be collected. Biofilter outlet sampling will be performed immediately after the corresponding inlet samples have been collected.

4. Gas Sample Analysis:
   a. The eight gas samples shall be analyzed for odor concentrations and intensity.
      1) Odor panel shall be performed in accordance with ASTM E679 and odor intensity in accordance with ASTM E544.
      2) Hedonic tone shall also be reported.
      3) Odor panelist presentation rates of 20 liters per minute shall be used.

5. Retesting: In the event the system fails to meet the performance requirements, the Supplier shall immediately make the necessary modifications, adjustments, and/or facility expansions to meet these requirements. The steps taken by the Supplier shall include, as necessary, topping off of media, upgrades to the system, or replacement of the media, all at no additional cost to the Owner.
    a. Additional performance tests will be conducted by Supplier until the performance requirements are met, at no additional cost to the Owner.
    b. If after two retests the performance requirements are still not met, the Owner will have the option, at the Owner's sole discretion, to accept the system as is or obtain a replacement at the expense of the Supplier.
    c. The maximum time between each retest will be 30 days.

C. Manufacturer's Field Services:

1. Manufacturer's Representative:
    a. Present at Site or classroom designated by Owner, for minimum person-days listed below, travel time excluded:
        1) 1 person-day for installation assistance and inspection.
        2) 3 person-days for functional, pre-performance and performance testing and completion of manufacturer's Certificate of Proper Installation.
        3) 1 person-day for prestartup classroom or Site training of Owner's personnel, specific sessions as outlined in Section 01640, Manufacturers' Services and Training.
        4) 1 person-day for facility startup.
2. The above field services shall be split into a minimum of two separate trips to Site.

END OF SECTION

SECTION 15060
PIPING SUPPORT SYSTEMS

PART 1 GENERAL

1.01 DEFINITIONS

A. Wetted or Submerged: Submerged, less than 1 foot above liquid surface, below top of channel wall, under cover or slab of channel or tank, or in other damp locations.

B. Ferrous Metal: Iron, steel, stainless steel, and alloys with iron as principal component.

1.02 SUBMITTALS

A. Action Submittals:

1. Shop Drawings shall include the following information:
   a. Catalog information and Drawings of piping support system, including framing support system, locating each support, seismic brace, hanger, guide, component, and anchor. Identify support, hanger, guide, seismic brace, and anchor type by catalog number and Shop Drawing detail number.
   b. Revisions to support systems resulting from changes in related piping system layout or addition of flexible joints.
   c. Complete design calculations, stamped by a registered engineer for piping support systems provided for piping systems.
   d. Anchorage and bracing drawings and cut sheets, as required by Section 01612, Anchorage and Bracing.
   e. Support channel end caps.

B. Informational Submittals: Anchorage and bracing calculations as required by Section 01612, Anchorage and Bracing.

1.03 QUALIFICATIONS

A. Piping support systems shall be designed, and Shop Drawings prepared and sealed by a Registered Professional Engineer in the State of Oregon.

PART 2 PRODUCTS

2.01 GENERAL REQUIREMENTS

A. The Contractor shall provide all pipe supports, seismic restraints, hangers, guides, and anchors, complete, in accordance with the Contract Documents.

B. Code Compliance and Design Requirements:

1. The Contract Documents provide design details for pipe supports for piping 12 inches and larger in diameter. Contractor shall be responsible for the design, size, and location of piping support systems for all piping smaller than 12 inches in accordance with the requirements specified herein and in general conformance with Drawings and the Design Details. The design shall be provided and stamped by a registered professional engineer registered in the State of Oregon and experienced in the design of such systems.
2. The presence of standard details and material of construction references on Drawings for piping smaller than 12 inches do not relieve the Contractor of the design responsibility for sizing, locating, and providing the piping supports.
3. Seismic forces in accordance with the International Building Code (IBC) and in accordance with Section 01612, Anchorage and Bracing.
4. Piping systems and pipe connections to equipment shall be properly anchored and supported to prevent undue deflection, vibration, dislocation due to seismic events and line pressures, and stresses on piping, equipment, and structures. Supports and parts thereof shall conform to the requirements of ASME B31.3, Process Piping, MSS SP 58, MSS SP 69, and MSS SP 89, except as supplemented or modified below. Supports for plumbing piping shall be in accordance with the latest edition of the applicable plumbing code or local administration requirements.
5. Contractor designed pipe support systems will be reviewed by Washington County Building Services as a project deferred submittal in accordance with Section 01600, Product Requirements.

C. Structural Members: Wherever possible, pipes shall be supported from structural members. Where it is necessary to frame structural members between existing members, such supplementary members shall be provided at no additional cost to the Owner. All supplementary members shall be in accordance with the requirements of the building code and the American Institute of Steel Construction and shall be acceptable to the Engineer.

D. Pipe Hangers: Pipe hangers shall be capable of supporting the pipe in all conditions operation, allowing free expansion and contraction of the piping, and preventing excessive stress on equipment. Hangers shall have a means of vertical adjustment after erection. Hangers shall be designed to prevent becoming disengaged by any movement of the supported pipe. Hangers subject to shock, seismic disturbances, or thrust imposed by the actuation of safety valves, shall include hydraulic shock suppressors. Hanger rods shall be subject to tensile loading only.

E. Hangers Subject to Horizontal Movements: At hanger locations where lateral or axial movement is anticipated, suitable linkage shall be provided to permit such movement. Where horizontal pipe movement is greater than 1/2-inch, or where the hanger rod deflection from the vertical is greater than 4 degrees from the cold to the hot position of the pipe, the hanger rod and structural attachment shall be offset in such a manner that the rod is vertical in the hot position.

F. Spring-Type Hangers: Spring-type pipe hangers shall be provided for piping subject to vibration or vertical expansion and contraction, such as engine exhausts and similar piping, Spring-type hangers shall be sized to the manufacturer’s printed recommendations and the loading conditions encountered. Variable spring supports shall be provided with means to limit misalignment, buckling, eccentric loading, or to prevent overstressing of the spring, and with means to indicated at all times the compression of the spring. Supports shall be capable of accommodating at least four times the maximum travel due to thermal expansion.

G. Thermal Expansion: Wherever expansion and contraction of piping is expected, a sufficient number of expansion loops or joints shall be provided, together with the necessary rolling or sliding supports, anchors, guides, pivots, and restraints permitting the piping to expand and contract freely in directions away from the anchored points. Components shall be structurally suitable to withstand loads imposed.

H. Heat Transmission: Supports, hangers, anchors, and guides shall be so designed and insulated, that excessive heat will not be transmitted to the structure or to other equipment.

I. Riser Supports: Where practical, risers shall be supported on each floor with riser clamps and lugs, independent of the connected horizontal piping.

J. Freestanding Piping: Freestanding pipe connections to equipment such as chemical feeders and pumps shall be firmly attached to steel frames fabricated from angles, channels, or I-beams anchored to the structure. Exterior, freestanding overhead piping shall be supported on fabricated pipe stands

consisting of pipe columns anchored to concrete footings, with horizontal, welded steel angles and U-bolts or clamps securing the pipes.

K. Materials of Construction: Pipe Support Material shall be per the Area Classification and Materials of Construction Table located on Drawings.

L. Point Loads: Any meters, valves, heavy equipment, and other point loads on PVC, FRP, and other plastic pipes, shall be supported on both sides, according to manufacturer's recommendations to avoid undue pipe stresses and failures. To avoid point loads, all supports on PVC, FRP, and other plastic piping shall be equipped with extra wide pipe saddles or galvanized steel shields.

M. Noise Reduction: To reduce transmission of noise to piping systems, copper tubes in buildings and structures shall be wrapped with a 2-inch wide strip of rubber fabric or similar, suitable material at each pipe support, bracket, clip, or hanger.

N. Support Channel End Caps: Provide white, neoprene strut channel end caps at all locations.

2.02 SUPPORT SPACING

A. Supports for piping with the longitudinal axis in approximately a horizontal position shall be spaced to prevent excessive sag, bending, and shear stresses in the piping, with special consideration given where components such as flanges and valves impose concentrated loads. Pipe support spacing shall not exceed the maximum spans in the table below. For temperatures other than ambient temperatures, or those listed, and for other piping materials or wall thicknesses, the pipe support spacings shall be modified in accordance with the pipe manufacturer's recommendations. Vertical supports shall be provided to prevent the pipe from being overstressed from the combination of all loading effects.

1. Support spacing for Schedule 40 and Schedule 80 steel and stainless steel pipe:

Nominal Pipe Diameter (inches)	**Maximum Span (Feet)**
1/4 to 1-1/4	7
1-1/2	9
2	10
2-1/2	11
3	12

Nominal Pipe Diameter (inches)	Maximum Span (Feet)
4	14
6	17
8	19
10	22
12	23

2. Support Spacing for Ductile-Iron Pipe:

Nominal Pipe Diameter (Inches)	Maximum Span (Feet)
All diameters	Two supports per pipe length or 10 feet (one of the two supports located at joint)

3. Support Spacing for Copper Tube:

Nominal Pipe Diameter (Inches)	Maximum Span (Feet)
1/4 thru 3/4	5
1	6
1-1/4	7
1-1/2 and 2	8
2-1/2	9
3	10
4	12
6	14
8	16
10	18
12	19

4. Support Spacing for PVC Pipe: Pipe support spacing shall be based on manufacturer's recommendation for the service conditions.

2.03 MANUFACTURED SUPPORTS

A. Stock Parts: Where not specifically indicated, designs which are generally accepted as exemplifying good engineering practice and use stock or production parts, shall be utilized wherever possible. Such parts shall be

locally available, new, of best commercial quality, designed and rated for the intended purpose.

B. Manufacturers:

1. Tolco.
2. Anvil (Grinnell).
3. Cooper B-Line.
4. Unistrut.
5. “Or-equal.”

2.04 FASTENERS

A. Anchor Bolts: Type 316 stainless steel as specified in Section 05500, Metal Fabrications.

2.05 FABRICATION

A. Shop Assembly: In accordance with MSS SP 89.

B. Shop Finishing:

1. In accordance with MSS SP 58.
2. Coat ungalvanized steel components as specified in Section 09900, Painting and Coating.

C. Stainless Steel Cleaning:

1. Stainless Steel: All stainless steel fabrications shall be passivated in accordance with ASTM A380.

2.06 SOURCE QUALITY CONTROL

A. Shop Tests: In accordance with MSS SP 89.

PART 3 EXECUTION

3.01 INSTALLATION

A. General:

1. Install support systems in accordance with ASME B31.1-Power Piping and Supports-Selection and Application and MSS SP 89, Pipe Hangers and Supports-Fabrication and Installation, unless shown otherwise.
2. Support piping connections to equipment by pipe support and not by the equipment.

3. Support large or heavy valves, fittings, and appurtenances independently of connected piping.
4. Support no pipe from the pipe above it.
5. Support pipe at changes in direction or in elevation, adjacent to flexible joints and couplings, and where shown.
6. Do not install pipe supports and hangers in equipment access areas or bridge crane runs.
7. Brace hanging pipes against horizontal movement by both longitudinal and lateral sway bracing.
8. Install lateral supports for seismic loads at all changes in direction.
9. Install pipe anchors where required to withstand expansion thrust loads and to direct and control thermal expansion.
10. Repair mounting surfaces to original condition after attachments are made.
11. Install protective neoprene caps on the ends of all exposed support channels.
12. Galvanized Surfaces: Re-coat all scratches, cuts, and drilled holes in galvanized surfaces with CRC Zinc-It or similar product.
13. Debur and break all sharp corners of pipe support systems.

B. Standard Pipe Supports:

1. Horizontal Suspended Piping:
   a. Single Pipes: Adjustable swivel-ring, splint-ring or clevis hangers.
   b. Grouped Pipes: Trapeze hanger systems.
   c. For insulated piping, furnish galvanized steel protection shields, welding insulation saddles, or precut sections of rigid insulation (with vapor barrier) at all hanger locations.
2. Horizontal Piping Supported from Walls:
   a. Single Pipes: Wall brackets or wall clips attached to wall with anchors. Clips attached to wall-mounted framing also acceptable.
   b. Stacked Piping:
      1) Wall-mounted framing system and clips acceptable for piping smaller than 3-inch minimal diameter.
      2) Piping clamps that resist axial movement of pipe through support not acceptable.
   c. Insulated piping shall have the insulation removed in the vicinity of wall brackets and piping clips to allow only direct pipe wall contact with the support system.
3. Horizontal Piping Supported from Floors:
   a. Stanchion Type:
      1) Pedestal type; adjustable with stanchion, saddle, and anchoring flange.

2) Use yoked saddles for piping whose centerline elevation is 18 inches or greater above the floor and for all exterior installations.
3) Provide neoprene waffle isolation pad under anchoring flanges, adjacent to equipment or where otherwise required to provide vibration isolation.

b. Floor-Mounted Channel Supports:
1) Use for piping smaller than 3-inch nominal diameter running along floors and in trenches at piping elevations lower than can be accommodated using pedestal pipe supports.
2) Attach channel framing to floors with anchor bolts.
3) Attach pipe to channel with clips or pipe clamps.

c. Concrete Cradles: Use for piping larger than 3-inch along floor and in trenches at piping elevations lower than can be accommodated using stanchion type.

4. Vertical Pipe:
a. Support with wall brackets and base elbow or riser clamps on floor penetrations.
b. Insulated piping shall have the insulation removed in the vicinity of wall brackets and riser clamps, to allow only direct wall contact with the support system.

5. Standard Attachments:
a. To Concrete Ceilings: Concrete inserts.
b. To Steel Beams: I-beam clamp or welded attachments.
c. To Concrete Walls: Concrete inserts or brackets or clip angles with anchor bolts.
d. Existing Walls and Ceilings: Install as specified for new construction, unless shown otherwise.

C. Saddles for Steel or Concrete Pipe: Provide 90-degree to120-degree pipe saddle for pipe sizes 6 inches and larger when installed on top of steel or concrete beam or structure, pipe rack, trapeze, or where similar concentrated point supports would be encountered.

D. Intermediate and Pipe Alignment Guides:

1. Provide pipe alignment guides, or pipe supports that provide same function, at expansion joints and loops.
2. Guide pipe on each side of expansion joint or loop at 4 pipe and 14 pipe diameters from each joint or loop.
3. Install intermediate guides on metal framing support systems not carrying pipe anchor or alignment guide.

E. Accessories:

1. Insulation Shield: Install on insulated nonsteel piping. Oversize rollers and supports.
2. Welding Insulation Saddle: Install on insulated steel pipe. Oversize rollers and supports.
3. Dielectric Barrier:
    a. Install between carbon steel members and copper or stainless steel pipe.
    b. Install between stainless steel supports and nonstainless steel ferrous metal piping.
4. Electrical Isolation: Install 1/4-inch by 3-inch neoprene rubber wrap between submerged metal pipe and oversized clamps.

3.02 FIELD FINISHING

A. Paint atmospheric exposed surfaces of steel components as specified in Section 09900, Painting and Coating.

B. Stainless Steel: All field fabricated stainless steel parts shall be cleaned, descaled, and passivated in accordance with ASTM A380.

END OF SECTION

SECTION 15080
PROCESS PIPING INSULATION

PART 1 GENERAL

1.01 SUBMITTALS

A. Action Submittals: Manufacturer's descriptive literature.

PART 2 PRODUCTS

2.01 PIPE AND FITTING INSULATION

A. Type 2—Fiberglass:

1. Material: UL rated, preformed, sectional bonded fiberglass per ASTM C585 with factory applied, Kraft paper with aluminum foil vapor barrier jacket with pressure-sensitive, self-sealing lap.
2. Insulation Temperature Rating: Zero to 850 degrees F.
3. Conductivity in accordance with ASHRAE 90.1 and maximum numerical value of 0.23 Btu-in./hr-square foot degrees F at 75 degrees F.
4. Jacketing per ASTM C1136 with minimum water vapor transmission for jacket of 0.02 perm-inch per ASTM E96/E96M. Furnish with no jacket if field finish system specified.
5. Joints: Matching pressure-sensitive butt strips for sealing circumferential joints.
6. Flame Spread Rating: Less than 25 per ASTM E84.
7. Smoke Developed Index: Less than 50 per ASTM E84.
8. Manufacturers and Products:
   a. Owens Corning Fiberglass; ASJ/SSL-11.
   b. John Manville; Micro-Lok with Jacket.

B. Type 3—Foamglass:

1. Material: Cellular glass per ASTM C552.
2. Nominal Density: 7.5 pcf.
3. Compressive Strength: 90 psi per ASTM C165.
4. Temperature Rating: Minus 290 degrees F to 900 degrees F.
5. Conductivity in accordance with ASHRAE 90.1 and maximum numerical value of 0.29 Btu-in./hr-square foot degrees F.
6. Minimum water vapor transmission for insulation of 0.00 perm-inch per ASTM E96/E96M.
7. Joints: Matching pressure-sensitive butt strips for sealing circumferential joints.

8. Flame Spread Rating: 0 per ASTM E84.
9. Smoke Developed Index: 0 per ASTM E84.
10. Follow manufacturer's recommendation, based upon temperature of piping to be insulated.
11. Manufacturer and Product: Pittsburgh Corning; Foamglas One.

2.02 INSULATION AT PIPE HANGERS AND SUPPORTS

A. Refer to Section 15060, Piping Support Systems.

B. Provide high-density insert, thickness equal to adjoining insulation of Type 3 or other rigid insulation or manufactured pre-insulated pipe hanger and insulation shield. Extend insert beyond shield.

2.03 INSULATION FINISH SYSTEMS

A. Type F1—PVC:

1. Polyvinyl chloride (PVC) jacketing, minimum 20 mils indoors and 30 mils outdoors, for straight run piping and fitting locations, temperatures to 140 degrees F.
2. Color: PVC jacketing shall be color coded to match colors listed in pipe schedule where suitable matching colors are available. If no suitable colors are available jacketing shall be white.
3. Flame Spread Rating: 25 per ASTM E84.
4. Smoke Developed Index: 50 per ASTM E84.
5. Manufacturers and Products:
   a. Knauf Insulation; Proto 1000.
   b. Johns Manville; Zeston 2000.
   c. Speedline; 25/50 Smoke-Safe.

B. Type F2—Aluminum:

1. Aluminum Roll Jacketing: For straight run piping, wrought aluminum Alloy 3003, 5005, 1100, or 3105 to ASTM B209 with H-14 temper, in accordance with ASTM C1729, minimum 0.016-inch thickness, with smooth mill finish.
2. Vapor Barrier: Provide factory applied vapor barrier, heat and pressure bonded to inner surface of aluminum jacketing.
3. Fitting Covers: Material as for aluminum roll jacketing, premolded, one or two piece covers, which includes elbows, tee/valves, end caps, mechanical line couplings, and specialty fittings.
4. Manufacturers:
   a. RPR Products; Insul-Mate.
   b. ITW, Pabco-Childers.

C. Type F3—Foamglass Jacketing:

1. Type 3 Insulation—Buried and Up to 1 Foot Above Grade: 70-mil bituminous resin with woven, glass fabric, aluminum foil layer, and plastic film coating, self-sealing manual pressure seals; Pittsburgh Corning Pittwrap SS.
2. Type 3 Insulation—Greater that 1 Foot Above Grade: 30-mil modified bituminous membrane with self-sealing manual pressure seals; Pittsburgh Corning Pittwrap CW30.

PART 3 EXECUTION

3.01 APPLICATION

A. General:

1. Insulate valve bodies, flanges, and pipe couplings.
2. Insulate and vapor seal hangers, supports, anchors, and other piping appurtenances that are secured directly to cold surfaces.
3. Do not insulate flexible pipe couplings and expansion joints.
4. Service and Insulation Thickness: Refer to Supplement Service and Insulation Thickness table following “End of Section” and to Piping Schedule on Drawings.

3.02 INSTALLATION

A. General:

1. Install in accordance with manufacturer’s instructions and as specified herein.
2. Install after piping system has been pressure tested and leaks corrected.
3. Install over clean dry surfaces.
4. Use insulating cements, lagging adhesives, and weatherproof mastics recommended by insulation manufacturer.
5. Do not allow insulation to cover nameplates or code inspection stamps.
6. Run insulation or insulation inserts continuously through pipe hangers and supports, wall openings, ceiling openings, and pipe sleeves, unless otherwise shown.
7. Install removable insulation sections on devices that require access for maintenance of equipment or removal, such as unions and strainer end plates.
8. Removable sections shall be secured using hook and loop strips.
9. Personnel Protection: Install on pipes from floor to 8 feet high. Install on pipes within 4 feet of platforms and to 8 feet high above platforms.

B. Connection to Existing Piping: Cut back existing insulation to remove portion damaged by piping revisions. Install new insulation.

C. Cold Surfaces: Provide continuous vapor seal on insulation on cold surfaces where vapor barrier jackets are used.

D. Placement:

1. Insulate valves and fittings with sleeved or cut pieces of same material.
2. Seal and tape joints.

E. Heat Traced Piping: Apply insulation after heat-tracing work is completed and inspected.

F. Roof Drain and Overflow Drain Sumps: Insulate entire sumps.

G. Vapor Barrier:

1. Provide continuous vapor barrier at joints between rigid insulation and pipe insulation.
2. Install vapor barrier jackets with pipe hangers and supports outside jacket.
3. Do not use staples and screws to secure vapor sealed system components.

H. Aluminum Jacket:

1. Use continuous friction type joint to hold jacket in place, providing positive weatherproof seal over entire length of jacket.
2. Secure circumferential joints with preformed snap straps containing weatherproof sealant.
3. Use caution when installing aluminum fitting covers to prevent damage to insulation or vapor barrier.
4. Do not use screws or rivets to fasten fitting covers.
5. Install removable prefabricated aluminum covers on exterior flanges and unions.
6. Caulk and seal exterior joints to make watertight.

3.03 FIELD FINISHING

A. Apply coating of insulating cement where needed to obtain smooth and continuous appearance.

B. Where pipe labels or banding are specified, apply to finished insulation, not to pipe.

C. Painting Piping Insulation:

1. Aluminum or color coded PVC jacketing does not require painting.
2. Buried insulation does not require painting.
3. If insulated piping system is indicated to be painted in Section 15200, Process Piping—General, piping shall receive the following:
   a. Coat piping under insulation in accordance with Section 09900, Painting and Coating, and the Piping Schedule on Drawings.

3.04 SUPPLEMENT

A. The supplement listed below, following “End of Section,” is a part of this specification:

1. Service and Insulation Thickness Table.

END OF SECTION

SERVICE AND INSULATION THICKNESS								
					Finish Systems			
Service Type	**Pipe Legend**	**Insulation Thickness**	**Fluid Temp (deg F)***	**Insulation**	**Concealed from View**	**Indoors Exposed**	**Outdoors**	**Buried**
Non-Potable Plant Water	NPW	Pipe Diameters Less than 1.5 Inches: 1.5-inch thickness. Pipe Diameters 1.5 Inches and greater: 2-inch thickness.	50 to 90	See Piping Schedule	None	None	See Piping Schedule	None
*Use these fluid temperatures unless otherwise noted in the Piping Schedule on the Drawings.								

SECTION 15200
PROCESS PIPING—GENERAL

PART 1 GENERAL

1.01 DEFINITIONS

A. Submerged or Wetted:

1. Zone below elevation of:
   a. Top face of channel walls and cover slabs.
   b. Liquid surface or within 2 feet above top of liquid surface.
   c. Top of tank wall or under tank cover.

1.02 DESIGN REQUIREMENTS

A. Where pipe diameter, thickness, pressure class, pressure rating, or thrust restraint is not shown or specified, design piping system in accordance with the following:

1. Process Piping: ASME B31.3, normal fluid service unless otherwise specified.
2. Building Service Piping: ASME B31.9, as applicable.
3. Sanitary Building Drainage and Vent Systems: ICC International Plumbing Code.
4. Buried Piping: H20-S16 traffic load with 1.5 impact factor, AASHTO HB-17, as applicable.
5. Thrust Restraints:
   a. All Piping systems shall be continuously restrained throughout their length, including connection points to equipment and to structures. Provide restraint using thrust ties at couplings, connections, expansion joints, bellows, and any other piping elements that are not inherently joint restrained whether shown or not.
   b. Design for test pressure shown in Piping Schedule.
   c. Allowable Soil Pressure: 2,000 pounds per square foot.

1.03 SUBMITTALS

A. Action Submittals:

1. Preinsulated Piping Systems:
   a. Shop Drawings: The Contractor shall submit complete Shop Drawings of all preinsulated piping systems with manufacturer's data on materials, covering, coating, insulation, piping, fittings, anchors, expansion joints, supports, seals and closures.
   b. Manufacturer's Data: The data submitted with the Shop Drawings shall verify that all materials used are meeting the indicated standards and conductivity (k)-factors, and that the proposed seating method will assure a watertight system.
2. Shop Fabricated Piping:
   a. Detailed pipe fabrication or spool drawings showing special fittings and bends, dimensions, coatings, and other pertinent information.
   b. Layout drawing showing location of each pipe section and each special length; number or otherwise designate laying sequence on each piece.
3. Pipe Wall Thickness: Identify wall thickness and rational method or standard applied to determine wall thickness for each size of each different service including exposed, submerged, buried, and concrete-encased installations for Contractor-designed piping.
4. Hydraulic Thrust Restraint for Restrained Joints: Details including materials, sizes, assembly ratings, and pipe attachment methods.
5. Dissimilar Buried Pipe Joints: Joint types and assembly drawings.
6. Pipe Corrosion Protection: Product data.
7. Anchorage and bracing drawings and cut sheets, as required by Section 01612, Anchorage and Bracing.

B. Informational Submittals:

1. Manufacturer's Certification of Compliance:
   a. Pipe and fittings.
   b. Welding electrodes and filler materials.
   c. Factory applied resins and coatings.
2. Anchorage and bracing calculations as required by Section 01612, Anchorage and Bracing.
3. Qualifications:
   a. Nondestructive Testing Personnel: SNT-TC-1A Level II certification and qualifications.
   b. AWS QC1 Certified Welding Inspector: Submit evidence of current certification prior to commencement of welding activities.

c. Welders:
1) Continuity log for welders and welding operators.
2) Welder qualification test records conducted by Contractor or manufacturer.

4. Welding Procedures: Qualified in accordance with ASME Boiler and Pressure Vessel Code, Section IX for weld type(s) and base metal(s).
5. Nondestructive inspection and testing procedures.
6. Test logs.
7. Pipe coating applicator certification.
8. Laboratory Testing Equipment: Certified calibrations, manufacturer's product data, and test procedures.
9. CWI inspection records and NDE test records.
10. Certified welding inspection and test results.

1.04 QUALITY ASSURANCE

A. Qualifications:

1. Independent Inspection and Testing Agency:
a. Ten years' experience in field of welding and welded pipe and fittings' testing required for this Project.
b. Calibrated instruments and equipment and documented standard procedures for performing specified testing.
c. Certified in accordance with ASNT SNT-TC-1A for testing procedures required for this Project.
d. Testing Agency: Personnel performing tests shall be NDT Level II certified in accordance with ASNT SNT-TC-1A.
e. Verification Welding Inspector: AWS QC1 Certified.
2. Welding Procedures: In accordance with ASME BPVC SEC IX (Forms QW-482 and QW-483) or AWS D1.1/D1.1M (Annex N Forms).
3. Welder Qualifications: In accordance ASME BPVC SEC IX (Form QW-484) or AWS D1.1/D1.1M (Annex N Forms).
4. Contractor's CWI: Certified in accordance with AWS QC1 and having prior experience with specified welding codes. Alternate welding inspector qualifications require approval by Engineer.

B. Quality Assurance: Provide services of independent inspection and testing agency for welding operations.

1. Note, the presence of Owner's Special Inspector or Verification CWI does not relieve Contractor from performing own quality control, including 100 percent visual inspection of welds.

1.05 DELIVERY, STORAGE, AND HANDLING

A. In accordance with Section 01600, Product Requirements, and:

1. Flanges: Securely attach metal, hardboard, or wood protectors over entire gasket surface.
2. Threaded or Socket Welding Ends: Fit with metal, wood, or plastic plugs or caps.
3. Linings and Coatings: Prevent excessive drying.
4. Cold Weather Storage: Locate products to prevent coating from freezing to ground.
5. Handling: Use heavy canvas or nylon slings to lift pipe and fittings.

PART 2 PRODUCTS

2.01 PIPING

A. As specified on Piping Data Sheet(s) located at the end of this section as Supplement and on Piping Schedule located on Drawings.

B. Diameters Shown:

1. Standardized Products: Nominal size.
2. Fabricated Steel Piping (Except Cement-Lined): Outside diameter, ASME B36.10M.
3. Cement-Lined Steel Pipe: Lining inside diameter.

2.02 JOINTS

A. Grooved End System:

1. Rigid type.
2. Use of flexible grooved joints allowed where shown on Drawings or with prior approval by Engineer.
3. Flanges: When required, furnish with grooved type flange adapters of same manufacturer as grooved end couplings.
4. Flanges at Equipment: Furnish with a grooved type flange adapter nipple.
    a. Manufacturers and Products:
        1) Gruvlok; Figure 7788.
        2) “Or-equal.”

B. Flanged Joints:

1. Flat-faced, carbon steel, or alloy flanges when mating with flat-faced cast or ductile iron flanges.
2. Higher pressure rated flanges as required to mate with equipment when equipment flange is of higher pressure rating than required for piping.

C. Threaded Joints: NPT taper pipe threads in accordance with ASME B1.20.1.

D. Mechanical Joint Anchor Gland Follower:

1. Ductile iron anchor type, wedge action, with break-off tightening bolts.
2. Thrust rated to 250 psi minimum.
3. Rated operating deflection not less than 2-1/2 degrees.
4. UL and FM approved.
5. Manufacturers and Products:
   a. EBAA Iron, Inc.; Megalug.
   b. Romac Industries, Inc.; RomaGrip.
   c. Ford Meter Box Co.; Series 1400.

E. Flexible Mechanical Compression Joint Coupling:

1. Stainless steel, ASTM A276, Type 305 bands.
2. Manufacturers:
   a. Pipeline Products Corp.
   b. Fernco Joint Sealer Co.

2.03 GASKET LUBRICANT

A. Lubricant shall be supplied by pipe manufacturer and no substitute or “or-equal” will be allowed.

2.04 PIPE CORROSION PROTECTION

A. Coatings: See Section 09900, Painting and Coating, and the Piping Schedule for details of coating requirements.

B. Heat Shrink Wrap:

1. Type: Cross-linked polyolefin wrap or sleeve with mastic sealant and meeting the requirements of AWWA C216.
2. Manufacturer and Product: Raychem; TPS; “or-equal.”

C. Polyethylene Encasement (Bagging):

1. Encasement Tube: Black polyethylene encasement tube, 8 mils minimum thickness, conforming to AWWA C105/A21.5, free of gels, streaks, pinholes, foreign matter, undispersed raw materials, and visible defects such as tears, blisters, and thinning at folds.
2. Securing Tape: Thermoplastic tape, 8 mils minimum thickness, 1 inch wide, pressure sensitive adhesive face capable of bonding to metal, bituminous coating, and polyethylene encasement tube.

D. Flange Isolation, Couplings, and Unions:

1. Materials:
   a. In accordance with applicable piping material specified in Pipe Data Sheet. Complete assembly shall have ASME B31.9 pressure rating equal to or higher than that of joint and pipeline.
   b. Galvanically compatible with piping.
   c. Resistant for intended exposure, operating temperatures, and products in pipeline.
2. Union Type, 2 Inches and Smaller:
   a. Screwed or solder-joint.
   b. O-ring sealed with molded and bonded insulation to body.
3. Flange Type, 2-1/2 Inches and Larger:
   a. Flange Isolation Kit, complete with a sealing-isolation gasket, full length isolation sleeves, isolation washers (two per bolt), steel back-up washers (two per bolt), bolts, nuts, and non-conductive lubrication.
   b. Sleeves shall be provided full length and pass through isolation washers and halfway through steel back-up washers.
   c. Ensure fit-up of components of flange isolation assembly to provide a complete functioning installation.
   d. AWWA C207 steel flanges may be drilled oversize up to 1/8-inch to accommodate isolation sleeves.
   e. No less than minimum thread engagement in accordance with specified bolting standards will be permitted to accommodate thicknesses of all required washers, flanges, and sealing-isolation gasket.
4. Flange Insulating Kits:
   a. Gaskets: One full faced sealing-isolation gasket, Type “E” (fits over bolt holes), 1/8-inch thick, G10 retainer containing a precision incline-plane groove to accommodate the controlled compression of an EPDM quad-ring sealing element.
   b. Isolation Sleeves: Full-length NEMA LI-1, G-10 grade.
   c. Isolation Washers: NEMA LI-1, G-10 grade.

d. Steel Back-Up Washers: Plated, hot-rolled steel, 1/8 inch thick.
   1) Flange Diameters 36 Inches or Less: Provide two washers per bolt.
   2) Flange Diameters Larger Than 36 Inches: Provide four washers per bolt.

5. Manufacturers and Products:
   a. Dielectric Flange Kits and Unions:
      1) Lamons ISOTEK, Golden, CO; ISOGUARD.
      2) PSI, Houston, TX; LineBacker.
      3) Advance Products and Systems, Lafayette, LA; Trojan.
   b. Insulating Couplings:
      1) Dresser; STAB-39.
      2) Baker Coupling Company, Inc.; Series 216.

2.05 THRUST TIES

A. Steel Pipe: Fabricated lugs and rods in accordance with details shown on Drawings and as specified in Section 15205, Process Piping Specialties.

B. Buried Ductile Iron Pipe and Fittings: Unless restraint is otherwise specified or shown, conform to NFPA 24. Tie-rod attachments relying on clamp friction with pipe barrel to restrain thrust are unacceptable.

2.06 VENT AND DRAIN VALVES

A. Pipeline 2-Inch Diameter and Smaller: 1/2-inch vent, 1-inch drain, unless shown otherwise.

B. Pipelines 2-1/2-Inch Diameter and Larger: 3/4-inch vent, 1-inch drain, unless shown otherwise.

2.07 FABRICATION

A. Mark each pipe length on outside with the following:

1. Size or diameter and class.
2. Manufacturer’s identification and pipe serial number.
3. Location number on laying drawing.
4. Date of manufacture.

B. Code markings according to approved Shop Drawings.

C. Flanged pipe shall be fabricated in the shop, not in the field, and delivered to the Site with flanges in place and properly faced. Threaded flanges shall be individually fitted and machine tightened on matching threaded pipe by the manufacturer.

2.08 CLEANING

A. Piping System Cleaner:

1. Detergent cleaning compound similar to Nalco 2567.
2. Suitable for removal of organic soil, hydrocarbons, flux, pipe mill varnish, pipe compounds, iron oxide, and like deleterious substances, with or without inhibitor.
3. Suitable for system metals without deleterious effects.
4. Cleaner shall not contain phosphate.

2.09 FINISHES

A. Factory prepare, prime, and finish coat in accordance with Pipe Data Sheet(s) and Piping Schedule.

B. Galvanizing:

1. Hot-dip applied, meeting requirements of ASTM A153/A153M.
2. Electroplated zinc or cadmium plating is unacceptable.
3. Stainless steel components may be substituted where galvanizing is specified.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify size, material, joint types, elevation, horizontal location, and pipe service of existing pipelines to be connected to new pipelines or new equipment.

B. Inspect size and location of structure penetrations to verify adequacy of wall pipes, sleeves, and other openings.

C. Welding Electrodes: Verify proper grade and type, free of moisture and dampness, and coating is undamaged.

3.02 CLEANING

A. Following assembly and testing, and prior to disinfection, startup and final acceptance, flush pipelines (except as stated below) with water at 2.5 fps minimum flushing velocity until foreign matter is removed. Provide capture screens as necessary to capture and remove material.

B. Prior to startup, and instrument installation, blow clean of loose debris plant process air and instrument air lines with compressed air at 4,000 fpm; do not flush with water. Clean and protect lines from metal shavings during and after tapping and threading activities. Provide capture screens as necessary to capture and remove material.

C. Insert cone strainers in the connections to attached equipment and leave until cleaning has been accomplished.

D. Contractor shall pig clean all lines prior to startup. Contractor shall be required to provide all appurtenances required for pigging such as but not limited to, valves, taps, pig launcher, pig catcher, pumps, or compressor.

E. Remove accumulated debris through drains 2 inches and larger or by dropping spools and valves.

F. All stainless piping and parts shall be cleaned, descaled, and passivated in accordance with ASTM A380.

3.03 CLEANING CLOSED LOOP SYSTEMS

A. Piping System:

1. General:
   a. Before installation of piping insulation, wash piping exterior surfaces to remove construction dirt, loose scale, and flux.
   b. Internally clean piping systems before they are used.
2. System Flush:
   a. Flush piping systems with water thoroughly, for 15 minutes or longer, as required to ensure removal of dirt and foreign matter from piping system.
   b. Bypass pumps and equipment, and remove strainers from strainer bodies.
   c. Provide temporary piping or hose to bypass coils, control valves, other factory cleaned equipment, and any component which may be damaged, unless acceptable means of protection are provided and subsequent inspection of hide-out areas takes place.
   d. Sectionalize system to obtain minimum velocity of 6 feet per second.
   e. Provide temporary piping to connect dead-end supply and return headers as necessary.
   f. Flush bottom of risers.
3. System Cleaning:
   a. After initial flushing of system, use portable pumping apparatus for continuous 24-hour, minimum, circulation of cold water detergent.

b. Add cleaner to closed systems at concentrations as recommended by cleaner manufacturer.
c. Flush detergent clear with continuous draining and raw water fill for additional 12 hours or until cleaner is removed from system.
d. Inspect, remove sludge, and flush low points with clean water after cleaning process is completed.
e. Replace strainers and reconnect permanent pumping apparatus and bypassed apparatus.
f. Drain cleaning water to Plant Drain.

B. Water Treatment: Fill and vent system with proper working fluids. Coordinate start up activities with District. District will provide Water treatment upon startup.

3.04 PREPARATION

A. See Piping Schedule and Section 09900, Painting and Coating, for additional requirements.

B. Notify Engineer at least 2 weeks prior to field fabrication of pipe or fittings.

C. Inspect pipe and fittings before installation, clean ends thoroughly, and remove foreign matter and dirt from inside.

D. Damaged Coatings and Linings: Repair using original coating and lining materials in accordance with manufacturer’s instructions, except for damaged glass-lined pipe that is to be promptly removed from Site.

3.05 WELDING

A. Perform in accordance with Section IX, ASME Boiler and Pressure Vessel Code and ASME B31.3 Pressure Piping, as may be specified on Piping Data Sheets, and if recommended by piping or fitting manufacturer.

B. Weld Identification: Mark each weld with symbol identifying welder.

C. Pipe End Preparation:

1. Machine Shaping: Preferred.
2. Oxygen or Arc Cutting: Smooth to touch, true, and slag removal by chipping or grinding.
3. Beveled Ends for Butt Welding: ASME B16.25.

D. Surfaces:

1. Clean and free of paint, oil, rust, scale, slag, or other material detrimental to welding.
2. Clean stainless steel joints with stainless steel wire brushes or stainless steel wool prior to welding.
3. Thoroughly clean each layer of deposited weld metal, including final pass, prior to deposition of each additional layer of weld metal with a power-driven wire brush.

E. Alignment and Spacing:

1. Align ends to be joined within existing commercial tolerances on diameters, wall thicknesses, and out-of-roundness.
2. Root Opening of Joint: As stated in qualified welding procedure.
3. Minimum Spacing of Circumferential Butt Welds: Minimum four times pipe wall thickness or 1 inch, whichever is greater.

F. Climatic Conditions: Do not perform welding if there is impingement of any rain, snow, sleet, or high wind on the weld area, or if the ambient temperature is below 32 degrees F.

G. Tack Welds: Performed by qualified welder using same procedure as for completed weld, made with electrode similar or equivalent to electrode to be used for first weld pass, and not defective. Remove those not meeting requirements prior to commencing welding procedures.

H. Surface Defects: Chip or grind out those affecting soundness of weld.

I. Weld Passes: As required in welding procedure.

J. Weld Quality: Free of cracks, incomplete penetration, weld undercutting, excessive weld reinforcement, porosity slag inclusions, and other defects in excess of limits shown in applicable piping code.

3.06 INSTALLATION—GENERAL

A. Join pipe and fittings in accordance with manufacturer’s instructions, unless otherwise shown or specified.

B. Clean out all piping and remove foreign objects prior to assembly and installation. Cap and protect open pipe ends when Work is not in progress and at the close of the day’s Work.

C. Flanged Joints:

1. Install perpendicular to pipe centerline.
2. Bolt Holes: Straddle vertical centerlines, aligned with connecting equipment flanges or as shown.
3. Use torque-limiting wrenches to ensure uniform bearing and proper bolt tightness.
4. Plastic Flanges: Install annular ring filler gasket at joints of raised-face flange.
5. Raised-Face Flanges: Use flat-face flange when joining with flat-faced ductile or cast iron flange.
6. Verify compatibility of mating flange to adapter flange gasket prior to selecting grooved adapter flanging.
7. Flange fillers are to be avoided, but if necessary, may be used to make up for small angles up to 6 degrees and for filling gaps up to 2 inches between flanges. Stacked flange fillers shall not be used.
8. Threaded flanged joints shall be shop fabricated and delivered to Site with flanges in-place and properly faced.
9. Manufacturers and Products:
   a. Same as pipe manufacturer.
   b. Victaulic; Flange Adapter.
   c. Anvil International, Inc.; Gruvlok.

D. Threaded and Coupled Joints:

1. Conform to ASME B1.20.1.
2. Produce sufficient thread length to ensure full engagement when screwed home in fittings.
3. Countersink pipe ends, ream and clean chips and burrs after threading.
4. Make connections with not more than three threads exposed.
5. Lubricate male threads only with thread lubricant or tape as specified on Piping Data Sheets.

E. Grooved-End Joints:

1. Piping shall be grooved in accordance with manufacturer’s latest published instructions and shall be accurately cut with tools conforming to coupling manufacturer’s standards and to AWWA C606.
2. Install grooved joint couplings and gaskets in accordance with manufacturer’s latest published installation instructions.

F. Pipe Connections at Concrete Structures: As specified in Article Piping Flexibility Provisions in Section 15205, Process Piping Specialties.

G. Soldered Joints:

1. Use only solder specified for particular service.
2. Cut pipe ends square and remove fins and burrs.
3. After thoroughly cleaning pipe and fitting of oil and grease using solvent and emery cloth, apply noncorrosive flux to the male end only.
4. Wipe excess solder from exterior of joint before hardened.
5. Before soldering, remove stems and washers from solder joint valves.

H. PVC Piping:

1. Provide Schedule 80 threaded nipple where necessary to connect to threaded valve or fitting.
2. Use strap wrench for tightening threaded plastic joints. Do not overtighten fittings.
3. Do not thread Schedule 40 pipe.

I. Ductile Iron Piping:

1. Cutting Pipe: Cut pipe with milling type cutter, rolling pipe cutter, or abrasive blade cutter. Do not flame cut.
2. Dressing Cut Ends:
   a. General: As required for the type of joint to be made.
   b. Rubber Gasketed Joints: Remove sharp edges or projections.
   c. Push-On Joints: Bevel, as recommended by pipe manufacturer.
   d. Flexible Couplings, Flanged Coupling Adapters, and Grooved End Pipe Couplings: As recommended by the coupling or adapter manufacturer.

3.07 INSTALLATION—EXPOSED PIPING

A. Piping Runs:

1. Parallel to building or column lines and perpendicular to floor, unless shown otherwise.
2. Piping upstream and downstream of flow measuring devices shall provide straight lengths as required for accurate flow measurement.

B. Supports: As specified in Section 15060, Piping Support Systems.

C. Group piping wherever practical at common elevations; install to conserve building space and not interfere with use of space and other work.

D. Unions or Flanges: Provide at each piping connection to equipment or instrumentation on equipment side of each block valve to facilitate installation and removal.

E. Install piping so that no load or movement in excess of that stipulated by equipment manufacturer will be imposed upon equipment connection; install to allow for contraction and expansion without stressing pipe, joints, or connected equipment.

F. Piping clearance, unless otherwise shown:

1. Over Walkway and Stairs: Minimum of 7 feet 6 inches, measured from walking surface or stair tread to lowest extremity of piping system including flanges, valve bodies or mechanisms, insulation, or hanger/support systems.
2. Between Equipment or Equipment Piping and Adjacent Piping: Minimum 3 feet, measured from equipment extremity and extremity of piping system including flanges, valve bodies or mechanisms, insulation, or hanger/support systems.
3. From Adjacent Work: Minimum 2 inch(es) from nearest extremity of completed piping system including flanges, valve bodies or mechanisms, insulation, or hanger/support systems.
4. Do not route piping in front of or to interfere with access ways, ladders, stairs, platforms, walkways, openings, doors, or windows.
5. Headroom in front of openings, doors, and windows shall not be less than the top of the opening.
6. Do not install piping containing liquids or liquid vapors in transformer vaults or electrical equipment rooms.
7. Do not route piping over, around, in front of, in back of, or below electrical equipment including controls, panels, switches, terminals, boxes, or other similar electrical work.

3.08 INSTALLATION—BURIED PIPE

A. Joints:

1. Dissimilar Buried Pipes:
   a. Provide flexible mechanical compression joints for pressure pipe.
   b. Provide concrete closure collar for gravity and low pressure (maximum 10 psi) piping or as shown.
2. Concrete Encased or Embedded Pipe: Do not encase joints in concrete, unless specifically shown.

B. Placement:

1. Keep trench dry until pipe laying and joining are completed.
2. Pipe Base and Pipe Zone: As specified on details and shown on Drawings.
3. Exercise care when lowering pipe into trench to prevent twisting or damage to pipe.

4. Measure for grade at pipe invert, not at top of pipe.
5. Excavate trench bottom and sides of ample dimensions to permit visual inspection and testing of entire flange, valve, or connection.
6. Prevent foreign material from entering pipe during placement.
7. Close and block open end of last laid pipe section when placement operations are not in progress and at close of day's work.
8. Lay pipe upgrade with bell ends pointing in direction of laying.
9. Deflect pipe at joints for pipelines laid on a curve using unsymmetrical closure of spigot into bell. If joint deflection of standard pipe lengths will not accommodate horizontal or vertical curves in alignment, provide:
    a. Shorter pipe lengths.
    b. Special mitered joints.
    c. Standard or special fabricated bends.
10. After joint has been made, check pipe alignment and grade.
11. Place sufficient pipe zone material to secure pipe from movement before next joint is installed.
12. Prevent uplift and floating of pipe prior to backfilling.

C. PVC Pipe Placement:

1. Lay pipe snaking from one side of trench to other.
2. Offset: As recommended by manufacturer for maximum temperature variation between time of solvent welding and during operation.
3. Do not lay pipe when temperature is below 40 degrees F, or above 90 degrees F when exposed to direct sunlight.
4. Shield ends to be joined from direct sunlight prior to and during the laying operation.

D. Tolerances:

1. Deflection from Horizontal Line, Except PVC: Maximum 2 inches.
2. Deflection from Vertical Grade: Maximum 1/4 inch.
3. Joint Deflection: Maximum of 75 percent of manufacturer's recommendation.
4. Horizontal position of pipe centerline on alignment around curves maximum variation of 1.75 feet from position shown.
5. Pipe Cover: Minimum 3 feet, unless otherwise shown.

3.09 INSTALLATION—CONCRETE ENCASED

A. Provide reinforced concrete pipe encasement where shown on Drawings and where otherwise required. Some piping may be required to be concrete encased for pipe strength requirements that are included in the Specifications. Piping under and within the influence of buildings, utility trenches, vaults, slabs, and other structures shall be concrete encased. See details on Drawings for encasement requirements.

B. Where concrete encased piping crosses structure construction and expansion joints, provide flexible piping joints to coincide with structure joints to prevent excessive pipe stress and breakage.

3.10 PIPE CORROSION PROTECTION

A. Piping General:

1. Pipe coating and corrosion protection shall be as shown in the Piping Schedule located on Drawings.
2. Pipe coating and corrosion protection requirements listed in order of governance:
    a. Piping Schedule, located on Drawings.
    b. Section 15200, Process Piping—General.
    c. Section 09900, Painting and Coating.

B. Ductile Iron Pipe:

1. Exposed: As specified in Section 09900, Painting and Coating, and as shown in Piping Schedule.
2. Buried: Asphalt (or bitumastic) and wrap with polyethylene bagging.
3. Submerged or Embedded: Coat with System No. 2 or No. 7 as specified in Section 09900, Painting and Coating. If in potable water service, use NSF 61 approved epoxy.

C. Carbon Steel Pipe:

1. Exposed: As specified in Section 09900, Painting and Coating, and as shown in Piping Schedule.
2. Buried:
    a. Pipe: Wrap with tape coating system as specified in Section 09900, Painting and Coating.
    b. Joints: Wrap with tape coating system as specified in Section 09900, Painting and Coating, or heat shrink wrap as specified herein.

D. Copper Pipe, Exposed: As specified in Section 09900, Painting and Coating, and as shown in Piping Schedule.

E. PVC Pipe, Exposed: As specified in Section 09900, Painting and Coating, and as shown in Piping Schedule.

F. Piping Accessories:

1. Exposed:
   a. Field paint black and galvanized steel, brass, copper, and bronze piping components as shown in the Piping Schedule and as specified in Section 09900, Painting and Coating.
   b. Accessories include, but are not limited to, pipe hangers, supports, expansion joints, pipe guides, flexible couplings, vent and drain valves, and fasteners.
2. Buried:
   a. Ferrous Metal and Stainless Steel Components: Coat with high build epoxy or petrolatum wax tape coat system as specified in Section 09900, Painting and Coating.
   b. Bolts, Nuts, and Similar Items: Coat with high build epoxy.
   c. Flexible Couplings, Grooved Couplings, and Similar Items: Wrap with heat shrink wrap or coat with cement.
   d. Buried Valves and Similar Elements on Wrapped Pipelines: Coat with high build epoxy and wrap entire valve in polyethylene encasement.
   e. Cement-Coated Pipelines: Cement coat appurtenances same as pipe.

G. Polyethylene Encasement: Install in accordance with AWWA C105/A21.5 and manufacturer’s instructions.

H. Tape Coating System: As specified in Section 09900, Painting and Coating.

I. Heat Shrink Wrap: Apply in accordance with AWWA C216 and manufacturer’s instructions to surfaces that are cleaned, prepared, and primed.

J. Insulating Flanges, Couplings, and Unions:

1. Applications:
   a. Dissimilar metal piping connections.
   b. Connections to existing metallic pipe.
   c. Where required for electrically insulated connection.
2. Pipe Installation:
   a. Insulating joints connecting immersed piping to nonimmersed piping shall be installed above maximum water surface elevation.

b. Metal piping in reinforced concrete shall be electrically isolated from the concrete reinforcement steel.
c. Align and install insulating joints as shown on Drawings and according to manufacturer's recommendations. Bolt lubricants that contain graphite or other metallic or electrically conductive components that can interfere with the insulating capabilities of the completed flange shall not be used.

3.11 THRUST RESTRAINT

A. Location:

1. Buried Piping: Where shown and where required to restrain force developed at pipeline tees, plugs, caps, bends, and other locations where unbalanced forces exist because of hydrostatic testing and normal operating pressure.
2. Exposed Piping: At all joints in piping.

B. Thrust Ties:

1. Steel Pipe: Attach with lugs fabricated in accordance with details shown on Drawings.
2. Ductile Iron Pipe: Attach with socket clamps anchored against grooved joint coupling or flange.
3. Flanged Coupling Adapters: For exposed installations, install manufacturer's anchor studs through coupling sleeve or use dismantling joints.

C. Mechanical Joint Valve Restraint in Proprietary Restrained Joint Piping: Install pipe joint manufacturer's adapter gland follower and pipe end retainer, or mechanical joint anchor gland follower.

3.12 SLAB, FLOOR, WALL, AND ROOF PENETRATIONS

A. Application and Installation: As specified in Section 15205, Process Piping Specialties.

3.13 BRANCH CONNECTIONS

A. Do not install branch connections smaller than 1/2-inch nominal pipe size, including instrument connections, unless shown otherwise.

B. When line of lower pressure connects to a line of higher pressure, requirements of Piping Data Sheet for higher pressure rating prevails up to and including first block valve in the line carrying the lower pressure, unless otherwise shown.

C. Threaded Pipe Tap Connections:

1. Ductile Iron Piping: Connect only with service saddle or at tapping boss of a fitting, valve body, or equipment casting.
2. Welded Steel or Alloy Piping: Connect only with welded threadolet or half-coupling as specified on Piping Data Sheet.

3.14 VENTS AND DRAINS

A. Vents and drains at high and low points in piping required for completed system may or may not be shown. Install vents on high points and drains on low points of pipelines at all low and high point locations.

3.15 INSULATION

A. See Section 15080, Process Piping Insulation.

3.16 FIELD FINISHING

A. Notify Engineer at least 3 days prior to start of surface preparation or coating application work.

A. As specified in Section 09900, Painting and Coating and as shown in the Piping Schedule.

3.17 PIPE IDENTIFICATION

A. As specified in Section 09900, Painting and Coating, and as shown on the Piping Schedule located on Drawings.

3.18 FIELD QUALITY CONTROL

A. Pressure Leakage Testing: As specified in Section 15955, Process Piping Leakage Testing.

B. Minimum Duties of Welding Inspector:

1. Job material verification and storage.
2. Qualification of welders.
3. Certify conformance with approved welding procedures.
4. Maintenance of records and preparation of reports in a timely manner.
5. Notification to Engineer of unsatisfactory weld performance within 24 hours of weld test failure.

C. Required Weld Examinations:

1. Perform examinations in accordance with Piping Code ASME B31.3.
2. Perform examinations for every pipe thickness and for each welding procedure, progressively, for all piping covered by this section.
3. Examine at least one of each type and position of weld made by each welder or welding operator.
4. For each weld found to be defective under the acceptance standards or limitations on imperfections contained in the applicable Piping Code, examine two additional welds made by the same welder that produced the defective weld. Such additional examinations are in addition to the minimum required above. Examine, progressively, two additional welds for each tracer examination found to be unsatisfactory.

D. Field Testing – Preinsulated Piping System:

1. Field testing of the preinsulated pipe shall be performed as follows:
   a. Inspection and Testing: After completion of the pipe installation, and prior to covering the field joints and backfilling, the entire pipe system shall be subject to a hydrostatic test of pressures indicated on in the Piping Schedule located on the Drawings and described in Section 15955, Process Piping Leakage Testing. Any leaks or loss of pressure shall be traced and repaired at that time, and system be retested until found tight.
   b. Acceptance Criteria: Acceptance of the preinsulated piping system shall be dependent on the satisfactory completion of the above mentioned test and after approval by the manufacturer’s field representative.

3.19 CLEANING

A. Following assembly and testing, and prior to disinfection, start-up and final acceptance, flush pipelines (except as stated below) with water at 2.5 fps minimum flushing velocity until foreign matter is removed. Provide capture screens as necessary to capture and remove material.

B. Prior to startup of pneumatically tested pipelines (FAD) blow clean of loose debris with compressed air at 4,000 fpm; do not flush with water. Clean protected lines from metal shaving during and after tapping and treading activities. Provide capture screens as necessary to capture and remove material.

C. If impractical to flush large diameter pipe at 2.5 fps or blow at 4,000 fpm velocity, clean in-place from inside by brushing and sweeping, then flush or blow lines at lower velocity.

D. Insert cone strainers in flushing connections to attached equipment and leave in-place until cleaning is complete.

E. Contractor shall clean all lines prior to startup.

F. Remove accumulated debris through drains 2 inches and larger, or by removing spools and valves from piping.

G. All Stainless piping and parts shall be cleaned descaled and passivated in accordance with ASTM A380.

3.20 PIPING SCHEDULE

A. The Piping Schedule is located in the General Sheets as shown on Drawings.

3.21 SUPPLEMENTS

A. The supplements listed below, following “End of Section,” are a part of this specification:

1. Data Sheets.

Number	Title
15200.10	Polyvinyl Chloride (PVC) Pipe and Fittings
15200.13	Copper and Copper Alloy Pipe Tubing and Fittings

END OF SECTION

SECTION 15200.10
POLYVINYL CHLORIDE (PVC) PIPE AND FITTINGS

Item	Size	Description
General	All	Materials in contact with potable water shall conform to NSF 61 acceptance.
Pipe	All	Schedule 80 PVC: Type I, Grade I or Class 12454-B conforming to ASTM D1784 and ASTM D1785. Pipe shall be manufactured with titanium dioxide for ultraviolet protection. Threaded Nipples: Schedule 80 PVC.
Fittings	All	Schedule to Match Pipe Above: ASTM D2466 and ASTM D2467 for socket weld type and Schedule 80 ASTM D2464 for threaded type. Fittings shall be manufactured with titanium dioxide for ultraviolet protection.
Joints	All	Solvent socket weld except where connection to threaded valves and equipment may require future disassembly.
Flanges	All	One-piece, molded hub type PVC flat face flange in accordance with Fittings above, ASME B16.1, Class 125 drilling.
Bolting	All	Flat Face Mating Flange and In Corrosive Areas: ASTM A193/A193M, Type 316 stainless steel Grade B8M hex head bolts, ASTM A194/A194M Grade 8M hex head nuts and ASTM F436/F436M Type 3 alloy washers at nuts and bolt heads. Achieve 40 percent to 60 percent of bolt minimum yield stress. With Raised Face Mating Flange: Carbon steel ASTM A307 Grade B square head bolts, ASTM A563 Grade A heavy hex head nuts and ASTM F436/F436M hardened steel washers at nuts and bolt heads. Achieve 40 percent to 60 percent of bolt minimum yield stress.

SECTION 15200.10
POLYVINYL CHLORIDE (PVC) PIPE AND FITTINGS

Item	Size	Description
Gaskets	All	Flat Face Mating Flange: Full faced 1/8-inch-thick ethylene propylene (EPR) rubber. Raised Face Mating Flange: Flat ring 1/8-inch ethylene propylene (EPR) rubber with filler gasket between OD of raised face and flange OD to protect the flange from bolting moment.
Solvent Cement	All	Socket type joints shall be made employing solvent cement that meets or exceeds the requirements of ASTM D2564 and primer that meets or exceeds requirements of ASTM F656 and as recommended by pipe and fitting manufacturer.
Thread Lubricant	All	Teflon Tape.

END OF SECTION

SECTION 15200.13
COPPER AND COPPER ALLOY PIPE, TUBING, AND FITTINGS

Item	Description
General	Materials in contact with potable water shall conform to NSF 61 acceptance.
Tubing	Seamless, conforming to ASTM B88 as follows: Water (exposed).....Type L, hard drawn Domestic hot water .....Type L, hard drawn Compressed air service.....Type L, hard drawn Laboratory air service.....Type L, hard drawn Laboratory vacuum service .....Type L, hard drawn Refrigerant service .....Type L, hard drawn P-Trap priming service.....Type L, soft temper Sample line service .....Type L, hard drawn Laboratory gas service.....Type L, hard drawn
Fittings	ASTM B75 commercially pure wrought copper, socket joint, dimensions conforming to ASME B16.22.
Flanges	Class 150, ASTM B75 commercially pure wrought copper, socket joint, ASME B16.24 standard.
Bolting	ASTM A307, carbon steel, Grade A hex head bolts, ASTM A563 Grade A hex head nuts and ASTM F436/F436M hardened steel washers at nuts and bolt heads. Achieve 40 percent to 60 percent of bolt minimum yield stress.
Gaskets	1/16-inch-thick nonasbestos compression type, full face, Cranite, John Manville.
Solder	Joints 2-1/2 Inch and Smaller: Wire solder (95 percent tin), conforming to ASTM B32 Alloy Grade Sn95. Do not use cored solder. Joints Larger Than 2-1/2 Inch: Wire solder, melt range approximately 440 degrees F to 660 degrees F, conforming to ASTM B32 Alloy Grade HB or HN. Do not use cored solder.

END OF SECTION

SECTION 15202
PROCESS VALVES AND OPERATORS

PART 1 GENERAL

1.01 EQUIPMENT SIGNAGE

A. Provide equipment labels as specified in Section 10400, Signage.

1.02 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
   a. Product data sheets for each make and model. Indicate valve Type Number, applicable Tag Number, and facility name/number or service where used.
   b. Complete catalog information, descriptive literature, specifications, and identification of materials of construction.
   c. Sizing calculations for actuators of open-close/throttle and modulating valves.
   d. Anchorage and bracing drawings and cut sheets, as required by Section 01612, Anchorage and Bracing.

B. Informational Submittals:

1. Anchorage and bracing calculations as required by Section 01612, Anchorage and Bracing.
2. Manufacturer’s Certificate of Compliance, in accordance with Section 01640, Manufacturers’ Services and Training, for:
   a. Electric actuators; full compliance with AWWA C540.
   b. Butterfly valves; full compliance with AWWA C504.
3. Tests and inspection data.
4. Manufacturer’s Certificate of Proper Installation, in accordance with Section 01640, Manufacturers’ Services and Training.

C. Technical Operation and Maintenance Information:

1. Operation and Maintenance Data: As specified in Section 01782, Operation and Maintenance Data.

PART 2 PRODUCTS

2.01 GENERAL

A. Valves to include operator, actuator, handwheel, chain wheel, extension stem, floor stand, operating nut, chain, wrench, and accessories to allow a complete operation from the intended operating level.

B. Valve to be suitable for intended service. Renewable parts not to be of a lower quality than specified.

C. Valve same size as adjoining pipe, unless otherwise called out on the Drawings.

D. Valve ends to suit adjacent piping.

E. Resilient seated valves shall have no leakage (drip-tight) in either direction at valve rated design pressure. All other valves shall have no leakage (drip-tight) in either direction at valve rated design pressure, unless otherwise allowed for in this section or in stated valve standard.

F. Size operators and actuators to operate valve for full range of pressures and velocities.

G. Valve to open by turning counterclockwise, unless otherwise specified.

H. Factory mount operator, actuator, and accessories.

2.02 MATERIALS

A. Bronze and brass valve components and accessories that have surfaces in contact with water to be alloys containing less than 16 percent zinc and 2 percent aluminum.

1. Approved alloys are of the following ASTM designations:
   a. B61, B62, B98/B98M (Alloy UNS No. C65100, C65500, or C66100), B139/B139M (Alloy UNS No. C51000), B584 (Alloy UNS No. C90300 or C94700), B164, B194, and B127.
2. Stainless steel Alloy 18-8 may be substituted for bronze.

2.03 FACTORY FINISHING

A. Epoxy Lining and Coating:

1. Use where specified for individual valves described herein.
2. In accordance with AWWA C550 unless otherwise specified.

3. Either two-part liquid material or heat-activated (fusion) material except only heat-activated material if specified as “fusion” or “fusion bonded” epoxy.
4. Minimum 7-mil dry film thickness except where limited by valve operating tolerances.

B. Exposed Valves:

1. In accordance with Section 09900, Painting and Coating. Match adjacent piping.
2. Safety isolation valves and lockout valves with handles, handwheels, or chain wheels “safety yellow.”

2.04 VALVES

A. Gate Valves:

1. General:
   a. AWWA gate valves to be in full compliance with stated AWWA standard and the following requirements:
      1) Provide 2-inch operating nut and handwheel for AWWA gate valves 12 inches and smaller.
      2) Provide totally enclosed spur or bevel gear operator with indicator for AWWA gate valves 14 inches and larger.
      3) Provide Affidavit of Compliance per the applicable AWWA standard for AWWA gate valves.
      4) Mark AWWA gate valves with manufacturer’s name or mark, year of valve casting, valve size, and working water pressure.
      5) Repaired AWWA gate valves shall not be submitted or supplied.
      6) Supply AWWA gate valves with stainless steel bolting.
2. Type V120 Gate Valve 3 Inches to 48 Inches for Water Service:
   a. AWWA C500, iron body, bronze mounted, flanged ends, double-disc gate, nonrising bronze stem, working water pressure 200 psi for 3 inches through 12 inches and 150 psi for 14 inches through 48 inches.
   b. Manufacturers and Products:
      1) M&H Valve Company; Style 67.
      2) Clow Valve Company; AWWA C500.

3. Type V132 Resilient Seated Gate Valve 2 Inches to 12 Inches, for Buried Service:
   a. Iron body, resilient seat, copper-alloy stem and stem nut, ANSI 125 pound flanged ends, nonrising stem, in accordance with AWWA C509, 2-inch operating nut, minimum design working water pressure 200 psig, full port, fusion-bonded epoxy coated inside and outside per AWWA C550, NSF/ANSI 61 certified.
   b. Manufacturers and Products:
      1) M&H Valve; AWWA C509.
      2) U.S. Pipe; A-USPO.

B. Globe Valves:

1. Type V200 Globe Valve 3 Inches and Smaller:
   a. All-bronze, NPT threaded ends, union bonnet, packed gland, inside screw, rising stem, TFE disk, Class 150 rated 150 psi SWP/300 psi CWP, complies with MSS SP-80 Type 2.
   b. Manufacturers and Products:
      1) Crane Cat.; No. 7TF.
      2) Stockham; B-22T.
2. Type V208 Needle Disc Type Globe Valve 1/8 Inch to 3/4 Inch:
   a. All-bronze, threaded bonnet, packed gland, rising stem, bronze body and stem, Class 200 rated 200 psi SWP/400 psi CWP, complies with MSS SP-80.
   b. Manufacturers and Products:
      1) Crane Cat.; No. 88.
      2) Stockham; B-64.
3. Type V234 Angle Type Hose Valve 1/2 Inch to 3/4 Inch:
   a. Bronze or manufacturer’s standard brass, angle sillcock type body, threaded or solder inlet as applicable, pressure rating 125 psi cold water.
   b. Manufacturer and Product: Nibco; QTX Series.
4. Type V236 Globe Style Hose Valve 1 Inch to 3 Inches:
   a. All-bronze, NPT threaded ends, inside screw-type rising stem, TFE disc, cast brass male NPT by male NHT adapter with hexagonal center wrench nut, complies with MSS SP-80, rated 300 WOG.
   b. Manufacturers and Products:
      1) Stockham; Figure B-22T.
      2) Crane Co.; Cat. No. 7TF.
      3) Nibco; Figure T-235-Y.

C. Ball Valves:

1. Type V300 Ball Valve 3 Inches and Smaller for General Water and Air Service:
   a. Two-piece, standard port, NPT threaded ends, bronze body and end piece, hard chrome-plated solid bronze, or brass ball, RTFE seats and packing, blowout-proof stem, adjustable packing gland, zinc-coated steel hand lever operator with vinyl grip, rated 600-pound WOG, 150-pound SWP, complies with MSS SP-110.
   b. Manufacturers and Products:
      1) Threaded:
         a) Conbraco Apollo; 70-100.
         b) Nibco; T-580-70.
      2) Soldered:
         a) Conbraco Apollo; 70-200.
         b) Nibco; S-580-70.
2. Type V301 Ball Valve 2 Inches and Smaller for General Water and Air Service:
   a. Two-piece, full port, NPT threaded ends, bronze body and end piece, hard chrome-plated solid bronze, or brass ball, RTFE seats and packing, blowout-proof stem, adjustable packing gland, zinc-coated steel hand lever operator with vinyl grip, rated 600-pound CWP, 150-pound SWP, complies with MSS SP-110.
   b. Manufacturers and Products:
      1) Threaded:
         a) Conbraco Apollo; 77-100.
         b) Nibco; T-585-70.
      2) Soldered:
         a) Conbraco Apollo; 77-200.
         b) Nibco; S-585-70.
3. Type V306 Stainless Steel Ball Valve 2 Inches and Smaller:
   a. Two-piece, full port, ASTM A276 GR 316 or ASTM A351/A351M GR CF8M stainless steel body and end piece, NPT threaded ends, ASTM A276 Type 316 stainless steel ball, reinforced PTFE seats, seals, and packing, adjustable packing gland, blowout proof stainless steel stem, stainless steel lever operator with vinyl grip, rated 1,000 psig CWP, complies with MSS SP-110.
   b. Manufacturers and Products:
      1) Conbraco Apollo; 76F-100 Series.
      2) Nibco; T-585-S6-R-66-LL.

4. Type V330 PVC Ball Valve 2 Inches and Smaller:
   a. Rated 150 psi at 73 degrees F, with ASTM D1784, Type I, Grade 1 polyvinyl chloride body, ball, and stem, end entry, double union design, solvent-weld socket ends, elastomer seat, Viton or Teflon O-ring stem seals, to block flow in both directions.
   b. Manufacturers and Products:
      1) Hayward; TB Series True Union.
      2) "Or-equal."

D. Plug Valves:

1. Type V400 Eccentric Plug Valve 2 Inches and Smaller:
   a. Nonlubricated type rated 175 psig CWP, drip-tight shutoff with pressure from either direction, ductile iron body, threaded ends, lever operator, ductile iron plug with round or rectangular port, plug coated with Buna-N, stem bearing lubricated stainless steel, stem seal multiple V-rings, or U-cups with O-rings of nitrile rubber.
   b. Manufacturers and Products:
      1) Pratt; Ballcentric.
      2) DeZurik; Style PEC.
      3) GA Industries; Figure 517.
      4) Milliken; Millcentric Series 613A.
2. Type V405 Eccentric Plug Valve 3 Inches to 12 Inches:
   a. Nonlubricated type rated 175 psig CWP, drip-tight shutoff with pressure from either direction, cast-iron body, exposed service flanged ends per ASME B16.1 or grooved ends in accordance with AWWA C606 for rigid joints, buried service mechanical joint ends, unless otherwise shown.
   b. Plug cast iron with round or rectangular port of no less than 80 percent of connecting pipe area and coated with Buna-N, seats welded nickel, stem bearings lubricated stainless steel or bronze, stem seal multiple V-rings, or U-cups with O-rings of nitrile rubber, grit seals on both upper and lower bearings.
   c. For buried service, provide external epoxy coating.
   d. Operators:
      1) 3-Inch to 4-Inch Valves: Wrench lever manual.
      2) 6-Inch to 12-Inch Valves: Totally enclosed, geared, manual operator with handwheel, 2-inch nut, or chain wheel. Size operator for 1.5 times the maximum operating shutoff pressure differential for direct and reverse pressure, whichever is higher. For buried service, provide completely sealed operator filled with heavy lubricant and 2-inch nut.

e. Manufacturers and Products:
1) DeZurik; Style PEC.
2) Pratt; Ballcentric.

3. Type V410 Three-Way, Nonlubricated, Tapered Plug Valve 3 Inches to 16 Inches:
a. Cast-iron body with Buna-N-coated plug, multiple V-rings or U-cups with O-ring seals, lubricated stainless steel bearings, and nickel- or epoxy-coated seat, rated 125 psi CWP minimum, flanged to ASME B16.1.
b. Operator: Lever type. Gear type, totally enclosed and lubricated, with handwheel.
c. Manufacturers and Products:
1) DeZurik; Style PTW, Combination.
2) Milliken; Millcentric Series 600.

E. Self-Regulated Valves:

1. Type V716 Pressure-Reducing/Back-Pressure Sustaining Valve 3 Inches and Larger:
a. Hydraulically operated, diaphragm actuated, pilot controlled globe valve, ductile iron body, ASME B16.1 Class 150 flanged ends, rated 250 psi, bronze or stainless steel trim, stainless steel stem, externally mounted strainers with cocks, maintains a constant downstream pressure while maintaining a minimum upstream pressure.
b. installed in accordance with AWWA C550.
c. Size/Rating: 1-1/2 inch, maximum of 125 gpm, with inlet pressure of 80 psig. Outlet pressure set at 70 psig.
d. Manufacturers and Products:
1) Cla-Val; 50-01 Series.
2) “Or-equal.”

2. Type V752 Sewage Air Release Valve 2 Inches to 4 Inches:
a. Suitable for sewage service; automatically exhausts entrained air that accumulates in a system.
b. Rated pressure of 150 psi, operating pressure as indicated in the Valve Schedule, built, and tested to AWWA C512.
c. Materials: Cast-iron or ductile iron body and cover with NPT threaded inlet and 1-inch NPT threaded outlet, concave or skirted stainless steel float and trim; Buna-N resilient seat.
d. Sewage air release valve fitted with blowoff valve, flushing valve with quick disconnect coupling, and minimum 5 feet of hose with quick disconnect coupling to permit back-flushing after installation without dismantling valve.

e. Manufacturers and Products:
   1) APCO Valve and Primer Corp.; Series 400 SARV or 450 SARV.
   2) Val-Matic Valve; Series 48 or Series 49.

F. Check Valves:

1. Type V600 Check Valve, 2 Inches and Smaller:
   a. All bronze, threaded cap, threaded or soldered ends, swing type replaceable bronze disc, rated 125-pound SWP, 200-WOG.
   b. Manufacturers and Products:
      1) Stockham; Figure B-319, threaded ends.
      2) Milwaukee; Figure 509, threaded ends.
      3) Stockham; Figure B-309, soldered ends.
      4) Milwaukee; Figure 1509, soldered ends.
2. Type V606 Check Valve 2 Inches to 12 Inches:
   a. Flanged end, cast-iron body, bronze mounted swing type, solid bronze or cast-iron disc, bronze seat ring, outside lever and weight, spring, rated 125-pound SWP, 200-pound WOG.
   b. Manufacturers and Products:
      1) Stockham; G-931.
      2) Crane Co.; Cat. No. 383.

G. Miscellaneous Valves:

1. Type V940 Solenoid Valve 1/4 Inch to 1-1/2 Inches:
   a. Two-way internal pilot operated disc type, slow-closing action, brass body, resilient seat suitable for air or water, solenoid coil molded epoxy, NEMA insulation Class F, 120V ac, 60-Hz, unless otherwise indicated. Solenoid enclosure NEMA 250, Type 4X unless otherwise indicated. Size and normal position (OPEN or CLOSED when de-energized) as indicated.
   b. Rated for minimum fluid temperature of 180 degrees F.
   c. Minimum operating pressure differential no greater than 5 psig, maximum operating pressure differential not less than 125 psig.
   d. Manufacturers:
      1) ASCO, Model 8221.
      2) Skinner.

2.05 OPERATORS AND ACTUATORS

A. Manual Operators:

1. General:
   a. For AWWA valves, operator force not to exceed requirements of the applicable valve standard. Provide gear reduction operator when force exceeds requirements.
   b. For non-AWWA valves, operator force not to exceed applicable industry standard or 80 pounds, whichever is less, under any operating condition, including initial breakaway. Provide gear reduction operator when force exceeds requirements.
   c. Operator self-locking type or equipped with self-locking device.
   d. Position indicator on quarter-turn valves. The arrow shall point perpendicular to flow when valve is fully closed and point in the direction of flow when valve is fully open. Paint flow arrow fluorescent yellow.
   e. Worm and gear operators one-piece design, worm-gears of gear bronze material. Worm of hardened alloy steel with thread ground and polished. Traveling nut type operator's threaded steel reach rod with internally threaded bronze or ductile iron nut.
2. Exposed Operator:
   a. Galvanized and painted handwheel.
   b. Cranks on gear type operators.
   c. Chain wheel operator with tiebacks, extension stem, floor stand, and other accessories to permit operation from normal operation level.
   d. Valve handles to take a padlock, and wheels a chain and padlock.

2.06 ACCESSORIES

A. Tagging: Provide tagging per the requirements specified in Section 10400, Signage.

B. Floor Stand:

1. Nonrising, heavy pattern, indicating type.
2. Complete with solid extension stem, coupling, handwheel, stem guide brackets, and yoke attachment. Stem length as required to connect valve operating nut and floor stand.
3. Stem Guide: Space such that stem L/R ratio does not exceed 200.
4. Anchor Bolts: Type 304 stainless steel.
5. Manufacturers and Products:
   a. Clow; Figure F-5515.
   b. Mueller, Figure A-26426.

C. Chain Wheel and Guide:

1. Handwheel direct-mount type.
2. Complete with chain.
3. Galvanized or cadmium-plated.
4. Manufacturers and Products:
   a. Clow Corp.; Figure F-5680.
   b. Walworth Co.; Figure 804.
   c. DeZurik Corp.; Series W or LWG.

D. Valve Chain Bar:

1. Epoxy coated steel bar to actuate quarter-turn valve.
2. Complete with stainless steel chain.
3. Manufacturer's safety mounting kit.
4. Manufacturers and Products:
   a. Babbitt Chainwheels; Chain Bar.
   b. "Or-equal."

PART 3 EXECUTION

3.01 INSTALLATION

A. Flange Ends:

1. Flanged valve bolt holes shall straddle vertical centerline of pipe.
2. Clean flanged faces, insert gasket and bolts, and tighten nuts progressively and uniformly.

B. Screwed Ends:

1. Clean threads by wire brushing or swabbing.
2. Apply joint compound.

C. PVC and CPVC Valves: Install using solvents approved for valve service conditions.

D. Valve Installation and Orientation:

1. General:
   a. Install valves so handles operate from fully open to fully closed without encountering obstructions.
   b. Install valves in location for easy access for routine operation and maintenance.
   c. Install valves per manufacturer's recommendations.

2. Gate, Globe, and Ball Valves:
   a. Install operating stem vertical when valve is installed in horizontal runs of pipe having centerline elevations 4 feet 6 inches or less above finished floor, unless otherwise shown.
   b. Install operating stem horizontal in horizontal runs of pipe having centerline elevations greater than 4 feet 6 inches above finish floor, unless otherwise shown.
3. Eccentric Plug Valves:
   a. Unless otherwise restricted or shown on the Drawings, install valve as follows:
      1) Liquids with Suspended Solids Service with Horizontal Flow: Install valve with stem in horizontal position with plug up when valve is open. Install valve with seat end upstream (flow to produce unseating pressure).
      2) Liquids with Suspended Solids Service with Vertical Flow: Install valve with seat in highest portion of valve (seat up).
      3) Clean Liquids and Gas Service: Install valve with seat end downstream of higher pressure when valve is closed (higher pressure forces plug into seat).
4. Check Valves:
   a. Install valve in horizontal or vertical flow (up) flow piping only for liquid services.
   b. Install valve in vertical flow (up) piping only for gas services.
   c. Install swing check valve with shaft in horizontal position.
5. Solenoid Valves: Install in accordance with manufacturer's instructions.

E. Install a line size ball valve and union upstream of each solenoid valve, in-line flow switch, or other in-line electrical device, excluding magnetic flowmeters, for isolation during maintenance.

F. Locate valve to provide accessibility for control and maintenance. Install access doors in finished walls and plaster ceilings for valve access.

G. Chain Wheel and Guide: Install chain wheel and guide assemblies or chain lever assemblies on manually operated valves over 6 feet 9 inches above finish floor. Install chain to within 3 feet 0 inch of finish floor. Where chains hang in normally traveled areas, use appropriate "L" type tie-back anchors. Install chains to within operator horizontal reach of 2 feet 6 inches maximum, measured from normal operator standing location or station. For chainwheels or handwheels with chainwheel attachments directly mounted on the actuator shaft, add a roll pin at the end of the shaft to retain the chainwheel or handwheel if the pin sheared.

3.02 TESTS AND INSPECTION

A. Valve may be either tested while testing pipelines, or as a separate step.

B. Test that valves open and close smoothly under operating pressure conditions. Test that two-way valves open and close smoothly under operating pressure conditions from both directions.

C. Inspect air and vacuum valves as pipe is being filled to verify venting and seating is fully functional.

D. Count and record number of turns to open and close valve; account for discrepancies with manufacturer's data.

E. Set, verify, and record set pressures for relief and regulating valves.

F. Automatic valves to be tested in conjunction with control system testing. Set opening and closing speeds, limit switches, as required or recommended by Engineer.

END OF SECTION

SECTION 15205
PROCESS PIPING SPECIALTIES

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American Society of Mechanical Engineers (ASME):
   a. B16.1, Gray Iron Pipe Flanges and Flanged Fittings (Classes 25, 125, and 250).
   b. B16.5, Pipe Flanges and Flanged Fittings: NPS 1/2 through NPS 24 Metric/Inch Standard.
2. American Water Works Association (AWWA):
   a. C110/A21.10, Ductile-Iron and Gray-Iron Fittings.
   b. C153/A21.53, Ductile-Iron Compact Fittings for Water Service.
   c. C210, Liquid-Epoxy Coating Systems for the Interior and Exterior of Steel Water Pipelines.
   d. C213, Fusion-Bonded Epoxy Coating for the Interior and Exterior of Steel Water Pipelines.
   e. C219, Bolted, Sleeve-Type Couplings for Plain-End Pipe.
   f. Manual M11, Steel Pipe—A Guide for Design and Installation.
3. ASTM International (ASTM):
   a. A153/A153M, Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
   b. A276, Standard Specification for Stainless Steel Bars and Shapes.
4. National Fire Protection Association (NFPA): 24, Standard for the Installation of Private Fire Service Mains and Their Appurtenances.
5. NSF International (NSF): NSF 61, Drinking Water System Components—Health Effects.

1.02 SUBMITTALS

A. Action Submittals: Manufacturer’s data on materials, construction, end connections, ratings, overall lengths, and live lengths (as applicable).

B. Informational Submittals:

1. Coupling Harness:
   a. Details, ratings, calculations, and test reports for thrust restraints relying on welded bars or rings.
   b. Weld procedure qualifications.
   c. Load proof-testing report of prototype restraint for any size coupling.

C. Operation and Maintenance Data as specified in Section 01782, Operation and Maintenance Data.

PART 2 PRODUCTS

2.01 GENERAL

A. Provide required piping specialty items, whether shown or not shown on Drawings, as required by applicable codes and standard industry practice.

B. Rubber ring joints, mechanical joints, flexible couplings, and proprietary restrained ductile iron pipe joints are considered flexible joints; welded, screwed, and flanged pipe joints are not considered flexible.

2.02 CONNECTORS

A. Elastomer Bellows Connector:

1. Type: Fabricated spool, with single filled arch.
2. Materials: EPDM tube and wrap-applied EPDM cover.
3. End Connections: Flanged, drilled 125-pound ASME B16.1 standard, with full elastomer face and steel retaining rings.
4. Working Pressure Rating: 140 psig, minimum, at 250 degrees F for sizes 12 inches and smaller.
5. Thrust Restraint: Control rods to limit travel of elongation and compression.
6. Manufacturers and Products:
   a. Garlock; Style 204.
   b. Unisource Manufacturing, Inc.; Style 1501.
   c. Proco Products, Inc.; Series 220.

B. Closure Collar Concrete: As specified in Section 03300, Cast-in-Place Concrete.

2.03 COUPLINGS

A. General:

1. Coupling linings for use in potable water systems shall be in conformance with NSF 61.
2. Couplings shall be rated for working pressure not less than indicated in Piping Schedule for the service and not less than 150 psi.
3. Couplings shall be lined and coated with fusion-bonded epoxy in accordance with AWWA C213.

4. Unless thrust restraint is provided by other means, couplings shall be harnessed in accordance with requirements of AWWA Manual M11 or as shown on Drawings.
5. Sleeve type couplings shall conform to AWWA C219 and shall be hydraulically expanded beyond minimum yield for accurate sizing and proofing of tensile strength.

B. Transition Coupling for Steel Pipe:

1. Manufacturers and Products:
   a. Dresser Piping Specialties; Style 162.
   b. Smith-Blair, Inc.; Style 413.

C. Flanged Coupling Adapter:

1. Anchor studs where required for thrust restraint.
2. Manufacturers and Products:
   a. Steel Pipe:
      1) Dresser Piping Specialties; Style 128.
      2) Smith-Blair, Inc.; Style 913.
   b. Ductile Iron Pipe:
      1) Dresser Piping Specialties; Style 128.
      2) Smith-Blair, Inc.; Style 912.

D. Restrained Flange Adapter:

1. Pressure Rating:
   a. Minimum Working Pressure Rating: Not less than 150 psi.
   b. Safety Factor: Not less than two times working pressure and shall be supported by manufacturer’s proof testing.
2. Thrust Restraint:
   a. Provide hardened steel wedges that bear against and engage outer pipe surface, and allow articulation of pipe joint after assembly while wedges remain in their original setting position on pipe surface.
   b. Products employing set screws that bear directly on pipe will not be acceptable.
3. Manufacturer and Product: EBAA Iron Sales Co.; Mega-Flange.

E. Restrained Dismantling Joints:

1. Pressure Rating:
   a. Minimum working pressure rating shall not be less than rating of the connecting flange.
   b. Proof testing shall conform to requirements of AWWA C219 for bolted couplings.

2. Manufacturers and Products:
   a. Dresser Piping Specialties; Style 131.
   b. Smith Blair, Inc.; Model 975.

F. Exposed Metallic Piping Plain End Couplings:

1. Plain end pipe couplings shall be self-restrained against hydrostatic thrust forces equal to not less than two times the working pressure rating of the coupling. Couplings shall accommodate 4 degrees angular deflection at the time of installation and subsequent to pressurization.
2. Casing, bolts, and nuts shall be Type 304 or Type 316 stainless steel. The sealing sleeve shall be EPDM or NBR elastomer as best suited for the fluid service.
3. Couplings manufacturer and products shall be Straub Couplings, Grip-L or Metal Grip, “or-equal.”

2.04 SERVICE SADDLES

A. Double-Strap Iron:

1. Pressure Rating: Capable of withstanding 150 psi internal pressure without leakage or over stressing.
2. Run Diameter: Compatible with outside diameter of pipe on which saddle is installed.
3. Taps: Iron pipe threads.
4. Materials:
   a. Body: Malleable or ductile iron.
   b. Straps: Galvanized steel.
   c. Hex Nuts and Washers: Steel.
   d. Seal: Rubber.
5. Manufacturers and Products:
   a. Smith-Blair; Series 313 or Series 66.
   b. Dresser; Style 91.

2.05 PIPE SLEEVES

A. Steel Pipe Sleeve:

1. Minimum Thickness: 3/16 inch.
2. Seep Ring:
   a. Center steel flange for water stoppage on sleeves in exterior or water-bearing walls, 3/16-inch minimum thickness.
   b. Outside Diameter: Unless otherwise shown, 3 inches greater than pipe sleeve outside diameter.
   c. Continuously fillet weld on each side all around.

3. Factory Finish:
   a. Galvanizing:
      1) Hot-dip applied, meeting requirements of ASTM A153/A153M.
      2) Electroplated zinc or cadmium plating is unacceptable.
   b. Shop Lining and Coating: Factory prepare, prime, and finish coat in accordance with Section 09900, Painting and Coating.

B. Molded Polyethylene Pipe Sleeve:

1. Molded HDPE with integral water stop ring not less than 3 inches larger than sleeve.
2. Provided with end caps for support during concrete placement.
3. Manufacturer and Product: Century-Line, Model CS sleeves as manufactured by PSI-Thunderline/Link-Seal.

C. Insulated and Encased Pipe Sleeve:

1. Manufacturer and Product: Pipe Shields, Inc.; Models WFB, WFB-CS and -CW Series, as applicable.

D. Modular Mechanical Seal:

1. Type: Interconnected synthetic rubber links shaped and sized to continuously fill annular space between pipe and wall sleeve opening.
2. Fabrication:
   a. Assemble interconnected rubber links with ASTM A276, Type 316 stainless steel bolts and nuts.
   b. Pressure plates shall be reinforced nylon polymer.
3. Size: According to manufacturer’s instructions for size of pipes shown to provide a watertight seal between pipe and wall sleeve opening, and to withstand a hydrostatic head of 40 feet of water.
4. Manufacturer: Thunderline Corp., Link-Seal Division.

2.06 SLAB, FLOOR, WALL AND ROOF PENETRATIONS

A. Ductile Iron Wall Pipe:

1. Diameter, Lining, and Ends: Same as connecting ductile iron pipe.
2. Thickness: Equal to or greater than remainder of pipe in line.
3. Fittings: In accordance with applicable Pipe Data Sheet.
4. Thrust Collars:
   a. Rated for thrust load developed at 250 psi.
   b. Safety Factor: 2, minimum.

c. Material and Construction: Ductile iron or cast iron, cast integral with wall pipe wherever possible, or thrust rated, welded attachment to wall pipe.

5. Manufacturers:
   a. American Cast Iron Pipe Co.
   b. U.S. Pipe and Foundry Co.

B. Steel or Stainless Steel Wall Pipe:

1. Same material and thickness as connecting pipe, except 1/4-inch minimum thickness.
2. Lining: Same as connecting pipe.
3. Thrust Collar:
   a. Outside Diameter: Unless otherwise shown, 3 inches greater than outside diameter of wall pipe.
   b. Continuously fillet welded on each side all around.

2.07 MISCELLANEOUS SPECIALTIES

A. Strainers, Water Service, 2 Inches and Smaller:

1. Type: Bronze body, Y-pattern, 200 psi nonshock rated, with screwed gasketed bronze cap.
2. Screen: Heavy-gauge Type 304 stainless steel or monel, 20-mesh.
3. Manufacturers and Products:
   a. Armstrong International; Inc.; Model F.
   b. Mueller Steam Specialty; Model 351M.

B. Strainers, Water Service, 2-1/2 Inches and Larger:

1. Type: Cast iron or ductile iron body, Y-pattern, 175 psi nonshock rated, with flanged gasketed iron cap.
2. Screen: Heavy-gauge Type 316 stainless steel, 0.045-inch perforations.
3. Manufacturer and Product: Armstrong International, Inc.; Model A7FL 125.

C. Water Hose:

1. Furnish 50-foot lengths of 1-inch and 50-foot lengths of 1-1/2-inch rubber hose. EPDM black cover and EPDM tube, reinforced with two textile braids. Provide each length with brass male and female NST hose thread couplings to fit hose nozzle and hose valve.
2. Rated minimum working pressure of 200 psi.
3. Manufacturers:
   a. Goodyear.
   b. Boston.

D. Hose Nozzles:

1. Furnish 1-inch and 1-1/2-inch anodized, 6061-T6 aluminum, nozzles with adjustable fog, straight-stream, and shut-off feature and rubber bumper.
2. Manufacturers:
   a. 1-inch; Dixon Valve & Coupling FFN100 with NPSH thread.
   b. 1-1/2-inch; Dixon Valve & Coupling GFN150NST with NST thread.

E. Hose Rack:

1. Furnish stainless steel hose racks and stainless-steel fasteners.
2. Manufacturer: Accu-Brand Products Dura-Loop Large Stainless Steel Hose Hanger.

2.08 ACCESSORIES

A. Equipment Identification Plates: Provide laminated phenolic plastic identification plate securely mounted on each separate equipment component in a readily visible location. Plate shall have white background and bear block type engraved black enamel filled lettering.

1. Text (Indicated in this section):
   a. Descriptive Name: 1-inch high lettering.
   b. Descriptive Tag: 1/2-inch high lettering.
2. Fastening: Secure with self tapping Type 316 stainless steel screws.
3. Size: 2-1/4-inch high plate.

PART 3 EXECUTION

3.01 GENERAL

A. Provide accessibility to piping specialties for control and maintenance.

3.02 PIPING FLEXIBILITY PROVISIONS

A. General:

1. Thrust restraint shall be provided as specified in Section 15200, Process Piping—General.
2. Install flexible couplings to facilitate piping installation, in accordance with approved Shop Drawings.

B. Flexible Joints at Concrete Backfill or Encasement: Install within 18 inches or one-half pipe diameter, whichever is less, from the termination of any concrete backfill or concrete encasement.

C. Flexible Joints at Concrete Structures:

1. Install 18 inches or less from face of structures; joint may be flush with face.
2. Install a second flexible joint, whether or not shown.
   a. Pipe Diameter 18 Inches and Smaller: Within 18 inches of first joint.
   b. Pipe Diameter Larger than 18 Inches: Within two to three pipe diameter of first joint.

D. Flexible expansion joints shall be provided to compensate for earth settlement at buried piping connections to structure wall pipes. Wrap complete joint assembly in a double layer of polyethylene encasement, as specified in Section 15200, Process Piping—General.

3.03 PIPING TRANSITION

A. Applications:

1. Provide complete closure assembly where pipes meet other pipes or structures.
2. Pressure Pipeline Closures: Plain end pieces with double flexible couplings, unless otherwise shown.
3. Restrained Joint Pipe Closures: Install with thrust tie-rod assemblies as shown or in accordance with NFPA 24.
4. Elastomer sleeves bonded to pipe ends are not acceptable.

B. Installation:

1. Concrete Closures:
   a. Locate away from structures so there are at least two flexible joints between closure and pipe entering structure.
   b. Clean pipe surface before placing closure collars.
   c. Wet nonmetallic pipe thoroughly prior to pouring collars.
   d. Prevent concrete from entering pipe.
   e. Extend collar a minimum of 12 inches on each side of joint with minimum thickness of 6 inches around outside diameter of pipe.
   f. Make entire collar in one placement.
   g. After concrete has reached initial set, cure by covering with well-moistened earth.

3.04 SERVICE SADDLES

A. Ferrous Metal Piping (except stainless steel): Double-strap iron.

3.05 COUPLINGS

A. General:

1. Install in accordance with manufacturer’s written instructions.
2. Before coupling, clean pipe holdback area of oil, scale, rust, and dirt.
3. Do not remove pipe coating. If damaged, repair before joint is made.
4. Application: Metallic Piping Systems: Flexible couplings, transition couplings, and flanged coupling adapters.

3.06 FLEXIBLE PIPE CONNECTIONS TO EQUIPMENT

A. Install to prevent piping from being supported by equipment, for vibration isolation, and where shown.

B. Product Applications Unless Shown Otherwise:

1. All Metallic Piping: Elastomer bellows connector.

C. Limit Bolts and Control Rods: Tighten snug prior to applying pressure to system.

3.07 PIPE SLEEVES

A. Application:

1. As specified in Section 15200, Process Piping—General.
2. Above Grade in Nonsubmerged Areas: Hot-dip galvanized after fabrication.
3. Below Grade or in Submerged or Damp Environments: Shop-lined and coated.
4. Alternatively, Molded Polyethylene Pipe Sleeve as specified may be applied.

B. Installation:

1. Support noninsulating type securely in formwork to prevent contact with reinforcing steel and tie-wires.
2. Caulk joint with specified sealant in non-submerged applications and seal below grade and submerged applications with wall penetration seal.

3.08 SLAB, FLOOR, WALL AND ROOF PENETRATIONS

A. Applications:

1. Watertight and Below Ground Penetrations:
   a. Wall pipes with thrust collars.
   b. Provide taps for stud bolts in flanges to be set flush with wall face.
2. Nonwatertight Penetrations: Pipe sleeves with seep ring.
3. Existing Walls: Rotary drilled holes.
4. Fire-Rated or Smoke-Rated Walls, Floors or Ceilings: Insulated and encased pipe sleeves.

B. Wall Pipe Installation:

1. Isolate embedded metallic piping from concrete reinforcement using coated pipe penetrations as specified in Section 09900, Painting and Coating.
2. Support wall pipes securely by formwork to prevent contact with reinforcing steel and tie-wires.

END OF SECTION

SECTION 15812
METALLIC PROCESS DUCTWORK

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. Air Movement and Control Association (AMCA): 500, Test Methods for Louvers, Dampers, and Shutters.
2. American Iron and Steel Institute (AISI).
3. American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE):
   a. HVAC Systems and Equipment Handbook, Duct Construction Chapter.
   b. Fundamentals Handbook.
4. American Society of Mechanical Engineers (ASME): A13.1, Scheme for the Identification of Piping Systems.
5. American Society for Nondestructive Testing (ASNT): SNT TC 1A, Recommended Practice for Personal Qualification and Certification in Nondestructive Testing.
6. American Welding Society (AWS):
   a. D1.1/D1.1M, Structural Welding Code - Steel.
   b. D9.1/D9.1M, Sheet Metal Welding Code.
   c. QC1, Standard for AWS Certification of Welding Inspectors.
7. ASTM International (ASTM):
   a. A36/A36M, Standard Specification for Carbon Structural Steel.
   b. A167, Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip.
   c. A176, Standard Specification for Stainless and Heat-Resisting Chromium Steel Plate, Sheet, and Strip.
   d. A240/A240M, Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications.
   e. A480/A480M, Standard Specification for General Requirements for Flat-Rolled Stainless and Heat-Resisting Steel Plate, Sheet and Strip.
   f. A568/A568M, Standard Specification for Steel, Sheet, Carbon, Structural, and High-Strength, Low-Alloy, Hot-Rolled and Cold-Rolled, General Requirements for.
   g. A653/A653M, Standard Specifications for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process.

h. A666, Standard Specification for Annealed or Cold-Worked Austenitic Stainless Steel Sheet, Strip, Plate, and Flat Bar.
i. A924/A924M, Specification for General Requirements for Sheet Steel, Metallic-Coated by the Hot-Dip Process.
j. B209, Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate.
k. E84, Standard Test Method for Surface Burning Characteristics of Building Materials.

8. Factory Mutual Research: 4922, Fume Exhaust Ducts or Fume and Smoke Exhaust Ducts.
9. National Fire Protection Association (NFPA):
   a. 90A, Standard for the Installation of Air-Conditioning and Ventilating Systems.
   b. 90B Standard for the Installation of Warm Air Heating and Air-Conditioning Systems.
   c. 91, Standard for Exhaust Systems for Air Conveying of Vapors, Gases, Mists, and Noncombustible Particulate Solids.
   d. 255, Standard Method of Test of Surface Burning Characteristics of Building Materials.
   e. 259, Standard Test Method for Potential Heat of Building Materials.
   f. 701, Standard Methods of Fire Tests for Flame Propagation of Textiles and Films.
10. Sheet Metal and Air Conditioning Contractors' National Association (SMACNA):
    a. Accepted Industry Practice for Industrial Duct Construction.
    b. HVAC Air Duct Leakage Test Manual.
    c. HVAC Duct Construction Standards – Metal and Flexible.
    d. HVAC Rectangular Industrial Duct Construction Standards.
    e. HVAC Round Industrial Duct Construction Standards.
    f. Seismic Restraint Manual: Guidelines for Mechanical Systems.
11. UL 181, Standard for Safety Factory-Made Air Ducts and Connectors.

1.02 DEFINITIONS

A. The following is a list of abbreviations which may be used in this section:

1. CFM: Cubic feet per minute.
2. FPM: Feet per minute.
3. MDFT: Mean dry film thickness.
4. PCF: Pounds per cubic foot.
5. ppm: Parts per million by volume.
6. WC: Water column.

B. Ductwork Dimensions: Net free, inside dimensions of duct.

C. Sealing Requirements:

1. For non-welded duct systems and components, the following definitions apply:
   a. Joints, duct surface connections including:
      1) Girth joints.
      2) Branch and subbranch intersections.
      3) Duct collar tap-ins.
      4) Fitting subsections.
      5) Louver and air terminal connections to ducts.
      6) Access door, and access panel frames and jambs.
      7) Duct, plenum, and casing abutments to building structures.
   b. Seams: Joining of two longitudinally (in direction of airflow) oriented edges of duct surface material occurring between two joints. All other duct surface connections made on perimeter are deemed to be joints.

1.03 SUBMITTALS

A. Action Submittals:

1. Product Data:
   a. Ductwork:
      1) Schedules of duct systems, materials, joints, sealing, gage and reinforcement, coatings.
      2) SMACNA figure numbers for each shop fabricated item.
      3) Reinforcing details and spacing.
      4) Seam and joint construction details.
      5) Hangers and supports, including methods for building attachment, vibration isolation, and duct attachment.
   b. Ductwork Accessories:
      1) Manufacturer’s product data including catalog sheets, diagrams, standard schematic drawings, installation instructions and details, details of materials, construction, dimensions of individual components, and finishes, including the following items:
         a) Fittings and volume control damper installation (both manual and automatic) details.
         b) Gasket and sealing materials.
         c) Test Ports for coated ducts.
         d) Drains for ducts carrying mists or condensate.
         e) Dampers: Include leakage, pressure drop, and maximum back pressure data.

f) Duct-mounted access panels and doors.
g) Flexible ducts.

2. Duct Fabrication Drawings:
   a. Prepare after actual Job measurements are obtained.
   b. Draw to a scale not smaller than 1/4 inch equals 1 foot, on drawing sheets same size as Contract Drawings.
   c. Include the following features:
      1) Fabrication, assembly, and installation details including plans, elevations, sections, details of components, and attachments to other work.
      2) Ductwork layout, indicating pressure classifications, slopes, drain and test port locations, and sizes in plain view.
      3) Interface and relationship between coated ductwork and adjacent equipment.
      4) Ductwork material and thickness.
      5) Fittings and volume control damper installation (both manual and automatic) details.
      6) Reinforcing details and spacing.
      7) Seam and joint construction details.
      8) Penetrations through fire-rated and other partitions.
      9) Ductwork accessories and control devices such as automatic dampers, terminal units, smoke detectors, regulators, and air distribution devices.
      10) Hangers and supports, including methods for building attachment, seismic bracing, vibration isolation, and ductwork attachment.
      11) Coordination with ceiling suspension members.
      12) Spatial coordination with other systems installed in same space with duct systems.
      13) Coordination of ceiling-mounted and wall-mounted access doors and panels required for access to dampers and other operating devices.
      14) Coordination with ceiling-mounted lighting fixtures, air outlets, and inlets.
      15) Coordination of ductwork with sprinkler piping and other mechanical and electrical services, and equipment.
3. Shop Fabricated Welded Duct:
   a. Detailed fabrication or spool drawings showing special fittings and bends, dimensions, coatings, and other pertinent information.
   b. Layout drawing showing location of each pipe section and each special length; number or otherwise designate laying sequence on each piece.
4. Anchorage and bracing drawings and cut sheets, as required by Section 01612, Anchorage and Bracing.

5. Equipment anchorage and support drawings and cut sheets indicating size, material, spacing, embedment and edge distances of anchors and other relevant information. Provide drawings reflecting results of calculations specified below.
6. Provide duct, fitting, and coating performance data upon request.
7. Acoustical Insulation and Jacketing:
    a. Type and Model.
    b. Material.
    c. Name of Manufacturer.

B. Informational Submittals:

1. Qualifications:
    a. Manufacturer: List of references substantiating experience.
    b. Installer: Manufacturer's certification that installer is qualified for installation work.
    c. Nondestructive Testing Personnel: SNT-TC-1A, Level II certification and qualifications.
    d. AWS QC1 Certified Welding Inspector: Submit evidence of current certification prior to commencement of welding activities.
    e. Welders:
        1) Continuity log for welders and welding operators.
        2) Welder qualification test records conducted by Contractor or manufacturer.
2. Anchorage and bracing calculations as required by Section 01612, Anchorage and Bracing.
    a. Anchorage, bracing, and support design criteria and calculations:
        1) Stamped by an Engineer licensed in the State of Oregon.
        2) Conform to manufacturer's requirements as well as design criteria provided in Structural General Notes on the Drawings and other referenced standards.
    b. Provide ICC-ES reports and special inspection requirements for anchors to be drilled and installed into completed concrete or masonry.
    c. Indicate edge distance, embedment, concrete thickness and strength, and other conditions assumed in anchor calculations.
    d. Verify assumed field conditions prior to anchor and bracing installation.
3. Welder certifications for sheet metal welders per AWS D9.1/D9.1M, Sheet Metal Welding Code.
4. Manufacturer's factory inspection report.
5. Damper and Blast Gate: AMCA 500-D leakage test results by AMCA-approved laboratory.

6. Operation and Maintenance Data: In accordance with Section 01782, Operation and Maintenance Data.
7. Record Drawings: Include duct systems routing, fittings details, and installed accessories and devices.

1.04 QUALITY ASSURANCE

A. Industry Standards:

1. Unless otherwise indicated, provide supports and seismic restraint in compliance with SMACNA, Seismic Restraint Manual: Guidelines for Mechanical Systems. Use Seismic Hazard Level (SHL) C.
2. Unless otherwise indicated or specified, provide ductwork and supports constructed and installed in accordance with:
   a. SMACNA HVAC Rectangular Industrial Duct Construction Standards.
   b. SMACNA HVAC Round Industrial Duct Construction Standards.
3. Comply with ASHRAE Fundamentals Handbook and ASHRAE HVAC Systems and Equipment Handbook recommendations, except as otherwise indicated.
4. Comply with NFPA 90A and NFPA 90B.

B. Manufacturers:

1. Factory Fabricated Ductwork: Firms regularly engaged in manufacture of ductwork products of types, materials, and sizes required, whose products have been satisfactorily used in service similar to that required for this Project for not less than 5 years.
2. Coated Ductwork Manufacturer: Certified by coating manufacturer in coating system application.

C. Suppliers of Duct and Fitting Components:

1. Provide the following information on request:
   a. Laboratory performance data for duct, including leakage rate, bursting strength, collapse strength, seam strength, and pressure loss.
   b. Laboratory performance data for fittings, including zero-length dynamic losses.
   c. Laboratory performance data for coating corrosion performance for intended service.

D. Qualifications:

1. Independent Inspection and Testing Agency:
   a. Ten years' experience in field of welding and welded duct and fittings' testing required for this Project.
   b. Calibrated instruments and equipment, and documented standard procedures for performing specified testing.
   c. Certified in accordance with ASNT SNT-TC-1A for testing procedures required for this Project.
   d. Testing Agency: Personnel performing tests shall be NDT Level II certified in accordance with ASNT SNT-TC-1A.
   e. Verification Welding Inspector: AWS QC1 Certified.
2. Welding Procedures: In accordance with ASME BPVC SEC IX (Forms QW-482 and QW-483) or AWS D9.1/D9.1M (Annex N Forms).
3. Welder Qualifications: In accordance ASME BPVC SEC IX (Form QW-484) or AWS D1.1/D1.1M (Annex N Forms).
4. Contractor's CWI: Certified in accordance with AWS QC1, and having prior experience with specified welding codes. Alternate welding inspector qualifications require approval by Engineer.

E. Quality Assurance: Provide services of independent inspection and testing agency for welding operations.

1. Presence of Owner's Special Inspector or Verification CWI does not relieve Contractor from performing their own quality control, including 100 percent visual inspection of welds.

F. Installation Firm: 5 years' minimum experience of successful installation on ductwork systems similar to that required for this Project.

G. Changes or alterations to layout or configuration of duct system:

1. Specifically approved in writing by Engineer.
2. Provide designer's confirmation that proposed layout will provide original design results, without increasing system total pressure.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Protect ductwork from dirt, water, and debris. During storage on Job Site, keep ends of ductwork covered to prevent foreign objects and water from entering ductwork.

B. Protect fabricated ductwork and fittings from damage during shipping, storage, and handling. Provide shrink-wrapped duct seal, applied to ends of ductwork and fittings to prevent end damage and prevent dirt and moisture from entering.

C. Separately package each piece of ductwork without internal nesting of ductwork or fitting pieces.

D. For nonflanged components, use either rigid plugs inside ends to prevent deflection or protect with wooden boxes.

E. Crate materials whenever practical prior to shipment.

F. Firmly fasten and pad components shipped to prevent shifting or flexing of components while in transit.

G. Inspect shipments upon delivery. Note damages and discrepancies on bill of lading and notify manufacturer within 24 hours.

H. Store coated ductwork on cardboard, Styrofoam, or similar material, out of traffic areas. Where possible, store ductwork indoors. Where necessary to store outdoors, store above grade and enclose with waterproof wrapping.

I. If ductwork coating is scratched, contact coating manufacturer for repair instructions. Repair or replace as determined by manufacturer.

J. Deliver sealant materials to Site in original unopened containers labeled with manufacturer, product name and designation, color, expiration period for use, pot life, curing time, and mixing instructions for multi-component materials.

K. Store and handle sealant materials in compliance with manufacturers' recommendations to prevent deterioration or damage as a result of moisture, high or low temperatures, contaminants, or other causes.

L. Deliver and store stainless steel sheets with mill-applied adhesive protective paper, maintained through fabrication and installation.

PART 2 PRODUCTS

2.01 GENERAL

A. Service Conditions:

1. Materials suitable for outside environment and airstream containing foul air with H2S concentration of 2 ppmV (average) and 5 ppmV (peak). Peak values are considered short-term at less than 5 percent of the time.
2. SMACNA Pressure Class: Plus 12 or minus 12 inches of water column.
3. SMACNA Duct System Class: Class 5 (corrosive, moist, non-abrasive)
4. Location: Indoors.
5. Seismic Requirements: As indicated on structural drawings.

B. For indicated Pressure Class and System Class, design and install ductwork, fittings, and components to meet applicable requirements of:

1. SMACNA HVAC Rectangular Industrial Duct Construction Standards.
2. SMACNA HVAC Round Industrial Duct Construction Standards.

C. Provide components of this ductwork system, including facings, mastics, and adhesives, with a fire hazard rating not to exceed 25 for flame spread without evidence of continued progressive combustion, and 50 for smoke developed, tested in accordance with ASTM E84 and NFPA 255 methods.

D. Minimize number of joints in ductwork system.

E. Ductwork thinner than 20-gauge will not be allowed.

F. Ductwork Interior Surfaces:

1. Smooth.
2. No sheet metal parts, tabs, angles, or other items may project into air ducts, unless otherwise specified.
3. Seams and Joints: External.
4. For ductwork that is required to be reinforced, use only external reinforcing.

G. Supports, Anchorage, and Restraints:

1. General:
    a. When supports, anchorages, and seismic restraints for equipment and supports and seismic restraints for ductwork are not shown on the Drawings, Contractor is responsible for their design.
    b. Design seismic restraints to avoid introducing stresses in ductwork caused by thermal expansion or contraction.
    c. Design connections to structural framing to avoid introducing twisting, torsion, or lateral bending in framing members. Provide supplementary steel as required.
2. Supports:
    a. Provide supports for ductwork in accordance with Section 15060, Piping Support Systems.
    b. Type: As indicated on the Drawings.
    c. Maximum Duct Deflection: 1/2 inch.

d. Support spacing as indicated on the Drawings and the following maximum spacing:
1) Interior Ductwork: 10 feet, maximum.

3. Suspended Ductwork: Provide seismic restraints in accordance with latest edition of the SMACNA Seismic Restraint Manual, Guidelines for Mechanical Systems, for seismic hazard level (SHL) as specified for the Project.
a. Provide supports for ductwork in accordance with Section 15060, Piping Support Systems.
b. Hanger Spacing: 8 feet, maximum.

2.02 FACTORY FABRICATED STAINLESS DUCTWORK

A. PTFE Coating:

1. Where indicated, stainless ductwork shall be factory-coated inside air stream for corrosion resistance.
2. Coatings:
a. Base Metal:
1) Longitudinal Seams: Fusion-welded using no filler rod.
2) Transverse Seams: Continuously welded.
3) Seam Finishing: Ground or polish smooth.
b. Coating System:
1) Acceptable Manufacturers: PTFE fluoropolymer 532-6005 primer, 532-6012 top coat by E.I. DuPont DeNemours and Company, Wilmington, Delaware, “or-equal.”
2) Description:
a) Electrostatically applied thermoplastic resin powder coating system. Ductwork interior applications to be a minimum of 10 mils to 12 mils thick MDFT to provide complete, uniform, and spark-free coverage.
b) Prepare base metal surfaces and apply coating in accordance with coating manufacturer’s requirements to ensure proper and complete adhesion of coating to base metal.
c) Exterior of ductwork and fittings to be free of over spray.
3) Fittings and Accessories: Prepare and coat ductwork fittings and accessories, such as dampers and blast gates, in same manner as ductwork in which they are to be installed.
4) Testing: Wet test the entire coated surface inside and out (where applicable) and edges, using a dc spark tester used at a minimum of 250 volts per mil of coating thickness to detect flaws and provide a void-free surface. Repair flaws and retest until all flaws are repaired.

3. Gaskets: Gore-Tex or envelope-style PTFE.
4. SMACNA duct pressure class for coated duct, fittings, and joints shall be minus 6-inch WC.
5. Dampers: Heavy-duty industrial butterfly provided by the duct system manufacturer. Unless otherwise shown on the Drawings the damper shall meet the same design conditions as the FRP dampers described in Section 15892, Foul Air Ductwork and Accessories.
6. For additional duct, fitting, and joint requirements, see below.
7. Acceptable Ductwork Manufacturer:
   a. Fab-Tech Inc.; Perma Shield Pipe.
   b. "Or-equal."

B. Factory Stainless Duct, Coated and Uncoated:

1. Factory fabricated from stainless steel sheet, AISI Type 316L.
2. Gauge and reinforcing to meet designated system class and pressure class in accordance SMACNA Round Industrial Duct Construction Standards.
3. Exterior Finish: No. 2 B (cold-rolled, bright) finish conforming to ASTM A167 and ASTM A480.
4. Comply with ASTM A167, ASTM A176, ASTM A240/A240M, and ASTM A480/A480M.
5. Duct material shall be factory-rolled and fused with laser weld along longitudinal seam.
6. Each pipe shall be factory-checked with light apparatus for welding flaws or gaps.
7. Rolled edge of pipe section shall be die-formed after inspection by rolling each end of pipe simultaneously.
8. Gauge and reinforcing to meet designated system class and pressure class in accordance SMACNA Round Industrial Duct Construction Standards.
9. Material to comply with ASTM A240.
10. SMACNA Duct pressure class for un-coated duct, fittings and joints shall be minus 6-inch WC.

C. Fabrication:

1. Fittings:
   a. Fabricate elbows, transitions, offsets, branch connections, and other ductwork construction in accordance with SMACNA Construction Manuals.
   b. Coating and material to match ductwork requirements.
   c. Elbows, Tees, Bends: Minimum centerline radius of 1-1/2 times ductwork diameter whenever possible.

d. Elbows above 45 degrees through 90 degrees to have a minimum of five gore construction.
e. Mitered elbows not permitted.
f. 90-Degree Tees, Laterals, and Conical Tees: Fabricate to conform to SMACNA Construction Standards with metal thicknesses specified for longitudinal seam straight duct.
g. Diverging Flow Fittings: Fabricate with a reduced entrance to branch taps with no excess material projecting from body onto branch tap entrance.
h. Transitions: Limit taper angle to 30 degrees for contracting and to 20 degrees for expanding transitions.
i. Branch Takeoff Connections: Unless specifically detailed otherwise, provide 45-degree laterals and 45-degree elbows.
j. 90-Degree Branch Takeoffs: Shoe-tap-type tees.
k. Provide single-thickness turning vanes for rectangular elbows.
l. Field installed taps are not acceptable.

D. Joints:

1. Flanged Joints:
   a. Use companion angle ring bolted flange (Van Stone) ductwork joints consisting of rolled or pressed angle rings, and Gore-Tex or envelope-style gaskets.
   b. Shall be used for negative pressure ducts 14 inches in diameter and greater, for all positive pressure ducts, and elsewhere as indicated.
   c. Flange Ring Materials: AISI Type 304 stainless steel.
   d. Elongated bolt holes.
   e. Flange dimensions and bolt pattern for duct-to-duct connections shall be factory standard.
   f. Flange dimensions and bolt patterns for flanges that connect to equipment, flexible connections, dampers, and new or existing FRP ductwork shall match opposing connection flange.
2. Lever Type Clamp Joints:
   a. Proprietary reusable “Speed” clamp or “Quick-Fit” clamp joints are allowed over rolled edge duct where indicated or approved.
   b. Clamps: AISI Series 300 stainless steel for ducts 14 inches and smaller in diameter with manufacturer’s recommended gaskets.
   c. For negative pressure installations only. Not allowed for positive pressure systems.
   d. Clamp Seal Material: Nitrile to meet or exceed ASTM D1056 standards with temperature rating not to exceed 158 degrees F constant temperature (or intermittent temperature of 194 degrees F).

e. Clamp Gasketing:
1) Rock River Silicone Sealant or Dow-Corning 999-A, “or-equal” (400 degrees F or lower).
2) Sealing O-rings, Buna-N, 70 Duro-Meter hardness (250 degrees F or lower).
3) Molded Sealing Gaskets per ASTM D2000 M2BG510 A24 B34 EO14 EO34 EF11 EF21 for use in systems where temperature is 225 degrees F or less and electrical conductivity is required.
4) Sponge O-ring shall meet material classification of either ASTM D1056-68 – SBE43 or ASTM D1056-85, 91, 98 - 2B3.

3. Slip Joints:
a. Spiral duct installations may use seam welded slip joint fittings, specifically designed for high-pressure spiral duct being used.
b. Spiral Manufacturing, Hranec, Industrial Duct Systems, others as approved.

2.03 MISCELLANEOUS MATERIALS

A. General: Provide miscellaneous materials and products of types and sizes indicated and, where not otherwise indicated, provide type and size required to comply with ductwork system requirements, including proper connection of ductwork and equipment.

B. Nuts, Bolts, and Washers: AISI Type 316 stainless steel.

C. Structural Members: Matching type conforming to ASTM A666.

D. Provide nonmetallic pad between lower attachment and ductwork to achieve dielectric separation.

E. Gaskets:

1. Use on all flanged joints.
2. Gore-Tex Joint Sealant; W.L. Gore and Associates, Inc., Elkton, MD.
3. Description: Form in-place, fully expanded 100 percent PTFE gasket material, size as recommended by manufacturer.
4. Full-face, thickness as recommended by ductwork manufacturer.

F. Drains:

1. Provide at low points on SMACNA System Class 5 duct systems.
2. On factory-coated systems, attach drains prior to coating.

3. Weld couplings to bottom of main and branch ducts that are trapped and/or where shown on the Drawings, to allow removal of condensed liquids.
4. Predetermine locations of ductwork drains prior to manufacturer's fabrication.

G. Sample and Test Ports:

1. Predetermine locations of pitot ports prior to manufacturer's fabrication. At minimum, provide pitot ports in each branch duct to equipment, in each major main duct, at each fan and scrubber inlet and outlet, and where shown on the Drawings.
2. Materials of Construction: PVC, fluoropolymer or fluoropolymer coated stainless steel.
3. Bulkhead fittings with threaded cap configured to allow free passage of a Dwyer 160 series pitot tube.
4. Where possible locate ports in side of ductwork. Port location in bottom 90 degree arc of horizontal ductwork is prohibited.

2.04 DUCTWORK HANGERS AND SUPPORTS

A. General:

1. Provide attachments, hangers, and supports for ductwork in accordance with SMACNA Manual referenced for type of duct system being installed.
2. Provide duct hanging system composed of three elements; upper attachment to building, hanger itself, and lower attachment to duct.
3. Wire hangers are not acceptable.
4. Class 5 Duct Supports: Design to support accumulation of water in duct.

B. Construction Materials: Supporting devices including, but not limited to, angles used for support and bracing, baseplates, rods, hangers, straps, screws, bolts shall be Type 316 stainless steel.

C. Building Attachments:

1. Concrete inserts, powder-actuated fasteners, or structural steel fasteners appropriate for building materials.
2. Do not use powder-actuated concrete fasteners for lightweight aggregate concrete or for slabs less than 4 inches thick.

3. Upper Attachment (Concrete):
   a. Drive pin fastener and expansion nail anchor may be used for ducts up to 18-inch maximum dimension.
   b. Threaded stud fastener may be used for ducts up to 36-inch maximum dimension.
   c. Concrete Attachment Material: Steel, field-painted where exposed.

D. Vibration Isolation:

1. Provide at each support location and where contact with ductwork is made.
2. Configure supports to allow for vibration isolation material thickness.
3. Material: Minimum 3/16 inch thickness EPDM-bonded to support structure. Do not bond material to ductwork.

E. Trapeze and Riser Supports: Steel shapes conforming to ASTM A480/A480M stainless steel.

2.05 EXPANSION JOINTS/ FLEXIBLE CONNECTIONS

A. Provide where indicated on the Drawings or as required for proper ductwork installation or thermal expansion.

B. In accordance with Section 15892, Foul Air Ductwork and Accessories.

2.06 DUCTWORK IDENTIFICATION

A. Refer to Piping Schedule on the Drawings for identification requirements.

B. Painted Identification Materials:

1. Stencils: Standard metal stencils, prepared for required applications with letter sizes generally comply with recommendations of ASME A13.1 for piping and similar applications, but not less than 1-1/4-inch-high letters for ductwork and not less than 3/4-inch-high letters for access door signs and similar operational instructions.
2. Stencil Paint: Standard exterior type stenciling enamel; black, except as otherwise indicated; either brushing grade or pressurized spray can form and grade.
3. Identification Paint: Standard identification enamel of colors indicated or in accordance with ASME A13.1 for colors for systems not identified herein.

C. Plastic Duct Markers:

1. General:
   a. Provide manufacturer's standard laminated plastic, color-coded duct markers. Conform to the following color code:
      1) White Text on Blue Background: Foul air.
      2) For other hazardous exhausts, use colors and designs recommended by ASME A13.1.

D. Nomenclature:

1. Include the following:
   a. Direction of air flow.
   b. Duct service (foul air).

E. Manufacturers:

1. W.H. Brady, Co.
2. Seton Identification Products.
3. Craftmark.
4. Brimar Industries, Inc.

2.07 SOURCE QUALITY CONTROL

A. Factory Inspection: Inspect fabrications for required construction, intended function, and conformance with referenced standards.

B. Inspection of products is required prior to shipment, unless specifically waived in writing by Engineer.

C. Notify Engineer 1 week prior to estimated date of inspection.

D. Repairs authorized by Engineer to be re-inspected before final acceptance, unless specifically waived.

PART 3 EXECUTION

3.01 PREPARATION

A. Verify dimensions and conditions in field.

B. Layout routing in straight lines parallel to building lines, unless otherwise indicated.

C. Avoid diagonal runs wherever possible.

D. Coordinate support locations with layout and joints.

3.02 GENERAL INSTALLATION

A. Miscellaneous:

1. Slope to drain. Provide drains at low points.
2. Install ductwork in accordance with SMACNA Construction Standards, NFPA 90A, and NFPA 90B.
3. Install ductwork in accordance with manufacturer's recommendations using manufacturer's recommended gaskets and accessories.
4. Align ductwork accurately at connections, within 1/8-inch misalignment tolerance and with internal surfaces smooth.
5. Install and torque flange and clamp bolts to manufacturer's recommendations.
6. Interface Between Ductwork and Equipment: Install necessary transitions between ductwork and equipment cabinet connections in accordance with SMACNA guidelines.

B. Ductwork Location:

1. As indicated by diagrams, details, and notations or, if not otherwise indicated, run ductwork in shortest route that does not obstruct usable space or block access for servicing building and equipment.
2. In general, install as close to bottom of structure as possible.
3. For ductwork concealed above ceiling, maximize clearance between bottom of ductwork and top of ceiling construction.
4. Hold ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.
5. Ductwork that must transition and drop below piping or other ductwork shall be transitioned back to bottom of structure immediately adjacent to obstruction.

C. Penetrations:

1. Provide duct sleeves or prepared openings for duct mains, duct branches, and ducts passing through roofs, walls and ceilings.
2. Clearances: Allow 1-inch clearance between duct and sleeve.
3. Closure Collars:
   a. Minimum 4 inches wide on each side of walls or floors where sleeves or prepared openings are installed.
   b. Fit collars snugly around ducts.
   c. Same gauge and material as duct.
   d. Grind edges of collar smooth.
   e. Use fasteners with maximum 6-inch centers on collars.
4. Packing: Mineral fiber in spaces between sleeve or opening and duct or duct insulation.

D. Coordination with Other Trades:

1. Coordinate duct installation with installation of accessories, dampers, coil frames, equipment, controls, and other associated work of ductwork system.
2. Configure, position, and install ductwork to permit light fixture installation as indicated on the Drawings.
3. Coordinate ductwork layout with suspended ceiling, lighting and sprinkler head layouts and similar finished work.
4. Electrical Equipment Spaces: Do not run ductwork through transformer vaults and other electrical equipment spaces and enclosures.
5. Do not run hazardous exhaust through fire or smoke rated penetrations.

3.03 DUCTWORK INSTALLATION

A. Inspection:

1. Examine areas and conditions under which ductwork is to be installed. Do not proceed with work until unsatisfactory conditions have been corrected.
2. Prior to assembling, examine components to determine if any have been damaged.
3. Repair of Scratches: Contact coating manufacturer for repair instructions. Unless otherwise recommended by manufacturer, coat all scratches, chips, and other damage to coating with a field-applied coating patch to cover an area 2 inches on each side of damaged area. Clean and prepare affected area as described in manufacturer’s instructions. Spark test repairs prior to installation.
4. Holes and Dents: Replace components having holes or dents.

B. Provide flanges at each ducting connection to equipment to facilitate installation and removal.

C. Install duct so that no load or movement in excess of that stipulated by equipment manufacturer will be imposed upon equipment connection; install to allow for contraction and expansion without stressing pipe, joints, or connected equipment.

D. Installation:

1. Assemble and install ductwork using extreme care not to scratch surface of coatings and in accordance with manufacturer’s instructions and recognized industry practices which will achieve airtight and liquid tight systems.

2. Do not penetrate coatings for any reason. Do not use fastening devices, such as Tek screws and rivets on any part of a coated ductwork application. Predetermine test holes for monitoring and measurement before fabrication and install before coating. Coordinate with testing and balance contractor for required test port locations.
3. Where ducts pass through interior partitions and exterior walls and are exposed to view, conceal space between construction openings and ductwork with sheet metal flanges of same material and gauge as duct. Overlap opening on all sides by at least 1-1/2 inches.
4. Provide drains with corrosion resistant drain plugs on SMACNA System Class 5 duct systems and other systems where water or other liquids could accumulate.
5. Provide test ports at all branches suitable for system balancing.
6. Slope duct as indicated on the Drawings.

E. Flanged Joints:

1. Install perpendicular to duct centerline.
2. Bolt Holes: Straddle vertical centerlines aligned with connecting equipment flanges or as shown.
3. Use torque-limiting wrenches to ensure uniform bearing and proper bolt tightness.
4. Raised-Face Flanges: Use flat-face flange when joining with flat-faced ductile or cast-iron flange.
5. Verify compatibility of mating flange to adapter flange gasket prior to selecting adapter flanging.
6. Flange fillers are to be avoided, but if necessary, may be used to make up for small angles up to 6 degrees and for filling gaps up to 2 inches between flanges. Stacked flange fillers shall not be used.
7. Threaded flanged joints shall be shop-fabricated and delivered to Site with flanges in-place and properly faced.
8. Manufacturer: Same as duct manufacturer for factory fabricated duct.

3.04 FIELD WELDING

A. No field welding allowed for internally coated ductwork.

3.05 DUCTWORK HANGERS AND SUPPORTS

A. Supports: As specified in Section 15060, Piping Support Systems. All supports shall have corrosion-resistance equivalent to that of duct supported.

B. Install ductwork with support systems in accordance with SMACNA Industrial Manuals and manufacturer’s recommendations. Provide supports designed to handle accumulations of liquid and particulate where indicated by system classification or as noted on the Drawings.

C. Penetrating fasteners of any type, such as Tek screws and rivets, are not permitted for hanging ductwork.

D. Support ducts rigidly with suitable ties, braces, hangers, and anchors which will hold ducts true-to-shape and prevent buckling.

E. Install additional bracing on ductwork as required, to prevent ballooning or breathing.

F. Support horizontal ducts within 2 feet of each elbow and within 4 feet of each branch intersection.

G. Support vertical ducts at maximum interval of 15 feet and at each floor.

H. Upper attachments to structures shall have allowable load not exceeding 1/4 of failure (proof test) load, but are not limited to specific methods indicated.

I. In new construction, install concrete insert prior to placing concrete.

J. Install seismic restraints on ductwork systems and sway bracing as described in SMACNA Guidelines for Seismic Restraints of Mechanical Systems and as required by the Building Code for seismic zone indicated.

3.06 DAMPERS

A. General:

1. Inspection:
   a. Inspect areas to receive dampers.
   b. Notify Engineer of conditions that would adversely affect installation or subsequent utilization of dampers.
   c. Do not proceed with installation until unsatisfactory conditions are corrected.
2. Install dampers at locations indicated on the Drawings and in accordance with manufacturer’s installation instructions.
3. Install with damper shaft in horizontal position.
4. Install square and level.
5. Handle damper using sleeve or frame. Do not lift damper using blades or jack-shaft.
6. Confirm that damper blades and hardware operate freely without obstruction.
7. Damper blades and hardware that bind within frame or obstructed by adjacent construction will not be acceptable.
8. Provide gasketed damper frames to eliminate leakage between duct and damper frames.

9. Suitable for installation in mounting arrangement shown.
10. Do not compress or stretch damper frame into duct or opening.

3.07 DUCT SEALING

A. If no specific duct sealing requirements are specified, seal in accordance with SMACNA Construction Standards.

B. Seal all audible leaks.

3.08 BALANCING OF AIR SYSTEMS

A. Perform air balancing in accordance with requirements of Section 15950, Testing, Adjusting, and Balancing for HVAC.

3.09 PROTECTION OF INSTALLED WORK

A. Cover open ends of installed ductwork systems to prevent dust, foreign objects, and water from entering ductwork.

B. Do not use ductwork systems for air conveyance until adequate air filtration devices are installed in air handling equipment, to prevent ingress of construction dust.

3.10 CLEANING

A. Clean ductwork of rust, dust, and debris, both internally and externally, before placing in operation.

B. Confirm that dampers are smooth, clean, and free of dirt when installed.

END OF SECTION

SECTION 15835
ODOR CONTROL FANS

EQUIPMENT AND COMPONENT NUMBER(S)

Biofilter Odor Control Fan 1: 200F4111.
Biofilter Odor Control Fan 2: 200F4112.

PART 1 GENERAL

1.01 GENERAL

A. Like items of equipment provided hereunder shall be the end products of one manufacturer in order to achieve standardization for operation, maintenance, spare parts, and manufacturers' services.

B. AC Induction Motor requirements: Conform to requirements of Section 16222, Low-Voltage Motors Up to 500 Horsepower.

C. Adjustable Frequency Drive requirements: Provided by Owner. Refer to Section 01645, Owner-Furnished Products

D. Air flow balancing requirements: Conform to requirements of Section 15950, Testing, Adjusting and Balancing for HVAC.

1.02 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. Acoustical Society of America (ASA): S2.19, Mechanical Vibration-Balance Quality Requirements of Rigid Rotors—Part 1, Determination of Permissible Residual Unbalance.
2. Air Movement and Control Association International (AMCA):
   a. 99, Standards Handbook.
   b. 201, Fans and Systems.
   c. 203, Field Performance Measurement of Fan Systems.
   d. 210, Laboratory Methods of Testing Fans for Rating.
   e. 300, Reverberant Room Method for Sound Testing of Fans.
   f. 301, Methods for Calculating Fan Sound Ratings from Laboratory Test Data.
   g. 99-2408, Operating Limits for Centrifugal Fans.
3. American Bearing Manufacturers Association (ABMA): 9, Load Ratings and Fatigue Life for Ball Bearings.
4. American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE): HVAC Applications Handbook.

5. ASTM International (ASTM):
    a. B117, Standard Practice for Operating Salt Spray (Fog) Apparatus.
    b. D2247, Standard Practice for Testing Water Resistance of Coatings in 100 Percent Relative Humidity.
    c. D2794, Standard Test Method for Resistance of Organic Coatings to the Effects of Rapid Deformation (Impact).
    d. D3363, Standard Test Method for Film Hardness by Pencil Test.
    e. D4167, Standard Specification for Fiber-Reinforced Plastic Fans and Blowers.
    f. E84, Standard Test Method for Surface Burning Characteristics of Building Materials.
6. National Electrical Manufacturers Association (NEMA).
7. Occupational Safety and Health Act (OSHA).
8. Society for Protective Coatings (SSPC):
    a. SP 3, Power Tool Cleaning.
    b. SP 5, White Metal Blast Cleaning.
    c. SP 6, Commercial Blast Cleaning.
    d. SP 10, Near-White Blast Cleaning.
9. UL: 507, Electric Fans.

1.03 DEFINITIONS

A. The following is a list of abbreviations which may be used in this section:

1. AC: Alternating Current.
2. CISD: Chemical Industry, Severe-Duty.
3. dB: Decibel.
4. FRP: Fiberglass Reinforced Plastic.
5. hp: Horsepower.
6. SWSI: Single Width, Single Inlet.
7. TEFC: Totally Enclosed, Fan Cooled.
8. UV: Ultraviolet.
9. XP: Explosion Proof.

1.04 SUBMITTALS

A. Action Submittals:

1. Provide for all products specified, as follows:
    a. Identification as referenced in Contract Documents.
    b. Manufacturer’s name and model number.
    c. Descriptive specifications, literature and Drawings.
    d. Dimensions and weights.

e. Fan sound power level data (reference 10 to power minus 12 Watts) at design operating point.
f. Fan Curves:
    1) Performance curves at design point indicating:
        a) Curve showing relationship of flow rate to static pressure.
        b) Brake horsepower curves.
        c) Acceptable selection range (surge curves, maximum revolutions per minute, etc.).
        d) Static pressure, capacity, horsepower demand and overall efficiency required at the duty point, including any estimated drive losses.
        e) Fan wheel revolutions per minute and tip speed.
g. Construction materials, including statement of resins and reinforcing proposed for use.
h. Fan type, wheel type, wheel diameter, wheel maximum safe speed, size, class, drive arrangement, discharge, rotation, and bearing type.
i. Motor submittals in conformance with Section 16222, Low-Voltage Motors up to 500 Horsepower.
j. Vibration isolation.
k. Acoustic housing jacket data including: Product information with noise attenuation calculations.
l. Factory finish system.
m. Color selection charts where applicable.
n. Corrosion protection coating product data.

2. Equipment anchorage and support drawings and/or cut sheets indicating size, material, spacing, embedment and edge distances of anchors and other relevant information in accordance with Section 01612, Anchorage and Bracing. Drawings should reflect the results of the calculations submitted below.
3. “Or-Equal” Equipment:
    a. Where submitted equipment results in change to fan inlet or outlet ductwork configuration shown on the Drawings, submit system effect factor calculations indicating increased static pressure requirements as described in AMCA 201.
    b. Where submitted equipment results in change to ductwork and equipment configuration shown on the Drawings, submit detailed information on structural, mechanical, electrical, or other modifications necessary to adapt arrangement to equipment furnished.

B. Informational Submittals:

1. Recommended procedures for protection and handling of products prior to installation.
2. Manufacturer's installation instructions.
3. Spare parts list with part numbers, current price list and purchasing contact.
4. Manufacturer's Certificate of Compliance in accordance with Section 01640, Manufacturers' Services and Training.
5. Factory Test Reports: Dynamic balancing, functional run test, performance test, vibration test, and sound test.
6. Field testing alignment report and vibration report.
7. Operation and maintenance data in conformance with Section 01782, Operation and Maintenance Data. Include as-built version of equipment schedules.
8. Support and anchorage calculations in accordance with Section 01612, Anchorage and Bracing.

1.05 QUALITY ASSURANCE

A. Performance Ratings: Tested in accordance with AMCA 210.

B. Sound Ratings: Tested in accordance with AMCA 300.

C. Fabrication: In accordance with AMCA 99.

1.06 EXTRA MATERIALS

A. Provide a list of spare parts recommended by the manufacturer, including part numbers, current price list and contact for purchasing.

B. Provide special tools required to maintain or dismantle equipment specified herein.

PART 2 PRODUCTS

2.01 EQUIPMENT SCHEDULES

A. Some specific equipment requirements are listed in Equipment Schedules. Refer to Article Supplement.

2.02 SPARK RESISTANT CONSTRUCTION

A. Fans required to be spark resistant shall comply with requirements of AMCA 99-0401.

2.03 PERFORMANCE REQUIREMENTS:

1. Fan shall operate at single stable point as indicated by fan curve. Fans having two potential operating points on a single RPM curve are not acceptable. Duty point shall be at least 10 percent below the crest of the fan curve.
2. Fan shall operate at a speed not greater than 90 percent of the maximum safe speed at selected design point.
3. Fan and motor combination shall be capable of operating at 105 percent of Supplier's selected speed at design point. Motor shall not operate into motor service factor over the published range of flow at this higher speed.

2.04 NAMEPLATES

A. All units shall include factory installed permanently attached nameplate displaying unit model and serial number.

2.05 OPERATING LIMITS

A. Fans designated to meet a specified fan class shall comply with requirements of AMCA 99-2408-69.

2.06 ACOUSTICAL LEVELS

A. Equipment selections shall produce sound power levels in each octave band no greater than shown in Equipment Schedule.

B. Fans shall be provided with acoustical jacketing as specified herein such that the overall A-Scale weighted sound pressure level of the installed equipment shall be no greater than 65 dBA at a distance of 5 feet from the equipment while operating at design conditions with Q equals 2.

2.07 FINISHES

A. Carbon Steel Parts: Factory finished in accordance with Article Corrosion Protection Coating.

B. Aluminum Parts: Finished smooth and left unpainted, unless stated otherwise.

C. Stainless Steel Parts: Finished smooth and left unpainted.

D. Fiberglass Parts: Finished in accordance with Paragraph Fiberglass Material.

2.08 UTILITY BLOWER, CENTRIFUGAL SWSI, FIBERGLASS

A. General:

1. Factory-assembled utility blower; including housing, fan wheel, drive assembly, motor, and accessories.
2. Fiberglass Construction: In accordance ASTM D4167.
3. Spark Resistant Construction:
    a. Carbon fiber veil impregnated in housing and wheel fiberglass resin corrosion barrier.
    b. Static grounding.
    c. Classification: AMCA 99-0401 Type B.
4. Suitable to convey air at temperatures up to 250 degrees F.
5. Airstream Hardware: Fiberglass encapsulated Type 316 stainless steel.
6. Base/Pedestal Hardware: Type 316 stainless steel.

B. Fiberglass Material:

1. Construction: Resin reinforced fiber cloth and mat.
2. Resin:
    a. Vinyl ester or other qualified thermosetting resin.
    b. Selected by fabricator, subject to approval by Engineer and suitable for intended service with no fillers or thixotropic agents.
    c. Premium grade and corrosion resistant.
    d. Structural wall resin may be of different chemical resistance, subject to conditions of service and approval by Engineer.
    e. Flame Spread Index:
        1) ASTM E84, less than 30; fire retardant additives used only in structural layer.
    f. For outdoor locations, add ultraviolet absorbers to surfacing resin to improve weather resistance.
    g. Color:
        1) Use no dyes, pigments, or colorants, except in exterior gel coat.
        2) Exterior gel coat color shall be factory standard.
3. Reinforcement:
    a. Veil: Chemical surfacing mat, Type C (chemical) glass veil.
    b. Chopped Strand Mat: Type E glass, minimum 1-1/2 ounces per square foot, with silane finish and styrene soluble binder.
    c. Continuous Roving for Chopper Gun Spray-Up: Type E glass.
    d. Woven Roving: Type E glass, nominal 24 ounces per square yard, 4 by 5 weave, with silane type finish.

4. Laminate:
    a. Inner Surface (Veil):
        1) Resin rich, veil reinforced, 10 mils to 20 mils thick.
        2) Use no additives.
        3) Finish and binder compatible with lay-up resin.
        4) Reinforcement Content: Not more than 20 percent.
    b. Interior (Corrosion) Layer:
        1) Resin rich, at least two plies of chopped strand mat, nominal 100 mils to 120 mils thick.
        2) Use no additives.
        3) Construct interior layer of resin reinforced with at least two plies of chopped strand mat backing the veil.
        4) Reinforcement Content: 25 plus or minus 5 percent.
    c. Exterior (Structural) Layer:
        1) Resin with mat, cloth, woven roving or chopped strand glass reinforcement.
        2) Enough resin present to prevent surface fiber show.
        3) Exterior surface smooth, with no exposed fibers or sharp projections.
    d. Wall Thickness: As required for equipment structural integrity, but no less than 3/16 inch.

C. Housing:

1. Material: Fiberglass.
2. Construction:
    a. Curved scroll configuration.
    b. Integral flanges to ensure housing concentricity and housing strength.
    c. Flanged Outlet: Heavy fiberglass construction, factory drilled and flanged.
    d. Flanged Inlet: Heavy fiberglass construction, factory drilled and flanged.
    e. Drain Connection: Minimum 1-inch NPT size and located at lowest point of fan housing.
    f. Inlet:
        1) Die-formed bell mouth of fiberglass construction.
        2) Fiberglass supports.
        3) Bolted to housing to permit wheel removal.
    g. Shaft Seal: Viton or Teflon labyrinth construction, located at shaft penetration of housing.
    h. Housing Access Doors: Bolted and gasketed.
3. Base/Pedestal: All-welded heavy gauge steel coated as specified in this section.

D. Unitary Subbase:

1. Structural metal subbase, same material, and coating as fan base/pedestal as specified in this section.
2. Bolted to bottom of fan base/pedestal.
3. Drilled for field installation of vibration isolators, including height-saving clips as shown on the Drawings.

E. Wheel:

1. Material: Fiberglass.
2. Centrifugal, one-piece, nonoverloading, backward inclined flat blade type.
3. Wheel hub permanently bonded to shaft and completely encapsulated in fiberglass.

F. Shaft, Bearings, Drive:

1. Shafts:
   a. Turned, ground and polished Type 316 stainless steel.
   b. Ends drilled and tapped for wheel installation.
   c. Keyed for sheave installation.
   d. Airstream portion fully encapsulated with FRP or SST sleeve bonded to fan wheel. Where shaft seal does not allow for encapsulation, for example, lip type, shaft to be Type 316 stainless steel.
   e. Fan Shafts: First critical speed of at least 125 percent of fan maximum operating speed.
   f. Tach hole on shaft for rpm measurement.
2. Bearings:
   a. Grease lubricated, precision antifriction ball, self-aligning type.
   b. Mounted in cast iron pillow block housing.
   c. Selected for average life (ABMA 9 L_{50}) of not less than 200,000 hours operation at maximum cataloged operating speed.
   d. Extended lube lines.
3. Drives:
   a. Fan drive type shall be direct drive with arrangement shown in Article Supplement.
   b. Entire drive assembly shall be sized for a minimum 150 percent of fan motor horsepower rating.

G. Safety Guards:

1. Shaft, and Bearing Guard: Carbon steel sheet metal for complete coverage of shaft and bearings.
2. Easily removable and meeting federal OSHA, and State safety requirements.
3. Guard faces of expanded metal having minimum 60 percent free area for ventilation.
4. OSHA safety yellow finish.

2.09 ACCESSORIES

A. Equipment Identification Plates: Furnish 16-gauge Type 316 stainless steel identification plate securely mounted on each separate equipment component in a readily visible location. Plate shall bear 3/8-inch high engraved block type black enamel filled equipment tag indicated in this specification.

B. Lifting Lugs: Furnish suitably attached for equipment assemblies and components weighing over 70 pounds.

C. Acoustic Jacket:

1. Custom formed, sectioned, removable cover designed to limit sound power level emissions from fan housing.
2. Suitable for outdoor installation.
3. Jacketing shall be designed as not limit access to fan shaft, bearings, access door, or other fan appurtenances.
4. Performance: The sound pressure level of the installed fan as measured at a distance of 5 feet from the fan shall not exceed the A-Scale weighted value as specified in Article Acoustical Levels.
5. Inner and Outer jacketing shall be 16.5 ounce per square yard Teflon impregnated fiberglass cloth. Liner shall be 16 ounce per square foot mass loaded acoustical septum. Insulation shall be 3-inches thick and consist of a combination of high and medium densities of fiberglass.
6. Provide Teflon cloth belts with stainless steel double D-rings with hoop and loop fasteners for attachments.
7. Manufacturer and Product:
   a. Advance Thermal Corp.; Model ACOUSTIRAP.
   b. “Or-equal.”

D. Vibration Isolation:

1. Freestanding, steel, open-spring isolators with seismic restraint.
2. Housing: Steel with resilient vertical limit stops to prevent spring extension because of wind loads or if weight is removed; factory-drilled baseplate bonded to 1/4-inch-thick elastomeric isolator pad attached to baseplate underside; and adjustable equipment mounting and leveling bolt that acts as blocking during installation and coated as specified in this section.
3. Outside Spring Diameter: 80 percent minimum of compressed height of spring at rated load.
4. Minimum Additional Travel: 50 percent of required deflection at rated load.
5. Lateral Stiffness: 80 percent minimum of rated vertical stiffness.
6. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
7. Isolators shall be mounted below clips attached to unitary base to minimize overall height, as shown on the Drawings.

E. Vibration Sensor Transmitter:

1. Provide factory-mounted vibration sensor on the top of the housing side bearing housing. Sensor shall be oriented radially from the shaft centerline or perpendicular to the shaft axis. Parallel alignment with the shaft axis is not acceptable.
2. Vibration sensor power requirement: 18V dc to 30V dc, loop powered from the plant control system.
3. Enclosure shall be stainless steel and rated for IP68.
4. Provide type 316 stainless steel terminal junction box, 6-inch square, with terminal strip.
5. Vibration sensor shall be IMI Model EX640B01 with range of 0 inch per second to 1-inch per second, peak, 50-foot shielded 4-conductor cable, and cable/connector Model 052BR050BZ.
6. Analog output (4 mA to 20 mA) shall be connected to the PLC for vibration monitoring.

2.10 MANUFACTURERS AND PRODUCTS:

1. New York Blower; Model FE.
2. Verantis; Model CLUB.
3. Hartzell, Series 41.

2.11 CORROSION PROTECTION COATING

A. General:

1. Provide factory-applied corrosion protection coating on these fan components: Steel components.
2. Coating system shall be baked enamel, air-dry epoxy, or baked epoxy.
3. Color shall be factory standard gray unless otherwise noted.
4. Quality Control:
   a. Verify dry film thickness before final baking.
   b. Finished coating system shall be free from voids, checks, cracks, and blisters.
5. Surface Cleaning:
   a. Clean parts to be coated as follows:
      1) Immerse parts in chemical cleaning solution to remove lubricants, machining oils, and residual factory contamination.
      2) Follow with immersion in potable water bath to neutralize and remove cleaning solution.

B. Baked Enamel:

1. Material: Alkyd modified urea-melamine single component baking enamel.
2. Surface Preparation: Clean surface to SSPC-SP 3.
3. Application: Standard air-pressurized spray equipment.
4. Curing: Oven baked at a metal temperature not to exceed 300 degrees F.
5. Finished Thickness: 1-mil to 2-mil dry film thickness.
6. Performance:
   a. Coating shall meet or exceed following criteria:
      1) Impact Resistance: 10 inch pounds, ASTM D2794 test method.
      2) Pencil Hardness: 2H, ASTM D3363 test method.
      3) Service Temperature: Maximum 230 degrees F, continuous.

C. Air-Dry Epoxy:

1. Material: Two-part catalyzed epoxy.
2. Surface Preparation: Clean surface to SSPC-SP 6.
3. Application: Standard air-pressurized spray equipment.
4. Curing: Air dry.
5. Finished Thickness: 6-mil to 8-mil dry film thickness.

6. Performance:
   a. Coating shall meet or exceed following criteria:
      1) Salt Spray Test: Minimum 1,500-hour duration, ASTM B117 test method.
      2) Pencil Hardness: H-2H, ASTM D3363 test method.
      3) Service Temperature: Maximum 150 degrees F, continuous.

D. Baked Epoxy:

1. Material: Epoxy.
2. Surface Preparation: Sandblast surface to SSPC-SP 10.
3. Application: Electrostatic spray.
4. Curing: Oven baked at a metal temperature not to exceed 400 degrees F.
5. Finished Thickness: 2.5-mil to 3.5-mil dry film thickness.
6. Performance:
   a. Coating shall meet or exceed following criteria:
      1) Salt Spray Test: Minimum 1,000-hour duration, ASTM B117 test method.
      2) Humidity Resistance: Minimum 1,000-hour duration, ASTM D2247 test method.
      3) Impact Resistance: 100 inch pounds, ASTM D2794 test method.
      4) Pencil Hardness: 2H, ASTM D3363 test method.
      5) Service Temperature: Maximum 230 degrees F, continuous.

2.12 MOTORS

A. Fan motors shall comply with all provisions of Section 16222, Low-Voltage Motors up to 500 Horsepower.

1. Winding Thermal Protection; Thermostats: Required.
2. Motor Space Heaters: Required.

B. Motors for fans specified for use with variable frequency drives shall be inverter duty type.

C. Motors shall not operate into service factor in any case.

D. Motors shall be suitable for operation within a Class 1, Division 2, Group D classified area.

2.13 SOURCE QUALITY CONTROL

A. General:

1. Factory run test and wheel dynamic balance for each fan.
2. Factory Test: Vibration test for each fan.
3. Factory Sound and Performance test for each fan size.

B. Sound and Performance:

1. Perform factory noise tests in accordance with AMCA 300 and AMCA 301 for each fan size.
2. Fan sound power levels (dB, Reference 10^{-12} Watts) shall be no greater than scheduled values.

3. Perform factory performance testing for air flow and static pressure for each fan size in accordance with AMCA 210. Provide written records of performance test as part of Informational Submittals.

C. Balancing: Unless noted otherwise, each fan wheel shall be statically and dynamically balanced to ASA S2.19 Grade G6.3.

D. Vibration Test:

1. Furnish factory run vibration test for fans with a 5-hp or larger motor, including vibration signatures taken on each bearing in horizontal, vertical, and axial direction.
2. Vibration reading as measured at scheduled rotational speed shall not exceed the following values when fan is rigidly mounted (filter in):
   a. Direct Drive: 0.10 inch per second peak velocity.
3. Provide written records of run test and vibration test as part of Informational Submittals.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install fans level and plumb.

B. Alignment: Laser shaft alignment and adjust and/or shim as necessary to ensure fan shaft alignment is within factory specifications performed by an independent testing agent. Submit alignment report to Engineer for review. Functional testing may not proceed until laser shaft alignment is complete and accepted by Engineer.

C. Scroll Drains: Pipe drain connection through running trap to drain location as indicated on the Drawings.

D. Labeling: Label fans in accordance with Article Accessories.

E. Service Access: Locate units to provide access spaces required for motor, bearing servicing, and fan wheel/shaft removal.

F. Equipment Support and Restraints:

1. Secure vibration controls to concrete bases using anchor bolts cast in concrete base.
2. Install fans with stainless steel shim plates under mounting pads of the isolation spring mounts. Cut shims to match the footprint of the spring mount. Do not use grout or leveling nuts under the isolation spring mounts.
3. Seismic Restraint Snubbers: Install with sufficient clearance so unit isolators are not restricted for proper free isolation but do limit movement in all directions.

G. Connections:

1. Section 15892, Foul Air Ductwork and Accessories.
2. Isolate duct connections to fans with flexible connections.
3. Install ductwork adjacent to fans to allow proper service and maintenance.
4. Connect fan housing grounding connection to suitable ground.

3.02 FIELD QUALITY CONTROL

A. Functional Tests:

1. Verify blocking and bracing used during shipping are removed.
2. Verify fan is secure on mountings and supporting devices, and connections to ducts and electrical components are complete.
3. Verify proper thermal-overload protection is installed for motors, starters, and disconnect switches.
4. Verify that cleaning and adjusting are complete.
5. Disconnect fan shaft from motor; verify proper motor rotation direction, and verify fan wheel free rotation and smooth bearing operation.
6. Reconnect fan shaft coupling system; align shafts and install safety guards.
7. Verify lubrication for bearings and other moving parts.
8. Verify fan isolation dampers in connected ductwork are in fully open position.

B. Performance Tests:

1. Starting Procedures:
   a. Energize motor and adjust fan to indicated revolutions per minute.
   b. Measure and record motor voltage and amperage.
2. Operational Test:
   a. After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
   b. Repair or replace malfunctioning units; retest as specified after repairs or replacement is made.
   c. Test and adjust control safeties.
   d. Replace damaged and malfunctioning controls and equipment.

C. Vibration Tests:

1. Test each fan for vibration after the completion of function tests, performance tests, and system balancing.
2. Dynamically balance wheels to Balance Quality Grade G6.3 per ANSI S2.19.
3. Test each assembled fan as installed at the rated fan rpm.
4. Take vibration signatures on each fan bearing in the horizontal, vertical, and axial directions.
5. The maximum allowable fan vibration level shall be as follows (all values are filter in):
   a. Direct Drive, Flexibly Mounted: 0.3 inch per second peak velocity.
   b. Direct Drive, Rigidly Mounted: 0.2 inch per second peak velocity.
6. Field-balance fans exceeding the maximum allowable vibration level until acceptable vibration levels are attained.
7. Replace fans that cannot be field balanced to within acceptable vibrational levels.

3.03 MANUFACTURER’S SERVICES

A. Provide manufacturer’s representative at site in accordance with Section 01640, Manufacturers’ Services and Training, for installation assistance, inspection and certification of proper installation, equipment testing, startup assistance, and training of Owner’s personnel for specified component, subsystem, equipment, or system.

B. Manufacturer's Representative:

1. Present at site or classroom designated by Owner, for minimum person-days listed below, travel time excluded:
   a. 1/2 person-day for installation assistance and inspection.
   b. 1/2 person-day for functional and performance testing and completion of Manufacturer's Certificate of Proper Installation.
   c. 1/2 person-day for prestartup classroom or site training.
2. Coordinate actual times with Owner and in accordance with Section 01640, Manufacturers Services and Training.

3.04 ADJUSTING

A. Lubricate bearings.

B. Balancing: Perform air system balancing as specified in Section 15950, Testing, Adjusting, and Balancing for HVAC.

3.05 CLEANING

A. After completing system installation, including outlet fitting and devices, inspect exposed finish. Remove burrs, dirt, and construction debris, and repair damaged finishes.

B. On completion of installation, internally clean fans according to manufacturers' written instructions. Remove foreign material and construction debris.

3.06 SUPPLEMENT

A. The supplement listed below, following "End of Section," is a part of this specification:

1. Odor Control Fans Schedule.

END OF SECTION

ODOR CONTROL FANS SCHEDULE

SYMBOL				200F4111	200F4112		
LOCATION				HEADWORKS BIOFILTER	HEADWORKS BIOFILTER		
TYPE				UTILITY BLOWER SWSI FIBERGLASS	UTILITY BLOWER SWSI FIBERGLASS		
FAN DATA	AIRFLOW	MAX	CFM	29,000	29,000		
		@ SP	IN W.G.	8.0	8.0		
		MIN	CFM	-	-		
	SPEED	RPM		1170	1170		
	DRIVE TYPE			DIRECT	DIRECT		
	WHEEL	TYPE		BI	BI		
		MIN. DIA.	INCH	42	42		
	MAXIMUM	BHP		52	52		
SOUND DATA	SOUND POWER LEVEL		63	104	104		
	dB (RE 10^{-12} W)		125	105	105		
	@ MID OCTAVE BAND		250	100	100		
	FREQUENCY (Hz)		500	97	97		
			1K	94	94		
			2K	92	92		
			4K	87	87		
			8K	81	81		
ELECTRICAL DATA	MOTOR		HP	60	60		
			RPM	1200	1200		
			ENCL.	TEFC	TEFC		
	VOLT			460	460		
	PH			3	3		
MAXIMUM DIMENSIONS	LENGTH		INCHES	116	116		
	WIDTH		INCHES	42	42		
	HEIGHT		INCHES	115	115		
	WEIGHT		LBS	2500	2500		
MANUFACTURER				NY Blower			
MODEL NO.				FE-42-MP			
APPLICABLE REMARKS:				A, B, C, D	A, B, C, D		

ABBREVIATIONS: FC: FORWARD CURVED BI: BACKWARD INCLINED AF: AIR FOIL

REMARKS:

FAN HOUSING RADIATED NOISE AT 5 FEET AND Q=1 SHALL NOT EXCEED 78 dBA (DUCTED) (WITHOUT ACOUSTIC HOUSING WR.

A: DIRECT DRIVE, ARRANGEMENT 8.

B: SPRING FEET ISOLATORS AND UNITARY BASE WITH HEIGHT-SAVING CLIPS

C: ACOUSTIC JACKET FOR FAN HOUSING (3" THICK) FOR NO GREATER THAN 65 dBA at 5 feet (Q=2)

D. VIBRATION MONITORS.

SECTION 15850
AIR OUTLETS AND INLETS

PART 1 GENERAL

1.01 DEFINITIONS

A. NC: Noise Criteria; background sound rating method for indoor sound.

B. VAV: Variable air volume.

C. WC: Water column.

1.02 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
   a. Manufacturer’s data and descriptive literature for products specified.
   b. Furnish the following information for each type of diffuser, register, and grille furnished.
      1) NC sound data.
      2) Static pressure loss data.
      3) Throw data.

PART 2 PRODUCTS

2.01 EXHAUST GRILLES AND REGISTERS

A. Louvered Exhaust Grilles and Registers (EG1, ER1):

1. Construction: As follows.
   a. Material: Type 316 or Type 304 stainless steel for foul air service.
   b. Finish: Bare, stainless steel.
   c. RR and ER Register Accessories:
      1) Gang-operated opposed-blade volume control damper.
      2) Material to match grille.
2. Fixed horizontal louvers set at 35 degrees to 45 degrees.
3. 1-inch minimum flat, rectangular frame.
4. Manufacturers and Products:
   a. Krueger; 9S80 Series.
   b. Carnes; Type RLRB.
   c. Titus; 350RL-SS.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install diffusers, grilles, and registers tight on their respective mounting surfaces, level, plumb, and true with room dimensions.

END OF SECTION

SECTION 15892
FOUL AIR DUCTWORK AND ACCESSORIES

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. Air Movement and Control Association (AMCA): 500-D, Laboratory Methods of Testing Dampers for Rating.
2. American National Standards Institute (ANSI).
3. American Society of Mechanical Engineers (ASME):
   a. B16.1, Gray Iron Pipe Flanges and Flanged Fittings (Classes 25, 125, and 250).
   b. B16.5, Pipe Flanges and Flanged Fittings NPS 1/2 through NPS 24.
   c. B18.22.1, Plain Washers.
4. ASTM International (ASTM):
   a. A193/A193M, Standard Specification for Alloy-Steel and Stainless Steel Bolting Materials for High Temperature or High Pressure Service and Other Special Purpose Applications.
   b. A194/A194M, Standard Specification for Carbon and Alloy Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both.
   c. C582, Standard Specification for Contact-Molded Reinforced Thermosetting Plastic (RTP) Laminates for Corrosion Resistant Equipment.
   d. D2240, Standard Test Method for Rubber Property -Durometer Hardness.
   e. D2996, Standard Specification for Filament-Wound “Fiberglass” (Glass Fiber Reinforced Thermosetting Resin) Pipe.
   f. D3982, Standard Specification for Contact Molded “Fiberglass” (Glass Fiber Reinforced Thermosetting Resin) Duct and Hoods.
   g. E84, Standard Test Method for Surface Burning Characteristics of Building Materials.
5. Sheet Metal and Air Conditioning Contractors’ National Association, Inc. (SMACNA):
   a. Thermoset FRP Duct Construction Manual.
   b. HVAC Air Duct Leakage Test Manual.

1.02 DUCT DIMENSIONS

A. Duct dimensions shown on the contract drawings are the airflow area.

1.03 DUCT SUPPORTS AND SEISMIC REQUIREMENTS

A. Design and install duct supports and systems in accordance with local codes. In addition, comply will all requirements of Section 01612, Anchorage and Bracing. See Section 01455, Special Tests and Inspections, for equipment and components requiring Certification of Compliance for Seismic Testing or Analysis.

B. Bracing and supports shall be designed and located to avoid conflicts with other building systems including piping, lighting, structural, and monorail travel. Location and orientation shall be acceptable to Engineer.

C. Materials of Construction:

1. Foul Air Duct shall meet the following material of construction requirements. Refer to Area Classification and Material Selection Table shown on the Drawings:

Exposure Conditions	**Material**
Outdoor Areas	Fiberglass reinforced plastic ductwork as specified in this section.
Indoor Areas	Type 316L stainless steel, internally coated, as specified in Section 15812 Metallic Process Ductwork.

1.04 SUBMITTALS

A. Action Submittals:

1. Duct and Fittings:
   a. Statement of resins and reinforcing proposed for use.
   b. Pressure, vacuum, and temperature rating of duct.
   c. Dimensions of subassemblies to be shipped.
   d. Manufacturer’s data and descriptive literature for duct accessories.
   e. Shop Drawings showing layout, support, and joint details.
   f. Details of fitting construction including lengths, joint, offsets and angle of transitions.
   g. Stamped and signed structural engineering design calculations.
   h. Name of manufacturer.
   i. Gel coat color chart. Provide three physical samples, 4-inch by 6-inch with different shades of color specified herein.

2. Expansion Joints:
   a. Type and model.
   b. Materials of construction.
   c. Name of manufacturer.
3. Supports:
   a. Location plan.
   b. Type and details.
   c. Materials of construction.
   d. Stamped and signed structural engineering design calculations for special supports. See Section 01612, Anchorage and Bracing, for specific requirements. See Section 01455, Special Inspection, Observation, and Testing, for equipment and components requiring certification of compliance for seismic testing or analysis.
4. Butterfly Dampers:
   a. Statement of resins and reinforcing proposed for use.
   b. Pressure, vacuum, and temperature rating.
   c. Materials of construction.
   d. Total weight including operator.
   e. Drawings showing overall dimensions and connection size.
   f. Operator type and manufacturer’s catalog data.
   g. Type and model.
   h. Name of manufacturer.
5. Flanges at all locations used.

B. Informational Submittals:

1. Qualifications:
   a. Fabricator: List of references substantiating experience.
   b. Installer: Manufacturer’s certification that installer is qualified for installation work.
2. Manufacturer’s Certificate of Compliance, in accordance with Section 01640, Manufacturers’ Services and Training.
3. Seismic anchorage and bracing calculations as required by Section 01612, Anchorage and Bracing.
4. Manufacturer’s factory inspection report.
5. Manufacturer’s installation instructions.
6. Manufacturer's Certificate of Proper Installation.
7. Detailed information on structural, mechanical, electrical, or other modifications necessary to adapt the arrangement or details shown to the ductwork installation.
8. Component and attachment testing seismic certificate of compliance as required by Section 01455, Special Inspection, Observation, and Testing.

9. Butterfly Dampers: AMCA 500-D leakage test results by AMCA-approved laboratory.

1.05 QUALITY ASSURANCE

A. Fabricator Qualifications: Minimum 5 years' experience.

B. Installer Qualifications: Minimum 5 years' experience.

C. FRP Joint Installer: Manufacturer certified.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Do not ship ducting by nesting small diameter components inside larger diameter components.

B. Protect flanged sections by bolting to the flange wooden blinds 2 inches greater than outside diameter of the flange.

C. For unflanged components use either rigid plugs inside the ends to prevent deflection or protect with wooden boxes.

D. Crate materials whenever practical prior to shipment.

E. Firmly fasten and pad components shipped to prevent shifting of the load or flexing of components while in transit.

F. Inspect shipments upon delivery. Note damages and discrepancies on bill of lading and notify manufacturer within 24 hours.

PART 2 PRODUCTS

2.01 GENERAL

A. Service Conditions: Ductwork and accessories shall be located in hydrogen sulfide (H_2S) rich environment. Ductwork and accessories will be exposed to (H_2S) gas to a maximum of 5 ppm saturated with water vapor.

B. FRP Ducting: Drawings do not indicate all field joint locations. It is anticipated bell and spigot or flanged duct connections shall be used throughout where inside overlay is not possible. Duct manufacturer shall indicate all field joint locations and type on the submitted Shop Drawings. Flange duct connections shall be provided as needed and where indicated on the Drawings. Coordinate with duct supports. Field butt joints are not allowed.

2.02 FIBERGLASS REINFORCED PLASTIC DUCTWORK

A. Materials:

1. Resin:
   a. Resin System: Premium corrosion-resistant, fire-retardant vinylester, or other qualified thermosetting resin. Resin to be selected by fabricator, subject to approval of Engineer, and suitable for intended service with no fillers or thixotropic agents.
   b. Liner Resin: Premium grade and corrosion resistant.
   c. FRP fabrications shall not exceed a flame spread index of 25 when tested in accordance with ASTM E84 Tunnel Test.
   d. Structural wall resin shall contain a minimum of 3 percent antimony trioxide if required to achieve the designed low flame spread index requirement.
   e. Color: Use no dyes, pigments, or colorants, except in the exterior gel coat. Exterior gel coat shall be grey.
2. Method of Construction:
   a. Inner Surface: Inner surface exposed to the exhaust environment shall be a resin-rich liner between 0.01-inch and 0.02-inch thick obtained by using one layer of Nexus veil saturated with the specified resin.
   b. Interior Layer: Resin-rich interior surface of nominal 100 mils thick to 120 mils thick for the entire corrosion barrier, using chopped strand glass mat or chopped glass roving backing the veil. Use no additive in the corrosion barrier. The inner surface and interior layer shall have a glass content of 27 percent plus or minus 5 percent.
   c. Structural Layer:
      1) Fabricated using either hand lay up construction or filament wound. Structural layer shall not be less than the following thicknesses:

Diameter (inches)	Thickness (inches)
6 – 18	1/8
20 – 28	3/16
30 – 58	1/4

   d. Exterior Coat: Resin rich with no exposed raw fibers. For exterior duct, gel coat with ultraviolet (UV) inhibitor.
3. Reinforcement:
   a. Chopped Strand Mat: Type E glass, minimum 1-1/2 ounces per square foot, with silane finish and styrene soluble binder.
   b. Continuous Roving for Chopper Gun Spray-Up: Type E glass.

c. Woven Roving: Type E glass, nominal 24 ounces per square yard, 4 by 5 weave, with silane type finish.
d. Continuous Roving for Filament Winding: Type E glass with a silane type finish.

4. Fasteners:
   a. Bolts: ASTM A193/A193M, Type 316 stainless steel, ANSI B18.2.1, ASA coarse thread series, Grade B 8M heavy hex head. Length such that after installation bolts will project 1/8-inch to 3/8-inch beyond outer face of the nut.
   b. Nuts: ASTM A194/A194M, Type 316 stainless steel, ANSI B18.2.2, Grade 8M.
   c. Washers: ANSI B18.22.1, flat, Type 316 stainless steel.

B. Ductwork Design:

1. Design Requirements:
   a. Conform to ASTM D2996, ASTM D3982 and/or SMACNA Thermoset FRP Duct Construction Manual.
   b. Duct manufacturer’s design for round section, including duct wall thickness and stiffeners.
   c. A 1/4-inch laminate shall have the following minimum physical properties:
      1) Minimum Ultimate Tensile Strength: ASTM D638, 12,000 psi.
      2) Minimum Flexural Strength: ASTM D790, 19,000 psi.
      3) Minimum Flexural Modulus of Elasticity (Tangent): ASTM D790, 800,000 psi.
   d. Take into account expansion from seasonal temperature variations.
   e. Provide duct with extra wall thickness as required to support duct at elevated spans or for cantilever where shown on the Drawings.
   f. Corrosion liner and barrier thicknesses shall not be included in the ductwork structural calculations.
2. Service Conditions:
   a. System Maximum Pressure: 10 inches of water column.
   b. System Maximum Vacuum: 10 inches of water column.
   c. Service: Hydrogen sulfide rich (5 ppm) air saturated with water vapor.
   d. Location: Outside as indicated on the Drawings.
   e. Ambient Temperature: 15 degrees F to 100 degrees F.
   f. Seismic Requirements: As shown on the Structural Drawings.
   g. Wind and Snow Loads: As shown on the Structural Drawings.

C. Ductwork Fabrication:

1. Fittings and special sections shall be reinforced or their shell thickness increased where combined stresses due to internal pressure and bending will exceed maximum stress. Shell thickness or reinforcing shall be as required to keep combined stresses below maximum recommended.
2. Round duct shall have a safety factor of 10 to 1 for pressure and 5 to 1 for vacuum service. Rectangular duct design criteria shall be submitted to the Engineer for review and approval. Rectangular duct design shall be based on a maximum 1 percent side wall deflection.
3. Flanged connections or bell and spigot wrapped connections shall be used as required.
4. Flange dimensions (except thickness) and drilling patterns for all flanges that connect to equipment are to correspond to ASME/ANSI B16.5, Class 150 or ASME/ANSI B16.1, Class 125. All other flanges shall comply with ASTM D3982, rated for specified pressure and vacuum. In all cases, Contractor shall coordinate with duct supplier and equipment supplier to match equipment flange dimensions and bolt pattern.
5. Furnish gussets on flanged nozzles from ducts.
6. Back Face of Flanges: Spot-faced, flat, and parallel to the flange face, and of sufficient diameter to accept an SAE metal washer under the bolt head or nut.
7. Duct and Fittings:
    a. Round: Contact molded or filament wound, meeting requirements of ASTM D3982 or D2996, as applicable.
    b. Rectangular: Contact molded to a thickness as dictated by structural calculation; reinforcing with angles or tees is acceptable to meet required pressure/vacuum service.
    c. Joints: Butt wrapped, bell and spigot, or flanged except all flanged at connections to expansion joints, butterfly valves, blast gates, or mechanical equipment to facilitate disassembly.
    d. Fittings: Plain end or flanged, manufacturer’s standard sizes. Comply with ASTM D3982 with a chemical resistance equal to or greater than the duct.
    e. Gaskets: Full-face, ASTM D2240, Type A Durometer 50-70; 3/16-inch minimum thickness, EPDM.
    f. Flanges for Duct to Duct Connections and Duct Wall Thicknesses: ASTM D3982, rated for specified pressure and vacuum.

g. Transitions: Glass-fiber reinforced, with wall stiffness equal to that of duct, designed using the pipe design criteria. Maximum deflection of a side shall be less than 1 percent of the width of that side at the design internal pressure. Shop-installed reinforcing such as ribs or angles shall be used if required to meet deflection requirements.
h. All elbow fittings shall have a centerline radius of 1.5 times duct diameter unless indicated otherwise or if site conditions dictate less. All elbow fittings 24-inch and below shall have a smooth non segmented radius unless indicated otherwise.
i. Install seismic restraints on all ductwork systems and sway bracing as described in SMACNA “Guidelines for Seismic Restraints of Mechanical Systems” and per Structural notes.

8. Marking:
   a. Identify each duct component with the fabricator’s name, resin, minimum thickness, and date of manufacture.
   b. Use permanent marking. Seal decals and labels into laminate exterior with resin.
   c. For piece marking used for installation, use oil-based paint for easy removal.
9. Cure products to at least 90 percent of the minimum Barcol hardness specified by resin manufacturer.

D. Manufacturers:

1. Spundstrand.
2. ECS Environmental Solutions.
3. Daniel Company.

2.03 FIBERGLASS REINFORCED PLASTIC BUTTERFLY DAMPERS

A. Dampers:

1. Single-blade type, complete with channel-type frame, close-fitting axle, and bearings.
2. Same inside diameter as connecting ductwork and supplied with matching flanged ends.
3. Shaft shall be Type 316 stainless steel and shall be continuous through damper.
4. When used for isolation service, shall be furnished with blade seal and shaft seal.
5. When used for balancing only, shall be furnished with full circumference molded in blade stop.

6. Isolation dampers shall have maximum leakage rate of 5.25 cubic feet per minute per square foot of damper area, at a differential pressure of 30 inches WC.

B. Design Requirements:

1. Each damper shall be designed for the following conditions:
   a. Air Temperature Range: 20 degrees F to 100 degrees F.
   b. Differential Pressure: 15-inch WC.

C. Materials:

1. FRP materials for dampers shall be same resin as used in ductwork.
2. Requirements for flame spread and smoke development shall be same as required for ductwork.

D. Construction:

1. Frames: Fiberglass reinforced plastic with resin as described herein.
2. Blades: Fiberglass reinforced plastic with resin as described herein. Blade thickness and stiffeners as required to meet design conditions.
3. Axles: Continuous stainless steel rod. Axle to extend 6 inches beyond frame.
4. Bearings: Molded PTFE.
5. Blade Stops: FRP with resin as described herein.
6. Blade Seals: Neoprene.
7. Shaft Seals: Neoprene.
8. Flanges: As specified to match ductwork flanges.
9. Color: Exterior gel coat to match FRP ductwork.

E. Lever Actuators:

1. Provide for dampers 24-inch diameter and smaller:
   a. Hand quadrant type.
   b. Constructed of Type 316 stainless steel.
   c. Locking quadrant suitable for positioning the blade at intermediate position.
2. Provide for dampers larger than 24-inch diameter:
   a. Hand actuators shall be worm geared driven.
   b. Actuators shall be totally enclosed, weather-proof, and permanently lubricated in a die-cast aluminum housing.
   c. Housing shall be epoxy-coated in the factory with a minimum dry film thickness of 8 mils.
   d. Hand wheel sizes shall be computed assuming a maximum rim effort of 80 pounds.

e. Actuator shall be bolted to damper with Type 316 stainless steel bolts as required.
f. Actuators shall be capable of being rotated about the damper shaft in 90-degree increments.
g. Number of turns of hand wheel in order to rotate blade 90 degrees: Minimum of four and maximum of twelve.
h. Provide indicating arrows identifying direction of rotation for correct operation of dampers with “Open” and “Close” clearly marked. Indication shall be legible and of substantial durability.
i. Hand actuators shall be Dynatorque DT Model 8 “or-equal.”

3. Provide chain wheel accessory for installations over 7 feet above adjacent level.
   a. Chain wheels shall be equipped with a chain guide, which will permit rapid handling of the operating chain without “gagging” of the wheel.
   b. Reasonable side pull on the chain shall be permitted by the chain wheel without “gagging” of the wheel.
   c. Provide suitable actuator extensions, if necessary, to prevent interference of chain and adjacent piping or facilities below.
   d. Operating chains shall be hot dip galvanized carbon steel. Loop and extend within 4 feet of the floor below damper.
   e. Provide and install galvanized tie back hooks on adjacent pipe supports or structures to hold operating chains out of walkways or access areas when damper is not in operation.

F. Manufacturers:

1. Spundstrand BA (Balancing type) or Zero-leak (Isolation).
2. ECS Environmental Solutions X01 (Balancing type), X02 (Isolation).
3. Swartwout 914 (balancing or isolation).

2.04 SUPPORTS

A. Supports for foul air ductwork shall be provided as work of Section 15060, Piping Support Systems, and as shown on the Drawings.

1. Ductwork to be designed to span supports as shown on the Drawings.
2. Maximum Duct Deflection: 1/2 inch, including special sections at road crossings.
3. Support Spacing:
   a. 24 Inch Diameter and Larger: 20 feet, maximum.
   b. 20 Inch Diameter and Smaller: 12 feet, maximum.

2.05 EXPANSION JOINTS/FLEXIBLE CONNECTIONS

A. Provide where required for proper duct installation. Expansion joints and flexible connections shall be flanged type unless specifically indicated to be plain end (slip-on) type on the Drawings.

B. Material: Fabric-reinforced EPDM resistant to UV light; continuous wrapping of material shall not be permitted.

C. Flanged type expansion joints shall be W-design configuration, constructed with compound curve molded corners with arch premolded. Corners on rectangular expansion joints shall be completely molded and free of splices.

D. Backing Rings: 3/8-inch thick, 2 inches wide, Type 316 stainless steel, ANSI/ASME B16.1, Class 25 diameter and drilling.

E. Length:

1. 12 inches, Flange-to-flange (sizes 24-inch diameter and larger):
   a. Extension: 1.0 inch.
   b. Compression: 4.0 inches.
   c. Lateral Offset: 3.0 inches.
2. 6 inches, Flange-to-flange (sizes 22-inch diameter and smaller):
   a. Extension: 0.5 inch.
   b. Compression: 2.0 inches.
   c. Lateral Offset: 1.0 inch.

F. Thickness: 1/4 inch, minimum.

G. Flanges shall be a minimum of 3/4-inch-thick.

H. Slip-on type expansion joints and flexible connections shall be sized to fit tightly on the outside diameter of the duct, secured in place by stainless steel worm screw type adjustable clamps to provide gas-tight connection.

I. Manufacturer and Product: Holz Rubber Company, Inc.; Style 945.

2.06 FLEXIBLE DUCT

A. Fabricate in accordance with:

1. UL 181, Class 1.
2. NFPA 90A and NFPA 90B.

B. Construction:

1. Lightweight black polyurethane wall hose construction reinforced with a spring steel wire helix.
2. Thickness: 0.02 inches.
3. Compression: 3 to 1, minimum.
4. Max Pressure Rating: 1 psi, minimum.

C. Environment: Suitable for continuous operation at temperature range of minus 20 degrees F to plus 200 degrees F.

D. Manufacturers and Products:

1. Ducting: Urethane Flex Light Duty.
2. “Or-equal.”

2.07 SAMPLE AND TEST PORTS:

A. Field or factory installed as shown on the Drawings.

B. Materials of construction FRP or PVC.

C. Port configuration shall allow the free passage of a Dwyer 160 series pitot tube.

D. Provide ports at the inlet to the biofilter and at the inlet and outlet of each fan as shown on the Drawings. Locate to allow for pressure testing and air sampling.

E. Provide ports for each branch connection upstream of each balancing damper. Locate to allow for flow rate measurement pressure testing and air sampling.

F. Where possible locate port in the side of the duct. Test ports shall not be located in the bottom 90-degree arc of the duct.

2.08 DUCTWORK IDENTIFICATION

A. Refer to Piping Schedule on the Drawings for identification requirements.

B. Painted Identification Materials:

1. Stencils: Standard metal stencils, prepared for required applications with letter sizes generally comply with recommendations of ASME A13.1 for piping and similar applications, but not less than 1-1/4-inch-high letters for ductwork and not less than 3/4-inch-high letters for access door signs and similar operational instructions.

2. Stencil Paint: Standard exterior type stenciling enamel; black, except as otherwise indicated; either brushing grade or pressurized spray can form and grade.
3. Identification Paint: Standard identification enamel of colors indicated or in accordance with ASME A13.1 for colors for systems not identified herein.

C. Plastic Duct Markers:

1. General:
   a. Provide manufacturer's standard laminated plastic, color-coded duct markers. Conform to the following color code:
      1) White Text on Blue Background: Foul air.
      2) For other hazardous exhausts, use colors and designs recommended by ASME A13.1.

D. Nomenclature:

1. Include the following:
   a. Direction of air flow.
   b. Duct service (foul air).

E. Manufacturers:

1. W.H. Brady, Co.
2. Seton Identification Products.
3. Craftmark.
4. Brimar Industries, Inc.

2.09 SOURCE QUALITY CONTROL

A. Factory Inspections: Inspect fabrications for required construction, intended function and conformance with referenced standards.

B. Inspection of products is required prior to shipment unless specifically waived in writing by Engineer.

C. Notify Engineer 1 week prior to the estimated date of inspection.

D. Repairs authorized by Engineer shall be reinspected before final acceptance unless specifically waived.

PART 3 EXECUTION

3.01 GENERAL

A. Ductwork shall be free of vibration when in operation. All necessary vibration isolation devices shall be provided and installed by Contractor.

B. Install plumb and straight and in proper alignment. For sloping ductwork, install at 1/8-inch per foot minimum in direction of flow or 1/4 inch per foot minimum in opposite direction of flow to allow internal condensation to drain to drainage points.

C. Provide drain connections at all low point locations whether shown on the Drawings or not. Drain pipe shall include a P-trap or valve as shown on the Drawings.

D. All necessary provisions shall be taken to provide for adequate expansion and contraction of ductwork and fittings.

E. Anti-seize thread compound shall be applied to all nuts and bolts.

F. Proper alignment and grade of ductwork shall be maintained by use of laser beam equipment or surveying instruments. Surveying instruments shall be utilized for verifying laser equipment accuracy due to thermal deflection from differences between the ground temperature and the air temperature within the pipe.

3.02 PREPARATION

A. Verify dimensions and conditions in the field.

B. Lay out routing in straight lines parallel to building lines.

C. Coordinate support locations with layout and joints.

3.03 FRP DUCTWORK INSTALLATION

A. Ductwork:

1. Cut, fit, and install in accordance with duct manufacturer’s recommendations. The SMACNA manual may be used for guidance, but duct manufacturer’s recommendations shall take precedence.
2. Seal cut edges with compatible resin.
3. Flange bolts shall be tightened to slightly compress gaskets without disturbing the flanges in order to make a good seal. A flat washer shall be installed under each nut and bolt head.

B. Field Joints:

1. Provide material in kit form; one kit for one joint.
2. Make joints only when ambient temperature is above 55 degrees F and below 100 degrees F.
3. Made by manufacturer-certified installer.

C. Dampers: Unless otherwise necessary for proper operation of damper, axles shall be installed in the horizontal position.

3.04 DUCTWORK HANGERS AND SUPPORTS

A. Install ductwork with support systems in accordance with SMACNA Manual, unless otherwise noted.

B. Support ducts rigidly with suitable ties, braces, hangers, and anchors of type, which will hold ducts true-to-shape and to prevent buckling.

C. Support horizontal ducts within 2 feet of each elbow and within 4 feet of each branch intersection.

D. Support vertical ducts at maximum interval of 16 feet and at each floor.

E. Upper attachments to structures shall have allowable load not exceeding 1/4 of failure (proof test) load, but are not limited to specific methods indicated.

F. In new construction, install concrete insert prior to placing concrete.

G. Install seismic restraints on ductwork systems and sway bracing as described in SMACNA Guidelines for Seismic Restraints of Mechanical Systems.

H. Install rubber caps on the ends of all support channels.

3.05 DAMPERS

A. General:

1. Inspection:
   a. Inspect areas to receive dampers.
   b. Notify Engineer of conditions that would adversely affect installation or subsequent utilization of dampers.
   c. Do not proceed with installation until unsatisfactory conditions are corrected.
2. Install dampers at locations indicated on the Drawings and in accordance with manufacturer’s installation instructions.

3. Install square and level.
4. Handle damper using sleeve or frame. Do not lift damper using blades or jack-shaft.
5. Damper blades and hardware shall operate freely without obstruction.

3.06 EXPANSION JOINTS INSTALLATION

A. Install such that flexible molded boot is not concave or otherwise twisted or deformed during normal operating conditions.

3.07 FLEXIBLE DUCTWORK

A. Install flexible ductwork in a manner that allows one radius elbows.

B. Field verify flexible duct connectors and replace in kind.

3.08 CLEANING

A. Ductwork shall be blown clean using the system fans; purged continuously for not less than 48 hours at a flow rate not less than the design flow rate. If required, the system fan shall be throttled on the inlet side to prevent motor overload. A temporary screen shall be installed on the system fan inlet to protect the fan from entering debris.

B. Dampers shall be smooth, clean, and free from blisters and dirt when installed.

3.09 FIELD TESTING

A. All ductwork specified in this section shall be field pressure tested after installation and before concealment or burying. Any leaks shall be corrected and the duct retested until no further leaks appear. Test methods shall be in accordance with SMACNA 016-2012 HVAC Air Duct Leakage Test Manual at pressure indicated in Piping Schedule.

3.10 ADJUSTING

A. After duct leakage testing, provide complete air balancing of entire system as described in Section 15950, Testing, Adjusting, and Balancing for HVAC.

END OF SECTION

SECTION 15950
TESTING, ADJUSTING, AND BALANCING FOR HVAC

PART 1 GENERAL

1.01 SUBMITTALS

A. Informational Submittals:

1. Documentation of experience record of testing authority.
2. Documentation of current AABC or NEBB certifications for those technicians in responsible charge of the work under this Contract.
3. Submit detailed test and balance procedures, including test conditions for systems to be tested, prior to beginning the Work.
4. Written verification of calibration of testing and balancing equipment.
5. Balancing Log Report following completion of system adjustments including test results, adjustments, and rebalancing procedures.

1.02 QUALITY ASSURANCE

A. Air Balancing and Test Agency Qualifications:

1. Certification by AABC of NEBB for testing, adjusting, and balancing of HVAC systems.
2. Corporately and financially independent organization functioning as an unbiased testing authority.
3. Professionally independent of manufacturers, suppliers, and installers of HVAC equipment being tested.
4. Have a proven record of at least five similar projects.
5. Employer of engineers and technicians regularly engaged in testing, adjusting, and balancing of HVAC equipment and systems.

PART 2 PRODUCTS

2.01 MATERIALS

A. Provide materials, tools, test equipment, computers and instrumentation required to complete the work included.

B. Test Hole Plugs: Plug test holes in ducts with plugs made for that purpose and replace any insulation removed to specified conditions.

C. Drives for Belt-Driven Fans:

1. Furnish cast iron or flanged steel sheaves.
2. Sheaves and belt combination shall be capable of providing 150 percent of motor horsepower.

PART 3 EXECUTION

3.01 GENERAL

A. Adjust and balance air systems in accordance with standard procedures and recognized practices of the AABC or SMACNA.

B. Adjust and balance the following systems:

1. Supply and foul air systems.

3.02 ADJUSTING AND BALANCING AIR AND FOUL AIR SIDES

A. Preparation:

1. Prior to beginning the Work, perform the following activities:
   a. Review Shop Drawings and installed system for adequate and accessible balancing devices and test points.
   b. Recommend to Engineer dampers that need to be added or replaced in order to obtain proper air control.
   c. Verify proper startup procedures have been completed on the system
   d. Verify controls installation is complete and system is in stable operation under automatic control.
   e. Verify test instruments have been calibrated to a recognized standard and are within manufacturer’s recommended calibration interval before beginning the Work.

B. General:

1. When adjustments are made to a portion of a fan system, reread other portions of that same system to determine effects imposed by adjustments. Readjust as necessary.
2. Lock and mark final positions of balancing dampers with permanent felt pen.

C. Equipment Data:

1. Collect the following data and included in final report:
   a. Type of unit.
   b. Equipment identification number.
   c. Equipment nameplate data (including manufacturer, model, size, type, and serial number).
   d. Motor data (frame, hp, volts, FLA rpm, and service factor).
   e. Sheave manufacturer, size, and bore.
   f. Belt size and number.
   g. Sheave centerline distance and adjustment limits.
   h. Starter and motor overload protection data.
   i. Include changes made during course of system balancing.

D. Fan Systems:

1. Measure fan system performance in accordance with AMCA 203.
2. In each system at least one airpath from fan to final branch duct termination shall have dampers fully open. Achieve final air quantities by adjusting fan speed.
3. Adjust Fan Air Volumes:
   a. Adjust fan speeds and motor drives for required equipment air volumes, with allowable variation of plus 10 percent minus 0 percent.
   b. After final adjustments, do not operate motor above nameplate amperage on any phase.
   c. After final adjustments, do not operate fan above maximum rated speed.
   d. Perform airflow test readings under simulated or actual conditions of full cooling, full heating, minimum outside air, full outside air and exhaust, and full return air.
   e. Provide and make drive and belt changes on motors or fans as required to adjust equipment to specified conditions. Drives shall be able to deliver 150 percent of motor horsepower. Provide written notice to air handling unit manufacturer and Owner if drive or belt changes were made.
4. Adjust outside air dampers, return air dampers, relief air dampers, exhaust air dampers, and motorized louvers for maximum and minimum air requirements.
5. Read and record static pressures at unit inlet and discharge, each filter set, coils, dampers, plenums, and mixing dual-duct or adjustable-volume boxes, on every supply, return, and exhaust fan for each test condition.
6. Read and record motor amperage on all phases for each test condition.

E. Air Outlets and Inlets:

1. In each system at least one air path from fan to final branch duct termination shall have dampers fully open.
2. Adjust air volumes on supply diffusers and grilles, and on return and exhaust grilles, to the quantity shown, with allowable variation of plus or minus 10 percent.
3. Adjust diffusers and grilles for proper deflection, throw, and coverage. Eliminate drafts and noise where possible.
4. After final adjustments are made secure dampers to prevent movement and mark final positions with permanent felt pen.
5. An induced flow stack measures the following valves:
   a. Inlet flow and pressure.
   b. Outlet flow.
   c. Calculated induced flow.

F. Duct Systems: Air flows at grilles and registers, when added, shall agree with associated fan measured flow within 10 percent disparity greater than 10 percent indicates excessive duct leakage, which must be rectified by Contractor.

3.03 FIELD QUALITY CONTROL

A. General: Perform functional tests as required by Section 01756, Testing and Facility Startup.

B. Performance Testing:

1. Vibration Testing: Upon completion of air system balance, perform vibration testing as specified below for the odor control fans.
   a. Test Procedures:
      1) Identify maximum vibration velocity limits as specified for each piece of equipment to be tested.
      2) Take measurements at each bearing housing using calibrated electronic analyzer.
      3) Measure velocity in direction parallel to rotating shaft, and in two directions perpendicular to shaft and to each other. Align measurement directions where possible to the horizontal and vertical planes.
      4) Record log shall include equipment symbol or tag, location, identification, specified vibration velocity limits, and maximum measured velocity in each direction.
      5) Notify Engineer if amplitude exceeds upper limit specified.

C. Balancing Log Report Requirements:

1. Include narrative description for each system explaining TAB methodology and assumptions used. Clearly identify test conditions for tests performed. Include control setpoint.
2. Log and record operational information from every test for each system, as necessary to accomplish services described.
3. Include equipment data for units tested.
4. Include reduced set of HVAC Drawings or system schematic diagrams with each element uniquely identified and indexed to balance log.
5. Indicate recorded site values, and velocity and mass correction factors used to provide equivalent standard air quantities.
6. Include separate section in log, if necessary, describing operating difficulties in air systems that could not be eliminated by specified procedures. Identify these problems by system and location within building; include outline or summary of condition and its effect on building, and describe corrective actions attempted and recommended.

D. Quality Control Verification:

1. After adjustments have been completed and balance logs submitted, balancing, and testing agency shall be available to demonstrate the following:
   a. Air balancing procedures, vibration tests, and verification of test results.
   b. Perform spot tests on a maximum of 20 percent of total diffusers and grilles, on two air handling fan devices per building, with measuring equipment used in original tests, at random points selected by Engineer.
   c. Results of these spot tests shall agree with balance logs within plus or minus 10 percent. Where this accuracy cannot be verified, rebalance portions of system as requested by Engineer.
   d. At completion of rebalance procedures, perform another spot test if required to verify results.

END OF SECTION

SECTION 15955
PROCESS PIPING LEAKAGE TESTING

PART 1 GENERAL

1.01 SUBMITTALS

A. Informational Submittals:

1. Testing Plan: Submit prior to testing and include at least the information that follows.
   a. Testing dates.
   b. Piping systems and section(s) to be tested.
   c. Test type.
   d. Method of isolation.
   e. Calculation of maximum allowable leakage for piping section(s) to be tested.
2. Certifications of Calibration: Testing equipment.
3. Certified Test Report.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 PREPARATION

A. Notify Engineer in writing 5 days in advance of testing. Perform testing in presence of Engineer.

B. Pressure Piping:

1. Install temporary thrust blocking or other restraint as necessary to protect adjacent piping or equipment and make taps in piping prior to testing.
2. Wait 5 days minimum after concrete thrust blocking is installed to perform pressure tests. If high-early strength cement is used for thrust blocking, wait may be reduced to 2 days.
3. Prior to test, remove or suitably isolate appurtenant instruments or devices that could be damaged by pressure testing.

4. New Piping Connected to Existing Piping:
   a. Isolate new piping with grooved-end pipe caps, spectacle blinds, blind flanges, or as acceptable to Engineer.
   b. Test joint between new piping and existing piping by methods that do not place entire existing system under test load, as approved by Engineer.
5. Test Pressure: As indicated on Piping Schedule.

C. Test section may be filled with water and allowed to stand under low pressure prior to testing.

D. Gravity Piping:

1. Perform testing after service connections, manholes, and backfilling have been completed between stations to be tested.
2. Determine groundwater level at time of testing by exploratory holes or other method acceptable to Engineer.
3. Pipe 42 Inches Diameter and Larger: Joint testing device may be used to isolate and test individual joints.

3.02 HYDROSTATIC TEST FOR PRESSURE PIPING

A. Fluid: Clean water of such quality to prevent corrosion of materials in piping system.

B. Exposed Piping:

1. Perform testing on installed piping prior to application of insulation.
2. Maximum Filling Velocity: 0.25 foot per second, applied over full area of pipe.
3. Vent piping during filling. Open vents at high points of piping system or loosen flanges, using at least four bolts, or use equipment vents to purge air pockets.
4. Maintain hydrostatic test pressure continuously for 30 minutes, minimum, and for such additional time as necessary to conduct examinations for leakage.
5. Examine joints and connections for leakage.
6. Correct visible leakage and retest as specified.
7. Empty pipe of water prior to final cleaning or disinfection.

C. Buried Piping:

1. Test after backfilling has been completed.
2. Expel air from piping system during filling.

3. Apply and maintain specified test pressure with hydraulic force pump. Valve off piping system when test pressure is reached.
4. Maintain hydrostatic test pressure continuously for 2 hours minimum, reopening isolation valve only as necessary to restore test pressure.
5. Determine actual leakage by measuring quantity of water necessary to maintain specified test pressure for duration of test.
6. Maximum Allowable Leakage:

$$L = \frac{SD(P)^{1/2}}{133{,}200}$$

where:

L	=	Allowable leakage, in gallons per hour.
S	=	Length of pipe tested, in feet.
D	=	Nominal diameter of pipe, in inches.
P	=	Test pressure during leakage test, in pounds per square inch.

7. Correct leakage greater than allowable, and retest as specified.

3.03 PNEUMATIC TEST FOR PRESSURE PIPING

A. Do not perform on:

1. PVC or CPVC pipe.
2. Piping larger than 18 inches.
3. Buried and other non-exposed piping.

B. Fluid: Oil-free, dry air.

C. Procedure:

1. Apply preliminary pneumatic test pressure of 25 psig maximum to piping system prior to final leak testing, to locate visible leaks. Apply soap bubble mixture to joints and connections; examine for leakage.
2. Correct visible leaks and repeat preliminary test until visible leaks are corrected.
3. Gradually increase pressure in system to half of specified test pressure. Thereafter, increase pressure in steps of approximately one-tenth of specified test pressure until required test pressure is reached.

4. Maintain pneumatic test pressure continuously for minimum of 10 minutes and for such additional time as necessary to conduct soap bubble examination for leakage.
5. Correct visible leakage and retest as specified.

D. Allowable Leakage: Piping system, exclusive as possible localized instances at pump or valve packing, shall show no visual evidence of leakage.

E. After testing and final cleaning, purge with nitrogen those lines that will carry flammable gases to assure no explosive mixtures will be present in system during filling process.

3.04 HYDROSTATIC TEST FOR GRAVITY PIPING

A. Testing Equipment Accuracy: Plus or minus 1/2-gallon water leakage under specified conditions.

B. Maximum Allowable Leakage: 0.16 gallons per hour, per inch diameter, per 100 feet. Include service connection footage in test section, subjected to minimum head specified.

C. Gravity Sanitary and Roof Drain Piping: Test with 15 feet of water to include highest horizontal vent in filled piping. Where vertical drain and vent systems exceed 15 feet in height, test systems in 15-foot vertical sections as piping is installed.

D. Exfiltration Test:

1. Hydrostatic Head:
   a. At least 6 feet above maximum estimated groundwater level in section being tested.
   b. No less than 6 feet above inside top of highest section of pipe in test section, including service connections.
2. Length of Pipe Tested: Limit length such that pressure on invert of lower end of section does not exceed 30 feet of water column.

E. Infiltration Test:

1. Groundwater Level: At least 6 feet above inside top of highest section of pipe in test section, including service connections.

F. Piping with groundwater infiltration rate greater than allowable leakage rate for exfiltration will be considered defective even if pipe previously passed a pressure test.

G. Defective Piping Sections: Replace or test and seal individual joints, and retest as specified.

3.05 FIELD QUALITY CONTROL

A. Test Report Documentation:

1. Test date.
2. Description and identification of piping tested.
3. Test fluid.
4. Test pressure.
5. Remarks, including:
   a. Leaks (type, location).
   b. Repair/replacement performed to remedy excessive leakage.
6. Signed by Contractor and Engineer to represent that test has been satisfactorily completed.

END OF SECTION

SECTION 16050
COMMON WORK RESULTS FOR ELECTRICAL

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes:

1. General requirements applicable to all Electrical Work.
2. General requirements for Electrical Submittals.

B. Related Sections:

1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
2. This section shall be applicable to all Division 16, Electrical specifications.
3. It is the Contractor's responsibility to schedule and coordinate the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.

C. Interfaces to Equipment, Instruments, and Other Components:

1. Drawings, Specifications, and overall design are based on preliminary information furnished by various equipment manufacturers which identify a minimum scope of supply from the manufacturers. This information pertains to, but is not limited to, instruments, control devices, electrical equipment, packaged mechanical systems, and control equipment provided with mechanical systems.
2. Provide all material and labor needed to install the actual equipment furnished, and include all costs to add any additional conduit, wiring, terminals, or other electrical hardware to the Work, which may be necessary to make a complete, functional installation based on the actual equipment furnished:
    a. Make all changes necessary to meet the manufacturer's wiring requirements.
3. Submit all such changes and additions to the Engineer for acceptance as specified in the General Conditions.

4. Review the complete set of Drawings and Specifications in order to ensure that all items related to the electrical power and control systems are completely accounted for. Include any such items that appear on the Drawings or in the Specifications from another discipline in the scope of Work:
    a. If a conflict between Drawings and Specifications is discovered, refer conflict to the Engineer as soon as possible for resolution.
5. Loop Drawings:
    a. Provide all electrical information required in the preparation of loop drawings including, but not limited to:
        1) Conduit numbers and associated signal(s) contained within each conduit.
        2) Wire numbers.
        3) Equipment terminal numbers.
        4) Junction boxes and signal(s) contained within each junction box.
        5) Equipment power sources, and associated circuit numbers.
        6) As-built drawings detailing wiring.

D. All electrical equipment and systems for the entire Project must comply with the requirements of the Electrical Specifications, whether referenced in the individual Equipment Specifications or not:

1. The requirements of the Electrical Specifications apply to all Electrical Work specified in other sections, including HVAC controls, packaged mechanical systems, LCPs, VCPs, etc.
2. Inform all vendors supplying electrical equipment or systems of the requirements of the Electrical Specifications.
3. The Owner is not responsible for any additional costs due to the failure of the Contractor to notify all subcontractors and suppliers of the Electrical Specifications requirements.

E. Special Subcontractor Requirements: As specified elsewhere in this section, provide the Work specified in the Electrical Specifications by a qualified electrical subcontractor.

F. Contract Documents:

1. General: Drawings and Specifications are complementary and are to be used together in order to fully describe the Work.
2. Specifications:
    a. The General and Supplementary Conditions of the Contract Documents govern the Work.
    b. These requirements are in addition to all General Requirements.

3. Contract Drawings:
   a. The Electrical and Instrumentation Drawings show desired locations, arrangements, and components of the Electrical Work in a diagrammatic manner.
   b. Locations of equipment, control devices, instruments, boxes, panels, etc. are approximate only; exercise professional judgment in executing the Work to ensure the best possible installation:
      1) The equipment locations and dimensions as indicated on the Drawings are approximate. Use Shop Drawings to determine the proper layout, foundation, pad requirements, and all conduit entrances from top or bottom to ensure those will align with the interior equipment layout, etc., for final installation. Coordinate with all subcontractors to ensure that all electrical equipment is compatible with other equipment and space requirements. Make changes required to accommodate differences in equipment dimensions.
      2) The Contractor has the freedom to select any of the named manufacturers as identified in the individual specification sections; however, the Engineer has designed the spatial equipment layout based upon a single manufacturer and has not confirmed that every named manufacturer's equipment fits in the allotted space and not confirmed all interconnection power and control wiring for the actual furnished manufacturer. It is the Contractor's responsibility to ensure that the equipment being furnished fits within the defined space.
   c. Installation Details:
      1) Drawings include typical installation details the Contractor is to use to complete the Electrical Work. For cases where a typical detail does not apply, develop installation details that may be necessary for completing the Work, and submit these details for review by the Engineer.
      2) Not all typical installation details are referenced within Drawing set. Apply and use typical details where appropriate.
   d. Schematic Diagrams:
      1) All controls are shown de-energized.
      2) Schematic diagrams show control function only. Incorporate other necessary functions for proper operation and protection of the system.

3) Add slave relays, where required, to provide all necessary contacts for the control system or where needed to function as interposing relays for control voltage coordination, equipment coordination, or control system voltage drop considerations.
4) Mount all devices shown on motor controller schematic diagrams in the controller compartment enclosure, unless otherwise noted or indicated.
5) Schematic diagrams are to be used in conjunction with the descriptive operating sequences in the Contract Documents. Combine all information and furnish a coordinated and fully functional control system.

1.02 REFERENCES

A. Code Compliance:

1. As specified in Section 01410, Permits and Regulatory Requirements.
2. The publications are referred to in the text by the basic designation only. The latest edition accepted by the Authority Having Jurisdiction of referenced publications in effect at the time of the bid governs.
3. The standards listed are hereby incorporated into this section.
   a. American National Standards Institute (ANSI).
   b. American Society of Civil Engineers (ASCE): ASCE 7, Minimum Design Loads for Buildings and Other Structures.
   c. ASTM International (ASTM).
   d. Illuminating Engineering Society (IES): Institute of Electrical and Electronics Engineers (IEEE).
   e. Insulated Cable Engineers Association (ICEA).
   f. International Code Council (ICC):
      1) International Code Council Evaluation Service (ICC-ES): AC 156, Acceptance Criteria for Seismic Certification by Shake Table Testing of Non-Structural Components (ICC-ES AC 156).
   g. International Society of Automation (ISA).
   h. National Electrical Manufacturers Association (NEMA): 250, Enclosures for Electrical Equipment (1,000 V Maximum).
   i. National Fire Protection Association (NFPA): 70, National Electric Code (NEC).
   j. National Institute of Standards and Technology (NIST).
   k. UL.

B. Compliance with Laws and Regulations: As specified in the General Conditions.

1.03 DEFINITIONS

A. Definitions of terms and other electrical and instrumentation considerations as set forth by:

1. IEEE.
2. NETA.
3. IES.
4. ISA.
5. NEC.
6. NEMA.
7. NFPA.
8. NIST.

B. Specific Definitions:

1. Factory Acceptance Test (FAT).
2. Instrumentation and Controls Subcontractor (ICSC).
3. Local Control Panel (LCP): Operator interface panel that may contain an HMI, pilot type control devices, operator interface devices, control relays, etc. and does not contain a PLC or RIO.
4. Local Control Station (LCS): Operator interface panel that may contain pilot type control devices, operator interface devices, etc.
5. Process Control Module (PCM):
   a. An enclosure containing any of the following devices:
      1) PLC, RTU, or RIO.
6. Process Control and Instrumentation System (PCIS).
7. Remote Telemetry Unit (RTU): A controller typically consisting of a PLC, and a means for remote communications. The remote communications devices typically are radios, modems, etc.
8. Space: That portion of the switchgear, motor control center, panel-board, switchboard or control panel that does not physically contain a device, but is capable of accepting a device with no modifications to the equipment, i.e., provide all standoffs, bus, and hardware, as part of the space.
9. Spare: That portion of the switchgear, motor control center, panelboard, switchboard, or control panel that physically contains a device with no load connections to be made.
10. System Supplier: Refer to Quality Assurance in this section.

11. Vendor Control Panel (VCP): Control panels that are furnished with equipment by a vendor other than the ICSC. These panels may contain PLCs, RIO, OIT, HMI, etc.
12. Unequipped Space: That portion of the switchgear, motor control center, panelboard, switchboard, or control panel that does not physically contain a device, standoff, bus, hardware, or other equipment.

1.04 SYSTEM DESCRIPTION

A. General Requirements:

1. The Work includes everything necessary for and incidental to executing and completing the Electrical Work as indicated on the Drawings and specified in the Specifications and reasonably inferable there from:
   a. The Electrical Drawings are schematic in nature; use the Structural, Architectural, Mechanical, and Civil Drawings for all dimensions and scaling purposes.
2. It is the intent of these Specifications that the entire electrical power, instrumentation, and control system be complete and operable. Provide all necessary material and labor for the complete system from source of power to final utilization equipment, including all connections, testing, calibration of equipment furnished by others as well as equipment furnished by the Contractor, whether or not specifically mentioned but which are necessary for successful operation.
3. Provide all Electrical Work, including conduit, field wiring, and connections by the electrical subcontractor under the provisions of the Electrical Specifications for all aspects of the Work, including heating, ventilating, and air conditioning.
4. Coordinate all aspects of the Work with the electrical Subcontractor and other subcontractors before bidding in order to ensure that all costs associated with a complete installation are included. The Owner is not responsible for any change orders due to lack of coordination of the Work between the Contractor, the electrical Subcontractor, the other Subcontractors or Suppliers.
5. Demolition:
   a. Where demolition is specified or as indicated on the Drawings, disconnect all associated electrical equipment, and render the equipment safe.
   b. Remove and dispose of all conduit, wire, electrical equipment, controls, etc. associated with the items and/or areas to be demolished as indicated on the Drawings unless otherwise indicated.
   c. Salvage electrical equipment as indicated on the Drawings.

d. For each piece of equipment to be removed, remove all ancillary components (e.g., instruments, solenoid valves, disconnect switches, etc.).
e. Conduit:
    1) Where conduit removal, other than associated with equipment to be removed, is indicated on the Drawings:
        a) Remove exposed conduit completely to source. For conduits that are partially concealed in concrete or below grade, remove exposed conduit to the point of encasement or burial.
        b) Cut conduit flush and plug or cap encased or buried conduit.
    2) Where conduits are to remain in place and removal is not indicated on the Drawings:
        a) Cap conduit open ends.
        b) Re-label empty conduits as spare.
f. Remove all wire back to the source for all conduits to be removed or abandoned in place.
g. Provide new nameplates for modified electrical distribution equipment, motor control centers etc. to identify equipment and circuits that are no longer used as spares.
h. Provide new typewritten schedules for all modified panelboards.
i. Provide KO seals in all penetrations in enclosures and equipment that are made available by the removal of conduits or raceways.
j. Seal all penetrations in walls and floors that are made available by the removal of conduits or raceways. Grout fill all penetrations in concrete.

6. Portions of this Project involve installation in existing facilities and interfaces to existing circuits, power systems, controls, and equipment:
    a. Perform and document comprehensive and detailed field investigations of existing conditions (circuits, power systems, controls, equipment, etc.) before starting any Work. Determine all information necessary to document, interface with, modify, upgrade, or replace existing circuits, power systems, controls, and equipment.
    b. Provide and document interface with, modifications to, upgrades, or replacement of existing circuits, power systems, controls, and equipment.
7. Do not penetrate existing enclosures, control panels, or equipment without the Owner present to observe the installation. The Owner shall observe the Contractor while these penetrations are created.

8. Provide all trenching, forming, rebar, concrete, back filling, hard surface removal and replacement, for all items associated with the Electrical Work and installation as specified in the Contract Documents.
9. Defective Work: As contained in Article 15 of the General Conditions.

B. Operating Facility:

1. As specified in Section 01140, Work Restrictions.
2. The facility is an operating facility. Portions of this facility must remain fully functional throughout the entire construction period. In consideration of this requirement, comply with the following guidelines:
   a. All outages must be of minimal duration and fully coordinated and agreed to by the Owner. Adjust the construction schedule to meet the requirements of the Owner. All changes in schedule and any needs to reschedule are included in the Work.
   b. As weather and water demand conditions dictate, re-adjust the construction schedule to meet the demands placed upon Owner by its users.
   c. Coordinate the construction and power renovation, bear all costs, so that all existing facilities can continue operation throughout construction.
3. According to individual circumstances and in compliance with Drawings, extend or replace conduit and cable connections from existing locations.
4. The standards of documentation, instrument tagging, cable and conductor ferruling, terminal identification and labeling that apply to the new installation apply equally to the existing installation which forms part of the modified system.

1.05 SUBMITTALS

A. Furnish submittals as specified in Section 01330, Submittal Procedures, and this section.

B. General:

1. Instruct all equipment suppliers of submittals and operation and maintenance manuals of the requirements in this section.
2. Furnish the submittals required by each section in the Electrical Specifications.
3. Adhere to the wiring numbering scheme specified in Section 16075, Electrical Identification, throughout the Project:
   a. Uniquely number each wire.
   b. Wire numbers must appear on all Equipment Drawings.

4. Use equipment and instrument tags, as indicated on the Drawings, for all submittals.
5. List of manufacturer's recommended spare parts.

C. Seismic Requirements:

1. Provide electrical equipment with construction and anchorage to supporting structures designed to resist site seismic loads as specified in Section 01612, Anchorage and Bracing.
   a. Substantiating Test Data: With seismic qualification and special seismic certification statements, submit results of testing in accordance with ICC-ES AC 156.
   b. Anchoring Design Calculations and Details: Submit project-specific drawings and supporting calculations, prepared, and sealed by a professional engineer licensed in the state where the Project is being constructed, and showing details for anchoring electrical equipment to its supports and for anchoring supports provided with the equipment to the structure. Prepare calculations in accordance with the requirements of Section 01612, Anchorage and Bracing.
2. Exemptions:
   a. A "statement of seismic qualification" and a "special seismic certification" are not required for the following equipment:
      1) Temporary or moveable equipment.
      2) Equipment anchored to the structure and having a total weight of 20 pounds or less.
      3) Distribution equipment anchored to the structure and having a total unit weight of 5 pounds per linear foot, or less.

D. Submittal Organization:

1. First Page:
   a. Specification section reference.
   b. Name and telephone number of individuals who reviewed submittal before delivery to Engineer.
   c. Name and telephone number of person who is primarily responsible for the development of the submittal.
   d. Place for Contractor's review stamp and comments.

2. Next Pages:
   a. Provide confirmation of specification compliance in a tabular form that individually lists each specification section, paragraph, and sub-paragraphs and unequivocally states compliance with said requirement or takes exception to the requirement and lists the reason for said exception and offers alternative means for compliance.
   b. Include a response in writing to each of the Engineer's comments or questions for submittal packages which are re-submitted:
      1) In the order that the comments or questions were presented throughout the submittal.
      2) Referenced by index section and page number on which the comment appeared.
      3) Acceptable responses to Engineer's comments are either:
         a) Engineer's comment or change is accepted, and appropriate changes are made.
         b) Explain why comment is not accepted or requested change is not made.
         c) Explain how requirement will be satisfied in lieu of comment or change requested by Engineer.
      4) Any re-submittal, which does not contain responses to the Engineer's previous comments shall be returned for Revision and Re-submittal.
      5) No further review by the Engineer will be performed until a response for previous comments has been received.
3. Remaining Pages:
   a. Actual Submittal Data:
      1) Organize submittals in the same order as the items are referenced, listed, and/or organized in the specification section.
      2) For submittals that cover multiple devices used in different areas under the same specification section, the submittal for the individual devices must list the area where the device is intended to be used.

E. Submittal Requirements:

1. Furnish submittals that are fully indexed with a tabbed divider for every component.
2. Sequentially number pages within the tabbed sections. Submittals and operation and maintenance manuals that are not fully indexed and tabbed with sequentially numbered pages, or are otherwise unacceptable, will be returned without review.

3. Edit all submittals and operation and maintenance manuals, so that the submittal specifically applies to only the equipment furnished.
    a. Neatly cross out all extraneous text, options, models, etc. that do not apply to the equipment being furnished, so that the information remaining is only applicable to the equipment being furnished.
4. Submit Copies of Shop Drawings, and Product Data: Show dimensions, construction details, wiring diagrams, controls, manufacturers, catalog numbers, and all other pertinent details.
5. Where submittals are required, provide a separate submittal for each specification section. In order to expedite construction, the Contractor may make more than one submittal per specification section, but a single submittal may not cover more than one specification section:
    a. The only exception to this requirement is when one specification section covers the requirements for a component of equipment specified in another section. (For example, circuit breakers are a component of switchgear. The switchgear submittal must also contain data for the associated circuit breakers, even though they are covered in a different specification section.)
6. Exceptions to Specifications and Drawings:
    a. Include a list of proposed exceptions to the Specifications and Drawings along with a detailed explanation of each.
    b. If there is insufficient explanation for the exception or deviation, the submittal will be returned requiring revision and re-submittal.
    c. Acceptance of any exception is at the sole discretion of the Engineer. Provide all items (materials, features, functions, performance, etc.) required by the Contract Documents that are not accepted as exceptions.
    d. Replace all items that do not meet the requirements of the Contract Documents, which were not previously accepted as exceptions, even if the submittals contained information indicating the failure to meet the requirements.
7. Specific Submittal Requirements:
    a. Shop Drawings:
        1) Required for materials and equipment listed in this and other sections.
        2) Furnish enough information to evaluate the suitability of the proposed material or equipment for the intended use, and for compliance with these Specifications.
        3) Shop Drawings Requirements:
            a) Front, side, and, rear elevations, and top and bottom views, showing all dimensions.
            b) Locations of conduit entrances and access plates.
            c) Component layout and identification.

d) Schematic and wiring diagrams with wire numbers and terminal identification.
e) Connection diagrams, terminal diagrams, internal wiring diagrams, conductor size, etc.
f) Anchoring method and leveling criteria, including manufacturer's recommendations for the Project Site seismic criteria.
g) Weight.
h) Finish.
i) Nameplates: As specified in Section 16075, Electrical Identification.
j) Temperature limitations, as applicable.

b. Product Data:
1) Submitted for non-custom manufactured material listed in this and other sections and shown on the Shop Drawings.
2) Include:
a) Catalog cuts.
b) Bulletins.
c) Brochures.
d) Quality photocopies of applicable pages from these documents.
e) Identify on the data sheets the Project name, applicable specification section, and paragraph.
f) Identify model number and options for the actual equipment being furnished.
g) Neatly cross out options that do not apply or equipment not intended to be supplied.

c. Detailed sequence of operation for all equipment or systems.

F. Operation and Maintenance Manuals: As specified in Section 01782, Operation and Maintenance Data.

G. Material and Equipment Schedules:

1. Furnish a complete schedule and/or matrix of all materials, equipment, apparatus, and luminaries that are proposed for use: Include sizes, names of manufacturers, catalog numbers, and such other information required to identify the items.

H. Roof Penetrations: Submit details of all portions of the electrical installation that penetrate the roof. Include details showing support of the penetrating component, and the sealing means to be utilized.

I. Record Documents:

1. Furnish as specified in Section 01770, Closeout Procedures.
2. Provide Record Documents of all Electrical Drawings.
3. Record Drawing Requirements:
   a. Update Record Drawings weekly.
   b. Record Drawings must be fully updated as a condition of the monthly progress payments.
   c. Submit Record Drawings upon completion of the Work for final review.
   d. Clearly and neatly show all changes, including the following:
      1) All existing pipe, conduit, wire, instruments, or other structures encountered or uncovered during construction.
4. Shop Drawings:
   a. Upon completion of the Work, update all Shop Drawings to indicate the final as-built configuration of the systems:
      1) Provide as-built Shop Drawings for all electrical equipment electronically.
      2) Provide electronic copies of these documents on in Auto-Cad by Autodesk and PDF. Verify the current version of Auto-CAD with the District. Size all drawings to be readable and legible on 11-inch by 17-inch media.
   b. Furnish written information prepared specifically for this Project using Microsoft Word and PDF: Provide electronic copies of these documents.
5. Review and Corrections:
   a. Correct any record documents or other documents found to be incomplete, not accurate, of poor quality, or containing errors.
   b. Promptly correct and re-submit record documents returned for correction.

J. Test Reports:

1. As specified in Section 01330, Submittal Procedures.
2. Include the following:
   a. A description of the test.
   b. List of equipment used.
   c. Name of the person conducting the test.
   d. Date and time the test was conducted.
   e. All raw data collected.
   f. Calculated results.
   g. Each report signed by the person responsible for the test.
3. Additional requirements for acceptance test reports are specified in Section 16950, Field Electrical Acceptance Tests.

K. Calculations:

1. Where required by specific Electrical Specifications: These calculations are being provided by a registered professional engineer, they will be reviewed for form, format, and content but will not be reviewed for accuracy and calculation means.

L. Factory Acceptance Test:

1. As specified in Section 01330, Submittal Procedures.
2. Include complete test procedure and all forms to be used during test.

1.06 QUALITY ASSURANCE

A. Furnish all equipment listed by and bearing the label of UL, FM, CSA TUV, or of an independent testing laboratory acceptable to the Engineer and the Authority Having Jurisdiction.

B. System Supplier Responsibilities:

1. Requirements as specified in the Instrumentation and Control Specifications.
2. System Supplier:
   a. Due to the critical and complex technical requirements of this Project, all Work (materials, equipment, products, submittals, labor, services, etc.) specified in the Electrical, and Instrumentation and Control Specifications, and shown on the Electrical and Instrumentation Drawings is to be furnished by a single system supplier who has single source responsibility for both the process control and instrumentation systems and the electrical power system.
3. Contractual Relationship:
   a. Form a contractual relationship between the electrical subcontractor and the ICSC.
   b. Requirements for the First-tier Subcontractor:
      1) Contract directly with the Contractor.
      2) Be either the electrical subcontractor or the ICSC.
   c. Requirements for the Second-tier Subcontractor:
      1) A division of the first-tier subcontractor.
      2) A joint venture with the first-tier subcontractor.
      3) A subcontractor to the first-tier subcontractor.

d. The system supplier manages, directs, and supervises all the Work of its second-tier subcontractor. The system supplier is solely responsible for the entire electrical and instrumentation system, including, but not limited to, all Electrical, Instrumentation, and Process Contract Drawings, Electrical Specifications, and Instrumentation and Control Specifications:
   1) Provide any additional conduit, wire, etc.
   2) Any additional I/O, programming, screens, interface devices needed by the system supplier are to be provided by the electrical subcontractor or the ICSC, under the above outlined working agreement.
   3) Ensure compatibility between the PCIS system and the electrical system being installed.

1.07 DELIVERY, STORAGE, AND PROTECTION

A. Shipping Precautions:

1. After completion of shop assembly and successful factory testing, pack all equipment in protective crates, and enclose in heavy duty polyethylene envelopes or secured sheeting to provide complete protection from damage, dust, and moisture.
2. Place dehumidifiers, when required, inside the polyethylene coverings.
3. Skid-mount the equipment for final transport.
4. Provide lifting rings for moving without removing protective covering.
5. Display boxed weight on shipping tags together with instructions for unloading, transporting, storing, and handling at the Job Site.

B. Delivery and Inspection: Deliver products in undamaged condition, in manufacturer’s original container or packaging with identifying labels intact and legible. Include date of manufacture on label.

C. Special Instructions: Securely attach special instructions for proper field handling, storage, and installation to each piece of equipment before packaging and shipment.

1.08 PROJECT OR SITE CONDITIONS

A. Site Conditions:

1. Provide an electrical, instrumentation and control system, including all equipment, raceways and any other components required for a complete installation that meets the environmental conditions for the Site as specified in the General Requirements and below.

2. Seismic Load Resistance: Provide electrical equipment with construction and anchorage to supporting structures designed to resist site seismic loads as specified in Section 01612, Anchorage and Bracing.
3. Wind Load Resistance: Provide electrical equipment with construction and anchorage to supporting structures designed to resist site wind loads as specified in Section 01612, Anchorage and Bracing.
4. Altitude, Temperature, and Humidity:
    a. Elevation: 155.
        1) Ambient Air Temperature: 23 degrees F to 95 degrees F.
        2) Ambient Air RH: 10 percent to 90 percent.
    b. Provide all electrical components and equipment fully rated for continuous operation at this altitude, with no additional de-rating factors applied.
    c. Provide additional temperature conditioning equipment to maintain all equipment in non-conditioned spaces subject to these ambient temperatures, with a band of 10 degrees F above the minimum operating temperature and 10 degrees F below maximum operating temperature, as determined by the equipment manufacturer's guidelines:
        1) Provide all power conduits wiring for these devices (e.g., heaters, fans, etc.) whether indicated on the Drawings or not.
5. Site Security: Abide by all security and safety rules concerning the Work on the Site, as specified in Section 01329, Safety.
6. Outdoor Installations:
    a. Provide electrical, instrumentation and control equipment suitable for operation in the ambient conditions where the equipment is located.
    b. Provide heating, cooling, and dehumidifying devices incorporated into and included with electrical equipment, instrumentation, and control panels to maintain the enclosures within the rated environmental operating ranges as specified in this section for the equipment:
        1) Provide all wiring necessary to power these devices.

B. Provide enclosures for electrical, instrumentation and control equipment, regardless of supplier or subcontractor furnishing the equipment, that meet the requirements outlined in NEMA 250 for the following types of enclosures:

1. NEMA Type 1: Intended for indoor use, primarily to provide a degree of protection from accidental contact with energized parts or equipment.

2. NEMA Type 4: Intended for indoor or outdoor use, primarily to protect equipment from exposure to windblown dust and rain, splashing or hose directed water, ice formation and freezing.
3. NEMA Type 4X: Made from corrosion resistant materials (Type 316 stainless steel) and are intended for indoor or outdoor use, primarily to protect equipment from exposure to windblown dust and rain, splashing or hose directed water, ice formation and freezing, and corrosion.
4. NEMA Type 12: Intended for indoor use, primarily to provide a degree of protection from dust, falling dirt and dripping non-corrosive liquids.
5. NEMA Type 6: Rated for submergence.
6. NEMA Type 6P: Rated for prolonged submergence.
7. NEMA Type 7: Intended for installation in locations where explosive or combustible gas or vapors may be present (Class I Division 1 or Class I Division 2) meeting the requirements outlined in Section 16052, Hazardous Classified Area Construction.
8. NEMA Type 8: Intended for installation in either indoor or outdoor locations where explosive or combustible gas or vapors may be present (Class I Division 1 or Class I Division 2), and the equipment is oil-immersed, meeting the requirements outlined in Section 16052, Hazardous Classified Area Construction.

C. Plant Area Electrical Work Requirements:

1. Provide all Electrical Work in accordance with the Area Classification and Materials Selection Table, located on the Drawings.
2. Provide stainless steel NEMA 4X enclosures and supports, and PCS conduit type for all Electrical work not included in the Area Classification and Materials Selection Table unless otherwise indicated on the Drawings. Conduit type definitions are listed under Section 16130, Conduit, and also in the Area Classification and Materials Selection Table.
3. Modify conduit runs as specified in Section 16130, Conduits.

1.09 WIRING WITHIN CONDUIT

A. All wiring shall be installed within a conduit, raceway, or tray as identified within Contract Documents, no exceptions.

1. All wiring associated with low voltage systems including, but not limited to, low voltage communications, electronic access control, building automation/HVAC control, security systems, and fire alarm systems shall be in conduit, no exceptions.
2. All Class II wiring shall be within conduit, no exceptions.

1.10 SCHEDULING

A. General:

1. As specified in Section 01756, Testing and Facility Startup.
2. Testing requirements are specified in Section 01756, Testing and Facility Startup, Section 16950, Field Electrical Acceptance Tests, and other sections.
3. General scheduling requirements are specified in Section 01324, Construction Schedule.
4. Work restrictions and other scheduling requirements are specified in Section 01140, Work Restrictions.
5. The Contractor shall complete and submit a Deactivation Request Form prior to de-energizing any electrical equipment. The Form shall be furnished to the Contractor by the District.
6. Testing and process Start-up requirements as specified in Section 01756, Testing and Facility Startup.

B. Pre-submittal Conference:

1. Before producing any submittals, schedule a pre-submittal conference for the purposes of reviewing the entire Project, equipment, control philosophy, schedules, and submittal requirements.
2. The Contractor, instrumentation and control subcontractor, electrical subcontractor, all suppliers, and individual equipment manufacturers furnishing major pieces of equipment must attend including, but not limited to:
   a. Vendor control panels.
   b. Electrical equipment shelter.
   c. Local control stations.
   d. Disconnect switches.
   e. Variable frequency drives.
   f. Lighting.
3. The Contractor shall produce a copy of the electrical permit at the presubmittal conference.

C. Factory Acceptance Testing:

1. Where factory acceptance testing is required for equipment covered by these Specifications, notify the Engineer in writing when the equipment is completed and ready for factory inspection and testing:
   a. Indicate the desired dates for inspection and testing.

b. Schedule the FAT after approval of the FAT procedure's submittal:
   1) Submit a copy of the test procedures including all forms at least 21 days before any scheduled test date.
   2) Notify the Engineer of the scheduled tests a minimum of 15 days before the date of the test.

1.11 WARRANTY

A. Warrant the Electrical Work: Shall be in accordance with the General Conditions, provide additional warranty as specified in the individual Electrical Specifications.

1.12 SYSTEM STARTUP

A. Replace or modify equipment, software, and materials that do not achieve design requirements after installation in order to attain compliance with the design requirements:

   1. Following replacement or modification, retest the system and perform additional testing to place the complete system in satisfactory operation and obtain compliance acceptance from the Engineer.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Provide similar items of same manufacturer throughout the electrical and instrumentation portion of the Project.

B. Allowable manufacturers are specified in individual Electrical Specifications.

2.02 MATERIALS

A. Furnish all materials under this Contract that are new, free from defects, and standard products produced by manufacturers regularly engaged in the production of these products and that bear all approvals and labels as required by the Specifications.

B. Provide materials complying with the applicable industrial standard in accordance with the General Conditions.

2.03 SOURCE QUALITY CONTROL

A. Provide all equipment that is new, free from defects, and standard products produced by manufacturers regularly engaged in the production of these products.

B. Arrange with all manufacturers of the electrical equipment, to allow the Owner and Engineer to inspect and witness the testing of the equipment at the site of fabrication:

1. Testing includes the cabinets, special control systems, power equipment, and other pertinent systems and devices.

C. Factory testing is specified in the individual sections of the Electrical Specifications.

PART 3 EXECUTION

3.01 EXAMINATION

A. The electrical subcontractor is encouraged to examine the premises completely before bidding.

B. The electrical subcontractor shall examine the bid documents completely before bidding.

C. It is the electrical subcontractor's responsibility to be fully familiar with the existing conditions and local requirements and regulations.

D. Review the Site conditions and examine all Shop Drawings for the various items of equipment in order to determine exact routing and final terminations for all wiring and cables.

E. Provide a Complete Electrical System: Install all extra conduits, cables, and interfaces as may be necessary to provide a complete and operating electrical, PCIS, and HVAC system.

3.02 INSTALLATION

A. Equipment locations shown on Electrical Drawings may change due to variations in equipment size or minor changes made by others during construction:

1. Verify all dimensions as indicated on the Drawings: Actual field conditions govern all final installed locations, distances, and levels.

2. Review all Contract Documents and approved equipment Shop Drawings and coordinate Work as necessary to adjust to all conditions that arise due to such changes.
3. Make minor changes in location of equipment before rough in, as directed by the Owner or Engineer.
4. Provide a Complete Electrical System: Install all extra conduits, cables, and interfaces as may be necessary to provide a complete and operational electrical, PCIS, and HVAC system.

B. Submit a Request for Information for any conflict between Drawings and Specifications prior to installation.

C. Install the equipment in accordance with the accepted installation instructions and anchorage details to meet the seismic and wind load requirements at the Project Site.

D. Cutting and Patching:

1. Perform all cutting, patching, channeling, core drilling, and fitting required for the Electrical Work, except as otherwise directed:
    a. Secure the permission of the Engineer before performing any operation likely to affect the strength of a structural member such as drilling, cutting, or piercing:
        1) Before cutting, channeling, or core drilling any surface, ensure that no penetration of any other systems will be made:
            a) Verify that area is clear and free of conduits, cables, piping, ductwork, post-tensioning cables, etc.
            b) Use tone-locate system or X-ray to ensure that area is clear of obstructions.
    b. Review the complete Drawing set to ensure that there are no conflicts or coordination problems before cutting, channeling, or core drilling any surface.
2. Perform all patching to the same quality and appearance as the original work. Employ the proper tradesmen to secure the desired results. Seal around all conduits, wires, and cables penetrating walls, ceilings, and floors in all locations with a fire stop material, typically:
    a. 3M; CP 25WB+, Caulk.
    b. 3M; Fire Barrier, Putty.
3. Seal around conduit penetrations of belowgrade walls with a waterproof, nonshrink, nonmetallic grout, unless otherwise indicated on the typical installation details:
    a. Use the installation details as indicated on the Drawings as a guide for acceptable sealing methods.

E. Install all conduits and equipment in such a manner as to avoid all obstructions and to preserve headroom and keep openings and passageways clear:

1. Install all conduits and equipment in accordance with working space requirements as outlined in the NEC.
   a. This includes any panel, disconnect switch or other equipment that can be energized while open exposing live parts regardless of whether it is likely to require examination or has serviceable parts.
2. Where Drawings do not show dimensions for locating equipment, install equipment in the approximate locations as indicated on the Drawings. Adjust equipment locations as necessary to avoid any obstruction or interferences.
3. Where an obstruction interferes with equipment operation or safe access, relocate the equipment.
4. Where Drawings do not indicate the exact mounting and/or supporting method to be used, use materials and methods like the mounting details as indicated on the Drawings.

F. Roof Penetrations: Seal conduit penetrations in accordance with roofing manufacturer’s instructions.

G. Terminations: Provide and terminate all conductors required to interconnect power, controls, instruments, panels, and all other equipment.

H. Miscellaneous Installation Requirements:

1. In case of interference between electrical equipment as indicated on the Drawings and the other equipment, notify the Engineer as specified in the General Conditions.
2. Location of manholes and pull-boxes as indicated on the Drawings are approximate. Coordinate exact location of manholes and pull-boxes with Mechanical and Civil Work.
3. Provide additional conduit bodies to those shown where they are required to make a workable installation.

I. Labeling: Provide all nameplates and labels as specified in Section 16075, Electrical Identification.

J. Equipment Tie-downs:

1. Anchor all instruments, control panels, and equipment by methods that comply with seismic and wind bracing criteria, which apply to the Site.
2. All control panels, VCPs, LCPs, RTUs, PCMs, etc., must be permanently mounted and tied down to structures in accordance with the Project seismic criteria.

3.03 TESTING AND FACILITY STARTUP

A. As specified in Section 01756, Testing and Facility Startup.

B. For Owner and Engineer Witnessed FAT: The Contractor is responsible for the Owner's and Engineer's costs associated with FAT as specified in individual equipment sections.

3.04 FIELD QUALITY CONTROL

A. Inspection:

1. Allow for inspection of electrical system installation as specified in Section 01455, Special Inspection, Observation, and Testing.
2. Provide any assistance necessary to support inspection activities.
3. Engineer inspections may include, but are not limited to, the following:
    a. Inspect equipment and materials for physical damage.
    b. Inspect installation for compliance with Drawings and Specifications.
    c. Inspect installation for obstructions and adequate clearances around equipment.
    d. Inspect equipment installation for proper leveling, alignment, anchorage, and assembly.
    e. Inspect equipment nameplate data to verify compliance with design requirements.
    f. Inspect raceway installation for quality workmanship and adequate support.
    g. Inspect cable terminations.
    h. Schedule inspection of all mounting of electrical devices and all penetration and connections to structures.
4. Inspection activities conducted during construction do not satisfy inspection or testing requirements specified in Section 16950, Field Electrical Acceptance Tests.

B. Field Testing:

1. Notify the Engineer when the Electrical Work is ready for field acceptance testing.
2. Perform the acceptance tests as specified in Section 16950, Field Electrical Acceptance Tests.
3. Record Results of the Required Tests Along with the Date of Test: Use conduit identification numbers to indicate portion of circuit tested.

C. Workmanship:

1. Leave wiring in panels, manholes, boxes, and other locations neat, clean, and organized:
   a. Neatly coil and label spare wiring lengths.
   b. Shorten, re-terminate, and re-label excessive used as well as spare wire and cable lengths, as determined by the Engineer.
   c. All spare conductors shall be labeled individually.
      1) The source of the spare conductor(s) shall be labeled at the destination.
      2) The destination of the spare conductors(s) shall be labeled at the source.

3.05 CLEANING

A. As specified in Section 01770, Closeout Procedures.

B. Remove all foreign material and restore all damaged finishes to the satisfaction of the Engineer and Owner.

C. Clean and vacuum all enclosures to remove all metal filings, surplus insulation and any visible dirt, dust, or other matter before energization of the equipment or system start-up:

1. Use of compressors or air blowers for cleaning is not acceptable.

D. Clean the electrical rooms associated with the project and areas of work prior to completion. Clean the floors, tops of enclosures, and cable trays of all debris, dirt, and dust.

E. As specified in other sections of the Contract Documents.

3.06 DEMONSTRATION AND TRAINING

A. Furnish all personnel and equipment necessary to conduct the demonstration and training requirements as specified in the individual sections.

3.07 PROTECTION

A. Protect all Work from damage or degradation until Substantial Completion.

B. Maintain all surfaces to be painted in a clean and smooth condition.

END OF SECTION

SECTION 16052
HAZARDOUS CLASSIFIED AREA CONSTRUCTION

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes: Executing and completing Work in hazardous and/or classified areas as defined by the NEC Articles 500 through 516, NFPA 820, and as indicated on the Drawings and specified in the Specifications.

B. Related Sections:

1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.

1.02 REFERENCES

A. As specified in Section 16050, Common Work Results for Electrical.

1.03 DEFINITIONS

A. As specified in Section 16050, Common Work Results for Electrical.

B. Specific Definitions: For the purposes of these Specifications, the terms "Hazardous" and "Classified" will be considered synonymous.

1.04 SYSTEM DESCRIPTION (NOT USED)

A. Furnish submittals as specified in Section 01330, Submittal Procedures, and Section 16050, Common Work Results for Electrical.

1.05 QUALITY ASSURANCE

A. As specified in Section 16050, Common Work Results for Electrical.

B. Regulatory Requirements:

1. All wiring in hazardous and/or classified locations shall comply with all applicable articles of the NEC, in particular Articles 500 through 516.
   a. Except as modified in Article 500 through Article 516, all other applicable rules contained in the NEC shall apply to electric equipment and wiring installed in hazardous and/or classified locations.
   b. All devices used in Class I Division 1 or Division 2 areas must have visible manufacturer installed nameplates specifically stating the Class, Division, and Group for which the device is approved.

1.06 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 16050, Common Work Results for Electrical.

1.07 PROJECT OR SITE CONDITIONS

A. A list of hazardous areas is shown on the Area Classification and Materials Selection Table on the Drawings.

PART 2 PRODUCTS

2.01 COMPONENTS

A. Conduit and Sealing Fittings: As specified in Section 16130, Conduits.

B. Conduit Boxes and Bodies: As specified in Section 16134, Boxes.

C. Wiring Devices: As specified in Section 16140, Wiring Devices.

PART 3 EXECUTION

3.01 INSTALLATION

A. As specified in Section 16050, Common Work Results for Electrical.

B. Conduit Installation:

1. As specified in Section 16130, Conduits.
2. Wrench tighten all conduit joints to minimize sparking when fault current flows through the conduit system.
3. Make all conduit connections so that there is a minimum of 5 threads fully engaged in the connection.

4. Flexible Conduit:
   a. Class I Division 1 Hazardous Areas:
      1) Approved and marked suitable for Class I Division 1.
      2) Listed for compatibility with the group type atmosphere where used.
   b. Class I Division 2 Areas: Liquid tight metal conduit with approved fittings.
   c. Maximum length as specified in Section 16130, Conduits.

C. Sealing Fittings:

1. Provide an approved seal, no more than 18 inches from the enclosure, for all conduits entering an enclosure containing switches, circuit breakers, fuses, relays, resistors, or any other apparatus which may produce arcs, sparks, or high temperatures:
   a. Only explosion proof unions, couplings, elbows, capped elbows, and conduit bodies like “L,” “T,” and “X” may be installed between the sealing fitting and the enclosure.
2. Provide entire assemblies approved for Class I locations for self-sealing or factory sealed assemblies where the equipment that may produce arcs, sparks, or high temperatures is located in a compartment separate from the compartment containing splices or taps, and an integral seal is provided where conductors pass from one compartment to the other:
   a. Seals are required in all conduit connections to the compartment containing splices and must be within 18 inches of the enclosure.
3. Install a conduit seal within 18 inches of the boundary in each conduit run entering or leaving a classified location. No union, coupling, box, or fitting is allowed in the conduit between the sealing fitting and the point at which the conduit leaves the classified location.
4. For underground conduits entering or leaving a classified location or between Class I Division 1 and Division 2 locations:
   a. Provide a conduit seal at both points where the conduit emerges from the ground:
      1) Place the conduit seal within 18 inches of finished grade.
      2) No union, coupling, box, or fitting is allowed in the conduit system between the seal fitting and the point at which the conduit enters the ground.
5. Separate all conductors within the conduit system and seal using an approved packing dam installed to both hold the sealing compound and to maintain the separation between the wires:
   a. Remove the outer jacket of multi-conductor non-shielded cables in the area of the sealing fitting and separate each conductor from the cable and seal individually.

6. Install seals with drains in all electrical control stations, low points of conduit or any place where moisture may condense and accumulate.
7. Install the sealing compound with a minimum thickness of 5/8 inch or the trade size of the conduit, whichever is greater.
8. All motors, actuators, and instrument transmitters required to have conduit seals shall have a union installed between the seal and the respective motor, actuator, or instrument transmitter. This will permit the motor, actuator, or transmitter to be disconnected or replaced without disturbing the wiring or conduit seal.

D. Boxes and Fittings:

1. Class I Division 1 Areas: Utilize threaded connections for all metallic boxes, fittings, and joints to the conduit system.
2. Class I Division 2 Areas: Provide approved grounding bushings on conduits entering and exiting metallic boxes to bond the conduits together.

E. Outlet Boxes and Bodies:

1. Provide conduits bodies and boxes suitable for the conduit system as specified in Section 16130, Conduits.
2. Class I Division 2 Areas:
   a. Boxes Not Containing Arcing Parts:
      1) Material and NEMA ratings as specified in Section 16050, Common Work Results for Electrical.
      2) Pressed metal boxes are not allowed.
   b. Provide heavy duty cast construction type conduit fittings and joints: Explosion proof rated fittings and joints are not necessary.
   c. Any enclosure containing arcing parts, etc., shall have all construction associated with the enclosure, conduit system, etc. conforming to Class I Division 1 construction.

F. Motor Connections:

1. Conduit installation in Class I Division 1 and Class I Division 2 locations for motors that contain arcing parts, shall proceed as follows:
   a. First: Conduit.
   b. Second: Explosion proof flexible coupling.
   c. Third: Sealing fitting.
   d. Fourth: Explosion proof union.
   e. Fifth: Connection to the motor terminal box.
2. Wiring connections to motor leads shall be as specified in Section 16150, Low Voltage Wire Connections.

3. Bond the non-current-carrying metal parts of equipment, raceways and other enclosures as required by the NEC to ensure electrical continuity.

G. Grounding: A grounding conductor shall be provided in all raceways, junction boxes, and enclosures located within all Class 1 Division 1 and Class 1 Division 2 locations.

3.02 TESTING AND FACILITY STARTUP

A. As specified in Section 01756, Testing and Facility Startup.

3.03 FIELD QUALITY CONTROL

A. As specified in Section 16050, Common Work Results for Electrical.

B. Obtain inspection and approval from the Engineer before and after each seal is poured.

END OF SECTION

SECTION 16055
PIPE HEAT TRACING

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. Factory Mutual.
2. Institute of Electrical and Electronics engineers, Inc (IEEE): 515, Testing, Design, Installation and Maintenance of Electrical Resistance Heat Tracing for Industrial Applications.
3. National Electrical Manufacturers' Association (NEMA): 250, Enclosures for Electrical Equipment (1,000 Volts Maximum).
4. UL.

1.02 SUBMITTALS

A. Action Submittals:

1. Manufacturer's descriptive literature.
2. Plastic Pipe Installations: Output adjustment factors for heating tape for the services indicated.
3. Pipe heat loss calculations for each pipe size to be heat traced.

PART 2 PRODUCTS

2.01 SYSTEM DESIGN REQUIREMENTS

A. Design Heating Load:

1. Heating load to be calculated based upon a 50 degree F delta, 20 mph wind if pipes are located outdoors, insulation as specified in Section 15080, Process Piping Insulation, pipe as specified in Section 15200, Process Piping—General, and shall include a 10 percent safety factor.
2. Heat loss calculations shall be based on IEEE 515, Equation 1, Page 19.

2.02 ELECTRICAL HEATING TAPE

A. Cable: Self-limiting, parallel circuit construction consisting of continuous inner core of variable resistance conductive heating material between two parallel copper bus wires. Provide tinned copper braid for PVC, FRP, and stainless steel pipe applications.

B. UL Listing: Listed as self-limiting pipe tracing material for pipe freeze protection application in ordinary conditions.

C. Maximum Maintenance Temperature: 150 degrees F (65 degrees C).

D. Maximum Intermittent Temperature: 185 degrees F (85 degrees C).

E. Service Voltage: As indicated by branch circuits provided for heat tracing on the Drawings.

F. Manufacturers and Products:

1. Raychem; BTV-CR.
2. Thermon; BSX.
3. Nelson; CL1-J1 or L1-J1.

2.03 CONNECTION SYSTEM

A. Rating: NEMA 250, Type 4 and Factory Mutual approved.

B. Operating Monitor Light: Furnish with each circuit power connection kit to indicate when heat tracing is energized.

C. Manufacturers and Products:

1. Splice Kit:
   a. Raychem; S-150.
   b. Thermon; PCS-1-SR.
   c. Nelson; PLT-BS.
2. Tee Kit:
   a. Raychem; T-100.
   b. Thermon; DS-S.
   c. Nelson; PLT-BY.
3. End Seal Kit:
   a. Raychem; E-150.
   b. Thermon; DE-S.
   c. Nelson; LT-ME.

2.04 SECURING TAPE

A. Plastic Piping Systems:

1. Type: Aluminum foil coated adhesive tape.
2. Manufacturers and Products:
   a. Raychem; AT-180.
   b. Thermon; AL-20P.
   c. Nelson; AT-50.

B. Metallic Piping Systems:

1. Type: Glass or polyester cloth pressure sensitive tape.
2. Manufacturers and Products:
   a. Raychem; GS54 or GT66.
   b. Thermon; PF-1.
   c. Nelson; GT-6 or GT-60.

2.05 PIPE MOUNTED THERMOSTAT

A. Type: Fixed, nonadjustable, set at 40 degrees F.

B. Sensor: Fluid-filled with 3-foot capillary.

C. Enclosure: Glass-filled nylon, NEMA 250, Type 4X weatherproof with gasketed lid.

D. Switch: SP-ST, UL listed, rated 22 amps, 120V ac to 240V ac.

E. Manufacturers and Products:

1. Raychem; DigiTrace Model AMC-F5.
2. Thermon; E4X-1.
3. Raychem; DigiTrace Model E507S-LS for hazardous areas.
4. Thermon; E7-25325 for hazardous areas.

2.06 HEAT TRACE CONTROL BOX

A. 12 inch wide by 12 inch tall by 6 inch deep NEMA 1 enclosure:

1. Wall mounted.
2. Hinged door.

B. Magnetic contactor:

1. UL listed.
2. Electrically operated, electrically held.

3. Main Contacts:
   a. Power driven in one direction with mechanical spring dropout.
   b. Silber alloy with wiping action and arc quenchers.
   c. Continuous duty rated 20 amperes.
   d. Poles: Two.

C. Control: Two-wire.

D. Auxiliary Contacts: One normally open and one normally closed, rated 7,200VA make, 720VA break, at 600V, A600 per NEMA ICS 5.

E. Manufacturers and Products:

1. Eaton/Cutler-Hammer; Class A201.
2. General Electric Co.; CR 353.
3. Square D Co.; Class 8910.

PART 3 EXECUTION

3.01 INSTALLATION

A. General:

1. Install in accordance with the manufacturer's instructions and recommended practices.
2. Provide insulation as specified in Section 15080, Process Piping Insulation, over all pipe heat tracing.
3. Ground metallic structures or materials used for support of heating cable or on which it is installed in accordance with applicable codes.
4. Wiring between power connection points of heat tracing cable branch lines shall be provided by heat tracing system supplier.
5. Provide end of circuit pilot lights on heat tracing circuits for buried piping.

B. Electrical Heating Tape:

1. Determine required length of electrical heating tape by considering length of circuit, number and type of fittings and fixtures, design heating load, and heating tape output.
2. Where design heating load exceeds heating tape capacity, install by spiraling.
3. Derate heating tape capacity when installed on plastic piping.

4. Install on services as follows:

Service	Piping Material	Placement	Location
NPW	PVC	REFER TO ELECTRICAL DRAWINGS	Outdoors

5. Install additional heating tape at bolted flanges, valves, pipe supports, and other fittings and fixtures as recommended by supplier, but not less than the following:

Item	Heating Tape Length (min. feet)
Bolted flanges (per pair)	Two times pipe diameter
Valves	Four times valve length
Pipe hanger or support penetrating insulation	Three times pipe diameter

C. Heat Tracing Circuits: Limit individual lengths of heat tracing circuits such that maximum single circuit capacity is 20 amps when starting the circuit at 40 degrees F. Provide multiple 20-amp circuits as required at individual heat tracing locations.

3.02 FIELD QUALITY CONTROL

A. Test each circuit with 500-volt insulation tester between circuit and ground with neutrals isolated from ground.

1. Insulation Resistance: Minimum 1,000 megohms per 1,000 feet.

END OF SECTION

SECTION 16060
GROUNDING AND BONDING

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes:

1. Grounding electrodes.
2. Grounding electrode conductors.
3. Equipment grounding conductors.
4. Ground connections.
5. General requirements for grounding.

B. Related Sections:

1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.

1.02 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. As specified in Section 16050, Common Work Results for Electrical.
2. ASTM International (ASTM):
   a. B3, Standard Specification for Soft or Annealed Copper Wire.
   b. B8, Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft.
3. Institute of Electrical and Electronics Engineers (IEEE):81, IEEE Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Grounding System.
4. UL: 467, Ground and Bonding Equipment.

1.03 DEFINITIONS

A. As specified in Section 16050, Common Work Results for Electrical.

1.04 SYSTEM DESCRIPTION

A. Ground equipment and raceway systems so that the completed installation conforms to all applicable code requirements.

B. Provide a complete electrical grounding system as indicated on the Drawings and as specified including but not limited to:

1. Ground electrodes.
2. Bonding jumpers.
3. Ground connections.

C. Provide bonding jumpers and wire, grounding bushings, clamps and appurtenances required for complete grounding system to bond equipment and raceways to equipment grounding conductors.

D. The ground system resistance (electrode to ground) of the completed installation, as determined by tests specified in Section 16950, Field Electrical Acceptance Tests, shall be:

1. 5 ohms or less for industrial systems.
2. 1 ohm or less for electrical buildings.

1.05 SUBMITTALS

A. Furnish submittals as specified in Section 01330, Submittal Procedures, and Section 16050, Common Work Results for Electrical.

B. Product Data: Catalog cut sheets.

1.06 QUALITY ASSURANCE

A. As specified in Section 16050, Common Work Results for Electrical.

B. All grounding components and materials shall be UL listed and labeled.

1.07 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 16050, Common Work Results for Electrical.

1.08 WARRANTY

A. As specified in Section 16050, Common Work Results for Electrical.

1.09 SYSTEM STARTUP

A. As specified in Section 16050, Common Work Results for Electrical.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Compression Connectors:

1. One of the following:
   a. FCI Burndy.
   b. Thomas & Betts.
   c. “Or-equal.”

B. Ground Rods:

1. One of the following, “or-equal:”
   a. Erico.
   b. Harger.
   c. Conex.

C. Ground Cable:

1. One of the following:
   a. Nehring.
   b. Harger.
   c. Southwire.
   d. “Or-equal.”

2.02 MATERIALS

A. Ground Rod:

1. Minimum: 3/4-inch diameter, 10 feet long.
2. Uniform 10 mil covering of electrolytic copper metallically bonded to a rigid steel core: The copper-to-steel bond shall be corrosion resistant.
3. In accordance with UL 467.
4. Sectional type joined by threaded copper alloy couplings.
5. Fit the top of the rod with a threaded coupling and steel-driving stud.

B. Ground Cable:

1. Requirements:
   a. Soft drawn (annealed).
   b. Concentric lay, coarse stranded in accordance with ASTM B8.
   c. Bare copper in accordance with ASTM B3.

2. Size is as indicated on the Drawings, but not less than required by the NEC.
3. Every wiring method shall have a dedicated equipment grounding conductor.

C. Compression Connectors:

1. Manufactured of high copper alloy specifically for the grounding application.
2. Suitable for direct burial in earth and concrete.

D. Identifying compression die number inscription to be impressed on compression fitting.

E. Exothermic (CAD weld) welding is not allowed.

F. Equipment Grounding Conductors:

1. Conductors shall be the same type and insulation as the load circuit conductors: Use 600-volt insulation for the equipment grounding conductors for medium voltage systems.
2. Minimum size in accordance with the NEC, or larger if indicated on the Drawings.

PART 3 EXECUTION

3.01 INSTALLATION

A. As specified in Section 16050, Common Work Results for Electrical.

B. Provide a separate, green insulated, grounding conductor in each raceway independent of raceway material:

1. Multi-conductor power and control cables shall include an integral green insulated grounding conductor.
2. Provide a separate grounding conductor in each individual raceway for parallel feeders.

C. Provide a separate grounding conductor for each motor and connect at motor terminal box. Do not use bolts securing motor box to frame or cover for grounding connectors:

1. When grounding motors driven by variable frequency drives (VFD) comply with the requirements of the VFD manufacturer.

D. Provide a grounding type bushing with lug for connection of grounding conductor for conduits that originate from each motor control center section, switchboard, or panelboard:

1. Individually bond these raceways to the ground bus in the equipment.

E. Provide grounding type bushings with lug for a connection to a grounding conductor for all conduits which terminate at a cable tray.

F. Provide grounding type bushings with lugs for connection of grounding conductor at both ends of metallic conduit runs. Bond ground bushings to the grounding system.

G. Provide a green insulated wire-grounding jumper from the ground screw to a box grounding screw and, for grounding type devices, to equipment grounding conductor.

H. Ground conductors passing through concrete structure shall run through a PVC sleeve within and completely through the concrete. Where there is a risk of tripping PVC sleeves shall continue to connection point.

I. Ground connections:

1. All connections to the ground grid system, the duct bank grounding system, equipment, ground rods, etc., shall be made using compression type grounding connectors as indicated on the Drawings, UL, CSA, or TUV listed, and labeled for the application.
2. Make ground connections in accordance with the manufacturer’s instructions.
3. Do not conceal or cover any ground connections until the Engineer or authorized representative has established and provided written confirmation that every grounding connection is as indicated on the Drawings and specified in the Specifications.
4. Extend grounding conductors through concrete to accessible points for grounding equipment and electrical enclosures.
5. Install grounding system at each structure where switchgear, motor control centers, switchboards, panelboards, panels, or other electrical equipment are installed.
6. Bond all metallic equipment likely to become energized.

J. Grounding electrode system:

1. Ground rods:
   a. Location as indicated on the Drawings.
   b. Length of rods forming an individual ground array shall be equal in length.

c. Drive ground rods and install grounding conductors before constriction on concrete slabs and duct banks.
d. Pre-crimp all ground rods, as recommended by the manufacturer, before crimping connector to ground rod.

K. Shield Grounding:

1. Shielded instrumentation cable shall have its shield grounded at one end only unless Shop Drawings indicate otherwise:
   a. The grounding point shall be at the control panel or at the power source end of the signal carried by the cable.
2. Terminate the shield drain wire on a dedicated terminal block.
3. Insulate the non-grounding end of the shielded cable.
4. Use manufacturer's terminal block jumpers to interconnect ground terminals.
5. Connection to the panel main ground bus shall be via a green No. 12 conductor to the main ground bus for the panel.

L. All grounding conductors inside control panels and control cabinets shall be insulated.

M. All grounding conductors shall be insulated Green or Green with yellow strip is acceptable.

3.02 FIELD QUALITY CONTROL

A. As specified in Section 16050, Common Work Results for Electrical.

B. Measure grounding electrode system resistance to ground in accordance with IEEE 81.

3.03 PROTECTION

A. As specified in Section 16050, Common Work Results for Electrical.

END OF SECTION

SECTION 16070
HANGERS AND SUPPORTS

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes: Mounting and supporting electrical equipment and components.

B. Related Sections:

1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.

1.02 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. As specified in Section 16050, Common Work Results for Electrical.
2. ASTM International (ASTM):
   a. A123, Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
   b. A153, Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
   c. A240, Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications.

1.03 DEFINITIONS

A. As specified in Section 16050, Common Work Results for Electrical.

1.04 SYSTEM DESCRIPTION

A. Design Requirements:

1. Conform to the requirements of the Building Code as specified in Section 01410, Permits and Regulatory Requirements.

2. Demonstrate the following using generally accepted engineering methods:
   a. That the anchors to the structure are adequate to resist the loads generated in accordance with the Building Code and equipment requirements.
   b. That the required load capacity of the anchors can be fully developed in the structural materials to which they are attached.
3. Design Loading and Anchoring Requirements:
   a. As indicated in the Building Code unless otherwise specified.
   b. Seismic Loading Requirements: Freestanding or wall-hung equipment shall be anchored in place by methods that will satisfy the requirements for the seismic design specified in Section 16050, Common Work Results for Electrical.
   c. Wind Loading Requirements: All exterior freestanding equipment shall be anchored in place by methods that will satisfy the requirements for wind design specified in Section 16050, Common Work Results for Electrical.
   d. Minimum Safety Factor Against Overturning: 1.5.
   e. The foundation and structures to which hangers and supports are attached shall be capable of withstanding all anchor loads.
   f. Size the supports for conduit racks and trapezes with 40 percent spare capacity of the largest raceway on the rack or trapeze.

B. Performance Requirements: Hangers and supports individually and as a system shall resist all weights and code-required forces without deflections and deformations that would damage the supporting elements, the equipment supported, or the surrounding construction.

1.05 SUBMITTALS

A. Furnish submittals as specified in Section 01330, Submittal Procedures, and Section 16050, Common Work Results for Electrical.

B. Product Data:

1. Supports:
   a. Materials.
   b. Geometry.
   c. Manufacturer.
2. Hardware:
   a. Materials.
   b. Manufacturer.

C. Shop Drawings:

1. Complete dimensioned and scalable Shop Drawings of all supporting structures, trapezes, wall supports, etc.
2. Complete anchoring details for equipment, lighting, and raceway, supporting structures, trapezes, wall supports for all equipment in excess of 200 pounds, and all freestanding supports:
   a. Stamped by a professional engineer licensed in the state where the Project is being constructed.
   b. Said submittals, by virtue of the fact that they bear the stamp of a registered engineer, will be reviewed for general consistency with the requirements specified in the Contract Documents, but not for context, accuracy, or method of calculation.
3. Include data on attachment hardware and construction methods that will satisfy the design loading and anchoring criteria.

D. Installation Instructions:

1. Furnish anchorage instructions and requirements based on the seismic and wind conditions of the Site:
   a. Stamped by a professional engineer licensed in the state where the Project is being constructed.

1.06 QUALITY ASSURANCE

A. As specified in Section 16050, Common Work Results for Electrical.

1.07 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 16050, Common Work Results for Electrical.

1.08 PROJECT OR SITE CONDITIONS

A. As specified in Section 16050, Common Work Results for Electrical.

1.09 WARRANTY

A. As specified in Section 16050, Common Work Results for Electrical.

1.10 SYSTEM STARTUP

A. As specified in Section 01756, Testing and Facility Startup.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. One of the following:

1. Thomas & Betts.
2. Power-Strut.
3. Unistrut.
4. Cooper B-Line.
5. Robroy.
6. Aickinstrut.
7. “Or-equal.”

2.02 MATERIALS

A. Use materials appropriate for the area as specified in Section 16050, Common Work Results for Electrical. Refer to the Plant Area Work Requirements table which specifies the permitted uses for these conduit types.

B. Stainless Steel:

1. Supports:
   a. In accordance with ASTM A240.
   b. ANSI Type 316 material.
   c. Minimum Size: 1-5/8 inches by 1-5/8 inches.
2. Hardware: ANSI Type 316 material.

C. PVC Coated Galvanized Steel:

1. Supports:
   a. Hot dip galvanized steel as specified in this section.
   b. PVC coating thickness of 10 mils to 20 mils.
   c. Minimum Size: 1-5/8 inches by 1-5/8 inches.
2. Hardware: ANSI Type 316 material.

2.03 ACCESSORIES

A. Anchor bolts: ANSI Type 316 material.

2.04 FINISHES

A. Paint and finish all supporting structures as specified in Section 09900, Painting and Coating.

PART 3 EXECUTION

3.01 INSTALLATION

A. As specified in Section 16050, Common Work Results for Electrical.

B. Mount all raceways, cabinets, boxes, fixtures, instruments, and devices on Contractor-fabricated racks unless otherwise indicated on the Drawings.

1. Provide the necessary sway bracing to keep trapeze type structures from swaying.

C. Brace and anchor freestanding equipment supports using methods that provide structural support based on the seismic loads and wind loads:

1. Lateral deflection at top of supports not to exceed support height divided by 240 unless otherwise approved by the Engineer.

D. Provide fabricated steel support pedestals for wall mounted panels that weigh more than 200 pounds:

1. Fabricate pedestals out of welded angle, tube sections, or preformed channel.
2. If the supported equipment is a panel or cabinet, match the supported equipment in physical appearance and dimensions.
3. Provide auxiliary floor supports for transformers hung from stud walls and weighing more than 200 pounds.
4. Mount all equipment, cabinets, boxes, instruments, and devices in damp or wet locations on minimum of 7/8-inch preformed mounting channel. Mount channel vertically along the length of the device so that water or moisture may run freely behind the device.

E. Corrosion Protection: Isolate dissimilar metals, except where required for electrical continuity. Use neoprene washers, 9-mil polyethylene tape, or gaskets for isolation.

F. Raceway:

1. Furnish all conduit racks and trapeze structures needed to support the raceway from the structure.
   a. Group conduits and position on racks to minimize crossovers.
   b. Provide the necessary bracing to keep trapeze type structures from swaying under loads from cable installation, seismic forces, or wind forces.
2. Conduit racks and trapeze structures shall be sized with 40 percent spare capacity of the largest conduit installed on the rack or trapeze units.

G. Anchoring Methods:

1. Solid Concrete: Anchor bolts, anchor rods or post-installed anchors as specified in Section 05500, Metal Fabrication.
2. Metal Surfaces: Machine screws or bolts.
3. Hollow Masonry Units: Post-installed anchors as specified in Section 05500, Metal Fabrication.

H. When supporting devices on metal or wood stud construction, provide a Listed steel bracket for supporting boxes. All boxes at the same elevation within a stud bay shall be supported by the same bracket.

I. Re-coat all scratches, cuts, and drilled holes in galvanized surfaces with CRC “Zinc-It” or similar product.

J. Re-coat all drilled holes and cut surfaces on PVC-coated materials.

K. Seal all drilled holes and cut surfaces on fiberglass materials.

L. Use manufacturer supplied strut splice clevises where two or more pieces of strut are joined.

M. Provide white strut plastic end caps on the ends of all struts. End caps shall cover exposed edges of strut.

N. Threaded rods shall not protrude more than 1/2 inch beyond the last nut.

3.02 FIELD QUALITY CONTROL

A. As specified in Section 16050, Common Work Results for Electrical.

3.03 PROTECTION

A. As specified in Section 16050, Common Work Results for Electrical.

END OF SECTION

SECTION 16075
ELECTRICAL IDENTIFICATION

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes Requirements for:

1. Identifying electrical, instrumentation, and process equipment and components.
2. Material, manufacturing, and installation requirements for identification devices.

B. Related Specifications:

1. Section 01330, Submittal Procedures.
2. Division 15, Mechanical.
3. Division 16, Electrical.
4. Division 17, Process Instrumentation and Controls.

1.02 REFERENCES

A. Refer to Section 16050, Common Work Results for Electrical.

1.03 DEFINITIONS

A. Refer to Section 16050, Common Work Results for Electrical.

1.04 SYSTEM DESCRIPTION

A. Nameplates:

1. Provide a nameplate for each piece of mechanical equipment, process equipment, valve, pump, mixer, feeder, fan, air-handling unit, motor, switch, receptacle, controller, instrument transducer, instrument power supply, solenoid, motor control center, starter, panelboard, switchboard, individually mounted or plug-in type circuit protector or motor controller, disconnect switch, bus duct tap switch, time switch, relay and for any other control device or major item of electrical equipment, either located in the field or within panels.
2. Provide all nameplates of identical style, color, and material throughout the facility.
3. Provide new nameplates for all existing equipment worked on in this Project.

B. Wire Numbers:

1. Coordinate the wire numbering system with all vendors of equipment so that every field wire has a unique number associated with it for the entire system:
   a. Control and Instrumentation wires and cables shall be assigned a unique identification number following Owner standards.
   b. Wire numbers shall correspond to the terminal block number to which they are attached in the control panel.
   c. Internal panel wires on a common terminal shall have the same wire number.
   d. Multiconductor cables shall be assigned a cable number that shall be attached to the cable at intermediate pull boxes and stub-up locations beneath freestanding equipment. All multi-conductor and instrumentation cables shall be identified at pull points as described above:
      1) Label armored multiconductor cable using the conduit number following the requirements for conduit markers as described within this Specification, except conduit markers shall only be required at the source and the destination.
      2) All spare conductors shall be individually labeled. Label the destination at the source and label the source at the destination.
      3) Spare wiring and terminals shall be tagged as spares.
2. Power cables and wires shall be assigned a unique identification number as specified by Owner.

1.05 SUBMITTALS

A. Furnish submittals in accordance with Section 01330, Submittal Procedures, and Section 16050, Common Work Results for Electrical.

B. Product Data:

1. Nameplates:
   a. Color.
   b. Size:
      1) Outside dimensions.
      2) Lettering.
   c. Material.
   d. Mounting means.
2. Equipment Nameplate Schedule:
   a. Show exact wording for each nameplate.
   b. Include nameplate and letter sizes.

c. Schedule format shall match equipment nameplate schedule attached at the end of this section.
d. Submit equipment nameplate schedule for approval before engraving nameplates.

3. Wire Numbers: Manufacturer's catalog data for wire labels and label printer.
4. The Contractor shall submit samples for each type of Electrical Identification device intended to be provided for this project for review and approval. Samples of the materials and colors proposed for the work and application instructions shall be included. Devices shall indicate proposed text sizes, lettering and background coloring and related information.

C. Record Documents: Update the circuit/raceway block diagrams to reflect the exact quantity of wire numbers including spares and destination points for all wires.

1.06 QUALITY ASSURANCE

A. Schedule a pre-installation conference in accordance with Section 16050, Common Work Results for Electrical, in order to clearly define the requirements specified for equipment identification:

1. Representatives of the Contractor, Owner, and Engineer shall convene before any major purchases of cable or conductors and before the installation or termination of any cables or conductors.

1.07 DELIVERY, STORAGE, AND HANDLING

A. Refer to Section 16050, Common Work Results for Electrical.

1.08 WARRANTY

A. Refer to Section 16050, Common Work Results for Electrical.

1.09 SYSTEM STARTUP

A. Refer to Section 16050, Common Work Results for Electrical.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Nameplates and Signs:

1. One of the following:
   a. Brady.
   b. Seton.
   c. “Or-equal.”

B. Conductor and Cable Markers:

1. Heat-Shrinkable Tubing:
   a. One of the following:
      1) Raychem.
      2) Brady.
      3) Thomas & Betts.
      4) Kroy.
      5) “Or-equal.”
2. Marker Printer:
   a. One of the following:
      1) Brady; XC Plus.
      2) “Or-equal.”

C. Conduit and Raceway Markers:

1. One of the following:
   a. Panduit.
   b. Almetek.
   c. “Or-equal.”

2.02 MATERIALS

A. Nameplates:

1. General:
   a. Identification tags shall utilize the Owner standard numbering system for equipment supplied and installed as part of this project. Identification tags installed for outdoor equipment shall be rated for weatherproof type.
   b. When identifying a power source for equipment, the tag shall include the source name and circuit or compartment number (i.e., “100MCC0101-4F” or “100IP0101, CKT. #1”).

c. For all equipment, identification shall include the descriptive name on the first line, the CWS standard tag number on the second line and the power source on the third line (e.g., Secondary Clarifier 7 RAS Pump #1 46P1801 Power Source 100MCC0101-4F).
d. Text shall be centered on all nameplates and identification devices.

2. Electrical Equipment:
   a. Disconnect Switches: Each local power disconnect switch and circuit breaker for motors, instrument transmitters, controllers, and other equipment shall be identified with a phenolic nameplate. The nameplate shall identify the load served by equipment name and tag number, and the power source. Nameplates shall be not less than 1 inch high with lettering not smaller than 1/4 inch. Nameplates shall be attached using self-tapping S.S. screws.
   b. Switchgear and MCC: Each switchgear/MCC shall be identified with a phenolic nameplate (e.g., “100SWGR0101” or “100MCC0101”). Each switchgear/MCC compartment/bucket shall be identified with a phenolic nameplate (e.g., “1A” or “4F”). The nameplate shall identify the load served by name and tag number. Stand-alone starters, drives, and similar equipment shall also identify the power source for the starter, drive, etc. Nameplates shall be attached using stainless steel self-tapping screws. Nameplates shall be not less than 2.25 inches high, with 1-inch high lettering and 1/2-inch-high tag number lettering.
   c. Switchgear/MCC compartments/buckets, VFDs, enclosed starter panels, and similar electrical equipment: Each compartment/bucket shall be identified with a phenolic nameplate for the load it serves (e.g., “Secondary Clarifier 7 RAS Pump #1, 46P1801”). Stand-alone starters, drives, and similar equipment shall also identify the power source for the starter, drive, etc. Nameplates shall be attached using stainless steel self-tapping screws. Nameplates shall be not less than 2 inches high, with 1/2-inch-high lettering and 1/2-inch-high tag number lettering.
   d. Local Control Panels (LCP), Local Control Stations (LCS): Each LCP and LCS shall include a nameplate on the enclosure face identifying the panel name and tag number. Include the power source for each panel. Each panel-mounted device (internal and external) shall be identified. Pilot devices shall utilize collar-type, oversize nameplates provided with the pilot devices. Non-pilot devices shall have phenolic nameplates, attached using permanent adhesive. Internal panel devices shall have phenolic identification plates (hand markings not permitted) and shall be attached using permanent adhesive. Wiring and terminal blocks.
      1) LCP and LCS master nameplate shall be not less than 1-inch-high with not less than 1/2-inch lettering.

2) External and internal panel devices shall have nameplates not less than 1/2-inch-high with not less than 3/16-inch lettering.

e. Field Instrument, Motor, and Pump Identification:
   1) Attach instrument tags to all field instrument devices that includes process switches, instrument elements, sensors, transducers, control valves, motors, and pumps. See Owner's "EQUIPMENT TAG NUMBERING STANDARDS" that includes an example figure and the following list of tagging material:
      a) Tag Material: SAFETYCAL FLAP TAG FT-1 Black 5 inches by 3 inches.
      b) Label Material: Brady 2-inch wide white (M71C-2000-595-WT, "or-equal") 3-3/4 inches by 2 inches.
      c) Font Size is 14-point standard except Instrument Number which is 24-point Bold. Label text color shall be white unless instrument is used for DEQ purposes, then text shall be red.
      d) Label text will be capitalized and centered. First line of tag will be Instrument Number. Second and if necessary third lines will be Instrument Description. Fourth line will be Instrument Type (pH transmitter, flow transmitter, etc.) Fifth line will be I/O address. Last line will be Power Source Location if four-wire device or say "Loop Powered" if two-wire device.
      e) Label will be neatly centered under laminated cover of tag with no air bubbles.
      f) Install 1/4-inch grommet for stainless steel fastener.
      g) Stainless steel wire fastener.
   2) Attach the nametag to the flexible conduit connection to the respective instrument, motor, or pump.

f. Instrument Panel Instrumentation:
   1) All back of panel instruments shall be provided with black background with white letters plastic laminate nameplates engraved with the instrument's full tag number. Nameplates shall be secured to the panel with stainless steel screws.
   2) All front of panel instruments shall include the instrument's full tag number, service description, and (if relevant) power source in the nameplate legend. Unless it is part of the instrument, the nameplate shall be engraved black background with white letters plastic laminate, secured with stainless steel screws.

3. Signs:
   a. Automatic Equipment and High Voltage Signs:
      1) Suitable for exterior use.
      2) In accordance with OSHA regulations.
4. Conductor and Cable Markers:
   a. Machine printed black characters on white tubing.
   b. 10-point type or larger.
5. Conduit and Raceway Markers:
   a. 16 GA stainless steel, 3/4-inch by 2-inch minimum.
   b. Stamped or engraved lettering.
   c. Minimum 1/4-inch high letters.
6. Equipment and Device Labels:
   a. Provide identifying nameplate and nametag on new and reused panels and equipment as shown in Supplement Signage for Existing Panels and Equipment, or as listed elsewhere. Enclosure identification shall be located on the enclosure surface of PLC control panel, local control stations, junction boxes, and any other power, control, or signal enclosure.
      1) Nameplates: Enclosure identification located on the enclosure face with rectangular screw-on nameplates.
      2) Materials: Laminated phenolic plastic nameplates with black background and engraved white enamel filled lettering.
      3) Fastening: Secure with self-tapping Type 316 stainless steel screws.
      4) Size: 2-1/4-inch high plate.
      5) Test:
         a) Descriptive Name: 1-inch-high block lettering.
         b) Descriptive Tag: 1/2-inch-high block lettering.
      6) For the same piece of equipment, descriptive nameplate shall be consistently provided at various locations for all associated equipment with that piece.

2.03 SOURCE QUALITY CONTROL

A. Nameplates:

1. Provide all nameplates for control panel operator devices (i.e., pushbuttons, selector switches, pilot lights, etc.):
   a. Same material and same color and appearance as the device nameplates, in order to achieve an aesthetically consistent and coordinated system.

b. Provide a nameplate on both the front and the back of all pilot device. The nameplate on the back of the device shall be visible when the respective enclosure door on which the pilot device is installed on is open.

PART 3 EXECUTION

3.01 INSTALLATION

A. Refer to Section 16050, Common Work Results for Electrical.

B. Nameplates:

1. Attach nameplates to equipment with self-tapping stainless-steel screws, approved waterproof epoxy-based cement or install in metal holders welded to the equipment as specified for each equipment.
2. Nameplates shall be aligned and level or plumb to within 1/64 inch over the entire length:
   a. Misaligned or crooked nameplates shall be remounted or provide new enclosures at the discretion of the Engineer.

C. Conductor and Cable Markers:

1. Apply all conductor and cable markers before termination.
2. Non-Heat-Shrinkable Tubing:
   a. Tubing shall be sized for the wire and insulation on which it is to be placed.
   b. Tubing shall be tight on the wire.
   c. Characters shall face the open panel and shall read from left to right or top to bottom.
   d. Marker shall start within 1/32 inch of the end of the stripped insulation point.
   e. Identification labels shall be installed at each conductor termination.
3. Conductor numbers shall be named based on the equipment tag of the field device utilizing the electrical power source. The form of the tag shall be 406P1205C2 where ‘406P1205’ represents the equipment designation; ‘C’ indicated a control cable and 2 is a sequential number developed as part of the circuit design. Cable type designations shall follow the designations listed below:
   a. C – Control.
   b. S - Signal (below 80 volts ac or dc).
   c. P – Power.
   d. N - Network (Ethernet, Profibus).

D. Conduit Markers:

1. Furnish and install conduit markers for every conduit in the electrical system or part of the process system. Conduits shall be identified as indicated on the circuit/raceway block diagrams.
   a. Conduit markings shall match the circuit/raceway block diagrams.
   b. For conduits not shown on circuit/raceway block diagrams, provide conduit markings as described below:
      1) Start with a prefix letter that designates its purpose (“C” for control, “P” for power, “S” for Signal, and “PC” for combined power and control), followed by a facility code, followed by a sequence number. e.g., C-100P0101 is a control conduit in the IPS facility for Pump 1. P-100P0101 is a power conduit in the IPS facility for Pump 1. S-100P0101 is a signal conduit in the IPS facility for Pump 1. PC-340FV1301 is a combined power and control conduit in PEPS facility for control valve (Combined circuit allowed per Owner approval only).
      2) If the conduit is a continuation or branch of another conduit, the last space is a letter, such as A, B, C, etc.
      3) When a single loop network circuit is utilized among equipment, conduit number for coming and leaving the equipment shall be assigned a prefix from and to. e.g., NFR: 100P0101 is a communication network from IPS Facility Pump 1. NTO: 100P0102 is a communication network to IPS Facility Pump 2.
2. Mark Conduits at the following Locations:
   a. Each end and every 100 feet for conduits greater than 10 feet in length.
   b. Where the conduit penetrates a wall or structure.
   c. Where the conduit emerges from the ground, slab, etc.
3. Mark conduits after the conduits have been fully painted.
4. Position conduit markers so that they are easily read from the floor.
5. 16-gauge Stainless Steel Tags 3/4-inch by 2-inch Minimum: Conduit tags shall be attached to the raceway with Type 316 stainless steel wires. Tags shall be laser engraved.
6. Mark conduits before construction review by Engineer for punch list purposes.
7. Label intrinsically safe conduits in accordance with the requirements of the National Electrical Code (NEC).

E. Labeling:

1. Furnish and install permanent warning signs at mechanical equipment that may be started automatically or from remote locations:
   a. Fasten warning signs with round head stainless steel screws or bolts.
   b. Locate and mount in a manner to be clearly legible to Operations Personnel.
2. Furnish and install permanent and conspicuous warning signs on equipment (front and back), doorways to equipment rooms, pull boxes, manholes, and where the voltage exceeds 600 volts.
3. Place warning signs on utilization equipment that has more than one source of power. Use warning signs to identify every panel and circuit number of the disconnecting means all external power sources:
   a. Place warning signs on utilization equipment that has 120V ac control voltage sources used for interlocking.
   b. Identify panel and circuit number or conductor tag for control voltage source disconnecting means.
4. Each switch, receptacle and similar device shall include a nameplate indicating the power source and circuit number providing power to the switch or receptacle. For circuits other than 120V, identify the voltage and phase (e.g., 277V, 1Ø or 480V, 3Ø).
5. Each panelboard shall be identified with a phenolic nameplate with the black outside cut to expose white lettering. The nameplate shall include the panel name and tag number, voltage, phase, ampere rating and power source. Nameplate shall be 2.25 inches-high with 1/2-inch-high lettering and attached using self-tapping stainless-steel screws.
6. Each manhole, handhole, vault or underground pull box lid shall be clearly identified as “Electric.” The text shall be stick welded onto the lid with 4-inch uppercase characters. The text shall include the identification number shown on the Drawings, and shall further identify the manhole, handhole or pull box as “Medium Voltage Power,” “Low Voltage Power,” “Control,” “Signal” or “Communication,” as applicable.
7. Aboveground pull boxes, junction boxes and terminal boxes shall be identified using a stainless-steel tag attached to the enclosure using stainless steel self-tapping screws. Identify the box as “Power,” “Control,” “Signal” or “Fiber Optic” as applicable. Assign unique box numbers in accordance with Owner standards.

8. Provide arc flash labeling in accordance with NEC.
9. Provide labeling indicating short circuit ratings for all power distribution equipment and control panels in accordance with the NEC and UL requirements. Label outside of all boxes with phenolic label. Nameplates shall be no less than 2.25 inches high with 1-inch-high lettering and 1/2-inch-high tag number lettering. Example: Electrical Junction Box, Electrical Pull Box, Control Junction Box, Control Pull Box, etc.
    a. Inside all pull junction boxes place Brady label by each conduit identifying what is fed.

F. Signs:

1. Automatic Equipment and High Voltage Signs:
    a. Mount permanent warning signs at mechanical equipment that may be started automatically from remote locations. Fasten warning signs with round head stainless steel screws or bolts. Locate and mount warning signs in a suitable manner that is acceptable to the Engineer.
    b. Mount permanent and conspicuous warning signs on the front and back of equipment, doorways to equipment rooms, pull boxes, and manholes where the voltage exceeds 600 volts.
    c. Place warning signs on equipment that has more than one source of power: Warning sign to identify every power source.
    d. Place warning signs on equipment that has a 120V ac control voltage source used for interlocking.
2. Provide room signage at Electrical room entrances indicating “Warning-High-Voltage.”
3. Provide additional signage in accordance with applicable NEC requirements.
4. Provide 20 placard-style signs (7-inch by 10-inch) with warnings to be selected by the Owner during construction. Placard signs shall be W.H. Brady; B-302 style, “or-equal.”

G. Equipment Labels:

1. Locate and install on equipment or concrete equipment base.
2. Anchor to equipment or base for easy removal and replacement with ordinary hand tools.

3.02 FIELD QUALITY CONTROL

A. Replace any nameplates, signs, conductor markers, cable markers or raceway labels that in the sole opinion of the Engineer do not meet the Engineer's aesthetic requirements.

3.03 SUPPLEMENT

A. The supplement listed below, following "End of Section," is a part of this specification:

1. Tagging Submittal.

END OF SECTION

EQUIPMENT TAG	TAG TYPE	TAG SIZE	LOCATION	TEXT ON LABEL

EQUIPMENT TAG	TAG TYPE	LOCATION	TEXT ON TAG

EQUIPMENT TAG	TAG TYPE	LOCATION	TEXT ON TAG

EQUIPMENT TAG	TAG TYPE	TAG SIZE	LOCATION	TEXT ON LABEL

CONDUIT TYPE	EQUIPMENT	SIZE	TEXT ON TAG	Quantity

SECTION 16123
600-VOLT OR LESS WIRES AND CABLES

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes Requirements for:

1. 600-volt class wire and cable.
2. Instrumentation class wire and cable.
3. Network cable, including fiber optic cable.

B. Related Sections:

1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.

1.02 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. Refer to Section 16050, Common Work Results for Electrical.
2. ASTM International (ASTM):
   a. B3, Standard Specification for Soft or Annealed Copper Wire.
   b. B8, Specification for Concentric-Lay–Stranded Copper Conductors, Hard, Medium-Hard, or Soft.
   c. A167, Standard Specification for Stainless and Heat Resisting Chromium-Nickel Steel Plate, Sheet, and Strip.
   d. B263, Standard Test Method for Determination of Cross-Sectional Area of Stranded Conductors.
3. Building Industry Consulting Service International (BICSI).
4. Federal Specification J-C 30A.
5. Institute of Electrical and Electronics Engineers, Inc. (IEEE): 48, Standard Test Procedures and Requirements for Alternating-Current Cable Terminations.
6. Insulated Cable Engineers Association (ICEA):
   a. IPCEA S-61-402 for thermoplastic insulated wire and cable for the transmission and distribution of electrical energy.
   b. IPCEA S-61-402 for rubber insulated wire and cable for the transmission and distribution of electrical energy.

c. T-29-520, Conducting Vertical Cable Tray Flame Tests and a Theoretical Heat Input of 210,000 Btu/hour.
d. S-58-679, Standard for Control Cable Conductor Identification.

7. National Electrical Manufacturers' Association (NEMA):
   a. CC 1, Electric Power Connectors for Substations.
   b. WC 55, Instrumentation Cables and Thermocouple Wire.
   c. WC 70, Standard for Nonshielded Power Cables Rated 2,000 Volts or Less for the Distribution of Electrical Energy.
8. National Fire Protection Association (NFPA):
   a. Article 70, National Electrical Code (NEC).
   b. Article 72, National Fire Alarm Code.
   c. Article 101, Life Safety Code.
   d. Article 262, Standard Method of Test for Flame Travel and Smoke of Wires and Cables for Use in Air-Handling Spaces.
9. UL:
   a. 13, Standard for Safety Power-Limited Circuit Cables.
   b. 44, Standard for Safety Thermoset - Insulated Wires and Cables.
   c. 62, Standard for Safety Flexible Cord and Fixture Wire.
   d. 486A, Standard for Safety; Wire Connectors and Soldering Lugs for Use with Copper Conductors.
   e. 486C, Splicing Wire Connectors.
   f. 510, Standard for Safety Polyvinyl Chloride, Polyethylene, and Rubber Insulating Tape.
   g. 854, Standard for Safety Service-Entrance Cables.
   h. 1063, Machine-Tool Wires and Cables.
   i. 1277, Electrical Power and Control Tray Cables with Optional Optical-fiber Members.
   j. 1424, Cables for Power-Limited Fire-Alarm Circuits.
   k. 1569, Metal-Clad Cables.
   l. 1581, Reference Standard for Electrical Wires, Cables, and Flexible Cords.
   m. 2196, Tests for Fire Resistive Cables.
   n. 2225, Metal-Clad Cables and Cable-Sealing Fittings for Use in Hazardous (Classified) Locations.

1.03 DEFINITIONS

A. Refer to Section 16050, Common Work Results for Electrical.

B. Definitions of terms and other electrical considerations as set forth in the:

1. Insulated Cable Engineering Association (ICEA).
2. ASTM International (ASTM).

1.04 SYSTEM DESCRIPTION

A. Furnish and install the complete wire and cable system.

1.05 SUBMITTALS

A. Furnish submittals in accordance with Section 01330, Submittal Procedures, and Section 16050, Common Work Results for Electrical.

B. Product Data:

1. Manufacturer of wire and cable.
2. Insulation:
   a. Type.
   b. Voltage class.
3. American Wire Gauge size.
4. Conductor material.
5. Pulling compounds.

C. Shop Drawings:

1. Show Splice Locations: For each proposed splice location, provide written justification describing why the splice is necessary. Splices are not allowed unless approved by the Owner.

D. Test Reports:

1. Submit test reports for megohm 1,000V dc tests.
2. Submit test reports for continuity tests.
3. Submit test reports for fiber optic cable testing.
4. All test shall conform with NETA standards. A printed hard copy of the test reports shall be provided to the Owner.

E. Calculations:

1. Submit cable pulling calculations for all cables larger than 2/0 AWG and pulling lengths longer than 200 feet.
2. Submit cable pulling calculations for all conductor sizes for pulling lengths longer than 500 feet.
3. Submit the calculations to the Engineer a minimum of 2 weeks before the cable pull.

1.06 CABLE TESTING AND REPLACEMENT

A. All cables that fail to meet NETA standards shall be replaced at the discretion of the Engineer and Owner.

B. All wires and cables shall be tested individually.

C. All tests shall conform to NETA standards.

1.07 QUALITY ASSURANCE

A. Refer to Section 16050, Common Work Results for Electrical.

B. All wires and cables shall be UL listed and labeled. CSA and TUV are acceptable.

1.08 DELIVERY, STORAGE, AND HANDLING

A. Refer to Section 16050, Common Work Results for Electrical.

1.09 WARRANTY

A. Refer to Section 16050, Common Work Results for Electrical.

1.10 SYSTEM STARTUP

A. Refer to Section 16050, Common Work Results for Electrical.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. One of the following:

1. 600-Volt Class Wire and Cable:
   a. General Cable.
   b. Okonite Company.
   c. Southwire Company.
   d. “Or-equal.”
2. Instrumentation Class Wire and Cable:
   a. Alpha Wire Company.
   b. Belden CDT.
   c. General Cable BICC Brand.
   d. Okonite Company.
   e. Rockbestos Surprenant Cable Corporation.
   f. “Or-equal.”

3. Network Cables:
   a. Belden CDT.
   b. Siemens.
   c. Lucent.
   d. “Or-equal.”
4. Fiber Optic Cables:
   a. AFL.
   b. Corning.
   c. “Or-equal.”

2.02 MATERIALS

A. Conductors:

1. Copper per ASTM B3.
2. Minimum 97 percent conductivity.

2.03 MANUFACTURED UNITS

A. General:

1. Conductors, include grounding conductors, shall be stranded copper. Solid conductors shall not be permitted. Aluminum conductor wire and cable will not be permitted.
2. Provide new wires and cables manufactured within 1 year of the date of delivery to the Site.
3. Permanently mark each wire and cable with the following at 24-inch intervals:
   a. American Wire Gauge (AWG) size.
   b. Voltage rating.
   c. Insulation type.
   d. UL symbol.
   e. Month and year of manufacture.
   f. Manufacturer’s name.
4. Identify and mark wire and cable as specified in Section 16075, Electrical Identification:
   a. Use integral color insulation for Number 2 AWG and smaller wire. Tape or integral color insulation shall be permitted for wire Number 2 AWG and larger.
   b. Wrap colored tape around cable larger than Number 2 AWG. Tape shall be 2 inches minimum. Provide two wraps minimum.

B. 600-Volt Class Wire and Cable:

1. Provide American Wire Gauge (AWG) or kcmil sizes as indicated on the Drawings:
   a. When not indicated on the Drawings, size wire as follows:
      1) In accordance with the National Electrical Code:
         a) Use 75 degrees C ampacity ratings.
         b) Ampacity rating after all derating factors, equal to or greater then rating of the overcurrent device.
      2) Provide Number 12 AWG minimum for power conductors.
      3) Provide Number 14 AWG minimum for control conductors.
   b. Provide tin plated copper ground wire to be used on aluminum cable tray.
2. Provide Class B Stranding per ASTM B8: Provide Class C stranding where extra flexibility is required.
3. Insulation:
   a. XHHW-2 for all individual power conductors No. 6 AWG and larger.
   b. THWN for all individual power conductors small than No. 6 AWG.
   c. THWN for all individual control conductors.
   d. 90 degrees C rating in wet or dry locations.
4. Conductors for feeders shall be sized to prevent a voltage drop exceeding 3 percent at the farthest outlet of power, heating, and lighting loads, or combinations of such loads, and where the maximum total voltage drop on both feeders and branch circuits to farthest connected load does not exceed 5 percent.
5. Multiconductor Cables:
   a. Type 1, Multiconductor Control Cable:
      1) Conductors:
         a) No. 14 AWG, seven -strand copper, tray cable rated.
         b) Insulation: 30-mil PVC.
         c) UL 1581 listed as Type THHN/TWWN-2 rated VW-1.
         d) Conductor group bound with spiral wrap of barrier type.
         e) Color Code: In accordance with ICEA S-58-679, Method 1, Table 2.
         f) Cable: Passes the ICEA T-29-520 210,000 Btu per hour Vertical Tray Flame Test.

2) Cable Sizes:

No. of Conductors	Max. Outside Diameter (Inches)	Jacket Thickness (Mils)
3	0.41	45
5	0.50	45
6	0.53	45
9	0.64	60
12	0.72	60
19	0.83	60
25	1.00	60
37	1.15	80

b. Type 2, Multi-conductor Power Cable:

1) Conductors:
   a) Class B stranded, coated copper.
   b) Insulation: Chemically cross-linked ethylene-propylene.
   c) UL 1581 listed as Type EPR, rated VW-1.
   d) Color Code:
      (1) Conductors, size No. 8 AWG and smaller, colored conductors, ICEA S-58-679, Method 1, Table 1.
      (2) Conductors, size No. 6 AWG and larger, ICEA S-58-679, Method Y.
2) Cable pass the ICEA T-29-520 210,000 Btu/hr Vertical Tray Flame Test.
3) Cable Sizes:

Conductor Size	Minimum Ground Wire Size	No. of Conductors (not including ground)	Max Outside Diameter (Inches)	Nominal Jacket Thickness (Mils)
12	12	2	0.42	45
		3	0.45	45
		4	0.49	45
10	10	2	0.54	60
		3	0.58	60
		4	0.63	60

Conductor Size	Minimum Ground Wire Size	No. of Conductors (not including ground)	Max Outside Diameter (Inches)	Nominal Jacket Thickness (Mils)
8	10	2	0.62	60
		3	0.66	60
		4	0.72	60
6	8	3	0.74	60
		4	0.81	60
4	6	3	0.88	60
		4	0.97	80
2	6	3	1.01	80
		4	1.11	80
1/0	6	3	1.22	80
		4	1.35	80
2/0	4	3	1.32	80
		4	1.46	80
4/0	4	3	1.56	80
		4	1.78	110

6. Instrumentation Cables:
   a. Type 3, No. 18 AWG, Twisted, Shielded Pair, Instrumentation Cable: Single pair, designed for noise rejection for process control, computer, or data log application is meeting NEMA WC 55 requirements.
      1) Outer Jacket: 45-mil nominal thickness.
      2) Individual Pair Shield: 1.35-mil, double-faced aluminum/synthetic polymer overlapped to provide 100 percent coverage.
      3) Dimension: 0.31-inch nominal OD.
      4) Conductors:
         a) Bare soft annealed copper, Class B, seven-strand concentric, meeting requirements of ASTM B8.
         b) 20 AWG, seven-strand tinned copper drain wire.
         c) Insulation: 15-mil nominal PVC.
         d) Jacket: 4-mil nominal nylon.
         e) Color Code: Pair conductors black and white.

b. Type 4, No. 18 AWG, Twisted, Shielded Triad Instrumentation Cable: Single triad, design for noise rejection for process control, computer, or data log applications meeting NEMA WC 55 requirements.
   1) Outer Jacket: 45-min nominal.
   2) Individual Pair Shield: 1.35-mil, double-faced aluminum/synthetic polymer, overlapped to provide 100 percent coverage.
   3) Dimension: 0.32-inch nominal OD.
   4) Conductors:
      a) Bare soft annealed copper, Class B, seven-strand concentric, meeting requirements of ASTM B8.
      b) 20 AWG, seven-strand, tinned copper drain wire.
      c) Insulation: 15-mil nominal PVC.
      d) Jacket: 4-mil nylon.
      e) Color Code: Triad conductors black, red, and white.

c. Type 5, No. 18 AWG, Multi-Twisted, Shielded Pairs with a Common, Overall Shield Instrumentation Cable: Designed for use as instrumentation, process control, and computer cable, meeting NEMA WC 55 requirements.
   1) Conductors:
      a) Bare soft annealed copper, Class B, seven-strand concentric, in Accordance with ASTM B8.
      b) Tinned copper drain wires.
      c) Pair drain wire size AWG 20, group drain wire size AWG 18.
      d) Insulation: 15-mil PVC.
      e) Jacket: 4-mil nylon.
      f) Color Code: Pair conductors black and red with red conductor numerically printed for group identification.
      g) Individual Pair Shield: 1.35-mil, double-faced aluminum/synthetic polymer.
   2) Cable Shield: 2.35-mil, double-faced aluminum/synthetic polymer, overlapped for 100 percent coverage.

3) Cable Sizes:

Number of Pairs	Max. Outside Diameter (Inches)	Nominal Jacket Thickness (Mils)
4	0.50	45
8	0.68	60
12	0.82	60
16	0.95	80
24	1.16	80
36	1.33	80
50	1.56	80

7. VFD Cables:
   a. Type 6, Flexible, shielded VFD cable with single ground conductor:
      1) UL 2277, 1,000V flexible motor supply cable.
      2) TC-ER rated, 90 degrees C wet or dry.
      3) Conductors:
         a) 12 AWG thru 10 AWG, tinned copper per ASTM B33, Class K stranding per ASTM B172.
         b) 8 AWG through 2 AWG, tinned copper per ASTM B33, Class H stranding per ASTM B173.
         c) Insulation: 45-mil XLPE for conductors 12 AWG through 10 AWG; 60-mil XLPE for conductors 8 AWG through 2 AWG.
         d) Three full-sized green solid or yellow-striped insulated ground conductors, same AWG size as the circuit conductors.
      4) Cable Shield: Overall aluminum shield with minimum 25 percent overlap with overall tinned copper braid with 85 percent coverage and full sized tinned copper drain wire(s).
      5) Jacket: UV-sunlight resistant, flame retardant and chemical resistant.

6) Cable Sizes:

Conductor Size	Minimum Ground Wire Size	No. of Conductors (not including ground)	Max Outside Diameter (Inches)	Nominal Jacket Thickness (Mils)
12	12	3	0.70	60
10	10	3	0.74	60
8	8	3	0.94	80
6	6	3	1.03	80
4	4	3	1.17	80
2	2	3	1.33	80

8. DLO Cables:
   a. Type 8, Diesel Locomotive Cable:
      1) Conductors:
         a) 2,000-volt, stranded copper.
         b) Insulation: Ethylene propylene rubber.
         c) Jacket: Chlorinated polyethylene.
         d) UL 44, 1685 Listed for types RHH, RHW-2 and VW-1.
         e) Suitable for continuous use.
      2) Cable: Passes the FT-4/IEEE1202 for #2/0 through 1,111 kcmil. Passes the UL 1685 ST-1 smoke release test for #2/0 through 1,111 kcmil.
      3) DLO cables shall only be permitted to be used within a control panel. DLO cables shall not be permitted to be used for any other application.
9. Armored Cables:
   a. Type 9, HFC-Type Cables:
      1) Cables:
         a) Stranded copper, 19 strands minimum.
         b) Insulation: THHN.
         c) Integral grounding conductor, fully sized.
         d) Integral #16 AWG bonding wire.
         e) Interlocking aluminum armor with green stripe. The armor and bonding wire shall serve as a redundant ground.
         f) Use only duplex, screw-clamp fittings, approved for use with AFC-type cable.
         g) Healthcare Facilities Type (HCF).

2) Supports:
   a) Support every 12 inches from a junction box or enclosure.
   b) Support every 54 inches maximum.

C. Network Cables:

1. Type 11, Shielded Category 6 (CAT 6):
   a. Conductors:
      1) 23 AWG solid bare copper conductors, 26 AWG drain wire.
      2) Shielded cable with shielded connectors.
      3) Overall Shield: 1.35-mil, double-faced aluminum/synthetic polymer overlapped to provide 100 percent coverage.
      4) Provide red stain relief boots over connectors.
   b. Insulation:
      1) Polyolefin.
      2) Four non-bonded twisted pair cables formed into a cable core.
   c. Color Code:
      1) Pair 1: White/Blue Stripe and Blue.
      2) Pair 2: White/Orange Stripe and Orange.
      3) Pair 3: White/Green Stripe and Green.
      4) Pair 4: White/Brown Stripe and Brown.
   d. Outer Jacket:
      1) PVC with ripcord.
      2) Color red.
      3) CMR rated.
   e. Electrical Characteristics:
      1) Frequency Range: 0.772 MHz to 100 MHz.
      2) Attenuation: 32.1 dB/100m.
      3) Near-End Crosstalk (NEXT): 39.3 dB.
      4) Power Sum NEXT: 37.3 dB.
      5) Attenuation to Crosstalk Ratio: 7.2 dB.
      6) Power Sum Attenuation to Crosstalk Ratio: 5.3 dB/100m.
      7) Equal Level Far-End Crosstalk (ELFEXT): 22.8 dB.
      8) Power-Sum ELFEXT: 19.8 dB/100m.
      9) Return Loss: 17.3 dB.
      10) Propagation Delay: 537 ns/100m.
      11) Delay Skew: 45 ns/100m.
      12) Propagation Delay (Skew), max: 2.5 ns/100m.
   f. Manufacturer and Product:
      1) Commscope; CS34R RED C6 4/23 F/UTP RL.
      2) “Or-equal.”

g. RJ45 Jacks:
1) Shall be CAT6 shielded.
2) Punch down and terminate on jacks as shown on the Drawings.
h. Patch Panels:
1) Shall be CAT6 shielded patch panels.
2) Punch down and terminate on patch panels as shown on the Drawings.
i. Terminate CAT6 cables in an 8P8C T568B fashion.

2. Fiber Optic Cables:
a. Type: Multimode, OM4, 50 micrometers core diameter, 125 micrometer cladding diameter.
b. Rating:
1) Tight Buffered Indoor/Outdoor.
2) Plenum Rated OFNR.
c. Fiber Count: 12 fibers.
d. Preferred Jacket Color: Black.
e. Connectors: Do not use pre-terminated connectors. Terminate at LC type connectors after installation.
1) Connector Type: LC UPC Splice-ON connectors.
f. Splicing: Not allowed, fiber shall be continuous from point of origin to termination. Cutting and splicing in the field is not acceptable.
g. Manufacturer and Product:
1) AFL; KR012L651801.
2) “Or-equal.”

2.04 ACCESSORIES

A. Tape:

1. Flame Retardant, Cold and Weather Resistant: 8.5-mil, vinyl plastic, Scotch Brand 88.

B. Connectors and Terminations:

1. Nylon, Self-Insulated Crimp Connectors:
a. Manufacturers and Products:
1) Thomas & Betts; Sta-Kon.
2) Burndy; Insulug.
3) ILSCO.

2. Nylon, Self-Insulated, Crimp Locking-Fork, Torque-Type Terminator:
   a. Manufacturers and Products:
      1) Thomas & Betts; Sta-Kon.
      2) Burndy; Insulug.
      3) ILSCO.

C. Cable Lugs:

1. In accordance with NEMA CC1.
2. Rated 600 volts of same material as conductor metal.
3. Insulated, Locking-Fork, Compression Lugs:
   a. Suitable for use with 75 degrees C wire at full NFPA 70, 75 degrees C ampacity.
   b. Seamless.
   c. Manufacturers and Products:
      1) Thomas & Betts; Sta-Kon.
      2) ILSCO; ILSCONS.
4. Uninsulated Crimp Connectors and Terminators:
   a. Suitable for use with 75 degrees C wire at full NFPA 70, 75 degrees C ampacity.
   b. Manufacturers and Products:
      1) Thomas & Betts; Color-Keyed.
      2) Burndy, Hydent.
      3) ILSCO.

D. Cable Ties:

1. Nylon, adjustable, self-locking, and reusable.
2. Manufacturer and Product: Thomas & Betts; TY-RAP.
3. Cable ties installed outdoors shall be UV resistant and rated for use in direct sunlight. Finish shall be black.

E. Heat Shrinkable Insulation:

1. Thermally stabilized, cross-linked polyolefin.
2. Manufacturer and Product: Thomas & Betts; SHRINK-KON.

F. Pulling Compound:

1. Nontoxic, noncorrosive, noncombustible, nonflammable, water-based lubricant; UL listed.
2. Suitable for rubber, neoprene, PVC, polyethylene, hypalon, CPE, and lead-covered wire and cable.
3. Suitable for zinc-coated steel, aluminum, PVC, bituminized fiber, and fiberglass raceways.

4. Manufacturers:
   a. Polywater, Inc.
   b. Ideal Clear Lube.

G. Innerduct:

1. Provide innerduct for fiber optic cable installations.
2. Function: Installs into conduit system to provide smooth, low-friction path through conduit.
3. Size: 25 mm or 32 mm innerduct installed in 2-inch conduit.
4. Type: Annular corrugated innerduct.
5. Color: Other than orange or black.
6. Strength: Minimum 600-pound tensile strength, with no more than 5 percent ovalization at 600-pound tension.
7. Lubrication: Pre-lubricated.
8. Manufacturers:
   a. Endocor.
   b. Dura-Line.

2.05 SOURCE QUALITY CONTROL

A. Assembly and testing of cable shall comply with the applicable requirement of ICEA Publication No. S-68-516.

B. Test in accordance with the requirements of UL 44 and UL 854 Standards.

PART 3 EXECUTION

3.01 INSTALLATION

A. Refer to Section 16050, Common Work Results for Electrical.

B. Color Coding:

1. Color coding shall be consistent throughout the facility.
2. The following color code shall be followed for all 240/120 Volt and 208/120 Volt systems:
   a. Phase A: Black.
   b. Phase B: Red.
   c. Phase C: Blue.
   d. Single Phase System: Black for one hot leg, red for the other.
   e. Neutral: White.
   f. High Phase or Wild Leg: Orange.
   g. Equipment Ground: Green.

3. The following color code shall be followed for all 480/277 Volt systems:
    a. Phase A: Brown.
    b. Phase B: Orange.
    c. Phase C: Yellow.
    d. Neutral: Gray.
    e. Equipment Ground: Green.
4. The following color code shall be followed for all 120V ac control wiring:
    a. Power: Red.
    b. Neutral: White.
5. The following color code shall be followed for all general purpose DC control circuits:
    a. Negative: White/blue stripe.
    b. Positive: Blue.
6. The following color code shall be followed for all signal (4 mA to 20 mA or 1V dc to 5V dc) circuits:
    a. Negative: Black.
    b. Positive: White.
7. Switch legs shall be violet. Three-way switch runners shall be pink.
8. Wires in intrinsically safe circuits shall be light blue.
9. Wire colors shall be implemented in the following methods:
    a. Wires manufactured of the desired color.
    b. Continuously spiral wrap the first 6 inches of the wire from the termination point with colored tape:
        1) Colored tape shall be wrapped to overlap 1/2 of the width of the tape.

C. Install conductors only after the conduit installation is complete, and all enclosures have been vacuumed clean, and the affected conduits have been swabbed clean and dry:

1. Install wires only in approved raceways.
2. Do not Install wire:
    a. In incomplete conduit runs.
    b. Until after the concrete work and plastering is completed.

D. Properly coat wires and cables with pulling compound before pulling into conduits and prevent mechanical damage to conductors during installation:

1. For all Number 4 AWG and larger, use an approved wire-pulling lubricant while cable is being installed in conduit.

E. Cable Pulling:

1. For cables Number 1 AWG and smaller, install cables by hand.
2. For cables larger than Number 1 AWG, power pulling winches may be used if they have cable tension monitoring equipment.
3. Provide documentation that maximum cable pulling tension was no more than 75 percent of the maximum recommended level as published by the cable manufacturer. If exceeded, the Engineer and Owner may, at his discretion, require replacement of the cable.
4. Ensure cable pulling crews have all calculations and cable pulling limitations while pulling cable.
5. Make splices or add a junction box or pullbox where required to prevent cable pulling tension or sidewall pressure from exceeding 75 percent of manufacturer's recommendation for the specified cable size:
    a. Make splices in manholes or pull boxes only.
    b. Leave sufficient slack to make proper connections.
    c. Splices in manholes shall consist of crimp connections with heat shrinkable tubing.
    d. Splices in pullboxes shall utilize insulated terminal blocks.

F. Use smooth-rolling sheaves and rollers when pulling cable into cable tray to keep pulling tension and bending radius within manufacturer's recommendations.

G. Install and terminate all wire in accordance with manufacturer's recommendations.

H. Neatly arrange and lace conductors in all switchboards, panelboards, pull boxes, and terminal cabinets by means of wire ties:

1. Do not lace wires in gutter or panel channel.
2. Install all wire ties with a flush cutting wire tie installation tool:
    a. Use a tool with an adjustable tension setting.
3. Do not leave sharp edges on wire ties.

I. Terminate solid conductors at equipment terminal screws with the conductor tightly wound around the screw so that it does not protrude beyond the screw head: Wrap the conductor clockwise so that the wire loop is closed as the loop is tightened.

J. Terminate stranded conductors on equipment box lugs such that all conductor strands are confined within the lug: Use ring type lugs if box lugs are not available on the equipment.

K. Splices:

1. Provide continuous circuits from origin to termination whenever possible. Obtain Owner's approval prior to making any splices.
2. Lighting and receptacle branch circuits may be spliced without approval from the Owner.
3. Where splices are necessary because of extremely long wire or cable lengths that exceed standard manufactured lengths:
    a. Refer to Section 16050, Common Work Results for Electrical, for box NEMA rating requirements.
    b. Make splices in labeled junction boxes for power conductors.
    c. Make splices for control and instrument conductors in terminal boxes or FD boxes near the instrument:
        1) Provide terminal blocks.
        2) Terminate all conductors on terminal blocks with wire ferrules.
        3) Splices shall not be made in conduit bodies.
4. Splices not permitted for power and control conductors.
5. If splices have been approved by the Owner, clearly label junction and terminal boxes containing splices with the word "SPLICE." Provide this label on approved power, control, and signal junction and terminal boxes.
6. Leave sufficient slack at junction boxes and termination boxes to make proper splices and connections. Do not pull splices into conduits.
7. Install splices with compression type butt splices and insulate using a heat-shrink sleeve:
    a. In NEMA 4 or NEMA 4X areas, provide heat-shrink sleeves that are listed for submersible applications.
8. Splices in below grade pull boxes, in any box subject to flooding, and in wet areas shall be made waterproof using:
    a. A heat shrink insulating system listed for submersible applications.
    b. An epoxy resin splicing kit.
    c. Other approved direct burial splice kit.

L. Apply circuit and wire markers to all wires and cables as described below:

1. Circuit Identification Location: Identify power, instrumentation, and control conductor circuits, using circuit name as described below, at each termination and in accessible locations such as manholes, hand-holes, panels, switchboards, motor control centers, pull boxes, and terminal boxes.
2. Circuit Name:
   a. Assign circuit name based on device or equipment at load end of circuit as indicated on the Drawings and as described in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.
   b. Where this would result in same name being assigned to more than one circuit, add number or letter to each otherwise identical circuit name to make it unique.
3. Method:
   a. Conductors No. 3 AWG and Smaller: Identify with sleeves or heat bond markers.
   b. Taped-on markers or tags relying on adhesives not permitted.
   c. Cables and Conductors No. 2 and Larger:
      1) Identify with marker plates; or
      2) Tie-on cable marker tags.
      3) Attach with nylon tie cord.

M. Instrumentation Class Cable:

1. Install instrumentation class cables in separate raceway systems from power cables:
   a. Install instrument cable in metallic conduit within non-dedicated manholes or pull boxes.
   b. Install cable without splices between instruments or between field devices and instrument enclosures or panels.
2. Do not make intermediate terminations, except in designated terminal boxes as indicated on the Drawings.
3. Refer to Section 16050, Common Work Results for Electrical, for shield grounding requirements.

N. Signal Cable: Separate and isolate electrical signal cables from sources of electrical noise and power cables by minimum 12 inches. Perpendicular crossings shall be acceptable.

O. Unsupported Cables: Provide Kellem’s grip or stainless steel wire mesh to support cable weight and avoid stress on insulation.

P. Wiring Allowances:

1. Equipment locations may vary slightly from the drawings. Include an allowance for necessary conductors and terminations for motorized equipment, electrical outlets, fixtures, communication outlets, instruments, and devices within 10 linear feet of locations indicated on the Drawings.
2. Locations for pull boxes, manholes, and duct banks may vary slightly from the drawings. Include an allowance for necessary conductors and related materials to provide conductors to all pull boxes, manholes and duct banks within 20 linear feet of locations as indicated on the Drawings.

Q. Wiring within Cabinets and Enclosures: All wiring within a cabinet or enclosure shall insulated.

R. Wire Ferrules: All conductors #14 AWG and smaller that terminate on terminal blocks shall be terminated using wire ferrules.

S. Fiber Optic Cables:

1. Installation of Fiber Optic Cables:
   a. Performed in accordance with BICSI standards and work done by installer with BICSI Installer 2, Optical Fiber (INSTF) certification.
   b. Install in innerduct.
   c. Installed in accordance with manufacturer’s requirements.
2. During installation, ensure that cable is:
   a. Not dented, nicked, or kinked.
   b. Not subjected to pull stress greater than manufacturer’s specification.
   c. Not bent to a radius below manufacturer’s minimum bend radius.
   d. Not subjected to treatment that may damage fiber strands during installation.
   e. Installed complete between termination points, with no intermediate splices.
   f. Arranged neatly at termination enclosures with 10-foot slack service loop.
3. Terminations:
   a. In accordance with TIA 568 C.3.
   b. Connectors: Terminate 100 percent of the fibers in each cable with LC connectors at existing fiber optic patch panels.
   c. Provide two OM3 fiber patch cords, two fibers per cord with LC style connectors, 10-feet long.

3.02 CATEGORY CABLE TESTING

A. The permanent link shall be tested.

B. All test results shall be used by the Contractor to determine any polarity and noise anomalies and Contractor shall take immediate corrective action for all anomalies.

C. Test results shall be used by the Contractor to determine the viability of each sheath for transmission in accordance with the specifications of the cable manufacturer and the requirements imposed by the transmission system. This shall form part of the acceptance procedure for the cable plant. All results obtained by use of pair-scanner testing shall be collated by terminal outlet number and or riser pair number and presented to the Owner at the conclusion of the testing. Test compilation shall be initialed and dated by the Contractor's technician performing the test.

D. The Contractor shall utilize a Level-III Fluke, PentaScanner, Wavetek, "or-equal," twisted pair test instrument for the testing of all System Category copper cabling. All Category cable paths shall be tested at each jack for the following parameters and meet the requirements imposed by the TIA/EIA 568-B3 building wiring standard.

E. Category data cabling systems shall be performance verified using an automated test set. This test set shall be capable of testing for the continuity and length parameters defined above and provide for the following tests.

1. Wire Map.
2. Cable Length.
3. Pair-to-Pair NEXT.
4. Power Sum NEXT.
5. Attenuation.
6. Pair-to-Pair ELFEXT.
7. Power Sum ELFEXT.
8. Return Loss.
9. Propagation Delay.
10. Delay Skew.

F. A complete cable certification report shall be provided covering all locations.

G. The Contractor shall compile test results into the forms that contain all applicable test data. An external drive containing the test data and appropriate application (software) to display such in a windows-based environment shall be provided.

3.03 FIELD QUALITY CONTROL

A. Refer to Section 16050, Common Work Results for Electrical.

B. Grounding: Refer to Section 16060, Grounding and Bonding.

C. Fiber Optic Cable Testing:

1. As part of this Contract, provide the services of an independent third-party tester to verify and test all optical fibers and LC connectors installed under this contract. The third-party tester shall have a minimum of 5 years of verifiable work experience performing fiber testing. A written list of references shall be made available to the Owner, if requested.
2. Test all fibers and connectors using an OTDR and provide traces with maximum fiber loss in compliance with standard TIA-568-C, not exceeding:
   a. 3 dB/km at 850 nm wavelength.
   b. 1.2 dB/km at 1300 nm wavelength.
   c. 0.4 dB per connector.
3. All fiber that fails the testing shall be replaced by the Contractor at no additional cost to the Owner.
4. Submit all test results to the Owner in electronic (PDF).

3.04 PROTECTION

A. Refer to Section 16050, Common Work Results for Electrical.

END OF SECTION

SECTION 16130
CONDUITS

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes:

1. Metallic conduits.
2. Nonmetallic conduits.
3. Conduit bodies.
4. Conduit fittings and accessories.
5. Conduit installation.

B. Related Sections:

1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.

1.02 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. As specified in Section 16050, Common Work Results for Electrical.
2. American National Standards Institute (ANSI):
   a. C80.1, Electrical Rigid Steel Conduit.
   b. C80.3, Steel Electrical Metallic Tubing.
   c. C80.5, Electrical Rigid Aluminum Conduit.
   d. C80.6, Electrical Intermediate Metal Conduit.
3. National Electrical Manufacturer's Association (NEMA):
   a. RN-1, Polyvinyl Chloride (PVC) Externally Coated Galvanized Rigid Steel Conduit and Intermediate Steel Conduit.
   b. TC2, Electrical Polyvinyl Chloride (PVC) Conduit.
   c. TC3, Polyvinyl Chloride (PVC) Fittings for Use with Rigid PVC Conduit and Tubing.
   d. TC7, Smooth-Wall Coilable Electrical Polyethylene Conduit.
   e. TC13, Electrical Nonmetallic Tubing.
   f. TC14, Reinforced Thermosetting Resin Conduit (RTRC) and Fittings.

4. UL:
    a. 1, Standard for Flexible Metal Conduit.
    b. 6, Standard for Electrical Rigid Metal Conduit - Steel.
    c. 6A, Standard for Electrical Rigid Metal Conduit - Aluminum, Red Brass, and Stainless Steel.
    d. 360, Standard for Liquid-Tight Flexible Steel Conduit.
    e. 651, Standard for Schedule 40 and Schedule 80 Rigid PVC Conduit and Fittings.
    f. 651B, Standard for Continuous Length HDPE Conduit.
    g. 797, Standard for Electrical Metallic Tubing - Steel.
    h. 1242, Standard for Electrical Intermediate Metal Conduit - Steel.
    i. 1653, Standard for Electrical Nonmetallic Tubing.
    j. 1660, Standard for Liquid-Tight Flexible Nonmetallic Conduit.
    k. 1684, Standard for Reinforced Thermosetting Resin Conduit (RTRC) and Fittings.

1.03 DEFINITIONS

A. As specified in Section 16050, Common Work Results for Electrical.

B. Specific Definitions and Abbreviations:

1. Conduit Bodies: A separate portion of a conduit system that provides access through a removable cover to the interior of the system at a junction of 2 or more conduit sections. Includes, but not limited to, shapes C, E, LB, T, X, etc.
2. Conduit Fitting: An accessory that serves primarily a mechanical purpose. Includes, but not limited to, bushings, locknuts, hubs, couplings, reducers, etc.
3. GRC: Galvanized rigid steel conduit.
4. PCS: PVC coated rigid steel conduit.
5. PVC: Polyvinyl chloride rigid nonmetallic conduit.
6. SLT: Sealtight – liquid-tight flexible steel conduit.
7. EFLX: Explosionproof flexible conduit.
8. FLX: Flexible steel conduit.
9. RAC: Rigid aluminum conduit.
10. EMT: Electrical Metallic Tubing conduit.
11. NPT: National pipe thread.

1.04 SYSTEM DESCRIPTION

A. Provide conduits, conduit bodies, fittings, junction boxes and all necessary components, whether or not indicated on the Drawings, as required, to install a complete electrical raceway system.

1.05 SUBMITTALS

A. Furnish submittals as specified in Section 01330, Submittal Procedures, and Section 16050, Common Work Results for Electrical.

B. Product Data:

1. Furnish complete manufacturer's catalog sheets for every type and size of conduit, fitting, conduit body, and accessories to be used on the Project.
2. Furnish complete manufacturer's recommended special tools to be used for installation if required.
3. Certified test results for PVC-coated metallic conduit showing the adhesive bond is stronger than the tensile strength of the PVC.
4. List of manufacturer's recommended spare parts.

C. Certifications: Furnish PVC-coated conduit manufacturer's certification for each installer.

D. Record Documents:

1. Incorporate all changes in conduit routing on electrical plan drawings.
2. Dimension concealed conduits from building lines.
3. Furnish hard copy drawings and electronic files in AutoCAD format Version 2010.

E. Installation Drawings: Installation drawings, including individual conduit numbers, routing, sizes, cable sizes, and circuit numbers for each conduit.

1.06 QUALITY ASSURANCE

A. As specified in Section 16050, Common Work Results for Electrical.

B. All conduits, conduit bodies, and fittings shall be UL listed and labeled.

C. Every installer of PCA or PCS conduits shall be certified by the manufacturer for installation of the conduit.

1.07 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 16050, Common Work Results for Electrical.

B. Do not expose type PVC, FRD, NFC and ENT to direct sunlight.

C. Do not store conduit in direct contact with the ground.

1.08 PROJECT OR SITE CONDITIONS

A. As specified in Section 16050, Common Work Results for Electrical.

1.09 SEQUENCING

A. Before installing any conduit or locating any device box:

1. Examine the complete set of Drawings and Specifications, and all applicable Shop Drawings.
2. Verify all dimensions and space requirements and make any minor adjustments to the conduit system as required to avoid conflicts with the building structure, other equipment, or the work of other trades.

1.10 WARRANTY

A. As specified in Section 16050, Common Work Results for Electrical.

1.11 SYSTEM STARTUP

A. As specified in Section 16050, Common Work Results for Electrical.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Galvanized Rigid Steel Conduit:

1. One of the following:
   a. Western Tube and Conduit.
   b. Allied Tube and Conduit.
   c. Wheatland Tube Co.
   d. “Or-equal.”

B. Polyvinyl Chloride-coated Rigid Steel Conduit:

1. One of the following:
   a. Robroy Industries.
   b. Ocal, Inc.
   c. “Or-equal.”

C. Rigid Aluminum Conduit (RAC).

1. One of the following:
   a. Allied Tube and Conduit.
   b. Patriot Aluminium Products.
   c. Republic Conduit.

d. Wheatland Tube Co.
e. “Or-equal.”

D. Flexible Steel Conduit:

1. One of the following:
a. AFC Cable Systems.
b. Southwire.
c. Electri-flex Company.
d. “Or-equal.”

E. Sealtight Liquid-tight Flexible Steel Conduit:

1. One of the following:
a. Thomas & Betts – LTA.
b. Southwire – Titan.
c. Electri-flex – Liquatite.
d. Anaconda Sealtite – MTC.
e. “Or-equal.”

F. Explosionproof Flexible Conduit:

1. One of the following:
a. Appleton.
b. Crouse Hinds.
c. Hubbell Killark.
d. “Or-equal.”

G. Electrical Metallic Tubing:

1. One of the following:
a. Allied Tube and Conduit.
b. Patriot Aluminium Products.
c. Republic Conduit.
d. Wheatland Tube Co.
e. “Or-equal.”

H. Conduit Bodies:

1. One of the following:
a. Crouse-Hinds.
b. Appleton.
c. O-Z/Gedney.
d. Ocal.
e. Robroy.

f. Carlon.
g. “Or-equal.”

I. Galvanized Rigid Steel Conduit Expansion Fittings:

1. One of the following:
a. Crouse-Hinds.
b. Appleton.
c. O-Z/Gedney.
d. “Or-equal.”

J. Conduit Sleeve:

1. One of the following:
a. Crouse-Hinds.
b. Appleton.
c. O-Z/Gedney.
d. “Or-equal.”

K. Conduit Seals:

1. One of the following:
a. Appleton.
b. Crouse-Hinds.
c. O-Z/Gedney.
d. “Or-equal.”

L. Conduit Hangers and Supports: As specified in Section 16070, Hangers and Supports.

M. Conduit through Wall and Floor Seals:

1. The following:
a. O-Z/Gedney:
1) Type “WSK”.
2) Type “CSM”.
b. “Or-equal.”

2.02 COMPONENTS

A. GRC:

1. All Threads: NPT standard conduit threads with a 3/4-inch taper per foot: Running conduit threads are not acceptable.
2. Hot-dip Galvanized Inside and Out: Ensures complete coverage and heats the zinc and steel to a temperature that ensures the zinc alloys with the steel over the entire surface. Electro-galvanizing is not acceptable.
3. Manufactured in accordance with:
   a. UL 6.
   b. ANSI C80.1.

B. PCS:

1. The steel conduit, before PVC coating, shall be new, unused, hot-dip galvanized material, conforming to the requirements for type GRC.
2. Coated Conduit NEMA Standard RN-1: The galvanized coating may not be disturbed or reduced in thickness during the cleaning and preparatory process.
3. Factory-bonded PVC Jacket:
   a. The exterior galvanized surfaces shall be coated with primer before PVC coating to ensure a bond between the zinc substrate and the PVC coating.
   b. Nominal thickness of the exterior PVC coating shall be 0.040 inch except where part configuration or application of the piece, dictate otherwise.
   c. PVC coating on conduit and associated fittings shall have no sags, blisters, lumps, or other surface defects and free of holes and holidays.
   d. The PVC adhesive bond on conduit and fittings shall be greater than the tensile strength of the PVC plastic coating:
      1) Confirm bond with certified test results.
4. A urethane coating shall be uniformly and consistently applied to the interior of all conduit and fittings:
   a. Nominal thickness of 0.002 inch.
   b. Conduit having areas with thin or no coating, are not acceptable.
   c. All threads shall be coated with urethane.
5. The PVC exterior and urethane interior coatings applied to the conduit shall afford sufficient flexibility to permit field bending without cracking or flaking at temperature above 30 degrees F.
6. PCS conduit bodies and fittings:
   a. Malleable iron.
   b. The conduit body, before PVC coating, shall be new, unused material and shall conform to appropriate UL standards.

c. The PVC coating on the outside of conduit bodies shall be 0.040-inch-thick and have a series of longitudinal ribs to protect the coating from tool damage during installation.
d. 0.002-inch interior urethane coating.
e. Utilize the PVC coating as an integral part of the gasket design.
f. Stainless steel cover screws heads shall be encapsulated with plastic to assure corrosion protection.
g. A PVC sleeve extending 1 conduit diameter or 2 inches, whichever is less, shall be formed at each female conduit opening.
    1) The inside diameter of the sleeve shall be the same as the outside diameter of the conduit to be used.
    2) The sleeve shall provide a vapor and moisture tight seal at every connection.

C. RAC:

1. Rigid aluminum conduit shall be manufactured of Alloy 6063-T1.
2. Manufactured in accordance with:
    a. ANSI C80.5.
    b. UL 6A.
3. Use of this conduit type is restricted to only locations permitted in Section 16050, Common Work Results for Electrical. Refer to the Plant Area Work Requirements table which specifies the permitted uses for these conduit types.

D. EMT:

1. Hot galvanized steel with corrosion resistant inner diameter coating.
2. Manufactured in accordance with:
    a. ANSI C80.3.
    b. UL 797.
3. Use of this conduit type is restricted to only locations permitted in Section 16050, Common Work Results for Electrical. Refer to the Plant Area Work Requirements table which specifies the permitted uses for these conduit types.

E. FLX:

1. Materials: Single strip steel hot-dip galvanized on all four sides before conduit fabrication.
2. Interlocking design formed from continuous metal strip for integrity and flexibility.
3. Manufactured in accordance with UL 1.

4. Use of this conduit type is restricted to only locations permitted in Section 16050, Common Work Results for Electrical. Refer to the Plant Area Work Requirements table which specifies the permitted uses for these conduit types.

F. SLT:

1. Temperature rated for use in the ambient temperature at the installed location but not less than the following:
   a. General Purpose: Temperature range minus 20 degrees C to plus 80 degrees C.
   b. Oil Resistant: Temperature range minus 20 degrees C to plus 60 degrees C.
2. Sunlight resistant, weatherproof, and watertight.
3. Manufactured from single strip steel, hot-dip galvanized on all four sides before conduit fabrication.
4. Strip steel spiral wound resulting in an interior that is smooth and clean for easy wire pulling.
5. Overall thermoplastic PVC jacket.
6. High flexibility.

G. EFLX:

1. Suitable for the hazardous Class and Group where installed as specified in Section 16050, Common Work Results for Electrical.
2. Metallic braid shall provide continuous electrical path.
3. Stainless steel construction.
4. Provide fittings and unions as required for the installation.

H. PVC:

1. Extruded from Virgin Polyvinyl Chloride Compound:
   a. Schedule 40 unless otherwise specified.
   b. Schedule 80 extra heavy wall where specified.
   c. Rated for 90 degrees C conductors or cable.
2. Rated for use in direct sunlight.

I. Conduit Bodies:

1. Material consistent with conduit type:
   a. Malleable iron bodies and covers when used with type GRC conduit.
   b. Cast aluminum bodies and covers when used with type RAC.
   c. PVC bodies and covers when used with type PVC.
   d. PVC-coated malleable iron bodies and covers when used with type PCS.

e. PVC-coated copper-free cast aluminum bodies and covers when used with type PCA.
f. Malleable iron or aluminum bodies with pressed steel or aluminum covers when used with EMT conduit.

2. Conduit Bodies to Conform to Form 7 or Mogul Design: Mogul design conforming to NEC requirements for bending space for large conductors for conduit trade sizes of 1 inch and larger with conductors 4 AWG and larger, or where required for wire bending space.
3. The cover shall have wedge-nut clips with integral gaskets for easy installation and removal. This applies to all material types.

2.03 ACCESSORIES

A. Connectors and Fittings: Manufactured with compatible materials to the corresponding conduit.

B. Insulated Throat Metallic Bushings:

1. Construction:
a. Malleable iron when used with steel conduit.
b. Aluminum when used with aluminum conduit.
c. Positive metallic conduit end stop.
d. Integrally molded non-combustible phenolic insulated surfaces rated 150 degrees C.
e. Use fully insulated bushings on nonmetallic conduit system made of high impact 150 degrees C rated noncombustible thermosetting phenolic.

C. Insulated Grounding Bushings:

1. Construction:
a. Malleable iron with a positive metallic end stop.
b. Integrally molded non-combustible phenolic insulated surfaces rated 150 degrees C.
c. Tin plated copper grounding saddle for use with copper or aluminum conductors.

D. Electrical Unions (Erickson Couplings):

1. Construction:
a. Malleable iron for use with steel conduit.
b. Aluminum for use with aluminum conduit.
c. Concrete tight, three-piece construction.
d. Rated for Class I Division 1 Group D in hazardous areas.

E. FLX Fittings:

1. Provide insulated die-cast clamp-on type connectors.
2. Binding screw connectors are not acceptable.

F. SLT Fittings:

1. Construction:
   a. Malleable iron.
   b. Furnished with locknut and sealing ring.
   c. Liquid-tight, rain-tight, oil-tight.
   d. Insulated throat.
   e. Furnish as straight, 45-degree elbows and 90-degree elbows.
   f. Designed to Prevent Sleeving: Verify complete bonding of the raceway jacket to the plastic gasket seal.
   g. Equipped with grounding device to provide ground continuity irrespective of raceway core construction. Grounding device, if inserted into raceway and directly in contact with conductors, shall have rolled over edges for sizes under 5 inches.
   h. Where terminated into a threadless opening using a threaded hub fitting, a suitable moisture resistant/oil resistant synthetic rubber gasket shall be provided between the outside of the box or enclosure and the fitting shoulder. Gasket shall be adequately protected by and permanently bonded to a metallic retainer.
2. Corrosion Resistant and Outdoor SLT fittings:
   a. Construction:
      1) PVC-coated liquid-tight fittings with a bonded 0.040-inch thick PVC coating on the metal connector to form a seal around the SLT conduit.
      2) Insulated throat and an integral sealing ring.
3. ST fittings shall only be used in Class 1 Division 2 locations.

G. All conduits shall use threaded hubs for connections to sheet metal enclosures.

1. Construction:
   a. Insulated throat.
   b. PVC coated when used in corrosive areas.
   c. Bonding locknut.
   d. Recessed neoprene O-ring to assure watertight and dust-tight connector.
   e. 1/2-inch through 6-inch steel zinc electroplated.
   f. Aluminum with aluminum conduit.

H. Sealing Fittings:

1. Construction:
   a. 40 percent wire fill capacity.
   b. Shall be rated for horizontal and vertical installations.
   c. PVC-coated when used in corrosive areas.
   d. Malleable iron with steel conduit.
   e. Aluminum with aluminum conduit.
   f. Crouse-Hinds Type EYD where drains are required.
   g. Crouse-Hinds Type EYS where drains are not required.
   h. UL listed for use in Class I, Division 1, Groups A, B, C, D; Class I, Division 2, Groups A, B, C, D; Class II, Divisions 1 and 2; Groups E, F, and G.
2. Sealing Compound:
   a. Fiber filler and cement as recommended by the sealing fitting manufacturer.
   b. Approved for the conditions and use. Not affected by surrounding atmosphere or liquids.
   c. Melting point shall be 200 degrees F minimum.

I. PVC Fittings:

1. Shall include the following:
   a. Couplings.
   b. Terminal adapters.
   c. Female adapters.
   d. Caps.
   e. Reducer bushings.
   f. Duct couplings.
   g. End bells.
   h. Expansion couplings.
   i. Duct couplings 5-degree.
   j. C-pull fittings.
   k. E-pull fittings.
   l. LB-pull fittings.
   m. LL-pull fittings.
   n. LR-pull fittings.
   o. T-pull fittings.
   p. X-pull fittings.
   q. Service entrance caps.
2. Materials:
   a. All devices shall be made of PVC, using the same materials as used for Type PVC conduit.
   b. All metal hardware shall be stainless steel.

J. EMT Fittings: Rain-tight compression fittings only. The use of set-screw connectors shall not be permitted. Connectors shall have insulated throat.

K. Through Wall and Floor Seals:

1. Materials:
   a. Body: Casting of malleable or ductile iron with a hot-dip galvanized finish.
   b. Grommet: Neoprene.
   c. Pressure Rings: PVC coated steel.
   d. Disc Material: PVC coated steel.
   e. Aluminum when used with conduit type RAC.

L. Expansion/deflection Couplings:

1. Use to compensate for movement in any directions between two conduit ends that they connect.
2. Shall allow movement of 3/4 inch from the normal in all directions.
3. Shall allow angular movement for a deflection of 30 degrees from normal in any direction.
4. Constructed to maintain electrical continuity of the conduit system.
5. Materials:
   a. End Couplings: Bronze or galvanized ductile iron.
   b. Sleeve: Neoprene.
   c. Bands: Stainless steel.
   d. Bonding Jumper: Tinned copper braid.

M. Expansion Couplings:

1. Shall allow for expansion and contraction of conduit. Permitting 8-inch movement, 4 inches in either direction.
2. Constructed to maintain electrical continuity of the conduit system.
3. Materials:
   a. Head: Malleable or ductile iron.
   b. Sleeve: Steel.
   c. Insulating Bushing: Phenolic.
   d. Finish: Hot-dip galvanized.
   e. Aluminum when used with conduit type RAC.

N. Conduit Markers: As specified in Section 16075, Electrical Identification.

2.04 SOURCE QUALITY CONTROL

A. As specified in Section 16050, Common Work Results for Electrical.

PART 3 EXECUTION

3.01 INSTALLATION

A. As specified in Section 16050, Common Work Results for Electrical. Refer to the Plant Area Work Requirements table which specifies the permitted uses for these conduit types.

B. General:

1. Conduit Routing:
   a. The Electrical Drawings are Diagrammatic in Nature:
      1) Install conduit runs as specified with schematic representation as indicated on the Drawings and as specified.
      2) Modify conduit runs to suit field conditions, as accepted by the Engineer:
         a) Make changes in conduit locations that are consistent with the design intent but are dimensionally different, or routing to bypass obstructions.
         b) Make changes in conduit routing due to the relocation of equipment.
      3) The Electrical Drawings do not indicate all required junction boxes and pull boxes:
         a) Provide junction boxes and pull boxes to facilitate wire pulling as required:
            (1) To meet cable manufacturer’s pulling tension requirements.
            (2) To limit total conduit bends between pull locations.
         b) Install junction boxes and pull boxes at locations acceptable to the Engineer.
   b. The Contractor shall submit to Engineer and Owner for review and approval for any proposed change to the conduit size and routing prior to installation:
      1) Incorporate any deviations on the Record Documents.
2. Use only tools recommended by the conduit manufacturer for assembling conduit system.
3. Provide adequate clearances from high-temperature surfaces for all conduit runs. Provide minimum clearances as follows:
   a. Clearances of 6 inches from surfaces 113 degrees F to 149 degrees F.
   b. Clearances of 12 inches from surfaces greater than 149 degrees F.

c. Keep conduit at least 6 inches from the coverings on hot water and steam pipes, 18 inches from the coverings on flues and breechings and 12 inches from fuel lines and gas lines.
d. Where it is necessary to route conduit close to high- temperature surfaces, provide a high-reflectance thermal barrier between the conduit and the surface.

4. Support conduit runs on water-bearing walls a minimum of 7/8-inch away from wall on an accepted preformed channel:
   a. Do not run conduit within water-bearing walls unless otherwise indicated on the Drawings.
5. Do not install 1 inch or larger conduits in or through structural members unless approved by the Engineer.
6. Run conduit exposed to view parallel with or at right angles to structural members, walls, or lines of the building:
   a. Install straight and true conduit runs with uniform and symmetrical elbows, offsets, and bends.
   b. Make changes in direction with long radius bends or conduit bodies.
7. Install conduit with total conduit bends between pull locations less than or equal to 270 degrees.
8. Max total conduit distance between boxes 250 feet.
9. Route all exposed conduit to preserve headroom, access space and workspace and to prevent tripping hazards and clearance problems:
   a. Install conduit runs so that runs do not interfere with proper and safe operation of equipment and do not block or interfere with ingress or egress, including equipment removal hatches.
   b. Route conduit to avoid drains or other gravity lines. Where conflicts occur, relocate conduit as required.
10. Conduit may be run in concrete members or slabs with permission of the Engineer or as indicated on the Drawings: Refer to the typical details for conduit spacing and size requirements.
11. When installing conduit through existing slabs or walls make provisions for locating any possible conflicting items where conduit is to penetrate. Use tone signal or X-ray methods to make certain that no penetrations will be made into existing conduit, piping, cables, post-tensioning cables, etc.
12. Plug conduits brought into pull boxes, manholes, handholes, and other openings until used to prevent entrance of moisture.
13. Install conduit through wall and floor seals where indicated on the Drawings.
14. For existing and new 2-inch and larger conduit runs, snake conduits with conduit cleaner equipped with a cylindrical mandrel of a diameter not less than 85 percent of nominal diameter of conduit:
    a. Remove and replace conduits through which mandrel will not pass.

15. Provide all sleeves and openings required for the passage of electrical raceways or cables even when these openings or sleeves are not specifically indicated on the Drawings.
16. Install complete conduit systems before conductors are installed.
17. Provide metallic conduits terminating in transformer, switchgear, motor control center or other equipment conduit windows with grounding bushings and ground with a minimum No. 6 AWG ground wire.
18. Underground and Embedded Conduits:
    a. Make underground conduit size transitions at handholes and manholes.
    b. Install spare conduits in underground duct banks towards top center of runs to allow for ease of installation of future cables as conduits enter underground manholes and handholes.
    c. All conduits coming out of grade shall have a cap installed, (not tape) during backfill and concrete pouring. Remove only to extend to final location.

C. Lighting and Receptacle Conduits:

1. Install conduit runs for lighting and receptacle circuits, whether or not indicated on the Drawings:
    a. Minimum Conduit Size:
        1) 3/4 inch for exposed conduits.
        2) 1 inch for underground or in slab conduits.
2. Provide conduit materials for the installed location as specified in Section 16050, Common Work Results for Electrical.

D. Hazardous Areas: As specified in Section 16050, Common Work Results for Electrical, for hazardous areas and specific Class and Division.

E. Conduit Usage:

1. Exposed Conduits:
    a. Rigid Conduit:
        1) Install the rigid conduit type for each location as specified in Section 16050, Common Work Results for Electrical.
        2) Minimum Size: 3/4-inch.
    b. Flexible Conduit:
        1) Use flexible conduit for final connections between rigid conduit and motors, vibrating equipment, instruments, control equipment or where required for equipment servicing:
            a) Use type SLT with rigid metallic conduit.
            b) Use type NFC with PVC conduit.

c) Use type EFLX in Class I Division 1 locations.
d) Use type FLX in finished areas.

2) Minimum Size: 3/4-inch.
a) 1/2 when required for connection to instruments.

3) Maximum Length:
a) Fixed Equipment:

Conduit Trade Size	Flexible Conduit Length (in)
3/4	18
1	18
1-1/4	18
1-1/2	18
2	36
2-1/2	36
3	36
3-1/2	38
4	40

b) Removable Instruments or Hinged Equipment: As required to allow complete removal or full movement without disconnecting or stressing the conduit.

2. Concrete Encased and Concrete Capped Embedded Conduits:
a. Type PVC Schedule 40 and PVC coated rigid metallic conduit as specified below:
1) Use Type PCS in underground and embedded installation as follows:
a) Stub-up and risers to grade floor or equipment from nonmetallic conduits.
b) Entering and exiting underground or embedded conduit runs a minimum 12 inches above and below grade or finished floor.
c) For any and all bends where the total deflection is greater than 45 degrees.

b. Minimum Size:
1) Two inches in duct banks unless otherwise indicated on the Drawings.
2) One inch for in slab conduits unless otherwise indicated on the Drawings.

c. Direct Buried And Sand Bedded Ductbank Conduits:
   1) Type PCS.
   2) Minimum Size: 1 inch.

3. PVC Coated Rigid Metallic Conduit: Use specifically manufactured or machined threading dies to manufacturer's specifications to accommodate the PVC jacket.
4. GRC: Conduit shall be cut square and reamed before threading.
5. PVC:
   a. Conduit terminations shall be via threaded adapters into threaded hubs on the junction boxes or conduit bodies.
   b. Conduit terminations into boxes without threaded hubs shall utilize a threaded adapter and a flat neoprene washer on the outside of the box. Use a locknut on the inside of the box to tighten the adapter to the box.

F. Conduit Joints and Bends:

1. General:
   a. Where conduit is underground, under slabs on grade, exposed to the weather or in NEMA Type 4 or NEMA Type 4X locations, make joints liquid-tight.
   b. Keep bends and offsets in conduit runs to an absolute minimum.
   c. All bends shall be symmetrical.
   d. For all types of high-voltage conductors, provide bends as required for lead-covered conductors of equivalent outside diameter.
   e. The following conduit systems shall use large radius sweep elbows:
      1) All conduits trade size 1-1/4-inch and larger.
      2) Exception shall be lighting and receptacle branch circuit conduits.
   f. Provide large radius factory-made bends for 1-1/4-inch trade size or larger.
   g. Make field bends with a radius of not less than the requirements found in the NEC:
      1) The minimum bending radius of the cable must be less than the radius of the conduit bend.
      2) Make all field bends with power bending equipment or manual benders specifically intended for the purpose:
         a) Make bends so that the conduit is not damaged, and the internal diameter is not effectively reduced.
         b) For the serving utilities, make bends to meet their requirements.
   h. Replace all deformed, flattened, or kinked conduit.

2. Threaded Conduit:
   a. Cut threads on rigid metallic conduit with a standard conduit cutting die that provides a 3/4-inch per foot taper and to a length such that all bare metal exposed by the threading operation is completely covered by the couplings or fittings used. In addition, cut the lengths of the thread such that all joints become secure and wrench tight just preceding the point where the conduit ends would butt together in couplings or where conduit ends would butt into the ends or shoulders of other fittings.
   b. Thoroughly ream conduit after threads have been cut to remove burrs.
   c. Use bushings or conduit fittings at conduit terminations.
   d. On exposed conduits, repair scratches and other defects with galvanizing repair stick, Enterprise Galvanizing “Galvabar” or CRC “Zinc It.”
   e. Coat conduit threads with an approved electrically conductive sealant and corrosion inhibitor that is not harmful to the conductor insulation:
      1) Use KOPR-Shield as manufactured by T&B on threads of ferrous conduit.
      2) Apply to the male threads and tighten joints securely.
      3) Clean excess sealant from exposed threads after assembly.
   f. Securely tighten all threaded connections.
   g. Any exposed threaded surface must be cleaned and coated with a galvanizing solution so that all exposed surfaces have a galvanized protective coating.
3. PVC:
   a. Use approved solvent-weld cement specifically manufactured for the purpose. Spray type cement is not allowed.
   b. Apply heat for bends so that conduit does not distort or discolor. Use a spring mandrel as required to assure full inside diameter at all bends: Utilize a heater specifically for PVC conduit as recommended by the conduit manufacturer.

G. Conduit Sealing and Drainage:

1. Conduit drainage and sealing other than required for hazardous and classified areas:
   a. Provide sealing and drainage in vertical drops of long (in excess of 20 feet), exterior, above grade conduit runs at the points at which the conduit enters buildings, switchgear, control panels, lighting panelboards, and other similar enclosures.
   b. Provide seal fittings with drains in vertical drops directly above grade for exterior, above grade conduit runs that are extended below grade.

c. Provide conduit seals with drains in areas of high humidity and rapidly changing temperatures:
   1) Where portions of an interior raceway pass through walls, ceilings or floors that separate adjacent areas having widely different temperatures.
d. Provide conduit seals similar to O/Z Gedney (Type CSM) on all conduits between corrosive and non-corrosive areas.
e. Seal one end only of all underground conduits at highest point with O/Z Gedney sealing (non-hazardous) filling, “or-equal.”

2. Install seals with drains at any location along conduit runs where moisture may condense or accumulate. This requirement includes, but is not limited to, the following locations: control panels, junction boxes, pullboxes, or low points of conduit.
3. All conduits which enter/leave a building shall be sloped away from the building to prevent the accumulation of water within the building.
4. All conduits which enter/leave a building shall be sealed with an approved duct seal.

H. Conduit Supports:

1. General:
   a. Provide appropriate hangers, supports, fasteners, and seismic restraints to suit applications:
      1) As specified in Section 16070, Hangers and Supports.
      2) Provide support materials consistent with the type of conduit being installed as specified in Section 16050, Common Work Results for Electrical.
   b. Support conduit at the intervals required by the NEC.
   c. Perforated strap and plumbers tape are not acceptable for conduit supports.
2. Finished Areas:
   a. Above Suspended Ceilings:
      1) Support conduit on or from the structure, do not support conduit from hanging wires or suspended ceiling grid.
      2) Provide independent hanger wires for all conduits.
      3) Identify the hanger wires using red spray paint.

I. Expansion or Expansion/Deflection Fittings:

1. General:
   a. Align expansion coupling with the conduit run to prevent binding.
   b. Follow manufacturer’s instructions to set the piston opening.

c. Install expansion fittings across concrete expansion joints and at other locations where necessary to compensate for thermal or mechanical expansion and contraction.
d. Furnish fittings of the same material as the conduit system.

2. For metallic conduit (PCS, PCA, GRC and RAC) provide expansion or expansion/deflection couplings, as appropriate, where:
   a. Install expansion fittings a minimum of every 200 feet in straight conduit runs.
3. For PVC provide expansion or expansion/deflection couplings, as appropriate, where length change due to temperature variation exceeds 2 inches:
   a. Rigidly fix the outer barrel of the expansion coupling so it cannot move.
   b. Mount the conduit connected to the piston loosely enough to allow the conduit to move as the temperature changes.

J. Empty Conduits:

1. Provide a “true tape” measuring tape rated 250 pounds tensile strength in each empty conduit more than 10 feet in length.
2. Provide one empty 3/4-inch conduit for each four spare unused circuits or spaces of each flush mounted branch circuit panelboard. Terminate empty 3/4-inch conduits in individual junction boxes that are accessible to enable extension of future branch circuits.
3. Seal ends of all conduit with approved, manufactured conduit seals, caps or plugs immediately after installation. Keep ends sealed until immediately before pulling conductors.

K. PCS Damaged Conduits: PCS conduits that have damaged PVC coating shall be replaced, no exceptions. Field repair shall not be acceptable.

L. Miscellaneous:

1. Seal roof penetrations for raceways and other items that penetrate the roof in accordance with roofing manufacturer’s instructions and as indicated on the Drawings.
2. Provide electrical unions at all points of union between ends of rigid conduit systems that cannot otherwise be coupled: Running threads and threadless couplings are not allowed.
3. Replace any conduit installed that the Engineer determines does not meet the requirements of this specification.

3.02 FIELD QUALITY CONTROL

A. As specified in Section 16050, Common Work Results for Electrical.

3.03 PROTECTION

A. As specified in Section 16050, Common Work Results for Electrical.

END OF SECTION

SECTION 16134
BOXES

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes:

1. Device boxes.
2. Raceway system boxes.

B. Related Sections:

1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
3. The following sections are related to the Work described in this section. This list of related sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
   a. Section 01330, Submittal Procedures.
   b. Section 16050, Common Work Results for Electrical.

1.02 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. As specified in Section 16050, Common Work Results for Electrical.
2. ASTM International (ASTM):
   a. A47, Standard Specification for Ferritic Malleable Iron Castings.
   b. D149, Standard Test Method for Dielectric Breakdown Voltage and Dielectric Strength of Solid Electrical Insulating Materials at Commercial Power Frequencies.
   c. D495, Standard Test Method for High-Voltage, Low-Current, Dry Arc Resistance of Solid Electrical Insulation.
   d. D570, Standard Test Method for Water Absorption of Plastics.
   e. D648, Standard Test Method for Deflection Temperature of Plastics Under Flexural Load in the Edgewise Position.

f. D790, Standard Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials.
g. D792, Standard Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement.

3. Joint Industry Conference (JIC).
4. UL: 94, Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances.

1.03 DEFINITIONS

A. As specified in Section 16050, Common Work Results for Electrical.

B. Specific Definitions:

1. Arcing Parts: Circuit breakers, motor controllers, switches, fuses, or any device intended to interrupt current during its operation.
2. Raceway System Boxes: Boxes that are used for wire and cable pull-boxes, conduit junction boxes, or terminal boxes.

1.04 SYSTEM DESCRIPTION

A. Provide outlet boxes for devices such as switches, receptacles, telephone and computer jacks, security systems, junction, and pull-boxes for use in the raceway systems, etc.

B. Provide boxes and conduit bodies as indicated on the Drawings or as needed to complete the raceway installation.

1.05 SUBMITTALS

A. Furnish submittals as specified in Section 01330, Submittal Procedures, and Section 16050, Common Work Results for Electrical.

B. Product Data:

1. Manufacturer.
2. Materials.
3. Dimensions:
   a. Height.
   b. Width.
   c. Depth.
   d. Weight.
   e. NEMA rating.

4. Conduit entry locations.
5. Catalog cut sheets.
6. Installation instructions.

C. Shop Drawings: Include identification and sizes of pull boxes.

1.06 QUALITY ASSURANCE

A. As specified in Section 16050, Common Work Results for Electrical.

B. Regulatory Requirements:

1. Outlet boxes shall comply with all applicable standards of:
   a. JIC.
   b. NEC.
   c. NEMA.
   d. UL.

1.07 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 16050, Common Work Results for Electrical.

1.08 PROJECT OR SITE CONDITIONS

A. As specified in Section 16050, Common Work Results for Electrical.

1.09 SEQUENCING

A. As specified in Section 16050, Common Work Results for Electrical.

1.10 WARRANTY

A. As specified in Section 16050, Common Work Results for Electrical.

1.11 SYSTEM STARTUP

A. As specified in Section 16050, Common Work Results for Electrical.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. One of the following:

1. Pressed Steel Boxes:
   a. Steel City.
   b. Appleton.
   c. Crouse - Hinds.
   d. Thomas & Betts.
   e. “Or-equal.”
2. Concrete Boxes:
   a. Appleton.
   b. Steel City.
   c. Cooper/Crouse Hinds.
   d. OZ Gedney.
   e. “Or-equal.”
3. Threaded-hub Boxes:
   a. Appleton.
   b. Crouse - Hinds.
   c. OZ/Gedney.
   d. “Or-equal.”
4. Plastic-coated Steel Boxes:
   a. Rob Roy.
   b. OCAL.
   c. “Or-equal.”
5. Cast Device Boxes:
   a. Appleton.
   b. Crouse - Hinds.
   c. OZ/Gedney.
   d. “Or-equal.”
6. Formed Steel Enclosures:
   a. Hoffman.
   b. Thomas and Betts.
   c. Stahlin.
   d. Rittal.
   e. Saginaw.
   f. “Or-equal.”
7. Stainless Steel Enclosures:
   a. Hoffman.
   b. Stahlin.
   c. Rittal.

d. Saginaw.
e. “Or-equal.”

8. In-Ground Junction Boxes: Old Castle.

2.02 MANUFACTURED UNITS

A. Pressed Steel Boxes:

1. One-piece galvanized pressed steel.
2. Knockout type boxes.
3. Minimum size 4-inch square by 2-1/8-inch deep.

B. Threaded-hub Boxes:

1. Construction:
   a. With internal green ground screw.
   b. Furnished with a suitable gasketed cover.
   c. With integral cast mounting lugs when surface mounted.
   d. Conduit sizes range from 3/4 inch to 1 inch.
   e. Tapered threaded hubs with integral bushing.
   f. Shall be FD-type, 2.69 inches deep minimum with mounting lugs and integral grounding screw.
2. Malleable Iron Boxes: Conforming to ASTM A47 Grade 32510.

C. Plastic-Coated Threaded-Hub Boxes:

1. Construction:
   a. With internal green ground screw.
   b. Furnished with a suitable gasketed cover.
   c. With integral cast mounting lugs when surface mounted.
   d. Conduit sizes range from 3/4 inch to 1 inch.
   e. Shall be FD-type, 2.69 inches deep minimum with mounting lugs and integral grounding screw.
   f. Double coated with a nominal 0.002-inch (2 mil) urethane on both the interior and exterior before application of PVC coating.
   g. With a minimum 0.040-inch (40 mil) PVC coating bonded to exterior.
   h. With pressure sealing sleeve to protect the connection with conduit.

D. Class I Division 1 Areas:

1. Provide boxes designed and listed for Class I Division 1 locations and group type atmosphere in which they will be used.
2. The approval ratings must be permanently marked on each item.

E. Class I, Division 2 Areas:

1. For boxes not containing arcing parts:
   a. As specified in Section 16050, Common Work Results for Electrical.
   b. Pressed metal boxes are not allowed.
2. For boxes containing arching parts provide:
   a. Boxes designed and listed for Class I Division 1 locations and group type atmosphere in which they will be used:
      1) The approval ratings must be permanently marked on each item.
3. Cast iron box and cover.
4. Precision machined flame path between box and cover with neoprene O-ring.
5. Bolt-on stainless steel slotted mounting feet for horizontal or vertical mounting.
6. For applications requiring hinged cover, provide flexible hinge mounting either left or right side.
7. External flange.
8. Shall be provided with manufacturer supplied backpanel.
9. Ground lug.

F. Formed Steel Enclosures:

1. Steel:
   a. NEMA Type 12.
   b. Fabricated from 14-gauge steel, minimum.
   c. All seams continuously welded ground smooth.
   d. Door:
      1) Rolled lip around three sides.
      2) Attached to enclosure by means of a continuous stainless-steel hinge and pin.
      3) The door is secured with a flush quarter-turn latch (coin style).
   e. Neoprene door gasket to provide a watertight, dust-tight, oil-tight seal:
      1) Attached with an adhesive.
      2) Retained by a retaining strip.
      3) Fabricate all external removable hardware for clamping the door to the enclosure body from zinc-plated heavy gauge steel with a hasp and staple for padlocking.
   f. Provide large enclosures with door and body stiffeners for extra rigidity.
   g. No holes or knockouts.

h. Finish:
   1) ANSI 61 gray electrostatically applied polyester powder inside and out over cleaned and primed surfaces.
   2) White electrostatically applied polyester powder mounting plate.
i. Heavy gauge steel external mounting brackets when surface mounted.
j. Shall be provided with manufacturer supplied backpanel.
k. Provide manufacturer supplied hinged deadfront as shown on the Drawings.

2. Stainless Steel:
   a. NEMA Type 4X:
      1) Boxes in locations subject to flooding or temporary submersion: NEMA Type 6.
   b. Fabricated from 14-gauge Type 316 stainless steel.
   c. All seams continuously welded.
   d. Door:
      1) Rolled lip around three sides.
      2) Attached to enclosure by means of a continuous stainless-steel hinge and pin.
      3) The door is secured with a flush quarter-turn latch (coin style).
   e. Neoprene door gasket to provide a watertight seal:
      1) Attached with an adhesive.
      2) Retained by a retaining strip.
   f. Fabricate all external removable hardware for clamping the door to the enclosure body from heavy gauge stainless steel with a hasp and staple for padlocking.
   g. Provide large enclosures with door and body stiffeners for extra rigidity.
   h. No holes or knockouts.
   i. Finish: Brushed.
   j. Stainless steel external mounting brackets when surface mounted.
   k. Shall be provided with manufacturer supplied backpanel.
   l. Provide manufacturer supplied hinged deadfront as shown on the Drawings.
   m. In-ground junction boxes:
      1) Suitable for use outdoors where subject to rain, dripping, or splashing water.
      2) Designed for flush mounting in grade.
      3) Minimum dimensions 13-inch by 24-inch by 12-inch deep.

4) Construction:
   a) Concrete polymer.
   b) Covers:
      (1) Concrete polymer flush covers suitable for H20 incidental traffic loads.
      (2) Cover shall have verbiage molded into the top identifying the type of service served such as electric, fiber optic, communications, etc.
      (3) Stainless steel screw covers.

2.03 ACCESSORIES

A. Fasteners:

1. Electroplated or stainless steel in boxes with wiring devices.
2. Screws, Nuts, Bolts, and Other Threaded Fasteners: Stainless steel.

PART 3 EXECUTION

3.01 INSTALLATION

A. As specified in Section 16050, Common Work Results for Electrical.

B. General:

1. Provide materials and construction suitable for environmental conditions at the location of the box as specified in Section 16050, Common Work Results for Electrical, Paragraph Plant Area Electrical Work Requirements.
2. Provide outlet box materials to match the conduit system:
   a. RGS: Painted cast ferrous boxes.
   b. PVC coated RGS: PVC coated cast ferrous boxes.
   c. PVC: PVC boxes.
3. Solid Type Gang Boxes:
   a. For more than two devices.
   b. For barriered outlets.
4. Support all wall mounted NEMA Type 4 or NEMA Type 4X boxes to maintain a minimum of 7/8-inch free air space between the back of the enclosure and the wall:
   a. Use machined spacers to maintain air space; built-up washers are not acceptable.
   b. Use stainless steel or nylon materials for spacers.
5. In Finished Areas: Provide specific pull or junction boxes only as indicated on the Drawings or as directed.
6. Fit all cast boxes and pressed steel boxes for flush mounting in concrete with cast, malleable box covers and gaskets.

7. In terminal boxes, furnish terminals as indicated on the Drawings, with a minimum of 50 percent spare terminals:
   a. Furnish wireways for discrete and analog/DC wiring.
   b. Separate analog wiring from 120V discrete or power wiring.
8. For fire-rated construction, provide materials and installation for use in accordance with the listing requirements of the classified construction.
9. All boxes and enclosures installed outdoors shall have hinges installed on the sides of the enclosure. No hinges on the top of the box or enclosure shall be permitted.
10. Conduits shall not enter the top of boxes in wet locations or in locations where subject to water.

C. Outlet Boxes:

1. Locate outlet boxes as indicated on the Drawings: Adjust locations so as not to conflict with structural requirements or other trades.
2. Use deep threaded-hub, FD-type, malleable iron, or aluminum boxes:
   a. In hazardous areas.
   b. Where exposed to the weather.
   c. In unheated areas.
   d. Where subject to mechanical damage: Defined as exposed boxes less than 10 feet above the floor.
   e. To act as a pull box for conductors in a conduit system.
   f. Accommodate wiring devices.
3. Use deep threaded-hub, FD-type, plastic coated malleable iron boxes in corrosive and NEMA Type 4X area and when the conduit system is PVC coated steel.

D. Pull Boxes and Junction Boxes: Install pull boxes so they are accessible as defined by the NEC.

E. For Boxes Not Indicated:

1. Provide types and mountings as required to suit the equipment and that will be consistent with the conduit system and environmental conditions as indicated in Section 16050, Common Work Results for Electrical.
2. Outlet, Switch, and Junction Boxes for Flush-mounting in General Purpose Locations: One-piece, galvanized, pressed steel.
3. Ceiling Boxes for Flush Mounting in Concrete: Deep, galvanized, pressed steel.
4. Outlet, Switch, and Junction Boxes where Surface Mounted in Exposed Locations: Cast ferrous boxes with mounting lugs, zinc, or cadmium plating finish.

5. Outlet, Control Station, and Junction Boxes for Installation in Corrosive Locations:
   a. PVC, stainless steel, or plastic-coated steel as specified in Section 16050, Common Work Results for Electrical.
   b. Furnished with mounting lugs.

F. Recessed Boxes:

1. Support recessed boxes in suspended ceilings or stud partitions with galvanized steel box hangers of types made specifically for the purpose or attach directly to wood members or blocking.
2. Secure hangers or boxes to wood with 1-inch long cadmium-plated Type A pan head screws: Fully or partially hammer-driven screws are not acceptable.

3.02 FIELD QUALITY CONTROL

A. As specified in Section 16050, Common Work Results for Electrical.

3.03 CLEANING

A. As specified in Section 16050, Common Work Results for Electrical.

3.04 PROTECTION

A. As specified in Section 16050, Common Work Results for Electrical.

END OF SECTION

SECTION 16140
WIRING DEVICES

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes:

1. Switches.
2. Receptacles.
3. Plates.

B. Related Sections:

1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
3. The following sections are related to the Work described in this section. This list of related sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
   a. Section 01330, Submittal Procedures.
   b. Section 16050, Common Work Results for Electrical.

1.02 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. As specified in Section 16050, Common Work Results for Electrical.
2. Federal Specifications (FS):
   a. W-C 596, Connector, Electrical, Power, General Specification for.
   b. W-S 896/2, Switches, Toggle (Toggle and Lock), Flush Mounted (General Specification).
3. National Electrical Manufacturers Association (NEMA):
   a. WD1, General Color Requirements for Wiring Devices.
   b. ICS 5, Industrial Control and Systems, Control Circuit and Pilot Devices.
   c. OS1, Sheet-Steel Outlet Boxes, Device Boxes, Covers and Box Supports.
   d. WD6, Wiring Devices Dimensional Specifications.

4. UL:
    a. 20, General Use Snap Switches.
    b. 498, Standard for Attachment Plugs and Receptacles.
    c. 514D, Cover Plates for Flush-Mounted Wiring Devices.
    d. 943, Ground-Fault Circuit-Interrupters.
    e. 1472, Solid State Dimming Controls.

1.03 DEFINITIONS

A. As specified in Section 16050, Common Work Results for Electrical.

B. Specific Definitions:

1. GFCI: Ground fault circuit interrupter.
2. P-S: Pass and Seymour.
3. Cooper: Cooper Wiring Devices, a division of Cooper Industries.
4. T&B: Thomas and Betts.

1.04 SYSTEM DESCRIPTION

A. Switches, receptacles, and plates as indicated on the Drawings wired and operable to form a complete system.

1.05 SUBMITTALS

A. Furnish submittals as specified in Section 01330, Submittal Procedures, and Section 16050, Common Work Results for Electrical.

B. Product Data: Catalog cut sheets.

C. Shop Drawings:

1. Engraving Schedule: Furnish complete engraving schedule for engraved nameplates.

1.06 QUALITY ASSURANCE

A. As specified in Section 16050, Common Work Results for Electrical.

B. Wiring devices shall be UL listed and labeled.

1.07 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 16050, Common Work Results for Electrical.

1.08 PROJECT OR SITE CONDITIONS

A. As specified in Section 16050, Common Work Results for Electrical.

1.09 WARRANTY

A. As specified in Section 16050, Common Work Results for Electrical.

1.10 SYSTEM STARTUP

A. As specified in Section 16050, Common Work Results for Electrical.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Switches:

1. One of the following:
   a. Hubbell.
   b. Leviton.
   c. Cooper.
   d. “Or-equal.”
2. Switches for Hazardous Areas:
   a. One of the following:
      1) Appleton.
      2) Crouse-Hinds.
      3) “Or-equal.”
3. Astronomic Timer: One of the following, “or-equal.”
   a. Intermatic.

B. Receptacles:

1. General Purpose Receptacles:
   a. One of the following:
      1) Hubbell.
      2) Leviton.
      3) Cooper.
      4) “Or-equal.”
2. Receptacles for Hazardous Areas:
   a. One of the following:
      1) Crouse-Hinds.
      2) Appleton.
      3) “Or-equal.”

C. Single-Ended Cordset:

1. The following:
   a. Brad Harrison.
   b. “Or-equal.”

D. Plates:

1. General Location:
   a. One of the following:
      1) P-S.
      2) Cooper.
      3) “Or-equal.”
2. Wet or Corrosive Areas:
   a. One of the following:
      1) Hubbell.
      2) Cooper.
      3) T&B.
      4) P-S.
      5) “Or-equal.”
3. Metal Heavy-duty In-use Covers:
   a. One of the following:
      1) TayMac.
      2) Cooper.
      3) P-S.
      4) T&B.
      5) “Or-equal.”

2.02 MANUFACTURED UNITS

A. Switches:

1. General:
   a. 120V ac to 277V ac.
   b. 20-ampere.
   c. Listed in accordance with UL 20.
   d. Designed and constructed in accordance with FS W-S-896/2.
   e. Specification grade, unless otherwise noted.
   f. Integral grounding terminal.
   g. Totally Enclosed: Color-coded body with color corresponding to ampere rating.

h. Provide switches with the operator style and contact arrangement as indicated on the Drawings and as required for proper operation.
i. Color:
1) Ivory in finished areas.
2) Gray in all other areas.

2. General Purpose Switches: Toggle type.
3. Switches for Hazardous Areas:
a. Suitable for use in Class I Division 1 and Class I Division 2 locations.
b. Factory sealed.
c. Through-feed or dead-end as required.
d. Astronomic Timer:
1) 7 Day in-wall switch.
2) Automatic Daylight Savings time.
3) Manual over-ride.
4) Battery backup.

B. Receptacles:

1. General Purpose Receptacles:
a. Single or duplex as indicated on the Drawings.
b. 125V ac.
c. 20 ampere or as indicated on the Drawings.
d. NEMA Type 5-20R configuration for 20-ampere receptacles.
e. Other NEMA configurations as indicated on the Drawings.
f. Listed in accordance with UL 498.
g. Designed and constructed in accordance with FS W-C-596.
h. Specification grade.
i. One-piece, rivet-less mounting strap.
j. Color:
1) Ivory in finished areas.
2) Brown in all other areas.
3) Orange when powered by a UPS.

2. Ground Fault Interrupter Receptacles (GFCI):
a. 125V ac.
b. 20-ampere.
c. Trip level 4 milliampere to 6 milliampere.
d. Individual and feed through protection.
e. UL 943 and UL 498 listed.
f. NEMA Type 5-20R configuration.
g. Weather resistant, in accordance with UL 498.

C. Single-Ended Cordsets:

1. No. 16 AWG CU yellow STOOW cable with US color code.
2. Oil resistant PVC jacket.
3. Non-metallic coupling nut.
4. Six-foot cable length minimum.
5. Available in in two-pole through six-pole. Provide cordsets with number of poles as shown on the Drawings.
6. Provide straight end connectors, male and female receptacles.

D. Plates:

1. General Location:
   a. Type 302 or Type 304 stainless steel.
   b. Brushed satin finish.
   c. Minimum Thickness: 0.032 inch.
   d. Rectangular or square shape.
   e. Labeling:
      1) Provide each switch plate with the following:
         a) Panel (source).
         b) Circuit number.
         c) Refer to CWS Equipment Tag Numbering Standards.
      2) Characters shall be block letter pantograph engraved with a minimum character height of 1/8-inch.
   f. Coordinate the number of gangs, number, and type of openings with the specific location.
2. Outdoor and Wet Areas Requiring NEMA Type 4 or NEMA Type 4X Enclosures:
   a. General:
      1) UL listed for wet locations.
      2) Gasketed.
      3) Die Cast Metal: Match material to box material.
   b. Switches:
      1) Lever Operated: Provide toggle switch.
      2) Carlon E98TSCN In-use cover.
   c. Receptacles:
      1) Weatherproof In-use Cover:
         a) Die cast metal construction with electrostatic powder coating for corrosion resistance.
         b) Gasketed.
         c) Lockable.
         d) UL listed and in accordance with NEC.

3. Corrosive Areas:
   a. Neoprene.
   b. Gasketed.
   c. Weatherproof.

PART 3 EXECUTION

3.01 INSTALLATION

A. As specified in Section 16050, Common Work Results for Electrical.

B. Mounting Heights:

1. Process and Production Areas: Switches and receptacles 48 inches from finished floor to top of plate.

C. Switches:

1. Over 300 Volts: Where switches used in systems of more than 300 volts between conductors, are to be ganged in outlet boxes, provide switches having no exposed live parts or use barriers between the individual switches.

D. Receptacles:

1. Provide GFCI receptacles as indicated on the Drawings.
   a. Provide weather resistant GFCI receptacles in all wet or damp areas. As specified in Section 16050, Common Work Results for Electrical.
2. Mount Non-weatherproof Receptacles Vertically: Ground slot down.
3. Mount Weatherproof Receptacles Horizontally: Neutral slot up.
4. Three-phase receptacles shall be consistent with respect to phase connection at the receptacle terminals. Correct errors in phasing at the source and not the receptacle.

E. Single-Ended Cordsets: Provide single-ended cordsets as the disconnecting means for wiring to instrument transmitters.

F. Ensure all plates make a firm seal with wall for recessed mounted devices: Outside edges of plates parallel with building lines.

3.02 FIELD QUALITY CONTROL

A. As specified in Section 16050, Common Work Results for Electrical.

3.03 DEMONSTRATION AND TRAINING

A. As specified in Section 16050, Common Work Results for Electrical.

B. Demonstrate the following to the Engineer and Owner:

1. Switching is as indicated on the Drawings.
2. All circuits conform to the Panel Schedules.
3. All ground fault receptacles operate at levels below or equal to OSHA maximum allowable fault levels.

3.04 PROTECTION

A. As specified in Section 16050, Common Work Results for Electrical.

END OF SECTION

SECTION 16150
LOW VOLTAGE WIRE CONNECTIONS

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes:

1. Wire connecting devices.
2. Terminations.
3. Splices: Splice are not allowed unless submitted, reviewed, and approved by Owner prior to installation.

B. Related Sections:

1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
2. It is the Contractor’s responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor’s Work.

1.02 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. As specified in Section 16050, Common Work Results for Electrical.
2. ASTM International (ASTM): D3005, Standard Specification for Low-Temperature Resistant Vinyl Chloride Plastic Pressure-Sensitive Electrical Insulating Tape.
3. CSA International (CSA): C22.2, No.197-M1983 (R2208) - PVC Insulating Tape.
4. UL: 510, Standard for Polyvinyl Chloride, Polyethylene, and Rubber Insulating Tape.

1.03 DEFINITIONS

A. As specified in Section 16050, Common Work Results for Electrical.

1.04 SYSTEM DESCRIPTION

A. Provide a complete system of wiring connectors, terminators, fittings, etc., for a complete wiring system suitable for the cables and conductors used.

1.05 SUBMITTALS

A. Furnish submittals as specified in Section 01330, Submittal Procedures, and Section 16050, Common Work Results for Electrical.

B. Product Data:

1. Catalog cut sheets.
2. Installation instructions.

1.06 QUALITY ASSURANCE

A. As specified in Section 16050, Common Work Results for Electrical.

B. All materials shall be UL listed.

1.07 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 16050, Common Work Results for Electrical.

1.08 PROJECT OR SITE CONDITIONS

A. As specified in Section 16050, Common Work Results for Electrical.

1.09 WARRANTY

A. As specified in Section 16050, Common Work Results for Electrical.

1.10 SYSTEM STARTUP

A. As specified in Section 16050, Common Work Results for Electrical.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Manufacturers for each type of technology are specified with the equipment in this section.

2.02 EQUIPMENT

A. Control Connections:

1. Use insulated ring type wire terminators for connections to all screw terminals:
   a. With chamfered/funneled terminal barrel entry.
   b. Deep internal serrations.

c. Long barrel design to reduce electrical resistance and increased insulator-barrel surface area to ensure that the insulator remains in contact with the barrel.
d. Electroplated-tin copper conductor.
e. Manufacturers:
1) One of the following:
a) Thomas and Betts.
b) Stakon.
c) “Or-equal.”

2. For process equipment connections work from manufacturer’s drawings.

B. Joints, Splices, Taps, and Connections:

1. 600-Volt Conductors:
a. Use solderless connectors.
b. Use only plated copper alloy connectors or lugs: Aluminum connectors or lugs are not acceptable for copper conductors.
c. Under those specific conditions where aluminum conductors have been allowed or are specified then the connectors for aluminum conductors shall be specifically designed for that purpose.
d. For wire Number 10 AWG and smaller, use compression splice caps, with insulating caps:
1) Manufacturer and Product:
a) The following:
(1) Ideal; winged wire connectors.
(2) “Or-equal.”
e. For wire Number 8 AWG and larger, use heavy duty copper compression connectors:
1) Manufacturers:
a) One of the following:
(1) Burndy.
(2) Thomas and Betts.
(3) “Or-equal.”
f. Heat Shrink Tubing:
1) Suitable for indoors, outdoors, overhead, direct burial or submerged applications.
2) Minimum Shrink Ratio: 4 to 1.
3) Continuous Operating Temperature: Minus 55 degrees C to 110 degrees C.
4) Internally applied adhesive sealant.

5) Cross-linked Polyolefin:
a) Manufacturers:
(1) One of the following:
(a) 3M ITCSN.
(b) Thomas & Betts Shrink-Kon.
(c) "Or-equal."

2. Instrumentation Class Cable Splices:
a. Suitable for indoor, outdoors, weather exposed, direct buried, or submersed applications.
b. Utilizing an epoxy, polyurethane, and re-enterable compounds.
c. For use with shielded or unshielded plastic- and rubber-jacketed, signal, control, and power cables rated up to 1 kilovolt.
d. Two-part mold body with tongue and groove seams and built in spacer webbing.
e. Manufacturer and Product:
1) The following:
a) 3M; Scotchcast 72-N.
b) "Or-equal."

C. Insulating Tape:

1. General Purpose Insulating Tape:
a. Minimum 7-mil vinyl tape.
b. Suitable for application in an ambient of minus18 degrees C (0 degree F).
c. Operating range up to 105 degrees C (220 degrees F).
d. Flame retardant, hot- and cold- weather resistant, UV resistant.
e. For use as a primary insulation for wire cable splices up to 600V ac.
f. Meeting and complying with:
1) ASTM D3005 Type I.
2) UL 510.
3) CSA C22.2.
g. Manufacturer and Product:
1) The following:
a) 3M; Scotch Number Super 33+.
b) "Or-equal."
2. General Purpose Color-coding Tape:
a. Minimum 7-mil vinyl tape.
b. Suitable for application on PVC and polyethylene jacketed cables.
c. For use indoors and outdoors in weather protected enclosures.
d. Available with the following colors:
1) Red.
2) Yellow.
3) Blue.

4) Brown.
5) Gray.
6) White.
7) Green.
8) Orange.
9) Violet.

e. For use as phase identification, marking, insulating, and harnessing.
1) Meeting and complying with:
a) UL 510.
b) CSA C22.2.

f. Manufacturer and Product:
1) The following:
a) 3M; Scotch Number 35.
b) “Or-equal.”

PART 3 EXECUTION

3.01 INSTALLATION

A. As specified in Section 16050, Common Work Results for Electrical.

B. Load Connections: Connect loads to the circuits as indicated. Color-code all branch circuits as specified in Section 16123, 600-Volt or Less Wires and Cables.

C. Zero to 600-Volt Systems:

1. Make all connections with the proper tool and die as specified by the device manufacturer.
2. Use only tooling and dies manufactured by the device manufacturer.
3. Insulate all connections and splices with Scotch 33+ tape and Scotchfill, or premolded plastic covers, or heat shrink tubing and caps.
4. Number all power and control wires before termination.

D. Motor Connections (600 volts and below):

1. Terminate wires with compression type ring lugs at motors.
2. Connection at both the motor leads and the machine wires shall have ring type compression lugs.
3. Cover bolted connectors with a heat shrinkable, cross-linked polyolefin material formed as a single opening boot:
a. In damp and wet locations, use a complete kit containing mastic that shall seal out moisture and contamination.
b. Shrink cap with low heat as recommended by manufacturer.

4. Wire markers shall be readable after boot installation.
5. Manufacturer and Product:
   a. The following:
      1) Thomas & Betts Motor Boot, MSC style.
      2) “Or-equal.”

3.02 FIELD QUALITY CONTROL

A. As specified in Section 16050, Common Work Results for Electrical.

3.03 PROTECTION

A. As specified in Section 16050, Common Work Results for Electrical.

END OF SECTION

SECTION 16222
LOW VOLTAGE MOTORS UP TO 500 HORSEPOWER

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes:

1. Low Voltage Motors up to 500 hp:
   a. Furnished separately.
   b. Part of driven equipment specified in other sections.
   c. Other electric motors required for a complete installation.

B. Related Sections:

1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
3. The following sections are related to the Work described in this section. This list of related sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
   a. Section 01330, Submittal Procedures.
   b. Section 16050, Common Work Results for Electrical.
   c. Section 16950, Field Electrical Acceptance Tests.

1.02 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. As specified in Section 16050, Common Work Results for Electrical.
2. American Bearing Manufacturers Association (ABMA):
   a. 9, Load Ratings and Fatigue Life for Ball Bearings.
   b. 11, Load Ratings and Fatigue Life for Roller Bearings.
3. American Petroleum Institute (API): 670, Vibration, Axial Position, and Bearing Temperature Monitoring Systems.
4. ASTM International (ASTM): B117, Standard Practice for Operating Salt Spray (Fog) Apparatus.

5. Institute of Electrical and Electronic Engineers (IEEE):
   a. 43, IEEE Recommended Practice for Testing Insulation Resistance of Rotating Machinery.
   b. 112, IEEE Standard Test Procedure for Poly-phase Induction Motors and Generators.
   c. 114, Standard Test Procedure for Single-Phase Induction Motors.
   d. 303, Recommended Practice for Auxiliary Devices for Rotating Electrical Machines in Class I, Division 2 and Zone 2 Locations.
   e. 841, Standard for Petroleum and Chemical Industry-Premium-Efficiency, Severe Duty, Totally Enclosed Fan-Cooled (TEFC) Squirrel Cage Induction Motors - Up to and Including 370 kW (500hp).
   f. 1349, Guide for Application of Electric Motors in Class I, Division 2 Hazardous (Classified) Locations.
6. National Electrical Manufacturers' Association (NEMA):
   a. MG-1, Motors and Generators.
   b. MG-2, Safety Standard for Construction and Guide for Selection, Installation, and Use of Electric Motors and Generators.
7. UL: 674, Electric Motors and Generators for Use in Division 1 Hazardous (Classified) Locations.

1.03 DEFINITIONS

A. As specified in Section 16050, Common Work Results for Electrical.

1.04 SYSTEM DESCRIPTION

A. Furnish and install electric motors and accessories as specified in this section and the sections specifying driven equipment to provide a complete and operable installation.

1.05 SUBMITTALS

A. Furnish submittals as specified in Section 01330, Submittal Procedures, and Section 16050, Common Work Results for Electrical.

B. Submit completed motor data sheets for each motor supplied:

   1. Conform to data sheet in the appendix of this section.
   2. Manufacturers or other data sheets are not acceptable.

C. Product Data:

1. Descriptive bulletins.
2. Machine tag and loop number as indicated on the Drawings and in the specification section number of the driven machine.
3. Complete electrical data.
   a. Rated size of motor, hp, and service factor.
   b. Efficiency at full, 3/4 and 1/2 load.
   c. Full load current.
   d. Locked rotor current.
4. Temperature rise and insulation rating.
5. Type of bearing.
6. Torque, Current, and Power Factor versus Speed Curves:
   a. At 100 percent rated voltage for all full voltage started and VFD driven motors.
   b. For motors on reduced voltage start at 70 percent, 80 percent, 90 percent, and 100 percent rated voltage.
7. Additional Data for Motors Installed in Classified Areas:
   a. Temperature code.
   b. Hazardous area approval indicating Class, Division and Group:
      1) For motors driven by variable frequency drives, provide manufacturer’s certification that the motor is suitable for operation in the hazardous area when driven by a variable frequency drive.
8. Accessories Data:
   a. Power Factor Correction Capacitors: Size in KVAR, for all motors not connected to variable frequency drives.
   b. Winding Temperature Detectors:
      1) Type.
      2) Rating.
      3) Moisture detectors.
9. Mechanical Data:
   a. Bearing design and bearing life calculations.
   b. Resonant frequencies for all VFD-driven motors 50 hp or greater.
10. List of manufacturer’s recommended spare parts.

D. Shop Drawings:

1. Motor weight.
2. Frame size.
3. Conduit box (es), size(s), and location(s).
4. Outline drawings with dimensions.
5. Installation details for the project seismic criteria.

E. Test Reports: Factory test reports with test reference standard identified.

F. Certification:

1. When motors are driven by variable speed drive systems, submit certification that selected motor:
   a. Is capable of satisfactory performance under the intended load.
   b. Meets the requirements of the latest edition of NEMA MG-1 Part 31.
   c. Is matched to the type of variable frequency drive specified.

G. Calculations: Where site conditions specified in Section 16050, Common Work Results for Electrical, exceed manufacturer's ratings, provide derating calculations for each motor.

1.06 QUALITY ASSURANCE

A. As specified in Section 16050, Common Work Results for Electrical.

1.07 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 16050, Common Work Results for Electrical.

B. Motors 200 hp and Larger: Rotate shaft 90 degrees once per month.

1.08 PROJECT OR SITE CONDITIONS

A. As specified in Section 16050, Common Work Results for Electrical.

1.09 WARRANTY

A. As specified in Section 16050, Common Work Results for Electrical.

1.10 SYSTEM STARTUP

A. As specified in Section 16050, Common Work Results for Electrical.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. One of the following:

1. Nidec/US Motors.
2. WEG.

3. ABB/Baldor/Reliance.
4. “Or-equal.”

2.02 EQUIPMENT

A. Three-phase Induction Motors, General:

1. Voltage: All motors 1/2 hp and larger shall be rated 460V, three-phase unless otherwise as indicated on the Drawings.
2. Motors driving identical machines shall be identical.
3. All motors greater than 1 hp and up to 500 hp shall meet the “NEMA Premium Efficiency” percent listed in NEMA MG-1.
4. Horsepower as indicated on the Drawings:
   a. Horsepower ratings as indicated on the Drawings are based on vendor’s estimates. Provide motors sized for the load of the actual equipment furnished without operating in the service factor.
5. Service Factor:
   a. 1.15 service factor on sine wave power.
   b. 1.0 when driven by VFD.
6. Torque:
   a. Provide motors that develop sufficient torque for acceleration to full speed at voltage 10 percent less than motor nameplate rating.
   b. When started using reduced voltage starters:
      1) Provide motors that develop sufficient torque for acceleration to full speed.
   c. NEMA Design B except where driven load characteristics require other than normal starting torque:
      1) In no case shall starting torque or breakdown torque be less than the values specified in NEMA MG-1.
7. Enclosures:
   a. As specified in the individual equipment Specifications or in this section.
   b. Totally Enclosed Fan Cooled:
      1) Cast iron conduit box.
      2) Tapped drain holes with Type 316 stainless steel plugs for frames 286 and smaller, and automatic breather and drain devices for frames 324 and larger.
   c. Explosion-Proof: Tapped drain holes with corrosion resistant plugs for frames 286 and smaller and automatic breather and drain devices for frames 324 and larger.
   d. Lifting Devices: All motors weighing 265 pounds (120 kilograms) or more shall have suitable lifting devices for installation and removal.

8. Manufactured with cast iron frames in accordance with NEMA MG-1 or manufacturer's standard material for the specified rating.
9. Nameplates:
    a. Provide all motors with a permanent, stainless steel nameplate indelibly stamped or engraved with:
        1) NEMA standard motor data.
            a) Indicate compliance with NEMA MG-1 Part 31 for inverter duty motors.
        2) AFBMA bearing numbers and lubrication instructions.
10. Hardware: Type 316 stainless steel.
11. Conduit Boxes:
    a. Cast iron or stamped steel.
    b. Split from top to bottom.
    c. Provide gaskets at the following interfaces:
        1) Frames and conduit boxes.
        2) Conduit boxes and box covers.
    d. Rotatable through 360 degrees in 90-degree increments. Where available based on the size of the conduit box.
    e. Exceeding the dimensions defined in NEMA MG-1. The main conduit box shall be oversized at least one size larger than NEMA standard. The main conduit box shall be sized for all indicated accessory leads. Motor furnished in NEMA 320 frame series and larger shall have conduit boxes designed and constructed to permit motor removal after installation without disconnecting raceways.
    f. Provide grounding lugs inside conduit boxes for motor frame grounding.
12. Motor Bearings:
    a. Antifriction.
    b. Oil-mist lubrication type for all applicable motors above 50 hp. Bearing mounting shall be deigned to prevent entrance of lubricant into the motor enclosure.
    c. Where oil-mist lubrication is not possible, provide regreasable type lubrication. Initially fill with grease. Provide permanently sealed bearings for motors 50 hp and below.
    d. Bearings and lubrication suitable for ambient temperature and temperature rise.
    e. Suitable for intended application and have ABMA L-10 rating life of 60,000 hours or more.
    f. Fit bearings with easily accessible grease supply, flush, drain, and relief fittings using extension tubes where necessary.
    g. Where specified in the equipment Specifications, provide split-sleeve type hydrodynamic radial bearings. Provide a bearing isolator to protect bearings from contaminants.

13. Insulation Systems:
    a. Motors Insulation:
        1) Provide Class H insulation.
        2) Design temperature rise consistent with Class H insulation.
        3) Rated to operate at an ambient temperature of 65 degrees C at the altitude where the motors will be installed.
14. Motor Leads:
    a. Insulated leads with non-wicking, non-hydroscopic material. Class F insulation.
    b. All motors rated 100 hp and larger, and all vertical motors shall have the direction of rotation marked by an arrow mounted visibly on the stator frame near the terminal housing, or on the nameplate, and the leads marked for phase sequence T1, T2, T3, to correspond to the direction of rotation and supply voltage sequence. Permanent instructions for making these connections shall be furnished inside the main conduit box or on the motor frame or nameplate.
    c. Motor leads shall be provided with single hole compression lugs.
15. Noise: Maximum operating noise level in accordance with NEMA MG-1.

B. Motors Driven by Variable Frequency Drives:

1. Compatible with the variable frequency drives specified.
2. Inverter duty rated and labeled.
3. Meet the requirements of NEMA MG-1 Part 31.
4. Winding insulation meets the requirements of NEMA MG-1 Part 31.4.4.2.
5. Capable of running continuously at 1/10th of full speed, with no harmful effects of overheating.
6. Shaft Grounding Ring:
    a. Provide a shaft grounding ring for each VFD driven motor.
    b. Aluminum frame and internal components.
    c. Conductive microfiber brushes.
    d. Maintenance free design.
    e. Aegis Bearing Protection ring as manufactured by Electro Static Technology, “or-equal.”
7. In addition to the requirements of NEMA MG-1, Part 31, motors shall be designed to be continually pulsed at the motor terminals with a voltage of 1,600V ac.

C. Motors Installed in Hazardous Locations:

1. Class I, Division 1 or Class II, Division 1 Areas:
   a. Enclosures:
      1) Explosion proof for three-phase motors.
      2) UL listed in conformance with UL 674.
      3) UL approval with nameplate and serial number.
2. Other Hazardous Areas:
   a. Enclosures:
      1) TEFC for motors in Class I, Division 2 areas.
      2) Vertical motors as specified herein.
      3) Hazardous area and temperature code approval stamped on nameplate.
3. Single-Phase Motors: Explosion proof motor enclosure.

D. Motors Installed in Corrosive Environments:

1. Nameplate indicating conformance to IEEE 841.
2. Stator double dipped in varnish and baked.
3. Stator and rotor coated with corrosion resistant epoxy.
4. Frame, brackets, fan guard and conduit box coated with minimum of two coats of epoxy paint.
5. Withstand salt spray tests in accordance with ASTM B117.
6. Suitable for hose down areas.

E. Integral Overload Protection.

F. Motors Installed in Corrosive Environments:

1. Nameplate indicating conformance to IEEE 841.
2. Stator double dipped in varnish and baked.
3. Stator and rotor coated with corrosion resistant epoxy.
4. Frame, brackets, fan guard and conduit box coated with minimum of two coats of epoxy paint.
5. Withstand salt spray tests in accordance with ASTM B117.
6. Suitable for hose down areas.

2.03 ACCESSORIES

A. Motor Winding Heaters:

1. Provide winding heaters only where specified or as shown on the Drawings.
2. Space heater rating shall be 120 volts, single-phase, unless otherwise indicated on the Drawings.

3. Power leads for heaters wired into conduit box.
4. Installed within motor enclosure adjacent to core iron.

B. Winding Temperature Detectors:

1. Provide factory installed winding temperature detector with leads terminating in the conduit box:
   a. Where required by the driven equipment Specification or as indicated on Drawings.
2. Temperature switches with normally closed contacts as indicated on the Drawings.

2.04 SOURCE QUALITY CONTROL

A. Factory Testing:

1. Motors Less than 250 hp:
   a. Perform manufacturer's standard production tests including, but not limited to:
      1) No load current.
      2) High potential test.
      3) Winding resistance.
      4) Core loss on motor rewinds.
   b. Furnish copies of standard test reports on prototype or identical units.

PART 3 EXECUTION

3.01 INSTALLATION

A. As specified in Section 16050, Common Work Results for Electrical.

B. Install motors in accordance with manufacturer's instructions.

3.02 FIELD QUALITY CONTROL

A. As specified in Section 16050, Common Work Results for Electrical.

B. Before startup, perform insulation resistance test on each motor furnished or installed on this Project:

1. Windings energized to 1,000V dc for 1 minute.
2. Resistance measured at the end of the test, recorded, and submitted to the Engineer for review.

3. Inform the Engineer of any unusual or unacceptable test results.
4. This test is in addition to the acceptance tests in Section 16950, Field Electrical Acceptance Tests.

3.03 PROTECTION

A. As specified in Section 16050, Common Work Results for Electrical.

3.04 SUPPLEMENT

A. The supplement listed below, following “End of Section,” is a part of this specification:

1. Motor Data Sheet.

END OF SECTION

MOTOR DATA SHEET

MOTOR/EQUIPMENT TAG

MOTOR NUMBER SPECIFICATION NUMBER OF DRIVEN MACHINE

MOTOR NAMEPLATE DATA

MANUFACTURER MODEL/SERIES MODEL NO.

FRAME ENCLOSURE NEMA DESIGN HP

SERVICE FACTOR

RPM INSULATION CLASS

VOLTS FULL LOAD AMPS

AMBIENT TEMP PHASE NO LOAD AMPS

DESIGN TEMP RISE HERTZ

LOCK ROTOR AMPS INRUSH CODE LETTER

100% LOAD 75% LOAD 50% LOAD

GUARANTEED MINIMUM EFFICIENCIES:

GUARANTEED MINIMUM POWER FACTOR:

MAXIMUM SIZE OF POWER FACTOR CORRECTION CAPACITOR: KVAR

ACCESSORIES

MOTOR WINDING HEATER VOLTS

WATTS WINDING THERMAL PROTECTION

WINDING TEMP SWITCHES (YES/NO) RTD:

TYPE

QUANTITY PER PHASE

OF WIRES NOMINAL RESISTANCE NOMINAL TEMP COEFFICIENT RECOMMENDED ALARM °C RECOMMENDED TRIP °C
SPECIAL APPLICATIONS INVERTER DUTY* (YES/NO) PART WINDING (YES/NO) WYE - DELTA (YES/NO) 2 SPEED, 1 WINDING (YES/NO) 2 SPEED, 2 WINDING (YES/NO) AREA CLASSIFICATION: CLASS _____ DIVISION _____ GROUP _____ TEMP CODE _____

** Conforms to NEMA MG-1 Part 31.*

SECTION 16411
DISCONNECT SWITCHES

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes: Fusible and nonfusible disconnect switches.

B. Related Sections:

1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.

1.02 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. As specified in Section 16050, Common Work Results for Electrical.
2. National Electric Manufacturer's Association (NEMA):
   a. 250, Enclosures for Electrical Equipment.
   b. KS 1-2001, Enclosed and Miscellaneous Distribution Equipment Switches (600 Volts Maximum).
3. UL:
   a. 20, General-Use Snap Switches.
   b. 98, Enclosed and Dead-Front Switches.
   c. 508, Standard for Industrial Control Equipment.

1.03 DEFINITIONS

A. As specified in Section 16050, Common Work Results for Electrical.

B. Specific definitions: Safety switches and disconnect switches are to be considered synonymous.

1.04 SYSTEM DESCRIPTION

A. Provide heavy-duty type disconnect switches as indicated on the Drawings and specified in the Contract Documents.

B. Provide disconnect switches with the number of poles, voltage, current, short circuit, and horsepower ratings as required by the load and the power system.

C. Provide a local horsepower rated disconnect switch as indicated on the Drawings.

D. Provide Auxiliary Contact for VFD applications to disable VFD control power when the disconnect is open.

1.05 SUBMITTALS

A. Furnish submittals as specified in Section 01330, Submittal Procedures, and Section 16050, Common Work Results for Electrical.

B. Product Data:

1. Manufacturer.
2. Manufacturer’s specifications and description.
3. Ratings:
    a. Voltage.
    b. Current.
    c. Horsepower.
    d. Short circuit rating.
4. Fused or nonfused.
5. NEMA enclosure type.
6. Dimensions:
    a. Height.
    b. Width.
    c. Depth.
7. Weight.
8. Dimensioned drawings.
9. Elementary diagrams.
10. Wiring diagrams.
11. Nameplate list.
12. Evidence that the equipment will be provided with all specified accessories, options, features, and characteristics.
13. Certifications that the equipment is designed and manufactured in conformance with applicable codes and standards.

C. Manual. Provide manufacturer’s installation and maintenance instruction manuals in conformance with Section 16050, Common Work Results for Electrical.

D. Shop Drawings:

1. Manufacturer’s installation instructions:
   a. Indicate application conditions and limitations of use stipulated by product testing agency specified under Quality Assurance, Regulatory Requirements below.
   b. Include instructions for storage, handling, protection, examination, preparation, installation, and operation of product.
2. Identify motor or equipment served by each switch; indicate nameplate inscription.

E. Installation Instructions:

1. Provide anchorage instructions and requirement based on the seismic requirements at the Project Site as specified in Section 16050, Common Work Results for Electrical, and calculations:
   a. Stamped by a professional engineer registered in the State of Oregon.

1.06 QUALITY ASSURANCE

A. As specified in Section 16050, Common Work Results for Electrical.

B. Regulatory Requirements:

1. NEMA KS1, Enclosed and Miscellaneous Distribution Switches (600 V Maximum).
2. UL 98, Enclosed and Dead-Front Switches.

C. Disconnect switches shall be UL listed and labeled.

1.07 SEISMIC REQUIREMENTS

A. Provide electrical equipment with construction anchorage to supporting structures designed to resist site seismic loads as specified in Section 01612, Anchorage and Bracing.

1.08 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 16050, Common Work Results for Electrical.

1.09 PROJECT OR SITE CONDITIONS

A. As specified in Section 16050, Common Work Results for Electrical.

1.10 WARRANTY

A. As specified in Section 16050, Common Work Results for Electrical.

1.11 SYSTEM STARTUP

A. As specified in Section 16050, Common Work Results for Electrical.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Disconnect Switch:

1. Switch Mechanism:
   a. Quick-make, quick-break heavy-duty operating mechanisms:
      1) Provisions for padlocking the switch in the OFF position.
      2) A minimum of 90-degree handle travel position between OFF and ON positions:
         a) Provide handle position indicators to identify the handle position.
      3) Full cover interlock to prevent opening of the switch door in the ON position and to prevent closing the switch mechanism with the door open:
         a) With an externally operated override.
2. Switch Interior:
   a. Switch blades visible when the switch is OFF and the cover is closed, window switch.
   b. Lugs:
      1) Front accessible.
      2) Removable.
      3) UL listed for 60 degrees C or 75 degrees C copper conductors.
   c. Current carrying parts completely plated to resist corrosion.
   d. Removable arc suppressors to facilitate easy access to line side lugs.
   e. Furnish equipment ground kits for every switch.
   f. Installed Auxiliary contact kit.
3. Ratings:
   a. UL horsepower rated for AC or DC with the rating not less than the load served.
   b. Current: 30 amperes to 1,200 amperes.
   c. Voltage:
      1) 250V ac, dc.
      2) 600 volts (30A to 200A, 600V dc).
   d. Poles: Two, three, four, and six poles.

e. UL Listed Short Circuit Ratings:
1) 10,000 RMS symmetrical amperes when used with or protected by Class H or K fuses (30 amperes to 600 amperes).
2) 200,000 RMS symmetrical amperes when used with or protected by Class R or J fuses (30 amperes to 600 amperes employing appropriate fuse rejection).
3) 200,000 RMS symmetrical amperes when used with or protected by Class L fuses (800 amperes to 1,200 amperes).

f. Where not indicated on the Drawings, provide switches with the NEMA ratings specified in Section 16050, Common Work Results for Electrical, for the installed location.

4. Size, fusing and number poles as indicated on the Drawings or as required.
5. Local power disconnects for 480V electrical actuators shall be three-pole, 600V, nonfusible, NEMA 4X stainless steel, 16 UL amps. Power disconnect shall be ABB EOT16U3S4-P, “or-equal.”
6. Auxiliary Contacts: Two sets of Form C contacts shall be provided for all disconnect switches. 24V, 50 mA rated.

2.02 ACCESSORIES

A. Disconnect switches to have provisions for a field installable “B” type electrical interlock for position indication as indicated on the Drawings.

B. Disconnect switches to have provisions for a field installed insulated neutral kit as indicated on the Drawings.

C. NEMA Type 7 and Type 9 enclosures furnished with drain and breather kit when used in outdoor applications.

1. Manufacturers:
a. One of the following:
1) Eaton.
2) Siemens.
3) Appleton.

PART 3 EXECUTION

3.01 INSTALLATION

A. As specified in Section 16050, Common Work Results for Electrical.

B. Locations of disconnect switches on the Drawings are schematic in nature only. Contractor shall install disconnects in a readily accessible location, as defined by the NEC. All NEC working clearances shall be maintained. The Contractor shall verify the location of all power connections for equipment requiring disconnects with the approved Submittals and install the disconnect to meet Code.

C. Install motor rated toggle switches at gate and valve actuators.

D. Install the equipment in accordance with the accepted installation instructions and anchorage details to meet the seismic and wind load requirements at the Project Site.

E. General:

1. Use Myers hubs or bolt-on hubs for all conduit penetrations on NEMA Type 12, Type 4, and Type 4X enclosures.
2. Conduits shall not enter the top of boxes in wet locations or in locations where subject to water.
3. Provide all mounting brackets, stands, supports and hardware as required:
    a. Match finish and materials for all brackets, stands, and hardware with the switch installed.
    b. Provide adequate supporting pillar(s) for disconnect switches in accordance with the approved seismic calculations, and locate aboveground or above decks, where there is no structural wall or surface for box.
4. When possible, mount switches rigidly to exposed building structure or equipment structural members:
    a. For NEMA Type 4 and Type 4X locations, maintain a minimum of 7/8-inch air space between the enclosure and supporting surface.
    b. When mounting on preformed channel, position channel vertically so that water may freely run behind the enclosure.
5. Provide a nameplate for each disconnect switch:
    a. Provide per requirements specified in Section 16075, Electrical Identification.
    b. Identify voltage, circuit, fuse size, and equipment served on the nameplate.

3.02 COMMISSIONING

A. As specified in Section 01756, Testing and Facility Startup.

3.03 FIELD QUALITY CONTROL

A. As specified in Section 16050, Common Work Results for Electrical.

3.04 CLEANING

A. As specified in Section 16050, Common Work Results for Electrical.

3.05 PROTECTION

A. As specified in Section 16050, Common Work Results for Electrical.

END OF SECTION

SECTION 16444
LOW VOLTAGE MOTOR CONTROL CENTERS

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes: Low voltage motor control centers.

B. Related Sections:

1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
2. It is the Contractor’s responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor’s Work.

1.02 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. As specified in Section 16050, Common Work Results for Electrical.
2. National Electrical Manufacturer's Association (NEMA): ICS 18-2001, Motor Control Centers.
3. UL: 845, Motor Control Centers.

1.03 DEFINITIONS

A. As specified in Section 16050, Common Work Results for Electrical.

1.04 SYSTEM DESCRIPTION

A. Work in this section shall include modifying existing motor control centers. No new motor control centers are to be provided. The new bucket components shall be compatible with existing MCC bus rating and short circuit interrupted rating.

1.05 SUBMITTALS

A. Furnish submittals as specified in Section 01330, Submittal Procedures, and Section 16050, Common Work Results for Electrical.

B. Product Data:

1. Manufacturer of motor control center.
2. Manufacturer of motor control center parts.

3. Nameplate schedule.
4. Bill of material.
5. Enclosure:
    a. NEMA rating.
    b. Finish color.
6. Ratings:
    a. Voltage.
    b. Phase.
    c. Current:
        1) Horizontal bus ampacity.
        2) Vertical bus ampacity.
        3) Ground bus ampacity.
    d. Short circuit withstand rating.
    e. Protective device interrupting rating.
7. List of manufacturer's recommended spare parts.
8. Catalog Cut Sheets:
    a. Submit complete manufacturer's catalog information: Clearly indicate the features of the equipment including any options necessary to meet the required functionality.
9. Furnish circuit breaker submittals as specified in Section 16050, Common Work Results for Electrical.
10. Submit a letter confirming each variable frequency drive (VFD) unit contained within the MCC has been coordinated with its respective driven load. Letter shall list VFD location and driven equipment tag numbers as well as the FLA rating of each driven load motor. Motor data sheets for each driven load motor shall be attached to the coordination letter for verification.
11. For equipment installed in structures designated as seismic design category C, D, E, or F submit the following as specified in Section 16050, Common Work Results for Electrical:
    a. Manufacturer's statement of seismic qualification with substantiating test data.
    b. Manufacturer's special seismic certification with substantiating test data.
12. List of manufacturer's recommended spare parts.

C. Shop Drawings:

1. Layout Drawings: Provide fully dimensioned and to scale layout drawings which include elevations of final modified motor control centers.
2. Interfaces to other equipment.
3. Complete component and unit layout drawings.
4. Indicate lug sizes, type, and manufacturer based on the cable size specified in the Contract Documents and as indicated on the Drawings.

5. Elementary Schematics:
   a. Provide one custom schematic diagram for each compartment:
      1) Include all remote devices.
      2) Show wire numbers on the schematics: Provide wire numbering as specified in Section 16075, Electrical Identification.
6. External connection diagram showing the wiring to the external controls and devices associated with the motor control center.
7. One-line Diagrams:
   a. Provide complete one-line diagrams for each motor control center, including but not limited to: protective devices, starters, drives, metering, and other equipment.
   b. Indicate electrical ratings of the equipment shown on the one-line diagrams.

D. Operation and Maintenance Manuals:

1. Provide complete operating and maintenance instructions presenting full details for care and maintenance of all types of equipment furnished and/or installed under this section. Include the following:
   a. Electrical ratings:
      1) Phase.
      2) Wire.
      3) Voltage.
      4) Ampacity.
      5) Protective device interrupting ratings.
   b. Manufacturer’s operating and maintenance instructions for the motor control center and all component parts, including:
      1) Starters.
      2) Overload relays and heater elements.
      3) Variable frequency drives.
      4) Protective devices including, but not limited to, fuses, circuit breakers and protective relays.
      5) Pilot devices.

E. Record Documents:

1. Elementary Schematics:
   a. Furnish as-built elementary schematics indicating final:
      1) Wire numbers.
      2) Interfaces with other equipment.

b. Provide one custom schematic diagram for each compartment:
   1) Include all remote devices.
   2) Show wire numbers on the schematics.
c. Layout Drawings: Provide complete dimensioned component and unit layout drawings.

2. The Record Documents shall reflect all modifications made during the submittal review process and during construction.

F. Calculations: Detailed calculations or details of the actual physical testing performed on the motor control center to prove the motor control center is suitable for the seismic requirements at the Project Site.

1.06 SPARE PARTS

A. No spare parts are required.

1.07 QUALITY ASSURANCE

A. As specified in Section 16050, Common Work Results for Electrical.

B. All portions of the motor control center, vertical bays, and components shall be UL listed and labeled.

1.08 DELIVERY, STORAGE AND HANDLING

A. As specified in Section 16050, Common Work Results for Electrical.

B. Ship the motor control center and associated equipment to the Job Site on a dedicated air ride vehicle that will allow the Contractor to utilize onsite off-loading equipment.

1.09 PROJECT OR SITE CONDITIONS

A. As specified in Section 16050, Common Work Results for Electrical.

1.10 SEQUENCING

A. Conduct the initial fault current study as specified in Section 16950, Field Electrical Acceptance Tests, and submit results for Engineer’s review.

B. After successful review of the initial fault current study, as specified in Section 16950, Field Electrical Acceptance Tests, submit complete equipment.

C. Submittal as specified in the Article Submittals, of this section for Engineer’s review.

D. Conduct internal factory test to ensure that systems and equipment are functional and submit certified test results for Engineer's review.

E. Conduct factory acceptance test, to be witnessed by Owner and Owner's representative.

F. Ship equipment to the Project Site after successful completion of factory acceptance test.

G. Assemble equipment in the field.

H. Conduct field acceptance test and submit results for Engineer's review.

I. Submit manufacturer's certification that the equipment has been properly installed and is fully functional for Engineer's review.

J. Conduct Owner's training sessions.

K. Formally energize, start-up and commission equipment.

1.11 SCHEDULING

A. As specified in Section 16050, Common Work Results for Electrical.

1.12 WARRANTY

A. As specified in Section 16050, Common Work Results for Electrical.

1.13 SYSTEM STARTUP

A. As specified in Section 16050, Common Work Results for Electrical.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. One of the following:

1. Eaton.
2. Allen-Bradley.
3. Schneider Electric.
4. "Or-equal."

B. Existing motor control centers 200MCC4101 and 200MCC4102 are Eaton Freedom Series 2100.

2.02 EQUIPMENT

A. General:

1. Furnish motor control centers components as specified in the Contract Documents and indicated on the Drawings.
2. Provide wire markers at each end of every wire as specified in Section 16075, Electrical Identification.
3. Provide complete and functional motor control centers, even when modifying existing.
4. Provide devices or accessories not specified in this section but necessary for the proper installation and operation of the equipment.
5. Provide new components of the latest construction series available from the manufacturer.

B. Design and construct motor control center components to operate at the voltage level and configuration indicated on the Drawings.

C. Bus System: Existing, no modifications planned.

D. Enclosures: Existing, no modifications to existing footprint planned. Modifications shall occur in existing vertical sections.

1. Enclosure Rating: Ensure that existing MCC ratings are maintained.
2. Wireways: Utilize existing wireways to accomplish the work.

E. Units:

1. A plug-in unit consists of:
   a. Unit assembly.
   b. Unit support pan.
   c. Unit door assembly.
2. Completely enclosed and isolated from adjacent units, buses, and wireways, except for conductor entries into the unit, by a metal enclosure.
3. Constructed so that any fault will be contained in the unit compartment.
4. Supported and guided by a removable unit support pan:
   a. Re-arrangement of units and the removal of a unit so that a new and possibly larger unit can be added without the removal of an in-service unit to gain access to the unit support pan.
5. Held in place by screws or other positive locking means after insertion.
6. Provide a test position with the unit supported in the structure but disengaged from the bus.
7. Integral plug-in ground stab.

8. Stabs:
    a. Free floating.
    b. Self-aligning.
    c. Backed by spring steel clips to ensure high pressure contacts:
    d. Electrolytically tin-plated copper.
9. Handle:
    a. Provide a flange mounted handle mechanism to operate each disconnect switch or circuit breaker.
    b. Door mounted operators or operator handles are not acceptable.
    c. Engaged with the disconnect device at all times as an integral part of the unit, independent of the door position.
    d. Lockable in the “OFF” position with up to three padlocks.
    e. Mechanically interlocked so that the door cannot be opened with the handle in the “ON” position.
        1) Provide a means for qualified personnel to defeat this interlock.
    f. Interlocked so the unit cannot be inserted or withdrawn with the handle in the “ON” position.
    g. Lockable in the “ON” position:
        1) This shall not prevent the circuit breaker from operating and opening the contacts in the event of a fault condition.
    h. Color-coded to indicate position.
    i. Located so the center of the grip when it is in its highest position is not more than 6 feet 7 inches above the finished floor, including the height of the housekeeping pad and mounting channels.
10. Identification: The manufacturer shall label each unit. The units shall be labeled as shown on the Drawings.
11. Where indicated on the Drawings, provide units for spaces and future equipment:
    a. Equip these units to accept a future plug-in unit without modification to the vertical sections.

2.03 COMPONENTS

A. Provide components contained within the motor control center as specified in:

1. Section 16075, Electrical Identification.
2. Section 16123, 600 Volt or Less Wires and Cables.
3. Section 16150, Low Voltage Wire Connections.
4. Section 17710, Control Systems: Panels, Enclosures and Components.

2.04 ACCESSORIES

A. Wiring:

1. Wire the motor control center in accordance with the following NEMA Class and Type as defined by NEMA ICS 18-2001:
   a. NEMA Class II-S:
      1) Furnish wiring diagrams for individual units consisting of drawings that identify electrical devices, electrical connections, and indicate terminal numbering designations.
      2) Furnish individual unit diagrams with each unit and include inter-wiring between units, i.e., electrical interlocking, etc., as specifically specified in the Contract Documents.
      3) Provide custom drawings with unique terminal numbering designations in lieu of standard manufacturer drawings.
   b. NEMA Type B Wiring:
      1) Control Wiring: Type B-T pull-apart terminal blocks.
      2) Power Wiring:
         a) Type B-T for Size 1 starters.
         b) Type B-T or B-D for Size 2 and Size 3 starters.
         c) Type B for Size 4 and larger starters and feeder units.

B. Lugs and Terminals:

1. For all external connections of No. 6 AWG wire or larger: UL listed for copper or aluminum conductors.
2. Compression type, requiring a hydraulic press and die for installation.
3. Provide 20 percent spare control block terminals.

C. Nameplates:

1. Provide nameplates as specified in Section 16075, Electrical Identification: Identifying the motor control center designation as indicated on the Drawings.
2. Identifying each vertical section: Mounted and centered on the top horizontal wireway of the vertical section.
3. Furnish individual nameplates for each unit indicated on the Drawings:
   a. One nameplate to identify the unit designation.
   b. One nameplate to identify the load served.
   c. Furnish space units with blank nameplates.
4. Manufacturer’s Labels:
   a. Furnish each vertical section with a label identifying:
      1) Serial number.
      2) Bus rating.
      3) Vertical section reference number.

4) Date of manufacture.
5) Catalog number of sections.

D. Pilot Devices:

1. Refer to Section 17710, Control Systems: Panels, Enclosures, and Components.
2. Provide 30-mm size for all pilot devices.
3. Provide LED lights for all pilot lights.

2.05 FINISHES

A. Finish metal surfaces and structural parts with phosphatizing, “or-equal,” treatment before painting.

B. Finish interior surfaces including bus support angles, control unit back plates, and top and bottom barrier plates with baked white enamel.

C. Finish exterior of enclosure with manufacturer’s standard gray.

PART 3 EXECUTION

3.01 INSTALLATION

A. As specified in Section 16050, Common Work Results for Electrical.

B. Install the equipment in accordance with the accepted installation instructions.

C. General:

1. Furnish all cables, conduit, lugs, bolts, expansion anchors, sealants, and other accessories necessary to completely install the motor control center for the line, load, and control connections.
2. Perform work in accordance with manufacturer’s instruction and Shop Drawings.
3. Furnish all components, and equipment necessary to complete the installation.
4. Replace hardware, lost or damaged during installation or handling, in order to provide a complete installation.

D. Provide openings in the top or bottom of the motor control center for conduit only. For existing motor control centers, new conduits shall come out the top unless otherwise indicated on the Drawings.

E. Bundle circuits together and terminate in each unit:

1. Tie with nylon wire ties as specified in Section 16123, 600 Volt or Less Wires and Cables.
2. Label all wires at each end with wire markers as specified in Section 16075, Electrical Identification, as shown on the approved elementary schematics.

3.02 FIELD QUALITY CONTROL

A. As specified in Section 16050, Common Work Results for Electrical.

B. Provide the services of a manufacturer's representative to inspect, verify, and certify that the motor control center installation meets the manufacturer's requirements.

3.03 ADJUSTING

A. Make all adjustments as necessary and recommended by the manufacturer, Engineer, or testing firm.

3.04 CLEANING

A. As specified in Section 16050, Common Work Results for Electrical.

3.05 DEMONSTRATION AND TRAINING

A. As specified in Section 16050, Common Work Results for Electrical.

B. Demonstrate the operation of the motor control center to the Engineer's and Owner's satisfaction.

C. Training: Provide training for motor control center components as specified in the individual component specifications.

3.06 PROTECTION

A. As specified in Section 16050, Common Work Results for Electrical.

END OF SECTION

SECTION 16510
LIGHTING: LED LUMINAIRES

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes: LED luminaires, drivers, poles, and accessories.

B. Related Sections:

1. Section 01330, Submittal Procedures.
2. Section 01756, Testing and Facility Startup.
3. Section 16050, Common Work Results for Electrical.

1.02 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. As specified in Section 16050, Common Work Results for Electrical.
2. Illuminating Engineering Society of North America (IESNA):
   a. LM-79, Approved Method for the Electrical and Photometric Measurements of Solid-State Lighting Products.
   b. LM-80, Approved Method: Measuring Lumen Maintenance of LED Light Sources.
   c. TM-21, Projecting Long Term Lumen Maintenance of LED Light Sources.
3. Institute of Electrical and Electronics Engineers (IEEE): C62.41, Recommended Practice for Surge Voltages in Low-Voltage AC Power Circuits.
4. National Electrical Manufacturers Association (NEMA): 410, Performance Testing for Lighting Controls and Switching Devices with Electronic Drivers and Discharge Ballasts.
5. UL:
   a. 1598, Luminaires.
   b. 8750, Light Emitting Diode (LED) Equipment for Use in Lighting Products.

1.03 SYSTEM DESCRIPTION

A. Provide luminaires, and accessories for all lighting systems, complete and operable, in accordance with the requirements of the Contract Documents.

B. Individual luminaire types are indicated on the Drawings and on the Luminaire Schedule.

1.04 SUBMITTALS

A. Furnish submittals as specified in Section 01330, Submittal Procedures, and Section 16050, Common Work Results for Electrical.

B. Product Data:

1. LED Luminaires:
   a. Catalog literature for each luminaire specified, cross- referenced to the luminaire type on the Luminaire Schedule on the Drawings.
   b. Provide for each Luminaire Type:
      1) Materials.
      2) Type of diffuser.
      3) Hardware.
      4) Gasketing.
      5) Reflector.
      6) Chassis.
      7) Finish and color.
      8) Driver type and protection.
      9) LED Luminaire:
         a) Initial lumen output at 40 degrees C ambient.
         b) Correlated color temperature.
         c) Lumen maintenance factors.
         d) Lumen ambient temperature multipliers.
         e) Drive current.
         f) Efficacy.
      10) Picture of luminaire.
      11) Dimensioned Drawings: Effective projected area rating for pole mounted luminaires.
      12) Weight.
      13) Photometric Data:
         a) Coefficient of utilization tables based on the IES zonal cavity system by an approved testing laboratory.
         b) Luminaire dirt depreciation factor.
         c) Candlepower distribution curves.
         d) Average luminaire brightness.
         e) Lumen output charts.
      14) Furnish support method for interior luminaires weighing more than 30 pounds and all wall-mounted luminaires:
         a) Support methods shall be based on seismic requirements at the Project Site as specified in Section 16050, Common Work Results for Electrical.

2. Driver:
   a. Provide for each driver type:
      1) Catalog number.
      2) Type of driver.
      3) Output wattage.
      4) Input voltage.
      5) Operating voltage range.
      6) Maximum input power.
      7) Efficiency.
      8) Operating line current.
      9) Power factor.
      10) Operating temperature range.
      11) Current output range in ambient temperatures of 30 degrees C to 55 degrees C.
      12) Surge suppression data.

C. List of manufacturer's recommended spare parts.

D. Record Documents: Update the Luminaire Schedule on the Drawings to reflect the acceptable substitutions, after the substitution has been reviewed and accepted by the Engineer.

1.05 SPARE PARTS

A. No spare parts are required.

1.06 QUALITY ASSURANCE

A. As specified in Section 16050, Common Work Results for Electrical.

1.07 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 16050, Common Work Results for Electrical.

1.08 PROJECT OR SITE CONDITIONS

A. As specified in Section 16050, Common Work Results for Electrical.

1.09 WARRANTY

A. As specified in Section 16050, Common Work Results for Electrical.

B. LED Luminaire: 5-year warranty from the date of installation including material, workmanship, photometrics, driver, and LED modules.

1.10 SYSTEM STARTUP

A. As specified in Section 16050, Common Work Results for Electrical.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Luminaires:

1. One of the following:
   a. As noted on the Luminaire Schedule on the Drawings.

B. Drivers:

1. One of the following:
   a. Philips Advance.
   b. Thomas Research.
   c. eldoLED.
   d. “Or-equal.”

C. Timer Controls:

1. One of the following:
   a. Intermatic.
   b. “Or-equal.”

D. Substitutions: The lighting design and luminaire selection has been based upon the photometric data of the identified luminaire. It is the Contractor’s responsibility to ensure and prove to the Engineer at time of submittal the substitutions meet the quality and photometric requirements of the original design.

2.02 EQUIPMENT

A. LED Luminaires:

1. General:
   a. Pre-wired with leads of 18-AWG, minimum, for connection to building circuits.
   b. Provide the luminaires furnished per the Luminaire Schedule on the Drawings: The Specifications noted herein are an addition or supplement to the Luminaire Schedule on the Drawings.
   c. Individual LEDs connected such that a catastrophic loss or the failure of one LED will not result in the loss of the entire luminaire.

2. Minimum ambient temperature range of 0 degree C to 40 degrees C.
3. Minimum Rated Life:
   a. Office Areas: Minimum 70,000 hours when operated at 25 degrees C.
   b. Process Areas: Minimum 100,000 hours when operated at 40 degrees C.
4. Minimum efficacy of 70 lumens/watt.
5. Minimum Color Rendering Index of 80.
6. Tested according to IESNA LM-79 and LM-80.
7. Lumen maintenance projection in accordance with IESNA TM-21.
8. RoHS compliant.
9. Integral driver.
10. Suitable for dry, damp, or wet locations as indicated on the Drawings or on the Luminaire Schedule.
    a. Wet or Damp Locations: UL 1598 listed.

B. Cord and Plug Connected Luminaires: All luminaires installed indoors within process areas, tunnels, electrical, and mechanical rooms shall be cord and plug connected.

C. Timer Controls:

1. Indoor lighting shall be controlled from 2-hour timers located at the entry to each area.
2. Where indoor light fixtures in one area are powered by multiple 120V circuits, the lights shall be controlled from the lighting contactor located in the Electrical Room.
3. 2-hour timers shall be Intermatic; FF32, “or-equal.”

2.03 POLES

A. Hinged pole base.

B. Material, Size, and Shape: As shown on the Drawings.

C. GFCI receptacle with metal cover on pole.

PART 3 EXECUTION

3.01 INSTALLATION

A. As specified in Section 16050, Common Work Results for Electrical.

B. Install luminaires per the manufacturer’s guidelines and submitted installation calculations to meet seismic and wind requirements at the Project Site.

3.02 TESTING AND FACILITY STARTUP

A. As specified in Section 01756, Testing and Facility Startup.

3.03 FIELD QUALITY CONTROL

A. As specified in Section 16050, Common Work Results for Electrical.

3.04 ADJUSTING

A. Aim and verify all exterior and outdoor luminaires alignment, during dark evening hours, as directed by Owner or the Engineer.

3.05 CLEANING

A. As specified in Section 16050, Common Work Results for Electrical.

B. Clean all lenses, diffusers, and reflectors. Refinish all luminaires' trim, poles, and support brackets, where finish has been damaged. Clean all LED luminaires (new and old), used during construction for construction lighting, before substantial completion.

3.06 PROTECTION

A. As specified in Section 16050, Common Work Results for Electrical.

3.07 SCHEDULES

A. Refer to the Luminaire Schedule on the Drawings.

END OF SECTION

SECTION 16950
FIELD ELECTRICAL ACCEPTANCE TESTS

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes:

1. Responsibilities for testing the electrical installation.
2. Adjusting and calibration.
3. Acceptance tests.

B. Related Sections:

1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
3. The following sections are related to the Work described in this section. This list of related sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
   a. Section 01330, Submittal Procedures.
   b. Section 01756, Testing and Facility Startup.
   c. Section 16050, Common Work Results for Electrical.
   d. Section 16060, Grounding and Bonding.

C. Copyright Information: Some portions of this section are copyrighted by the InterNational Electrical Testing Association, Inc. (NETA). See NETA publication ATS for details.

1.02 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. As specified in Section 16050, Common Work Results for Electrical.
2. American National Standards Institute (ANSI).
3. ASTM International (ASTM):
   a. D877, Standard Test Method for Dielectric Breakdown Voltage of Insulating Liquids Using Disk Electrodes.
   b. D923, Standard Practices for Sampling Electrical Insulating Liquids.

c. D971, Standard Test Method for Interfacial Tension of Oil Against Water by the Ring Method.
d. D974, Standard Test Method for Acid and Base Number by Color-Indicator Titration.
e. D1298, Standard Test Method for Density, Relative Density, or API Gravity of Crude Petroleum and Liquid Petroleum Products by Hydrometer Method.
f. D1500, Standard Test Method for ASTM Color of Petroleum Products (ASTM Color Scale).
g. D1524, Standard Test Method for Visual Examination of Used Electrical Insulating Oils of Petroleum Origin in the Field.
h. D1816, Standard Test Method for Dielectric Breakdown Voltage of Insulating Liquids Using VDE Electrodes.
i. D2285, Standard Test Method for Interfacial Tension of Electrical Insulating Oils of Petroleum Origin Against Water by the Drop Weight Method.
j. D3612, Standard Test Method for Analysis of Gases Dissolved in Electrical Insulating Oil by Gas Chromatography.

4. Institute of Electrical and Electronics Engineers (IEEE):
   a. 43, Recommended Practice for Testing Insulation Resistance of Rotating Machinery.
   b. 81, Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Grounding System.
   c. 95, Recommended Practice for Insulation Testing of AC Electric Machinery (2,300 V and Above) With High Direct Voltage.
   d. 421.3, Standard for High-Potential Test Requirement for Excitation Systems for Synchronous Machines.
   e. 450, Recommended Practice for Maintenance, Testing, and Replacement of Vented Lead-Acid Batteries for Stationary Applications.
   f. 1106, Recommended Practice for Installation, Maintenance, Testing, and Replacement of Vented Nickel-Cadmium Batteries for Stationary Applications.
   g. 1188, Recommended Practice for Maintenance, Testing, and Replacement of Valve-Regulated Lead-Acid (VRLA) Batteries for Stationary Applications.
   h. C57.13, Standard Requirements for Instrument Transformers.
   i. C57.13.1, Guide for Field Testing of Relaying Current Transformers.
   j. C57.13.3, Guide for Grounding of Instrument Transformer Secondary Circuits and Cases.
   k. C57.104, Guide for the Interpretation of Gases Generated in Oil-Immersed Transformers.

5. Insulated Cable Engineer's Association (ICEA).
6. InterNational Electrical Testing Association (NETA): ATS-2009, Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems.
7. International Electrotechnical Commission (IEC).
8. Manufacturer's testing recommendations and instruction manuals.
9. National Fire Protection Association (NFPA):
    a. 70, National Electrical Code (NEC).
    b. 110, Standard for Emergency and Standby Power Systems.
10. National Institute of Standards and Technology (NIST).
11. Specification sections for the electrical equipment being tested.
12. Shop Drawings.

1.03 DEFINITIONS

A. As specified in Section 01756, Testing and Facility Startup, and Section 16050, Common Work Results for Electrical.

B. Specific Definitions:

1. Testing Laboratory: The organization performing acceptance tests.

1.04 SYSTEM DESCRIPTION

A. Testing of all electrical equipment installed under this Contract in accordance with the manufacturer's requirements and as specified in this section.

B. Conduct all tests in the presence of the Engineer or the Engineer's representative: The Engineer will witness all visual, mechanical, and electrical tests and inspections.

C. The testing and inspections shall verify that the equipment is operational within the tolerances required and expected by the manufacturer, and these Specifications.

D. Responsibilities:

1. Contractor Responsibilities: Ensure that all resources are made available for testing, and that all testing requirements are met.
2. Electrical Subcontractor Responsibilities:
    a. Perform routine tests during installation.
    b. Demonstrate operation of electrical equipment.
    c. Commission the electrical installation.

d. Provide the necessary services during testing, and provide these services to the testing laboratory, Contractor, and other subcontractors, including but not limited to:
   1) Providing electrical power as required.
   2) Operating of electrical equipment in conjunction with testing of other equipment.
   3) Activating and shutting down electrical circuits.
   4) Making and recording electrical measurements.
   5) Replacing blown fuses.
   6) Installing temporary jumpers.

3. Testing Laboratory Responsibilities:
   a. Perform all acceptance tests specified in this section.
   b. Provide all required equipment, materials, labor, and technical support during acceptance tests.

E. Upon completion of testing or calibration, attach a label to all serviced devices. The label shall indicate the date serviced and the company that performed the service.

1.05 SUBMITTALS

A. Furnish submittals as specified in Section 01330, Submittal Procedures, and Section 16050, Common Work Results for Electrical.

B. Manufacturers' Testing Procedures: Submit manufacturers' recommended testing procedures and acceptable test results for review by the Engineer.

C. Test Report:

1. Include the following:
   a. Summary of Project.
   b. Description of equipment tested.
   c. Description of tests performed.
   d. Test results.
   e. Conclusions and recommendations.
   f. Completed test forms.
   g. List of test equipment used and calibration dates.

D. Testing Laboratory Qualifications:

1. Submit a complete resume and statement of qualifications from the proposed testing laboratory detailing their experiences in performing the tests specified:
   a. This statement will be used to determine whether the laboratory is acceptable, and shall include:
      1) Corporate history and references.
      2) Resume of individual performing test.
      3) Equipment list and test calibration data.

E. Division of Responsibilities: Submit a list identifying who is responsible for performing each portion of the testing.

1.06 QUALITY ASSURANCE

A. As specified in Section 16050, Common Work Results for Electrical.

B. Testing Laboratory Qualifications:

1. The testing laboratory may be qualified testing personnel from the electrical subcontractor's staff or an independent testing company.
2. Selection of the testing laboratory and testing personnel is subject to approval by the Engineer based on testing experience and certifications of the individuals and testing capabilities of the organization.

1.07 PROJECT OR SITE CONDITIONS

A. As specified in Section 16050, Common Work Results for Electrical.

1.08 SEQUENCING

A. At least 30 days before commencement of the acceptance tests, submit the manufacturer's complete field testing procedures to the Engineer and to the testing laboratory, complete with expected test results and tolerances for all equipment to be tested.

B. Perform testing in the following sequence:

1. Perform routine tests as the equipment is installed including:
   a. Insulation-resistance tests.
   b. Continuity tests.
   c. Rotational tests.
2. Adjusting and preliminary calibration.

3. Acceptance tests.
4. Demonstration.
5. Commissioning and plant startup.

1.09 WARRANTY

A. As specified in Section 16050, Common Work Results for Electrical.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 PREPARATION

A. Test Instrument Calibration:

1. Utilize a testing laboratory with a calibration program which maintains all applicable test instrumentation within rated accuracy.
2. The accuracy shall be traceable to the NIST in an unbroken chain.
3. Calibrate instruments in accordance with the following frequency schedule:
   a. Field Instruments: 6 months maximum.
   b. Laboratory Instruments: 12 months maximum.
   c. Leased Specialty Equipment where the Accuracy is Guaranteed by the Lessor (such as Doble): 12 months maximum.
4. Dated calibration labels shall be visible on all test equipment.
5. Maintain an up-to-date instrument calibration record for each test instrument:
   a. The records shall show the date and results of each calibration or test.
6. Maintain an up-to-date instrument calibration instruction and procedure for each test instrument.

B. Do not begin testing until the following conditions have been met:

1. All instruments required are available and in proper operating condition.
2. All required dispensable materials such as solvents, rags, and brushes are available.
3. All equipment handling devices such as cranes, vehicles, chain falls and other lifting equipment are available or scheduled.
4. All instruction books, calibration curves, or other printed material to cover the electrical devices are available.
5. Data sheets to record all test results are available.

3.02 TESTING AND FACILITY STARTUP

A. As specified in Section 01756, Testing and Facility Startup.

3.03 FIELD QUALITY CONTROL

A. Low Voltage Cables, 600-volt Maximum:

1. Visual and Mechanical Inspection:
   a. Compare cable data with Drawings and Specifications.
   b. Inspect exposed sections of cable for physical damage and correct connection as indicated on the Drawings.
   c. Inspect bolted electrical connections for high resistance by one of the following methods:
      1) Use of low-resistance ohmmeter.
      2) Verify tightness of accessible bolted electrical connections by the calibrated torque wrench method: Refer to manufacturer's instructions for proper foot-pound levels or NETA ATS tables.
   d. Inspect compression applied connectors for correct cable match and indentation.
   e. Inspect for correct identification and arrangement.
   f. Inspect cable jacket insulation and condition.
2. Electrical Tests:
   a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter.
   b. Perform insulation resistance test on each conductor with respect to ground and adjacent conductors:
      1) Applied potential shall be 500V dc for 300-volt rated cable and 1,000V dc for 600-volt rated cable.
      2) Test duration shall be 1 minute.
   c. Perform continuity tests to ensure correct cable connection.
   d. Verify uniform resistance of parallel conductors.
   e. Resistance testing is required for wire sizes AWG #6 and larger.
3. Test Values:
   a. Compare bolted connection resistance values to values of similar connections: Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
   b. Insulation-resistance values shall be in accordance with manufacturer's published data:
      1) Refer to NETA ATS tables in the absence of manufacturer's published data.
      2) Investigate values of insulation-resistance less than the allowable minimum.

c. Cable shall exhibit continuity.
d. Investigate deviations in resistance between parallel conductors.

B. Low Voltage Molded Case and Insulated Case Circuit Breakers:

1. Visual and Mechanical Inspection:
   a. Compare equipment nameplate data with the Contract Documents.
   b. Inspect physical and mechanical condition.
   c. Inspect anchorage and alignment.
   d. Verify that all maintenance devices are available for servicing and operating the breaker.
   e. Verify the unit is clean.
   f. Verify the arc chutes are intact.
   g. Inspect moving and stationary contacts for condition and alignment.
   h. Verify that primary and secondary contact wipe and other dimensions vital to satisfactory operation of the breaker are correct.
   i. Perform all mechanical operator and contact alignment tests on both the breaker and its operating mechanism in accordance with manufacturers published data.
   j. Operate circuit breaker to ensure smooth operation.
   k. Inspect bolted electrical connections for high resistance by one of the following methods:
      1) Use of low-resistance ohmmeter.
      2) Verify tightness of accessible bolted electrical connections by the calibrated torque wrench method: Refer to manufacturer’s instructions for proper foot-pound levels or NETA ATS tables.
   l. Inspect operating mechanism, contacts, and arc chutes in unsealed units.
   m. Verify cell fit and element alignment.
   n. Verify racking mechanism operation.
   o. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.
   p. Perform adjustments for final protective device settings in accordance with the coordination study.
   q. Record as-found and as-left operation counter readings.

2. Electrical Tests:
   a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter.
   b. Perform insulation-resistance tests for 1 minute on each pole, phase-to-phase and phase-to-ground with the circuit breaker closed and across each open pole:
      1) Apply voltage in accordance with manufacturer's published data.
      2) Refer to NETA ATS tables in the absence of manufacturer's published data.
   c. Perform a contact/pole-resistance test.
   d. Perform insulation-resistance tests on control wiring with respect to ground. Applied potential shall be 500V dc for 300-volt rated cable and 1,000V dc for 600V rated cable. Apply the test voltage for 1 minute: For solid state devices that cannot tolerate the applied voltage, follow the manufacturer's recommendation.
   e. Determine long-time pickup and delay by primary current injection.
   f. Determine short-time pickup and delay by primary current injection.
   g. Determine ground-fault pickup and delay by primary current injection.
   h. Determine instantaneous pickup value by primary current injection.
   i. Test functions of the trip unit by means of secondary injection.
   j. Perform minimum pickup voltage tests on shunt trip and close coils in accordance with manufacturer's published data.
   k. Verify correct operation of any auxiliary features such as trip and pickup indicators, zone interlocking, electrical close and trip operation, trip-free, antipump function and trip unit battery condition: Reset all trip logs and indicators.
   l. Verify operation of charging mechanism.
3. Test Values:
   a. Compare bolted connection resistance values to values of similar connections: Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
   b. Bolt-torque levels shall be in accordance with manufacturer's published data: Refer to NETA ATS tables in the absence of manufacturer's published data.

c. Insulation-resistance values shall be in accordance with manufacturer's published data:
   1) Refer to NETA ATS tables in the absence of manufacturer's published data.
   2) Investigate values of insulation-resistance less than the allowable minimum.
d. Microhm or dc millivolt drop values shall not exceed the high levels of the normal range as indicated in the manufacturer's published data: If manufacturer's data is not available, investigate any values which deviate from adjacent poles or similar breakers by more than 50 percent of the lowest value.
e. Insulation-resistance values of control wiring shall not be less than 2 megohms.
f. Long-time pickup values shall be as specified, and the trip characteristic shall not exceed manufacturer's published time-current characteristic tolerance band including adjustment factors: If manufacturer's curves are not available, trip times shall not exceed the value shown in NETA ATS tables.
g. Short-time pickup values shall be as specified, and the trip characteristic shall not exceed manufacturer's published time-current tolerance band.
h. Ground fault pickup values shall be as specified, and the trip characteristic shall not exceed manufacturer's published time-current tolerance band.
i. Instantaneous pickup values shall be as specified and within manufacturer's published tolerances: Refer to NETA ATS tables in the absence of manufacturer's published data.
j. Pickup values and trip characteristics shall be within manufacturer's published tolerances.
k. Minimum pickup voltage of the shunt trip and close coils shall conform to the manufacturer's published data: Refer to NETA ATS tables in the absence of manufacturer's published data.
l. Breaker open, close, trip, trip-free, antipump, and auxiliary features shall function as designed.
m. The charging mechanism shall operate in accordance with manufacturer's published data.

C. Grounding Systems:

1. Visual and Mechanical Inspection:
   a. Inspect ground system for compliance with that indicated on the Drawings, specified in Specifications, and in the NEC.
   b. Inspect physical and mechanical condition.

c. Inspect bolted electrical connections for high resistance using one of the following methods:
   1) Use of low-resistance ohmmeter.
   2) Verify tightness of accessible bolted electrical connections by calibrated torque wrench method: Refer to manufacturer's instructions for proper foot-pound levels or NETA ATS tables.
d. Inspect anchorage.

2. Electrical Tests:
   a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter.
   b. Perform fall of potential test or alternative test in accordance with IEEE 81 on the main grounding electrode or system.
   c. Perform point-to-point tests to determine the resistance between the main grounding system and all major electrical equipment frames, the system neutral and any derived neutral points.
3. Test Values:
   a. Grounding system electrical and mechanical connections shall be free of corrosion.
   b. Compare bolted connection resistance values to values of similar connections: Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
   c. Bolt-torque levels shall be in accordance with manufacturer's published data: Refer to NETA ATS tables in the absence of manufacturer's published data.
   d. The resistance between the main grounding electrode and ground shall be as specified in Section 16060, Grounding and Bonding. Investigate point-to-point resistance values that exceed 0.5 ohm.

D. Variable Frequency Drive Systems:

1. Visual and Mechanical Inspection:
   a. Compare equipment nameplate data with the Contract Documents.
   b. Inspect physical and mechanical condition.
   c. Inspect anchorage, alignment, and grounding.
   d. Verify the unit is clean.
   e. Ensure vent path openings are free from debris and that heat transfer surfaces are clean.
   f. Verify correct connections of circuit boards, wiring, disconnects, and ribbon cables.

g. Motor Running Protection:
   1) Verify drive overcurrent setpoints are correct for their application.
   2) If drive is used to operate multiple motors, verify individual overload element ratings are correct for their application.
   3) Apply minimum and maximum speed setpoints. Verify setpoints are within limitations of the load coupled to the motor.

h. Inspect bolted electrical connections for high resistance using one of the following methods:
   1) Use of low-resistance ohmmeter.
   2) Verify tightness of accessible bolted electrical connections by the calibrated torque wrench method: Refer to manufacturer's instructions for proper foot-pound levels or NETA ATS tables.

i. Verify correct fuse sizing in accordance with manufacturer's published data.

j. Perform visual and mechanical inspection of input circuit breaker as specified in this section.

2. Electrical Tests:
   a. Perform resistance measurements through bolted connections with low resistance ohmmeter.
   b. Test the motor overload relay elements by injecting primary current through the overload circuit and monitoring trip time of the overload element.
   c. Test for the following parameters in accordance with relay calibration procedures specified in this section or as recommended by the manufacturer:
      1) Input phase loss protection.
      2) Input overvoltage protection.
      3) Output phase rotation.
      4) Overtemperature protection.
      5) Direct current overvoltage protection.
      6) Overfrequency protection.
      7) Drive overload protection.
      8) Fault alarm outputs.
   d. Perform continuity tests on bonding conductors as specified in this section.
   e. Perform start-up of drive in accordance with manufacturer's published data. Calibrate drive to the system's minimum and maximum speed control signals.

f. Perform operational tests by initiating control devices:
   1) Slowly vary drive speed between minimum and maximum. Observe motor and load for unusual noise or vibration.
   2) Verify operation of drive from remote start/stop and speed control signals.
g. Perform electrical tests of input circuit breaker as specified in this section.

3. Test Values:
   a. Compare bolted connection resistance values to values of similar connections: Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
   b. Bolt-torque levels shall be in accordance with manufacturer's published data: Refer to NETA ATS tables in the absence of manufacturer's published data.
   c. Overload test trip times at 300 percent of overload element rating shall be in accordance with manufacturer's published time-current curve.
   d. Test values for input circuit breaker shall be as specified in this section.
   e. Relay calibration results shall be as specified in this section.
   f. Continuity of bonding conductors shall be as specified in this section.
   g. Control devices shall perform in accordance with system requirements.
   h. Operational tests shall conform to system design requirements.

3.04 CLEANING

A. As specified in Section 16050, Common Work Results for Electrical.

B. After the acceptance tests have been completed, dispose of all testing expendables, vacuum all cabinets, and sweep clean all surrounding areas.

3.05 PROTECTION

A. As specified in Section 16050, Common Work Results for Electrical.

END OF SECTION

SECTION 17050
BASIC MEASUREMENT AND CONTROL INSTRUMENTATION MATERIALS AND METHODS

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes:

1. This section includes general design, material, equipment fabrication, and documentation requirements for instrumentation and control systems.
2. Additional or more stringent requirements, when given in other sections, shall prevail.

1.02 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. CWS Specifications:
   a. Section 01640, Manufacturers' Services and Training.
   b. Section 01756, Testing and Facility Startup.
   c. Section 16050, Common Work Results for Electrical.
   d. Section 16950, Field Electrical Acceptance Tests.
2. American National Standards Institute (ANSI): B16.5, Pipe Flanges and Flanged Fittings.
3. American National Standards Institute/American Petroleum Institute (ANSI/API):
   a. API RP550, Manual on Installation of Refinery Instruments and Control Systems.
   b. 551, Process Measurement Instrumentation.
4. ASTM International (ASTM): A269, Seamless and Welded Austenitic Stainless Steel Tubing for General Service.
5. Instrumentation, Systems, and Automation Society (ISA):
   a. RP7.1, Pneumatic Control Circuit Pressure Test.
   b. RP60.3, Human Engineering for Control Centers.
   c. S5.1, Instrumentation Symbols and Identification.
   d. S5.3, Graphic Symbols for Distributed Control/Shared Display Instrumentation, Logic and Computer Systems.
   e. S5.4, Instrument Loop Diagrams.
   f. S5.5, Graphic Symbols for Process Displays.
   g. S7.3, Quality Standard for Instrument Air.

h. S12.4, Instrument Purging for Reduction of Hazardous Area Classification.
i. S18.1, Annunciator Sequences and Specifications.
j. S20, Specification Forms for Process Measurement and Control Instruments, Primary Elements, and Control Valves.
k. S51.1, Process Instrumentation Terminology.
l. S71.04, Environmental Conditions for Process Measurement and Control Systems: Airborne Contaminants.

6. National Electrical Manufacturers Association (NEMA): 250, Enclosures for Electrical Equipment (1,000 Volts maximum).
7. National Fire Protection Association (NFPA):
   a. 70, National Electric Code (NEC).
   b. 496, Purged and Pressurized Enclosures for Electrical Equipment.
   c. 820, Standard for Fire Protection in Wastewater Treatment and Collection Facilities.
8. UL: 508, Industrial Control Equipment.

1.03 DEFINITIONS

A. Where a term is used in specification section number Series 17000 through Series 17999 relating to instrumentation, and the meaning is not defined therein or elsewhere in the Contract Documents, the meaning of the term shall be as defined in ISA S51.1, Process Instrumentation Terminology, or if not contained in ISA 51.1, as defined in listed reference standards under "References."

B. Control Circuit: Any circuit operating at 80V ac or 80V dc or more, whose principal purpose is the conveyance of information and not the conveyance of energy for the operation of an electrically powered device.

C. ORT-1 - Operational Readiness Testing, Part 1:

1. ORT-1 testing is a verification of circuit functionality based on circuit diagrams and loop drawings. Testing includes checkout from/to field instruments, local control stations, VFDs, Starter Buckets, MCCs, Vendor Panels, and Plant PLC. Testing activities includes the following:
   a. Wiring Terminations and Circuit Continuity.
   b. Conductor and Conduit Labels.
   c. Power and Control Circuits.
   d. Instrument Signals.
   e. PLC Signal Response Based on Process Value or Position at Field Device.

D. ORT-2 - Operational Readiness Testing, Part 2: Control System Software (PLC & HMI) is verified by the programmer as detailed in the Control Loop Descriptions.

E. PAT - Performance Acceptance Testing: Testing described in Section 01756, Testing and Facility Startup.

F. Panel: An instrument support system which may be either a flat surface, a partial enclosure, or a complete enclosure for instruments and other devices used in process control systems. Unless otherwise specified or clearly indicated by the context, the term “panel” in these Contract Documents shall be interpreted as a general term, which includes flat panels, enclosures, cabinets, and consoles.

G. Power Circuit: Any circuit operating at 80V (ac or dc) or more, whose principal purpose is the conveyance of energy for the operation of an electrically powered device.

H. PICS: Process Instrumentation and Control System.

I. SCADA: Supervisory Control and Data Acquisition.

J. Signal Circuit: Any circuit operating at less than 80V ac or 80V dc.

1.04 INSTRUMENTATION AND CONTROL SYSTEM DESCRIPTION

A. Overview:

1. New instrumentation and control for Headworks Odor Control system and associated upgrades.
2. Interface to existing PLC panels.
3. Extensions of plant PLC Ethernet networks.
4. Local Control Stations for process equipment.
5. Ventilation system monitoring and alarm.
6. Refer to Section 17101, Control Loop Descriptions, for Control Descriptions.

B. Work Includes:

1. Instrumentation and control works shall include, but not be limited to, field instrumentation and controls, field panels for control stations and intrinsically-safe barriers, control panel work, testing, training, documentation, and related items.

2. The Contractor shall provide, through the services of a qualified Process Control and Instrumentation System (PCIS) subcontractor, a complete and functioning control system. The PCIS shall be responsible for all control work except as excluded in this paragraph. PLC and SCADA programming are to be provided by the Owner.
3. Portions of this Project involve installation in existing facilities and interfaces to existing circuits, power systems, controls, and equipment.
    a. Perform and document comprehensive and detailed field investigations of existing conditions (circuits, power systems, controls, equipment, PLC inputs and outputs, etc.) before performing any Work.
    b. Provide and document interface with, modifications to, upgrade, or replacement of existing circuits, power systems, controls, and equipment.
    c. Documentation for modified panels shall be in the form of AutoCAD drawings. Markups of existing Drawings are not acceptable. As-built Drawings are available, however, CAD drawings for existing panels are not available. Only modified portions of modified panels are required to be documented.

C. Work by Others:

1. The Owner will provide PLC hardware and control panel terminal blocks. The Contractor shall coordinate all wiring assignments with Owner and land all field wiring at PLC panel terminals.
2. The Owner will provide network switches and patch panels. The Contractor shall route all network cables and terminate with connectors for plugging into equipment.
3. The Owner will provide application programming for the Plant PLCs and SCADA workstations. The Contractor shall, provide assistance with the onsite check out of application software provided by the Owner per Article Field Quality Control.
4. Subsequently, field testing of the revised control programs shall be performed per Article Field Quality Control.

1.05 DESIGN REQUIREMENTS

A. Review other sections and divisions of the Contract Documents for full compliance with the total Contract Documents. In the event of a conflict between sections, the Contractor shall promptly seek clarification from the Engineer.

B. Unless different requirements are clearly specified or shown elsewhere, instrumentation and control design, materials, equipment, installation, and testing shall comply with the requirements of the following specifications:

1. Division 15, Mechanical.
2. Division 16, Electrical.
3. Division 17, Process Instrumentation and Controls.

C. Detailed Wiring Design:

1. Typical panel wiring diagrams, interconnecting wiring diagrams, and loop wiring diagrams are included on the Drawings and designed to completely show control panel wiring, terminations, interfaces with other systems, hardwire functions, interlocks, and wiring of components provided.
2. The Drawings contain typical wiring diagrams that apply to multiple circuit diagrams, such as loop drawings and control wiring diagrams. The Contractor shall create an individual drawing from each piece of equipment or instrument listed in the typical drawings and customize for each control circuit and loop.

D. Completeness:

1. Provide a complete and fully functional instrumentation and control system ready for use.
2. Components which are not identified on the Drawings and Specifications, but necessary to meet the full functional operation and performance requirements, shall be provided.
3. Equipment shall be designed and installed in full conformity with the Drawings, Specifications, and instructions and recommendations of the related equipment manufacturer.

E. Connections and Appurtenances:

1. The instrumentation and control systems shall include all necessary connections to sources of electrical power, air, water, drains, and vents, with all required valves, switches, and accessories as specified or as recommended for best operation by the manufacturer of the equipment furnished.
2. All necessary mounting panels, stands, hangers, and brackets shall be furnished and installed and shall comply with the relevant sections of these Specifications.

F. Coordination:

1. Systems and equipment provided under this section shall be designed and coordinated for proper operation with related equipment and materials provided under other sections of these Specifications, and where applicable, under other referenced contracts, and with identified existing equipment.
2. Coordinate all aspects of the Work between Contractor and all subcontractors before bidding to ensure that all costs associated with a complete installation are included. The Owner is not responsible for any change orders due to lack of coordination of the Work between the Contractor, the System Supplier, the other subcontractors, or suppliers.

G. Control Functions: Control functions are provided in Section 17101, Control Loop Descriptions.

H. Instrument Tagging: Refer to Section 16075, Electrical Identification, for tagging requirements.

I. Hazardous (Classified) Areas:

1. Instrumentation and control equipment specified, is subject to the requirements for hazardous (classified) areas as specified in Division 16, Electrical, and indicated on the Drawings.
2. Two-wire transmitters to be installed in a hazardous (classified) area shall be Factory Mutual approved intrinsically safe, and made safe by means of suitably rated Factory Mutual approved intrinsically safe barriers installed in a non-hazardous area.
3. Switches to be installed in a hazardous (classified) area shall be made safe by means of suitably rated Factory Mutual approved intrinsically safe barriers or intrinsically safe relays installed in a nonhazardous area.

J. Equipment Locations:

1. The monitoring and control system configurations are diagrammatic. The locations of the equipment are approximate. The exact locations and routing of wiring and cables shall be governed by structural conditions and physical interference and by the electrical terminations on the equipment.
2. Equipment shall be located and installed so that it is readily accessible for operations and maintenance but does not obstruct the removal of equipment.

K. Documentation to be provided:

1. All aspects of the instrumentation and control systems design shall be fully documented, and subsequently revised to conform to the "As-Built" installation.
2. The numbering of all instruments, equipment, terminal blocks, conductors, and cables shall be shown on all related documents.

L. Testing and Startup:

1. After installation of equipment and instrumentation is complete, testing shall be performed by the PCIS contractor in a series of steps as described below and detailed in Section 01756, Testing and Facility Startup. Refer to Division 16, Electrical, specification for testing and verification requirements for electrical. Sections described in Section 01756, Testing and Facility Startup, include the following:
   a. Instrument calibrations.
   b. ORT-1.
   c. ORT-2.
   d. Performance Acceptance Testing (PAT).

1.06 SUBMITTALS

A. General:

1. Submit in accordance with Section 01330, Submittal Procedures.
2. Submittal data shall be grouped in a logical manner to facilitate review of subsystems and each submittal shall be substantially complete. Individual drawings and data sheets submitted at random intervals will not be accepted for review.
3. Incomplete submittals will be returned to the Contractor without the Engineer's review and without contract time extension.
4. Design Data submittals shall be reviewed and returned with resubmittal not required, before fabrication is started.
5. All panel drawings and loop drawings shall be produced with latest version of AutoCAD software.
6. Variations: A notice of variation shall be included in any submittal deviating from the Drawings or Specifications.
7. Hardware submittals shall be provided within 60 days of the Notice to Proceed.

B. Presubmittal Conference:

1. The Engineer shall arrange and conduct a Pre-submittal Conference within 60 days (number of days to be determined based on Project size) after award of the Contract. The purpose of the Presubmittal Conference is to review and approve the manner in which the Contractor intends to carry out its responsibilities for Shop Drawing submittal on the Work to be provided under this section. The Contractor and the Engineer shall attend. Both the Contractor and the Engineer may invite additional parties at their discretion.
2. The Contractor shall allot one, 4-hour half-day for the Conference.
3. The Contractor shall present the following for discussion at the Conference:
    a. A list of equipment and materials required for the PICS and the manufacturer's name and model number for each proposed item. See Section 01330, Submittal Procedures.
    b. A list of proposed clarifications to the Contract Documents along with a brief explanation of each. Resolution shall be subject to a separate formal submittal and review by the Engineer.
    c. An exact one-to-one sample of each type of submittal herein, including control loop drawings as described in Project-Wide Wiring Drawing Submittal.
    d. A schedule developed in MS Excel or MS Project for all system related activities from the Pre-submittal Conference through startup and training. Dates of submittals, design, fabrication, programming (by others), factory testing, deliveries, installation, field testing, and training shall be shown. The schedule shall be subdivided to show activities relative to each major item or group of items when everything in a given group is on the same schedule.
    e. An overview of the proposed training plan. The Owner's staff and Engineer will review the overview and may request changes. All changes to the proposed training shall be resolved at the presubmittal conference. The overview shall include the following for each proposed course.
        1) Course title and objectives.
        2) Prerequisite training and experience of attendees.
        3) Course Content: A topical outline.
        4) Course duration.
        5) Course Format: Lecture, laboratory demonstration, etc.
4. The Engineer shall take minutes of the Conference, including all events, questions, and resolutions. Prior to adjournment, all parties must concur with the accuracy of the minutes and sign accordingly.

C. The system supplier shall submit wiring diagrams for approval by the Engineer and Owner at the following three stages:

1. Initial wiring diagrams shall be submitted 60 days after Notice to Proceed. The templates included in the Contract Documents will be used to document each and every loop on the Project. All control panel wiring and terminal block numbering shall be shown, including any power wiring. The diagrams at the initial stage are not required to include any non-PCIS equipment terminal information or actual wiring numbers. After this submittal is approved satisfactorily the control panel fabrication can proceed.
2. Construction wiring diagrams shall be submitted 30 days after approval of initial wiring diagrams and the approval of all the equipment submittals that have connections to PCIS equipment, including valve actuators, VFDs and vendor provided control panels. This set of wiring diagrams will be used throughout the construction phase of the Project and shall include all termination information for all equipment, including packaged equipment and all instruments provided for the Project. Each diagram will also include complete wiring numbers that comply with Article Installation, and as indicated on the instrument drawings. These diagrams do not include electrical power distribution system or HVAC systems, or the internal wiring of equipment such as valve actuators, VFD drives, or other equipment not supplied as part of the PCIS. After this set of wiring diagrams have been approved by the Engineer they shall be used as a construction tool by the electrical subcontractor, system supplier, and the Contractor for field wiring, testing and startup activities. The system supplier shall be responsible for maintaining the diagrams throughout the construction phase of the Project by incorporating any “as-built” information and changes from the electrical subcontractor and Contractor as the construction phase progresses. These construction wiring diagrams may be submitted in subsets to better align with the actual construction sequence.
3. Preliminary field markup as-built wiring diagrams shall be submitted 5 days after all equipment has successfully completed the ORT-1, ORT-2, and performance tests. The wiring diagrams shall fully document any changes that have occurred during the construction phase of the Project. Final as-built wiring diagrams shall be submitted 30 days after all equipment has successfully completed the ORT-1, ORT-2, and performance testing.

D. Product Data:

1. General:
   a. Submitted for noncustom manufactured material listed in this and other sections and shown on Shop Drawings.
   b. Furnish sufficient information to evaluate the suitability of the proposed material or equipment for the intended use, and for compliance with these Specifications.
   c. Include:
      1) Catalog cuts.
      2) Bulletins.
      3) Brochures.
      4) Quality photocopies of applicable pages from these documents.
      5) Identify on the data sheets the Project name, applicable specification section, and paragraph.
      6) Identify model number and options for the actual equipment being furnished.
   d. Legibly cross out options that do not apply or equipment not intended to be supplied.
2. Material and Equipment Schedules:
   a. Furnish a complete schedule and/or matrix of all materials, equipment, apparatus, and instruments for this Project.
   b. Include sizes, names of manufacturers, catalog numbers, and such other information required to identify the items.
3. Instrument Data Sheets and Cut Sheets:
   a. Partially completed data sheets are provided at the end of each instrument specification. The Contractor shall use the Specifications and Drawings to complete the Instrument Data Sheets.
      1) The partially completed data sheets are not intended to be used as a takeoff list. The Contractor shall provide instruments as indicated in Project Specifications and on the Drawings.
   b. Furnish fully completed data sheets, both electronically in Microsoft Word or Excel and in hardcopy, for each instrument and component according to ISA S20 Specification Forms for Process Measurement and Control Instruments, Primary Elements and Control Valves. Include the following information on the data sheet:
      1) Component functional description used herein and on the Drawings.
      2) Manufacturers model number or other product designation.

3) Tag number used herein and on the Drawings.
4) System or loop of which the component is a part.
5) Location or assembly at which the component is to be installed.
6) Input and output characteristics.
7) Scale range with units and multiplier.
8) Requirements for electric supply.
9) Requirements for air supply.
10) Power consumption.
11) Response timing.
12) Materials of construction and of component parts that are in contact with, or otherwise exposed to, process media, and or corrosive ambient air.
13) Special requirements or features, such as specifications for ambient operating conditions.
14) Features and options that are furnished.

c. Provide a technical brochure or bulletin ("cut sheet") for each instrument on the Project. Submit with the corresponding data sheets:
1) Where the same make and model of instrument is used in two or more applications on the Project, and the process applications are nearly identical, and the materials, features and options are identical submit one brochure or bulletin for the set of identical instruments.
2) Include a list of tag numbers for which it applies with each brochure or bulletin.
3) Furnish technical product brochures that are complete enough to verify conformance with all Contract Document requirements, and to reflect only those features supplied with the device.
4) Cross out models, features, options, or accessories that are not being provided.
5) Clearly mark and identify special options and features.

4. Organization: Index the data sheets and brochures in the submittal by systems or loops.

E. Shop Drawings:

1. General:
a. Preparation of Shop Drawings shall not commence until adjournment of the Presubmittal Conference.

b. Coordinate all aspects of the Work so that a complete, instrumentation, computer, and control system for the facility is supported by accurate shop and Record Drawings: Clearly show every wire, circuit, and terminal provided under this contract on one or more submitted wiring diagrams.
c. Show all interfaces between any of the following: instruments, vendor control panels, motor control centers, motor starters, variable speed drives, control valves, flow meters, chemical feeders and other equipment related to the PICS.
d. Generate all drawings developed for this Project utilizing AutoCAD by Auto Desk: Furnish on CD-ROM disks, as well as hard copies on 11-inch by 17-inch plain bond paper.
e. Organize the Shop Drawing submittals for inclusion in the Operation and Maintenance Manuals:
    1) Furnish the initial Shop Drawing submittal bound in one or more standard size, three-ring, D-ring, loose leaf, vinyl plastic, hard cover binders suitable for bookshelf storage.
    2) Binder Ring Size: Not to exceed 3 inches.
f. Include the letterhead and/or title block of the firm responsible for the preparation of all Shop Drawings. Include the following information in the title block, as a minimum:
    1) The firm’s registered business name.
    2) Firm’s physical address, email address, and phone number.
    3) Owner’s name.
    4) Project name and location.
    5) Drawing name.
    6) Revision level.
    7) Personnel responsible for the content of Drawing.
    8) Date.

2. Shop Drawing Requirements:
    a. Front, side, and, rear elevations, and top and bottom views, showing all dimensions.
    b. Locations of conduit entrances and access plates.
    c. Component layout and identification.
    d. Schematic and wiring diagrams with wire numbers and terminal identification.
    e. Connection diagrams, terminal diagrams, internal wiring diagrams, conductor size, etc.
    f. Anchoring method and leveling criteria, including manufacturer’s recommendations for the seismic and wind conditions specified in Section 01612, Anchorage and Bracing.
    g. Weight.
    h. Finish.

i. Nameplates: Refer to Section 16075, Electrical Identification.
j. Temperature limitations, as applicable.
k. Interfaces between instruments, motor starters, control valves, variable speed drives, flow meters, chemical feeders and other equipment related to the PICS shall be included in the Shop Drawing submittal.

3. The Contractor shall submit wiring diagrams for approval by the Engineer and Owner:
   a. Wiring diagrams shall be submitted 90 days after notice to proceed. The templates included in the contract documents will be used to document each and every loop on the Project. All control panel wiring and terminal block numbering shall be shown, including any power wiring. After this submittal is approved satisfactorily the control panel fabrication can proceed.
   b. Preliminary field mark-up as-built wiring diagrams shall be submitted 5 days after all equipment has successfully completed the ORT-1, ORT-2 and Performance Tests. The wiring diagrams shall fully document any changes that have occurred during the construction phase of the Project. Final as-built wiring diagrams shall be submitted 30 days after all equipment has successfully completed the ORT-1, ORT-2 and Performance Testing.
4. Itemized instrument summary. The summary shall be prepared with Microsoft Excel software and shall be submitted on hard copy. The instrument summary shall list all of the key attributes of each instrument provided under this Contract. As a minimum, attributes shall include:
   a. Tag number.
   b. Manufacturer.
   c. Model number.
   d. Service.
   e. Area location.
   f. Calibrated range.
   g. Loop drawing number.
   h. Associated LCP and PLC.
5. Instrument Installation Drawings:
   a. Submit instrument installation, mounting, and anchoring details for all components and assemblies in an electronic AutoCAD and hard copy format, including access requirements and conduit connection or entry details.
   b. Furnish for each instrument a dedicated 8-1/2-inch by 11-inch installation detail that pertains to the specific instrument by tag number.

c. For each detail, provide certification and the hard copies, by the instrument manufacturer, that the proposed installation is in accordance with the instrument manufacturer's recommendations and is fully warrantable.
d. For each detail, provide, as a minimum, the following contents:
   1) Necessary sections and elevation views required to define instrument location by referencing tank, building or equipment names and numbers, and geographical qualities such as north, south, east, west, basement, first floor, etc.
   2) Ambient temperature and humidity where the instrument is to be installed.
   3) Corrosive qualities of the environment where the instrument is to be installed.
   4) Hazardous rating of the environment where the instrument is to be installed.
   5) Process line pipe or tank size, service, and material.
   6) Process tap elevation and location.
   7) Upstream and downstream straight pipe lengths between instrument installation and pipe fittings and valves.
   8) Routing of tubing and identification of supports.
   9) Mounting brackets, stands, anchoring devices, and sun shades.
   10) Conduit entry size, number, location, and delineation between power and signal.
   11) NEMA ratings of enclosures and all components.
   12) Clearances required for instrument servicing.
   13) List itemizing all manufacturer makes, model numbers, quantities, lengths required, and materials of each item required to support the implementation of the detail.

6. Control Panel Drawings:
   a. Layout Drawings:
      1) Submit panel, enclosure, console, furniture, and cabinet layout drawings for all items provided.
      2) As a minimum, include the following information:
         a) To scale front, side, and plan views.
         b) Dimensions.
         c) Interior and exterior arrangements.
         d) Mounting information, including conduit entrance location.
         e) Finish data.

f) Tag number and functional name of items mounted in and on each panel, console, and cabinet.
g) Nameplate legend including text, letter size, and colors.

b. Wiring and Piping Diagrams:
1) Submit panel wiring and piping diagrams for every panel that contains wiring and/or piping.
2) Include the following information:
a) Name of panel.
b) Wiring and piping sizes and types.
c) Terminal strip numbers.
d) Wire tags and labels.
e) Functional name and manufacturer's designation for items to which wiring and piping are connected.
f) Electrical control schematics in accordance with ANSI standards.

c. Installation Drawings:
1) Provide site-specific installation drawings for all control equipment panels, including dimensions.
2) Provide scaled drawings and show the position of the equipment at its intended installation location.
3) Show the placement of all equipment being provided under this Contract and its spatial relationship to all other equipment located in the abutting and adjoining areas.
4) Show all required access and clearances associated with the equipment with a statement of compliance to manufacturer's recommendations, NEC, and other applicable codes.

7. Control System Diagram:
a. Submit a complete set of control system diagrams including the following information:
1) All PLCs, workstations, printers, communication devices, and communication links:
a) Show all PLCs with their current I/O allocation, and future I/O allocation, current plus spares provided, and maximum potential I/O based on available slots.
(1) All cables required for communication requirements.
(2) Show each component fully annotated with conduit size and number associated with the power source.

F. Testing and Startup Plan Submittal: Refer to Section 01756, Testing and Facility Startup, for Testing and Startup Plan Submittal requirements.

G. Technical Manuals/Operation and Maintenance Manuals:

1. Manuals shall be based upon the approved Shop Drawing submittals as modified for the conditions encountered in the field.
2. Furnish the Engineer with a complete preliminary set of written Operation and Maintenance Manuals 8 weeks before calibration, startup and/or testing.
3. Furnish in accordance with Section 01782, Operation and Maintenance Data, and the following additional requirements.
4. Submit preliminary sets of these manuals to the Engineer for review of format and content:
    a. Engineer will return one set with comments.
    b. Revise and/or amended as required and submit the requisite number of copies to the Engineer 15 days before Precommissioning of the systems.
5. Incorporate changes that occur during startup and submit as part of the final manuals.
6. Provide comprehensive information on all systems and components to enable operation, service, maintenance, and repair.
7. Include Record Documents and the approved Shop Drawing submittals, modified for conditions encountered in the field during the work.
8. Provide installation, connection, operating, calibration, setpoints (e.g., pressure, pump control, time delays, etc.), adjustment, test, troubleshooting, maintenance, and overhaul instructions in complete detail.
9. Provide exploded or other detailed views of all instruments, assemblies, and accessory components together with complete parts lists and ordering instructions.
10. Spare Parts List:
    a. Include a priced list of recommended spare parts for all the equipment furnished under this Contract: Include recommended quantities sufficient to maintain the furnished system for a period of 5 years.
    b. Annotate the list to indicate which items, if any and quantity are furnished as part of this Contract.
    c. Provide the name, address, and phone number of manufacturer and manufacturer’s local service representative of these parts.
11. Include signed and completed calibration sheets, ORT-1 forms, and Performance Acceptance Testing form.

H. Training Submittals: The Training Submittal shall be based on the preliminary submittal provided at the Presubmittal Conference.

1. Refer to Section 01640, Manufacturers' Services and Training, for Training Submittal requirements.

I. Record Documents:

1. Furnish in accordance with Section 01770, Closeout Procedures.
2. Provide record documents of all instrumentation drawings.
3. Record Drawing Requirements:
    a. Submit final fully updated Record Drawings upon completion of the Work for final review.
    b. Clearly and neatly show all changes in accordance with Section 01770, Closeout Procedures, and the following:
        1) All existing pipe, conduit, wire, instruments, or other structures encountered or uncovered during construction.
4. Shop Drawings:
    a. Upon completion of the Work, update all Shop Drawings to indicate the final as-built configuration of the systems:
        1) Should an error be found in a Shop Drawing during installation or startup of equipment, note the correction, including any field changes found necessary, on the drawing and submit the corrections in the Record Documents.
        2) Update, check, and revise all wiring drawings and other submitted drawings and documents to show final installed conditions.
    b. Provide "As-Built" Shop Drawings for all instrumentation equipment on 11-inch by 17-inch paper. Provide actual field markups (redlines) upon Substantial Completion.
    c. Provide electronic copies of these documents on CD-ROM disks in AutoCAD Version 2014 by Autodesk and .pdf. Size all Drawings to be readable and legible on 11-inch by 17-inch media.
5. Submittal Documents:
    a. Provide an interim submittal of Record Documents after the PICS system Pre-commissioning.
    b. Submit final Record Documents before Substantial Completion or earlier if so specified in Section 01770, Closeout Procedures, or the General Requirements.

6. Review and Corrections:
   a. Correct any Record Documents or other documents found to be incomplete, not accurate, of poor quality, or containing errors.
   b. Promptly correct and re-submit Record Documents returned for correction.

J. Project Closeout Submittals:

1. Recommended Spare Parts List.
2. Operation and Maintenance Manuals for Project, fully indexed, incorporating all instrumentation and control system documentation submitted and produced, and revised to conform to the "As-Built" installation. Application specific operation and maintenance instruction and application program records shall be included. Submit one set for review and four sets of the final accepted manuals.
3. Submit reproducible Drawings revised to conform to "As-Built" installation for the Owner's records after acceptance of the Project Operation and Maintenance Manuals.
4. Electronic files, two sets, in the form of CD-ROM disks, bearing all electronically formatted documents including "As-Built" CAD Drawings and application programs, shall be submitted for information only and the Owner's records, after acceptance of Operation and Maintenance Manuals for Project. The media shall contain a table of contents, ASCII formatted, identifying the contents of each file and the software program/version with which it was produced. The media shall contain a CAD plotting document providing definition of, and correlation between layers/colors and line types for all CAD files. A Portable Document Format (*.pdf) version of each CAD drawing shall also be provided as part of the disk set.
5. "As-Built" Wiring Diagrams Submittals: Final "As-Built" set of wiring diagrams with Contractor, Division 16, Electrical, and PICS supplier coordination signature that each suppler has completed all "As-Built" markups to every detailed wiring diagram in the construction set of wiring diagrams.

1.07 QUALITY ASSURANCE

A. Procurement Restriction: Certain equipment manufacturers with marketing operations based on local agents, have terms where the selling agent has responsibility for after sales service. In such cases, the Contractor's procurement of such equipment is restricted to the selling agent within whose service area the equipment will be finally installed, thus assuring the Owner of the availability of local after sales service.

B. Quality Assurance Procedure:

1. A quality assurance procedure shall be defined and implemented by the Contractor supervising instrumentation and control systems. The procedure shall:
   a. Require that the project manager schedule and budget for in-house and inter-Contractor checking.
   b. Specify qualifications required for engineering and technical personnel in the execution and checking of specific tasks.
   c. Identify the responsibilities of the executor and the checker.
   d. Provide quality assurance data sheets listing specific tasks and stages of tasks, with space for the printed names of the executor and checker, and the checker's signature and date.
2. The quality assurance procedure shall form part of the contractual requirements for subcontractors, and manufacturers or suppliers with unit responsibility.
3. The quality assurance data sheets shall be maintained current and shall be available for inspection upon request.

C. Substitutes and "Or-Equals":

1. Substitutes and "Or-equals" may be proposed in accordance with the General Conditions.
2. Where manufacturers of instrumentation or control system products other than those specified are proposed, they shall have a minimum of 5 years' experience in the manufacture of comparable equipment used in similar applications. The Contractor shall provide manufacturers' references to existing installations upon request of the Engineer. Noncompliance shall be a basis for rejection.

D. Coordination Meetings:

1. General: In accordance with Section 01110, Summary of Work.
   a. Attendees may Include: Engineer, Owner, Contractor, and PICS Subcontractor.
   b. First Meeting: Schedule per the requirements of Section 01110, Summary of Work. Thereafter, monthly, prior to first startup activity and weekly during startup activities. Include meetings on progress schedule.

1.08 DELIVERY, STORAGE, AND HANDLING

A. Storage:

1. Equipment shall not be stored outdoors. Equipment shall be stored in dry permanent shelters, including in-line equipment, and shall be adequately protected against mechanical injury. If any apparatus has been damaged, such damage shall be repaired by the Contractor. If any apparatus has been subject to possible injury by water, it shall be thoroughly dried out and put through tests as directed by the Engineer. If such tests reveal defects, the equipment shall be replaced.
2. Store all equipment and materials delivered to the Job Site in a location that will not interfere with the construction or the Owner's operations.

B. Delivery Timing: No instrumentation or control system equipment shall be delivered to the Job Site until required for integration with other construction, and all necessary environmental preparations have been made.

C. Intermediate Storage and Handling:

1. When the Contractor is obliged to take delivery in advance of this time, the Contractor shall do so at a bonded air-conditioned warehouse.
2. The Contractor shall provide for storage at the warehouse and transport of the equipment to the Job Site by suitably qualified movers with moving equipment (e.g., floating bed truck) as recommended by the manufacturer.

D. Noncompliance:

1. Should the equipment be delivered to the Job Site and be stored in adverse conditions or installed in improper environmental conditions, then at the Engineer's discretion, prior testing may be declared void.
2. The prior testing (e.g., factory acceptance testing) shall be repeated and/or, at the discretion of the Engineer, a reduced value dollar credit shall be provided by the Contractor.
3. The equipment shall still be required to satisfy Site testing performance criteria.

1.09 SITE CONDITIONS

A. General: Instrumentation and control systems equipment shall be suitable, or made suitable, for Site conditions at the Project location.

B. Temperature:

1. Electrical and Control Room Temperature: 60 degrees F to 100 degrees F.
2. Field Locations Temperature: 20 degrees F to 120 degrees F.
3. Above temperatures do not include effects of direct sunlight or wind chill.

C. Relative Humidity (RH):

1. Electrical and Control Rooms RH: 20 percent to 80 percent.
2. Field Locations RH: 10 percent to 100 percent.

D. Atmospheric Contaminants:

1. Atmospheric contaminants include hydrogen-sulfide, chlorine, ammonia, and dust in indeterminate concentrations.
2. Corrosive atmosphere testing shall be conducted, where specified.

E. Electromagnetic Radiation:

1. Electromagnetic Radiation:
   a. 27 MHz to 500 MHz: 10 volts/m.

PART 2 PRODUCTS

2.01 MATERIALS

A. Refer to other instrumentation and control sections.

2.02 SOURCE QUALITY CONTROL

A. Factory Testing:

1. Tests shall be observed by the Owner. Tests may be observed by the Electrical Engineer and the Project Engineer.
2. The Owner shall bear costs associated with travel for this test including, but not limited to, lodging, meals, travel time, time to witness tests, etc., for up to three representatives of the Owner.
3. Costs associated with accommodation of the witness testing at the testing facility shall be paid for by Contractor.
4. The Engineer shall be reimbursed by the Owner for all costs associated with these tests.

5. Prerequisites to Factory Testing:
   a. Approved test plan.
   b. Notice to the Owner given 21 working days prior to the start of testing.
6. Instrumentation and control systems shall be factory tested and calibrated.
7. Factory test/calibration records shall be submitted to the Engineer to show that the equipment has achieved the specified performance and accuracy.
8. Additional Factory Testing: Refer to other instrumentation and control sections.

PART 3 EXECUTION

3.01 INSTALLATION

A. General: Install instrumentation and control systems in accordance with the Drawings and Specifications, final submittals, manufacturer's instructions, and (where applicable) American Petroleum Institute RP550/551.

B. Electrical: Install cable and wiring in accordance with applicable sections in Division 16, Electrical.

C. Piping: Install piping and fittings in accordance with applicable sections of Division 05, Metals, and Division 15, Mechanical.

D. Wiring Identification Numbers:

1. Each wire shall be labeled per the Clean Water Services standards as demonstrated on the example wiring diagrams provided as part of the Drawings and as summarized below:
   a. Cable numbers shall be named based on the equipment tag of the field device utilizing the electrical power source. The form of the tag shall be 406P1205C2 where '406P1205' represents the equipment designation; 'C' indicated a control cable and 2 is a sequential number developed as part of the circuit design. Cable type designations shall follow the designations listed below:
      1) C – Control.
      2) S – Signal (below 80V ac or 80V dc).
      3) P – Power.
      4) N – Network (Ethernet, Profibus, etc.).

5) Examples for Cable Numbers:
   a) Signal cable from Control Valve (406LCV1205) to PLC terminals:
      (1) Input Twisted Shielded Pair: 406FCV1205S1+ and 406FCV1205S1-.
      (2) Feedback Twisted Shielded Pair:
         (a) 406FCV1205S2+ and 406FCV1205S2-.
         (b) Control cable to “Open” and “Closed” limit switches on control valve.
   b) Power from PLC: 406ZSO1206C1.
      (1) Return from ZSO: 406ZSO1206C2.
      (2) Return from ZSC: 406ZSC1206C1.

b. Within PLC cabinets, PLC control and signal wiring from/to I/O cards and PLC terminal strips shall be labeled based on the rack, slot, and point number of the I/O point. Labels shall take one of the following forms:
   1) RXSYPZ - Discrete PLC I/O Wiring.
   2) RXSYPZ+/- - Analog PLC I/O Wiring.
   3) AC~ - Power Connection.
      a) Where X is replaced with the PLC rack of the I/O point.
      b) Where Y is replaced with the slot of the rack the I/O point is located.
      c) Where Z is replaced with the point number of the slot I/O point is located.

E. Ancillary Devices: The Contractor shall be responsible for providing any additional or different type connections as required by the instruments and specific installation requirements. Such additions and such changes, including the proposed method of installation, shall be submitted to the Engineer for approval prior to commencing the Work. Such changes shall not be a basis of claims for extra work or delay.

3.02 FIELD QUALITY CONTROL

A. Operational Readiness Testing: Operational Readiness Tests, ORT-1 and ORT-2, shall be performed as described in Section 01756, Testing and Facility Startup. ORT forms are located in the supplemental Section 01756, Testing and Facility Startup.

B. Performance Acceptance Tests (PAT): These are the activities that Section 01756, Testing and Facility Startup, refers to as performance testing.

C. Specialty Equipment: For certain components or systems provided under this section but not manufactured by PICS Subcontractor, provide services of qualified manufacturer's representative during installation, startup, demonstration testing, and Owner training.

3.03 TRAINING

A. Onsite Training: Training shall be performed as described in Section 01640, Manufacturers' Services and Training.

3.04 CLEANING

A. Clean area during construction and after completion of construction.

B. Vacuum panels, cabinets, and enclosures to remove dust and debris. Wipe surfaces clean.

END OF SECTION

SECTION 17101
CONTROL LOOP DESCRIPTIONS

PART 1 GENERAL

1.01 SUMMARY

A. This section includes control loop descriptions for the processes associated with this Project.

1.02 SUPPLEMENT

A. The supplement listed below, following "End of Section," is a part of this specification:

1. Control Loop Descriptions: Headworks Biofilter and Odor Control Fans.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION (NOT USED)

END OF SECTION

Control Loop Description	HEADWORKS BIOFILTER AND ODOR CONTROL FANS

Process Description:

Foul air is collected from the following areas of the Headworks facility: screenings room, screenings washer/compactor room, grit dumpster room, grit channels, and upwells. The collected foul air is treated in an engineered media biofilter. Two fans operate in a LEAD/STANDBY mode. One foul air exhaust fan runs continuously. To accommodate changing system airflow, the fans are variable speed and controlled to maintain a duct static pressure at the fan suction header. Each fan is equipped with a differential pressure switch to shut down the fan in the event of a closed damper. Suction pressure and discharge pressure are monitored using pressure transmitters. Fan vibration is monitored.

The biofilter has an intermittent irrigation water spray to maintain moisture of the engineered media. The sprays are controlled by activating a solenoid valve for each irrigation zone on a timed basis. Vendor provides a water panel with irrigation valves and accessories. Two irrigation zones are used. The frequency and duration timer setpoints are provided by the Vendor.

A continuous water spray located in the humidifier just upstream of the biofilter air inlet maintains the moisture in the media. A flow transmitter in the water panel measures the flow rate of irrigation and humidification water and trends the amount of water used each day. The flow is monitored to alert operators of unexpected conditions.

Reference Drawing(s):	008-I-001		
Last Update/Review:		**Approved By:**	

Equipment

Unit Equipment:

Tag No.	Description	Notes
200F4111	Biofilter Odor Control Fan 1	
200VFD4111	Biofilter Odor Control Fan 1 VFD	
200F4112	Biofilter Odor Control Fan 2	
200VFD4112	Biofilter Odor Control Fan 1 VFD	
200OS4114	Biofilter Unit	
200SV4613	Biofilter Irrigation Valve 1	
200SV4614	Biofilter Irrigation Valve 2	
200PCP4610	Biofilter Water Panel	

Instrumentation:

Tag No.	Description	Notes
200PIT4110	Biofilter Odor Control Inlet Pressure Transmitter	-2" to 0" WC
200PDSH4111	Biofilter Odor Control Fan 1 Differential Pressure Switch	3"-10" WC
200PDSH4112	Biofilter Odor Control Fan 2 Differential Pressure Switch	3"-10" WC
200VT4111A	Biofilter Odor Control Fan 1 Vibration Transmitter A	0.0-1.0 in/sec

200VT4111B	Biofilter Odor Control Fan 1 Vibration Transmitter B	0.0-1.0 in/sec
200VT4112A	Biofilter Odor Control Fan 2 Vibration Transmitter A	0.0-1.0 in/sec
200VT4112B	Biofilter Odor Control Fan 2 Vibration Transmitter B	0.0-1.0 in/sec
200PIT4113	Biofilter Odor Control Discharge Pressure Transmitter	10 in WC
200FE/FIT4111	Biofilter Total Water Flow	0-60 gpm
200PI4612	Biofilter Humidifier Water Pressure	0 – 100 PSIG
200FI4112	Biofilter Humidifier Water Flow	0-5 gpm
200PI4613	Biofilter Irrigation Water Pressure	0 – 100 PSIG

Control Strategies

Local Control Operation and Alarm Reset

VFD Control Panel

Biofilter Odor Control Fans are provided with a VFD cabinet housing power and controls for operating the fan motor. Operator adjustments are through pilot devices mounted on the panel door. A panel-mounted keypad for the VFD is provided for indication and programming only. The following functions are located on the VFD control panel door:

a) Manual speed pot.
b) Running light.
c) Power on light.
d) Fault light.
e) Pressure Differential light.

Motor Control Center

None

MFR Control Center

None

Local Control Station

Local control stations are provided for Biofilter Odor Control Fans. The following functions are located on each Local Control Station:

1. Selector Switch with LOCAL, OFF/RESET, REMOTE selections.
2. Start pushbutton.
3. Stop pushbutton.
   Operators will start and stop the fans in LOCAL mode but will not be able to start more than one fan at any time. A hardwired interlock will prevent a second fan from running if the first fan is running.
4. High Differential Pressure light.

SCADA Control Operation and Alarm Reset

SCADA Manual

Biofilter Odor Control Fans can be manually operated from the SCADA workstation. On-Off and manual speed controls are available. Operators will only be able to run one fan at any time. The PLC logic should not allow both fans to run at any time.

SCADA Auto

Biofilter Odor Control Fans are setup as LEAD/STANDBY. The LEAD fan should be running at all times when in Remote Auto. It turns on automatically and fan SPEED is automatically controlled to maintain a setpoint suction pressure in upstream duct, set at approximately minus 2.0 inches WC (operator adjustable). Fan speed and suction pressure setpoint to be determined by air balance report, to achieve the design airflow.

SCADA Display

Status and Process Display

- Biofilter Odor Control Fans Suction Pressure
- Biofilter Odor Control Fan 1 Running Status
- Biofilter Odor Control Fan 1 Remote Status
- Biofilter Odor Control Fan 1 Auto/Manual Status
- Biofilter Odor Control Fan 1 Speed Feedback
- Biofilter Odor Control Fan 1 Vibration A
- Biofilter Odor Control Fan 1 Vibration B
- Biofilter Odor Control Fan 2 Running Status
- Biofilter Odor Control Fan 2 Remote Status
- Biofilter Odor Control Fan 2 Auto/Manual Status
- Biofilter Odor Control Fan 2 Speed Feedback
- Biofilter Odor Control Fan 2 Vibration A
- Biofilter Odor Control Fan 2 Vibration B
- Biofilter Odor Control Fans Discharge Pressure
- Biofilter Odor Control Humidifier Spray Valve Open
- Biofilter Odor Control Humidifier Spray Zone Time Remaining
- Biofilter Odor Control Irrigation Spray Valve 1 Open
- Biofilter Odor Control Irrigation Spray Zone 1 Time Remaining
- Biofilter Odor Control Irrigation Spray Valve 2 Open
- Biofilter Odor Control Irrigation Spray Zone 2 Time Remaining
- Biofilter Water Panel Flow

Operator Entries

- Biofilter Odor Control System Auto/Manual,
- Biofilter Odor Control System, Lead/Standby Selector
- Biofilter Odor Control Fan 1 Start/Stop
- Biofilter Odor Control Fan 1 Speed Setpoint
- Biofilter Odor Control Fan 2 Start/Stop
- Biofilter Odor Control Fan 2 Speed Setpoint
- Biofilter Odor Control Suction Pressure Setpoint

• Biofilter Odor Control Humidifier Spray Zone Time On • Biofilter Odor Control Humidifier Spray Zone Time Off • Biofilter Odor Control Irrigation Spray Zone 1 Time On • Biofilter Odor Control Irrigation Spray Zone 1 Time Off • Biofilter Odor Control Irrigation Spray Zone 2 Time On • Biofilter Odor Control Irrigation Spray Zone 2 Time Off
SCADA Alarms and Resets
• Biofilter Odor Control Fan 1 Differential Pressure High • Biofilter Odor Control Fan 1 Fail • Biofilter Odor Control Fan 1 Vibration High (>0.2 in/sec) • Biofilter Odor Control Fan 1 Vibration High High (>0.4 in/sec) • Biofilter Odor Control Fan 2 Differential Pressure High • Biofilter Odor Control Fan 2 Fail • Biofilter Odor Control Fan 2 Vibration High (>0.2 in/sec) • Biofilter Odor Control Fan 2 Vibration High High (>0.4 in/sec) • Biofilter Odor Control Fans Discharge Pressure High (>7 in WC) • Biofilter Water Panel Low Flow
Hard-Wired Interlocks
• Biofilter Odor Control Fan 1 High Differential Pressure – Shut down fan • Biofilter Odor Control Fan 2 High Differential Pressure – Shut down fan
Software Interlocks
• Biofilter Odor Control LEAD Fan Interlock – Only one fan can run in Remote control • Biofilter Odor Control Fan 1 High High Vibration – Shut down fan > 0.4 in/sec • Biofilter Odor Control Fan 2 High High Vibration – Shut down fan > 0.4 in/sec
Historical Trending and Run-time Counters
• Biofilter Odor Control Fans Suction Pressure • Biofilter Odor Control Fans Discharge Pressure • Biofilter Odor Control Fan 1 Speed • Biofilter Odor Control Fan 1 Vibration A • Biofilter Odor Control Fan 1 Vibration B • Biofilter Odor Control Fan 1 Runtime Hour Meter • Biofilter Odor Control Fan 2 Speed • Biofilter Odor Control Fan 2 Vibration A • Biofilter Odor Control Fan 2 Vibration B • Biofilter Odor Control Fan 2 Runtime Hour Meter • Biofilter Odor Control Non-potable water flow

Equipment Failure Sequence
None
Equipment Automatic Failover Sequence
Equipment (Auto/Manual) Restart After Power Interruption
SCADA Auto: Upon restart from power interruption the LEAD fan will resume operation.

SECTION 17402
PRESSURE/VACUUM MEASUREMENT: INSTRUMENT VALVES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes requirements for valve manifolds and instrument valves.

B. Related Sections: The Contract Documents are a single integrated document, and as such all divisions and sections apply. It is the responsibility of the Contractor and its subcontractors to review all sections to ensure a complete and coordinated project.

C. Provide all valve manifolds and instrument valves identified in the Contract Documents.

1.02 REFERENCES

A. Refer to Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

1.03 DEFINITIONS

A. Refer to Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

1.04 SUBMITTALS

A. Furnish submittals in accordance with Section 01330, Submittal Procedures, and Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

B. Additional Requirements:

1. Product Data:
    a. Valve type.
    b. Body material.
    c. Size.
    d. Options.
2. Shop Drawings: Mounting details for all manifold valves.

1.05 QUALITY ASSURANCE

A. Refer to Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

B. Examine the complete set of Contact Documents and verify that the instruments are compatible with the installed conditions including:

1. Process conditions: Fluids, pressures, temperatures, flows, materials, etc.
2. Physical Conditions:
   a. Installation and mounting requirements.
   b. Location within the process.
   c. Accessories: Verify that all required accessories are provided and are compatible with the process conditions and physical installation.

C. Notify the Engineer if any installation condition does not meet the instrument manufacturer's recommendations or specifications.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Refer to Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

B. Protect valve manifolds and protective coatings from damage during handling and installation. Repair coating where damaged.

1.07 PROJECT OR SITE CONDITIONS

A. Refer to Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

1.08 WARRANTY

A. Refer to Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

1.09 MAINTENANCE

A. Refer to Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Valve Manifold Manufacturers:

1. One of the following, “or-equal:”
   a. Anderson Greenwood, TESCOM (Emerson).
   b. Hex Valve.
   c. Noshok.
   d. Rosemount 300 series.

B. Block and Bleed Valve Manufacturers:

1. One of the following, “or-equal:”
   a. Anderson Greenwood, TESCOM (Emerson).
   b. Hex Valve.

C. Gauge Valve Manufacturers:

1. One of the following, “or-equal:”
   a. Anderson Greenwood, TESCOM (Emerson).
   b. Hex Valve.

2.02 MANUFACTURED UNITS

A. Valve Manifolds:

1. General:
   a. Provide two-valve, three-valve, blowdown type five-valve, or metering type five-valve manifolds as indicated on the Drawings.
   b. Valve manifolds shall have one piece bonnet with a metal to metal seal to the valve body below the bonnet threads.
2. Requirements:
   a. Bonnet lock pin to prevent accidental loosening.
   b. Gas leak tested metal-to-metal hard seat design for hard seat valves.
   c. Gas leak tested soft seat design with replaceable seat for soft seat valves.
   d. Manifold valves shall have straight through portion for bi-directional flow and easy roddable cleaning.
   e. Manifold valves shall allow for direct or remote instrument mounting.

f. Shall be able to withstand pressures up to 6,000 psi for soft seat valves and 10,000 psi for hard seat valves at maximum 200 degrees F.
g. Materials of Construction:
    1) Body Material: Type 316 stainless steel.
    2) O-Ring: Teflon.
h. Two-Valve Manifolds: One isolation valve and one drain/vent and calibration valve.
i. Three-Valve Manifolds:
    1) Two isolation valves and one equalizing valve for differential pressure applications.
    2) Plugged vent connections used for vent/drain or calibration.
j. Blowdown Five-Valve Manifold: Two isolation valves, one equalizing valve, two blowdown valves for differential pressure applications.
k. Metering Five-Valve Manifold: Two isolation valves, two equalizing valves, one vent/drain and calibration valve for differential pressure applications.

B. Block and Bleed Valves:

1. General:
    a. Valve shall provide process isolation and venting/draining capabilities.
    b. Gas leak tested metal-to-metal hard seat design for hard seat valves.
    c. Gas leak tested soft seat design with replaceable seat for soft seat valves.
2. Requirements:
    a. Materials of Construction:
        1) Body Material: Type 316 stainless steel.
        2) O-Ring: Teflon.

C. Gauge Valves:

1. General:
    a. Valve shall provide process isolation from pressure instrument.
    b. Gas leak tested metal to metal hard seat design for hard seat valves.
    c. Gas leak tested soft seat design with replaceable seat for soft seat valves.

2. Requirements:
   a. Materials of Construction:
      1) Body Material: Type 316 stainless steel.
      2) O-Ring: Teflon.

2.03 ACCESSORIES

A. Provide tube fitting, female NPT, or pipe butt weld connections if necessary.

B. Provide stainless steel concentric or eccentric pipe nipples when necessary.

2.04 SOURCE QUALITY CONTROL

A. Refer to Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

B. Factory calibrate each instrument at a facility that is traceable to the National Institute of Testing Standards (NIST).

PART 3 EXECUTION

3.01 INSTALLATION

A. Refer to Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

B. Coordinate the installation with all trades to ensure that the mechanical system has all necessary appurtenances including weldolets, valves, etc., for proper installation of instruments.

3.02 FIELD QUALITY CONTROL

A. Refer to Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

B. Provide manufacturer’s services to perform start-up and calibration or verification.

3.03 ADJUSTING

A. Verify factory calibration of all instruments in accordance with the manufacturer’s instructions: Return factory calibrated devices to the factory if they do not meet the field verification requirements for calibration.

3.04 CLEANING

A. Refer to Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

3.05 DEMONSTRATION AND TRAINING

A. Refer to Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

B. Demonstrate performance of all instruments to the Engineer before commissioning.

3.06 PROTECTION

A. Refer to Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

3.07 SCHEDULES

A. The provided information does not necessarily include all required instruments. Provide all instruments identified in the Contract Documents: Instruments may be shown on the Drawings, in the Specifications, or both.

END OF SECTION

SECTION 17403
PRESSURE/VACUUM MEASUREMENT: SWITCHES

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes: Pressure/vacuum switches.

B. Related Sections:

1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
3. The following sections are related to the Work described in this section. This list of related sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
   a. Section 01330, Submittal Procedures.
   b. Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.
   c. Section 17402, Pressure/Vacuum Measurement: Instrument Valves.

C. Provide all instruments specified in the Contract Documents.

1.02 REFERENCES

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

1.03 DEFINITIONS

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

1.04 SUBMITTALS

A. Furnish submittals as specified in Section 01330, Submittal Procedures, and Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

B. Additional Requirements:

1. Product Data: Accessories such as diaphragm seals, valve manifold, snubbers, and pulsation dampeners.

1.05 QUALITY ASSURANCE

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

B. Examine the complete set of Contract Documents and verify that the instruments are compatible with the installed conditions including:

1. Process Conditions: Fluids, pressures, temperatures, flows, materials, etc.
2. Physical Conditions:
   a. Installation and mounting requirements.
   b. Location within the process.
   c. Accessories: Verify that all required accessories are provided and are compatible with the process conditions and physical installation.

C. Notify the Engineer if any installation condition does not meet the instrument manufacturer’s recommendations or specifications.

1.06 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

1.07 PROJECT OR SITE CONDITIONS

A. Project environmental conditions as specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

1. Provide instruments suitable for the installed site conditions including, but not limited to, material compatibility, site altitude, site seismic conditions, humidity, and process and ambient temperatures.

1.08 WARRANTY

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

1.09 MAINTENANCE

A. Furnish all parts, materials, fluids, etc., necessary for operation, maintenance, and calibration purposes throughout the warranty period. Deliver all of these supplies before Project Substantial Completion.

PART2 PRODUCTS

2.01 MANUFACTURERS

A. Mechanical Type Pressure and Differential Pressure Switch:

1. One of the following:
   a. Ashcroft; B Series Type 400, 700.
   b. United Electric Controls; 400 Series, 120 Series.
   c. “Or-equal.”

2.02 MANUFACTURED UNITS

A. Mechanical Type Differential Pressure Switches:

1. General: Pressure switch shall be diaphragm or diaphragm-sealed piston type.
2. Performance Requirements:
   a. Pressure Range: As specified in Instrument List.
   b. Accuracy: Within 1.0 percent of range.
   c. Repeatability: Within 1.0 percent of range.
3. Element:
   a. Type: Diaphragm, diaphragm-sealed piston, or bourdon tube.
   b. Overpressure:
      1) Minimum 130 percent of maximum range pressure without damage to switch or sensing element.
      2) Minimum 400 percent of nominal range without leakage or rupture.
   c. Sensing element shall not require ambient temperature compensation.
   d. Wetted Materials: Stainless steel.
   e. Process Medium Temperature: Operate up to 170 degrees F.
   f. Setpoint:
      1) Dual.
      2) Switch shall activate at setpoint on increasing pressure for high-pressure alarm applications and on decreasing pressure for low-pressure alarm applications.
   g. Fixed deadband.

h. Switch Elements:
   1) Snap acting.
   2) Single pole-double throw (SPDT) where required.
   3) Two single pole-double throw (SPDT) where required.
   4) Hermetically sealed.
   5) Rated at 5A, 125/250V ac.
   6) Manual reset type.

i. Enclosure:
   1) Epoxy Coated:
      a) NEMA Type 4X unless otherwise note.
      b) Explosion-proof housing where noted.

j. Switch Mounting:
   1) Process Connection: 1/2-inch NPT.

4. Components: Provide all necessary hardware for pressure switch mounting.

2.03 ACCESSORIES

A. Pulsation Dampeners and Snubbers:

1. Provide pulsation dampener or snubber with each pressure switch installed on discharge of positive displacement type pump.
2. Materials: Stainless steel.
3. Mount pulsation dampener or snubber integrally to the pressure switch.
4. Connection: 1/2-inch NPT.

B. Furnish block and bleed valves as specified in Section 17402, Pressure/Vacuum Measurement: Instrument Valves.

C. Furnish gauge valves as specified in Section 17402, Pressure/Vacuum Measurement: Instrument Valves.

2.04 SOURCE QUALITY CONTROL

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

B. Factory calibrate each instrument with a minimum 3-point calibration or according to Manufacturer’s standard at a facility that is traceable to the NIST. Submit calibration data sheets to the Engineer at least 30 days before shipment of the instruments to the Project Site.

PART 3 EXECUTION

3.01 INSTALLATION

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

B. Coordinate the installation with all trades to ensure that the mechanical system has all necessary appurtenances including weldolets, valves, etc., for proper installation of instruments.

3.02 FIELD QUALITY CONTROL

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

3.03 ADJUSTING

A. Verify factory calibration of all instruments in accordance with the manufacturer’s instructions: Return factory calibrated devices to the factory if they do not meet the field verification requirements for calibration.

3.04 CLEANING

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

3.05 DEMONSTRATION AND TRAINING

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

B. Demonstrate performance of all instruments to the Engineer before commissioning.

C. Furnish 1 hour of Owner training.

3.06 PROTECTION

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

3.07 SCHEDULES

A. As specified in Section 17901, Instrument List. The provided information does not necessarily include all required instruments. Provide all instruments specified in the Contract Documents: Instruments may be indicated on the Drawings, specified in specifications, or both.

END OF SECTION

SECTION 17404
PRESSURE/VACUUM MEASUREMENT: GAUGES

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes: Pressure/vacuum gauges.

B. Related Sections:

1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
3. The following sections are related to the Work described in this section. This list of related sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
   a. Section 01330, Submittal Procedures.
   b. Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.
   c. Section 17402, Pressure/Vacuum Measurement: Instrument Valves.

C. Provide all instruments specified in the Contract Documents.

1.02 REFERENCES

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

B. American Society of Mechanical Engineers (ASME): B40.100, Pressure Gauges and Gauge Attachments.

1.03 DEFINITIONS

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

1.04 SUBMITTALS

A. Furnish submittals as specified in Section 01330, Submittal Procedures, and Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

B. Additional Requirements:

1. Product Data: Accessories such as diaphragm seals, valve manifold, snubbers, and pulsation dampeners.

1.05 QUALITY ASSURANCE

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

B. Examine the complete set of Contract Documents and verify that the instruments are compatible with the installed conditions including:

1. Process Conditions: Fluids, pressures, temperatures, flows, materials, etc.
2. Physical Conditions:
   a. Installation and mounting requirements.
   b. Location within the process.
   c. Accessories: Verify that all required accessories are provided and are compatible with the process conditions and physical installation.

C. Notify the Engineer if any installation condition does not meet the instrument manufacturer’s recommendations or specifications.

1.06 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

1.07 PROJECT OR SITE CONDITIONS

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

1.08 WARRANTY

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

1.09 MAINTENANCE

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Manufacturers and Products:

1. One of the following:
   a. Ashcroft:
      1) Maximum pressure less than 10 pounds per square inch: Model 1188.
      2) Maximum pressure greater than or equal to 10 pounds per square inch: Model 1279.
   b. Wika.
   c. Ametek U.S. Gauge.
   d. “Or-equal.”

2.02 MANUFACTURED UNITS

A. General: Pressure gauge assembly shall include pressure sensing element, gauge case, and dial mechanism.

B. Performance Requirements:

1. Pressure Range: As specified in the Contract Documents.
2. Accuracy:
   a. Grade 2A, as defined by ASME B40.100.
   b. Within 1.0 percent of span after friction errors are eliminated by tapping or vibration.
   c. Maximum Allowable Friction Inaccuracy: Within 1.0 percent of span.
3. Element:
   a. Where the maximum pressure is less than 10 pounds per square inch, provide socket and bellows; for all other pressure ranges, employ a Bourdon tube.
   b. Socket Tips for Bellows and Bourdon Tube:
      1) Materials: Type 316 stainless steel.
   c. Overpressure: Minimum 130 percent of maximum range pressure without damage to gauge or sensing element.
   d. Wetted Materials: Type 316 stainless steel.
   e. Process Medium Temperature: Operate up to 170 degrees F.

4. Dial Gauge:
   a. Dial Size: 4-1/2 inches.
   b. Dial Case Material:
      1) Maximum pressure less than 10 pounds per square inch: Phenolic.
      2) Maximum pressure greater than or equal to 10 pounds per square inch: Phenolic.
   c. Provide safety gauge with safety blow out through the back or top of the unit.
   d. Dial Face: Gasketed shatterproof glass or polycarbonate.
   e. Provide gauge locks on all pressure gauges directly connected to diaphragm seals.
   f. Provide gauge locks where possible.
   g. Dry case; hermetically sealed.
   h. Connection and Mounting:
      1) Direct mounted and suitable for outdoor installation.
      2) 1/2-inch NPT.
      3) Connection Material: Stainless steel.
   i. Pointer: Externally adjustable.

2.03 ACCESSORIES

A. Pulsation Dampeners and Snubbers:

1. Provide pulsation dampener or snubber with each pressure gauge installed on discharge of positive displacement type pump.
2. Provide piston-type snubber if pressure spikes will exceed 130 percent of gauge maximum range.
3. Materials: Type 316 stainless steel.
4. Mount pulsation dampener or snubber integrally to the pressure gauge.
5. Connection: 1/2-inch NPT.

2.04 SOURCE QUALITY CONTROL

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

B. Factory calibrate each pressure gauge at a facility that is traceable to the NIST.

C. Provide complete documentation covering the traceability of all calibration instruments.

PART 3 EXECUTION

3.01 INSTALLATION

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

B. Coordinate the installation with all trades to ensure that the mechanical system has all necessary appurtenances including weldolets, valves, etc., for proper installation of instruments.

3.02 FIELD QUALITY CONTROL

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

3.03 ADJUSTING

A. Verify factory calibration of all instruments in accordance with the manufacturer’s instructions: Return factory calibrated devices to the factory if they do not meet the field verification requirements for calibration.

3.04 CLEANING

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

3.05 DEMONSTRATION AND TRAINING

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

B. Demonstrate performance of all instruments to the Engineer before commissioning.

C. Furnish 0.5 hour of Owner training.

3.06 PROTECTION

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

3.07 SCHEDULES

A. As specified in Section 17901, Instrument List. The provided information does not necessarily include all required instruments. Provide all instruments identified in the Contract Documents: Instruments may be indicated on the Drawings, specified in specifications, or both.

END OF SECTION

SECTION 17405
PRESSURE/VACUUM MEASUREMENT: DIRECT

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes: Pressure transmitters and indicators.

B. Related Sections:

1. Section 01330, Submittal Procedures.
2. Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.
3. Section 17402, Pressure/Vacuum Measurement: Instrument Valves.

C. Provide all instruments identified in the Contract Documents.

1.02 REFERENCES

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

1.03 DEFINITIONS

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

B. Specific definitions:

1. Lower Range Value (LRV): Lowest pressure that the pressure transmitter is capable of measuring.
2. Upper Range Value (URV): Highest pressure that the pressure transmitter is capable of measuring.
3. Calibrated Range: The range that the pressure transmitter is configured to measure. The low end of the calibrated range must be greater than the LRV of the Transmitter. The high end of the calibrated range must be less than or equal to the URV. The calibrated range corresponds to the flow signal sent from the transmitter.

1.04 SUBMITTALS

A. Furnish submittals as specified in Section 01330, Submittal Procedures, and in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

B. Provide complete documentation covering the traceability of all calibration instruments.

1.05 QUALITY ASSURANCE

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

B. Examine the complete set of Contract Documents and verify that the instruments are compatible with the installed conditions including:

1. Process Conditions: Fluids, pressures, temperatures, flows, materials, etc.
2. Physical Conditions:
   a. Installation and mounting requirements.
   b. Location within the process.
   c. Accessories: Verify that all required accessories are provided and are compatible with the process conditions and physical installation.

C. Notify the Engineer if any installation condition does not meet the instrument manufacturer’s recommendations or specifications.

D. Provide instruments manufactured at facilities certified to the quality standards of ISO 9001.

1.06 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

1.07 PROJECT OR SITE CONDITIONS

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

B. Project environmental conditions as specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

1. Provide instruments suitable for the installed site conditions including, but not limited to, material compatibility, site altitude, site seismic conditions, humidity, and process and ambient temperatures.

1.08 WARRANTY

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

1.09 MAINTENANCE

A. Furnish all parts, materials, fluids, etc., necessary for operation, maintenance, and calibration purposes throughout the warranty period. Deliver all of these supplies before project substantial completion.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. One of the following:

1. Rosemount; 3051 Series.
2. Yokogawa; EJA Series.
3. Endress+Hauser; Cerabar S Series.
4. “Or-equal.”

2.02 MANUFACTURED UNITS

A. Pressure Transmitters – Direct:

1. General: Pressure transmitter assembly shall include a diaphragm type pressure transducer and microprocessor based transmitter for measurement of gauge, vacuum, or absolute pressure.
2. Performance Requirements:
   a. Maximum Ratio of Total Instrument Range to Calibrated Span: 10 to 1.

b. Accuracy:
    1) Reference Accuracy: Plus or minus 0.075 percent of calibrated span, including effects of hysteresis, nonlinearity, and repeatability.
    2) Total Performance Accuracy: Plus or minus 0.30 percent of calibrated span, including reference accuracy effects, static pressure and ambient temperature effects.
    3) Stability: Plus or minus 0.15 percent of upper range limit over 5 years.

3. Element:
    a. Diaphragm type transducer integral to pressure transmitter.
    b. Diaphragm Material: Stainless steel or ceramic.
    c. Process Material Compatibility: Verify all material compatibilities with the instrument manufacturer.
    d. Process Connection: As specified in the Instrument List.
4. Transmitter:
    a. Power Supply:
        1) 24V dc - two wire loop powered.
        2) Power Consumption: 3 VA maximum.
    b. Outputs: Isolated 4 mA dc to 20 mA dc with HART communication protocol.
    c. Provided with WLAN or Bluetooth.
    d. Provided with electronic microprocessor.
    e. Adjustments: Adjustable electronic zero and span, with elevated or suppressed zero as required by application. Adjustment shall be possible without mechanical fulcrum points or handheld configurator.
    f. Local Display:
        1) 5-digit LCD.
        2) Scaled in engineering units.
    g. Enclosure: NEMA Type 7.
    h. Over Range Protection: To maximum process line pressure.
    i. Conduit: 1/2-inch male NPT.
5. Components:
    a. Transmitter Mounting:
        1) As specified in the Instrument List or as shown.
        2) Provide all necessary hardware for transmitter mounting.

2.03 ACCESSORIES

A. Provide Valve Manifolds as specified in Section 17402, Pressure/Vacuum Measurement: Instrument Valves.

1. Mount valve manifold integrally to the transmitter.
2. Valve manifold and transmitter shall be assembled by manufacturer and shipped as an assembly.

B. Provide sunshades for outdoor installations.

2.04 SOURCE QUALITY CONTROL

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

B. Factory calibrate each instrument with a minimum 3-point calibration or according to Manufacturer's standard at a facility that is traceable to the NIST. Submit calibration data sheets to the Engineer at least 30 days before shipment of the instruments to the Project Site.

C. Provide complete documentation covering the traceability of all calibration instruments.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine the installation location for the instrument and verify that the instrument will work properly when installed. Notify the Engineer promptly if any installation condition does not meet the instrument manufacturer's recommendations or specifications.

3.02 INSTALLATION

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

B. Coordinate the installation with all trades to ensure that the mechanical system has all necessary appurtenances including weldolets, valves, etc., for proper installation of instruments.

3.03 FIELD QUALITY CONTROL

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

B. Provide manufacturer's services to perform startup and calibration or verification.

3.04 ADJUSTING

A. Verify factory calibration of all instruments in accordance with the manufacturer's instructions:

1. Return factory calibrated devices to the factory if they do not meet the field verification requirements for calibration.

3.05 CLEANING

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

3.06 DEMONSTRATION AND TRAINING

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

B. Demonstrate performance of all instruments to the Engineer before commissioning.

C. Furnish 1 hour of Owner training.

3.07 PROTECTION

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

3.08 SCHEDULES

A. As specified in Section 17901, Instrument List. The provided information does not necessarily include all required instruments. Provide all instruments identified in the Contract Documents: Instruments may be indicated on the Drawings, specified in specifications, or both.

END OF SECTION

SECTION 17710
CONTROL SYSTEMS: PANELS, ENCLOSURES, AND PANEL COMPONENTS

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes:

1. Design, fabrication, and assembly of all instrumentation enclosures, control panels and components provided under this Contract, including but not limited to:
   a. Custom built instrumentation and control panels, including all enclosures for hand stations controllers, low-voltage power distribution, terminal junction boxes, and marshalling panels.
   b. Control panels furnished as part of equipment systems specified in other Divisions, such as vendor control panels (VCPs), package control panels (PCPs), and chemical feed panels.
   c. Control components.
   d. Control panel installation.

B. Related Sections:

1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
2. It is the Contractor’s responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor’s Work.
3. The following sections are related to the Work described in this section. This list of related sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
   a. Section 01330, Submittal Procedures.
   b. Section 01612, Anchorage and Bracing.
   c. Section 16050, Common Work Results for Electrical.
   d. Section 16075, Electrical Identification.
   e. Section 16222, Low Voltage Motors Up to 500 Horsepower.
   f. Section 16444, Low Voltage Motor Control Centers.
   g. Section 16950, Field Electrical Acceptance Tests.
   h. Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

C. Provide all instruments identified in Contract Documents.

1.02 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.
2. Institute of Electrical and Electronics Engineers (IEEE): C62.41.1-Guide on the Surge Environment in Low-Voltage (1,000 V and less) AC Power Circuits.
3. UL:
   a. 508C, Standard for Industrial Control Equipment.
   b. 913, Standard for Intrinsically Safe Apparatus and Associated Apparatus for Use in Class I, II, III, Division 1, Hazardous (Classified) Locations.
   c. 1283, Standard for Electromagnetic Interference Filters.
   d. 1449, Standard for Surge Protective Devices.

1.03 DEFINITIONS

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

B. Specific Definitions: The term “panel” in this section is interchangeable with the term “enclosure.”

1.04 SYSTEM DESCRIPTION

A. Panel Dimensions:

1. Minimum dimensions are scalable from or as indicated on the Drawings and are based upon manufacturer’s noncertified information. It is the responsibility of the Contractor or manufacturer to design and size all panels:
   a. Size panels to provide space for all equipment, wiring, terminations, and other items in the panel, including space for future build out.
   b. Panel sizes that substantially deviate (within 3 inches in any dimension) from the sizes indicated on the Drawings must be approved by the Engineer.
   c. Maximum Panel Depth: 30 inches, unless otherwise indicated.

B. Structural Design: Completed and installed panel work shall safely withstand seismic requirements at the Project Site as specified in Section 16050, Common Work Results for Electrical. Enclosures, and internal equipment shall be braced to prevent damage from specified forces.

1.05 SUBMITTALS

A. Provide submittals as specified in Section 01330, Submittal Procedures, and Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

B. Provide a control panel hardware submittal, for each control panel and enclosure being provided on this Project, including but not limited to:

1. Product Data:
   a. Enclosure construction details and NEMA type.
   b. Manufacturer’s literature and specification data sheets for each type of equipment to be installed within or on the panel or enclosure.
2. Shop Drawings:
   a. Scaled, detailed exterior panel (front and side views) and interior panel layout showing equipment arrangement and dimensional information: Provide draft for review and approval by Engineer. The Engineer has the authority to substantially alter initial panel layouts.
   b. Complete nameplate engraving schedule.
   c. Structural details of fabricated panels.
3. Calculations:
   a. Provide installation details based on calculated shear and tension forces: Calculations shall be signed and sealed by a Professional Engineer licensed in the state where the cabinets and panels will be installed.
   b. For assembled enclosures and other equipment with a weight of 200 pounds or more, provide calculations for:
      1) Weight including panel internal components.
      2) Seismic forces and overturning moments.
      3) Shear and tension forces in connections.
   c. Cooling calculations to include, but not limited to:
      1) Highest expected ambient temperature for the enclosure's location
      2) Internal heat load.
      3) Exposure to direct sunlight.
      4) Dimensions of the enclosure in inches.
      5) Maximum allowable temperature inside the enclosure, based on the lowest operating temperature limit of the installed components.

4. Bill of material, including quantity, description, manufacturer, part number, serial number, vendor name with phone, and spare part list with unit price. Bills of material shall include all items within enclosure. Provide the Bill of material on CD-ROM in Microsoft Excel format.

C. Seismic Design:

1. Seismic Panel Construction:
   a. Seismic Anchorage: Provide seismic design calculations and installation details for anchorage of all panels, enclosures, consoles, etc. to meet seismic requirements in Section 01612, Anchorage and Bracing. Stamped by a Professional Engineer registered in the state where the Project is being constructed.
   b. For floor mounted free standing panels weighing 200 pounds or more (assembled, including contents), submit calculations, data sheets, and other information to substantiate that panel, base, and framing meet minimum design strength requirements and seismic requirements as specified in Section 01612, Anchorage and Bracing. Calculations shall be signed and sealed by a Professional Engineer licensed in the state where the cabinets and panels will be installed.

1.06 QUALITY ASSURANCE

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

B. Assemble panels, enclosures, and rack systems along with all internal and external devices, wiring, equipment, and materials in a facility that is recognized by UL to assemble and certify UL-labeled control panels:

1. Provide all panel components with UL 508 listing.
2. All control panels shall be constructed by a UL 508A certified panel shop.

1.07 DELIVERY, STORAGE AND HANDLING

A. Project environmental conditions as specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

1. Provide instruments suitable for the installed site conditions including, but not limited to, material compatibility, site altitude, site seismic conditions, humidity, and process and ambient temperatures.

1.08 PROJECT OR SITE CONDITIONS

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

1.09 WARRANTY

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. As listed below in the individual component paragraphs.

B. Provide instruments and other components performing similar functions of the same type, model, or class, and from one manufacturer.

2.02 EXISTING PRODUCTS

A. Provide labor and materials for complete modifications to existing panels as required.

B. Field cut and refinish existing panel faces to original condition to accommodate installation of new instruments, removal of existing instruments and fitting of blanks to suit new layouts. New instrument supports shall be provided as required for complete installation.

2.03 MATERIALS

A. Construct and finish enclosures using materials capable of withstanding the mechanical, electrical, and thermal stresses, as well as the effects of humidity and corrosion that are likely to be encountered in normal service:

1. Enclosures shall have the following properties:
   a. NEMA Type 4: Steel with gasketed door, rain tight.
   b. NEMA Type 4X: Type 316 stainless steel.

B. Bolting Material:

1. Commercial quality 1/2-inch diameter, stainless steel hex-head Grade 5 bolts, nuts and washers, with unified coarse (UNC) threads.
2. Carriage bolts for attaching end plates.
3. All other bolted joints shall have S.A.E. standard lock washers.

2.04 MANUFACTURED UNITS

A. Panels/enclosures:

1. Manufacturers:
   a. One of the following:
      1) Saginaw.
      2) Pentair Hoffman.
      3) "Or-equal."
2. Panel Assembly:
   a. General guidelines for panel fabrication include:
      1) Continuous welds ground smooth.
      2) Exposed surfaces free of burrs and sharp edges.
      3) Base formed of heavy channel iron, either galvanized or powder coated, minimum 1/2-inch holes at 12-inch spacing to accommodate anchoring of freestanding enclosures to floor.
   b. Construct enclosure and mounting panel using stretcher level quality sheet metal having minimum thickness not less than the following sizes (U.S. Standard Gauge):

Enclosure Height (inches)	Minimum Enclosure Steel Thickness (gauge)	Minimum Back Mounting Panel Thickness (gauge)
Up to 57	12	12
57 - 69	12	10
69 - 82	12, except 10 on back	10
82 or more	10	10

      1) Use heavier sheet metal to meet seismic requirements at the Project Site or when required due to equipment requirements.
   c. Construct supporting frame structure with angled, channeled, or folded rigid section of sheet metal, rigidly attached to and having essentially the same outer dimensions as the enclosure surface and having sufficient torsional rigidity to resist the bending moments applied via the enclosure surface when it is deflected.
   d. Provide stiffeners for back mounting panels in enclosures larger than 4 feet. In addition, secure the panels in place by collar studs welded to the enclosure.

e. Door Construction:
   1) Turned-back edges suitably braced and supported to maintain alignment and rigidity without sagging.
   2) Sufficient width to permit door opening without interference with rear projection of flush mounted instruments.
   3) Heavy gauge piano type continuous stainless steel hinges.
   4) For NEMA Type 12, Type 4, and Type 4X, provide oil resistant neoprene sealing gasket and adhesive to seal cover to enclosure.
   5) Gasket installed to seal against roll lip on the enclosure opening.

f. Latches:
   1) For panels each door provided with a three-point latching mechanism and locking handle with rollers on the ends of the latch rods. Latch rods connected to a common door handle, hold doors securely, forming a compressed seal between door and gasket, at the top, side, and bottom.
      a) Provide padlock for each enclosure with padlock provisions.
   2) Include an oil-tight key-locking, three-point latching mechanism on each door:
      a) Provide two keys per panel.
      b) All locks keyed alike.
   3) For large type NEMA Type 4 and NEMA Type 4X cabinets, not available with three-point latching hardware, provide multiple clips and padlock hasps.
   4) Provide quick release latches for all NEMA Type 4 and Type 4X enclosures.

g. Panel Cut-outs:
   1) Cut, punch, or drill cutouts for instruments, devices, and windows. Smoothly finish with rounded edges.
   2) Allow a minimum of 3-inch envelope around all displays, controllers, and monitors.
   3) Reinforce around cut-outs with steel angles or flat bars for the following:
      a) Large panel cutouts; for example, openings for local operator interfaces.
      b) Pilot device groupings, where the removed metal exceeds 50 percent of the available metal.

3. In addition to the requirements specified above the following requirements for NEMA Type 4X powder coated stainless steel enclosures apply:
   a. Minimum 14-gauge, Type 316 stainless steel.
   b. Captive stainless steel cover screws threaded into sealed wells.

c. Inside Finish: White polyester powder coating.
d. Specifically designed for use with flange-mounted disconnect handles where required or as indicated on the Drawings.
e. NEMA Type 4X powder coated stainless steel enclosures are not an acceptable substitute for stainless steel.

4. Outdoor Panels:
   a. Supplementary requirements for panels located outdoors are as follows:
      1) All enclosures located outdoors shall be explicitly designed and rated for outdoor service by the manufacturer.
      2) Door Hardware: stainless steel.
      3) Provide rain canopy and sun shield.
      4) Bases: Heavy channel, gasketed stainless steel bases, flanges up, for anchoring to pad.

B. Arrangement of Components:

1. Arrange panel internal components for external conduit and piping to enter into panel either from above or below.
2. Arrange panel instruments and control devices in a logical configuration associating pushbutton and selector switches with related readout devices, or as indicated on the Drawings.
3. Mount internal control components on an internal back-panel. Devices may be mounted on the side-panel only by special permission from the Engineer.
4. All control panel mounted operator interface devices shall be mounted between 3 feet and 5 feet above finished floor.

C. Overcurrent Protection:

1. Main Overcurrent Device:
   a. Where the electrical power supply voltage to the control panel is more than 120V ac, provide the panel with a flange mounted disconnect handle operating a molded case circuit breaker, and provide a control power transformer for 120V ac circuits:
      1) Door-mounted disconnect handles are not acceptable.
      2) Mechanically interlocked the disconnect switch with the control enclosure doors so that no door can be opened unless the power is disconnected, and the disconnect switch cannot be closed until all doors are closed.
      3) Provide means to defeat the interlock.
      4) Lockable in the off position.

b. Control Panels Supplied with 120V ac:
   1) Provide an internal breaker with the line side terminals covered by a barrier.
   2) Provide a nameplate prominently positioned on the control panel identifying the location of the power source and a warning statement requiring the source to be disconnected before opening the door to the enclosure.

2. Provide circuit breakers as specified in Section 16444, Low Voltage Motor Control Centers.
3. Selection and Ratings of Protective Devices:
   a. Interrupting Ratings: Not less than the system maximum available fault current at the point of application.
   b. Voltage Rating: Not less than the voltage of the application.
   c. Select current rating and trip characteristics to be suitable for:
      1) Maximum normal operating current.
      2) Inrush characteristics.
      3) Coordination of the protective devices to each other and to the source breaker feeding the panel.
4. Provide a separate protective device for each powered electrical device:
   a. An individual circuit breaker for each 120V ac instrument installed within its respective control panel and clearly identified for function.
   b. An individual fuse for each PLC discrete output. Provide with individual blown fuse indication external of the I/O card:
      1) Size external fuse to open before any I/O card mounted fuses.
   c. An individual 1-ampere fuse for each discrete input loop.
   d. An individual 1/2-ampere fuse for each 4 mA to 20 mA analog loop powered from the control panel.
   e. Install protective devices on the back mounting panel and identify by a service nameplate in accordance with the wiring diagrams.
5. Fuses for 4 mA to 20 mA Signals:
   a. Provide durable, readily visible label for each fuse, clearly indicating the correct type, size, and ratings of replacement fuse:
      1) Label shall not cover or interfere with equipment manufacturer’s instructions.
   b. Provide fuses rated for the voltage and available short circuit current at which they are applied.
   c. Manufacturers:
      1) One of the following:
         a) Ferraz Shawmut.
         b) Littelfuse.
         c) Bussmann.
         d) ‘Or-equal.”

6. Fuse Holders:
   a. Modular Type:
      1) DIN rail mounting on 35-millimeters rail.
      2) Touch Safe Design: All connection terminals to be protected against accidental touch.
      3) Incorporates blown fuse indicator.
   b. Provide Nameplate Identifying Each Fuse: As specified in Section 16075, Electrical Identification.
   c. Manufacturers and Products:
      1) One of the following:
         a) Phoenix Contact.
         b) Allen-Bradley; 1492-FB Series B.
         c) "Or-equal."
7. Control Circuit Breakers:
   a. DIN rail mounting on 35-millimeters rail.
   b. Manual OPEN-CLOSE toggle switch.
   c. Rated 250V ac.
   d. Interrupting Rating: 10 kiloampere (kA) or available fault current at the line terminal, whichever is higher.
   e. Current Ratings: As indicated on the Drawings or as required for the application.
   f. Provide nameplate identifying each circuit breaker: As specified in Section 16075, Electrical Identification.
   g. Manufacturers:
      1) One of the following:
         a) Phoenix Contact.
         b) ABB.
         c) Allen-Bradley Series.
         d) Square D.
         e) "Or-equal."

D. Conductors and Cables:

1. Power and Control Wiring:
   a. Materials: Stranded, soft annealed copper.
   b. Insulation: 600V Type MTW.
   c. Minimum Sizes:
      1) Primary Power Distribution: 12 AWG.
      2) Secondary Power Distribution: 14 AWG.
      3) Control: 16 AWG.

d. Color:
1) BLACK, RED – 120/240V ac Single-Phase (line and load) conductors.
2) RED – 120V ac conductors within control panel (Discrete Input and Output).
3) ORANGE – 120V control conductors internal to the control panel.
4) YELLOW - 120V conductors external to the control panel.
5) GREEN - Ground wire.
6) WHITE - 120V Neutral conductors.
7) A-Brown, B-Orange, C-Yellow – 277/480V three-phase conductors.
8) GRAY - 277 Neutral conductors.
9) BLUE - DC positive conductors.
10) WHITE with BLUE stripe - DC negative (grounded) conductors.

2. Signal Cables, Twisted Shielded:
a. Materials: Stranded, soft annealed copper.
b. Insulation: 600V, PVC outer jacket.
c. Minimum Size: 18 AWG paired/triad.
d. Overall aluminum shield (tape).
e. 20 AWG seven-strand tinned copper drain wire.
f. Color:
1) Two Conductor:
a) Positive (+): WHITE.
b) Negative (-): BLACK.
2) Three Conductor:
a) Positive (+): WHITE.
b) Negative (-): BLACK.
c) Signal: RED.
g. Insulate the foil shielding and exposed drain wire for each signal cable with heat shrink tubing.

E. Conductor Identification:

1. Identify each conductor and cable with unique wire numbers as specified in Section 16075, Electrical Identification.
2. Readily identified without twisting the conductor.

F. General Wiring Requirements:

1. Wiring Methods: Wiring methods and materials for panels shall be in accordance with the NEC requirements for General Purpose (no open wiring) unless otherwise specified.

2. Install all components in accordance with the manufacturer's instructions included in the listing and labeling.
3. Provide a nameplate on the cover of the control panel identifying all sources of power supply and foreign voltages within the control panel.
4. Provide transformers, protective devices, and power supplies required to convert the supply voltage to the needed utilization voltage.
5. Provide power surge protection for all control panels.
6. Provide signal surge protection within control panels for each analog I/O, discrete I/O, and data line (Copper Ethernet, Coax, Fieldbus signals) that originates from outdoor devices.
7. Provide nonmetallic ducts for routing and organization of conductors and cables:
    a. Size ducts for ultimate build-out of the panel, or for 20 percent spare, whichever is greater.
    b. Provide separate ducts for signal and low voltage wiring from power and 120V ac control wiring:
        1) 120V ac: Grey colored ducts.
        2) 24V dc: White colored ducts.
8. Cables shall be fastened with cable mounting clamps or with cable ties supported by any of the following methods:
    a. Screw-on cable tie mounts.
    b. Hammer-on cable tie mounting clips.
    c. Fingers of the nonmetallic duct.
9. The free ends of cable ties shall be cut flush after final adjustment and fastening.
10. Provide supports at the ends of cables to prevent mechanical stresses at the termination of conductors.
11. Support panel conductors where necessary to keep them in place.
12. Conductors and cables shall be run from terminal to terminal without splice or joints. Exceptions:
    a. Factory applied connectors molded onto cables shall be permitted. Such connectors shall not be considered as splices or joints.
13. The control panel shall be the source of power for all 120V ac devices interconnected with the control panel including, but not limited to:
    a. Solenoid valves.
    b. Instruments both mounted in the control panel and remotely connected to the control panel.

2.05 COMPONENTS

A. Thermal Management:

1. Provide heating, cooling, and dehumidifying devices in order to maintain all instrumentation and control devices to within a range as specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.
2. Heating:
    a. Provide all panels located in areas that are not climate controlled with thermostatically controlled strip heaters; except, where all of the following conditions apply:
        1) The panel is not supplied with 120V ac power.
        2) There are no electronics or moisture-sensitive devices in the enclosure.
        3) The panel is smaller than 38 inches high.
3. Heat Exchanger:
    a. Closed-loop design ensuring separation of ambient air and clean air inside the cabinet.
    b. Filterless design to facilitate easy cleaning of the core.
    c. Mounting: Indicated on the Drawings.
4. Enclosure temperature sensor as indicated on the Drawings.
5. Enclosure Temperature Switch:
    a. Provide wall mount bimetallic switch transmitter (to measure internal cabinet temperature in all enclosures) containing electrical components such as PLCs, RTUs, RIO, and VFDs.
    b. Sensor and electronic enclosure.
    c. Accuracy: Within 2.0 degrees F.
    d. Manufacturer and Product:
        1) The following:
            a) Hoffman; ATEMNC.
            b) “Or-equal.”
6. Fan Ventilation:
    a. Temperature Control Switch and Alarm:
        1) Power: 120V ac.
        2) Bimetallic temperature senor.
        3) Adjustable Setpoint Range: 30 degrees F to 140 degrees F.
        4) Manufacturer and Product:
            a) Hoffman; ATEM series.
            b) “Or-equal.”

B. Panel meters.

C. Pilot Devices:

1. General:
   a. Provide operator pushbuttons, switches, and pilot lights, from a single manufacturer.
   b. Size: 30.5 millimeters.
   c. Heavy duty.
   d. Pushbuttons:
      1) Contacts Rated: NEMA Type A600.
      2) Furnish one spare normally open and normally closed contact with each switch.
   e. Selector Switches:
      1) Contacts Rated:
         a) NEMA Type A600.
         b) Knob type.
      2) Furnish one spare normally open contact and normally closed contact with each switch.
      3) Provisions for locking in the OFF position where lockout provisions are indicated on the Drawings.
   f. Pilot Lights:
      1) Type: LED.
      2) Push to test.
      3) Lamp Color:
         a) On/Running/Start: Red.
         b) Off/Stop: Green.
         c) Power: White.
         d) Alarm: Amber.
         e) Status or Normal Condition: White.
         f) Opened: Red.
         g) Closed: Green.
         h) Failure: Amber.
2. Indoor and Outdoor Areas:
   a. NEMA Type 4/13.
   b. Manufacturers and Products:
      1) One of the following:
         a) Allen-Bradley; Type 800T.
         b) Square D; Class 9001 Type K.
         c) General Electric; Type CR104P.
         d) IDEC; TWTD.
         e) “Or-equal.”

3. Corrosive Areas:
   a. NEMA Type 4X.
   b. Corrosion resistant.
   c. Exterior parts of high impact strength fiberglass reinforced polyester or multiple-layer epoxy coated zinc.
   d. Manufacturers and Products:
      1) One of the following:
         a) Cutler Hammer; Type E34.
         b) Square D; Class 9001 Type SK.
         c) Allen-Bradley; Type 800H.
         d) IDEC; TWTD.
         e) "Or-equal."
4. Hazardous (Classified) Areas/Class I Division 2:
   a. NEMA Type 4X.
   b. Corrosion resistant.
   c. Exterior parts of high impact strength fiberglass reinforced polyester or multiple-layer epoxy coated zinc:
      1) All contacts contained within a hermetically sealed chamber:
         a) Pushbuttons.
         b) Selector switches.
         c) Push-to-test contacts on pilot lights.
      2) UL listed and labeled for Class I Division 2 areas.
   d. Manufacturers and Products:
      1) One of the following:
         a) Cutler Hammer; Type E34.
         b) ABB/Entrelec; M4/8 Series.
         c) "Or-equal."

D. Potentiometer and Slidewire Transmitters:

1. Provide a dc output in proportion to a potentiometer input.
2. Potentiometer Input:
   a. 100 ohms to 100 K ohms.
   b. Impedance Greater or equal to 1 M ohms.
   c. Zero Turn-up: 80 percent of full scale input.
   d. Span Turn-down: 80 percent of full scale input.
3. Field Configurable Output:
   a. Voltage and Current: All conventional current loops and voltage control signals.
4. Accuracy including linearity and hysteresis within 0.1 percent max at 25 degrees C.
5. Operating Temperature: 0 degree C to 55 degrees C.
6. Supply Power: 9V dc to 30V dc.

7. Manufacturer:
   a. The following:
      1) Phoenix Contact.
      2) "Or-equal."

E. Signal Isolators and Converters:

1. Furnish signal isolators that provide complete isolation of input, output, and power input:
   a. Minimum Isolation Level: 1.5 kilovolts ac/50 hertz for at least 1 minute.
   b. Adjustable span and zero.
   c. Accuracy: Within 1.0 percent of span.
   d. Ambient Temperature Range: Minus 20 degrees C to plus 65 degrees C.
2. Manufacturers and Products:
   a. One of the following:
      1) Phoenix Contact; MCR Series.
      2) Acromag; 1500, 600T, 800T, Flat Pack or ACR Series.
      3) Action Instruments; Q500 Series or Ultra SlimPakII.
      4) AGM Electronics; Model TA-4000.
      5) "Or-equal."

F. Relays:

1. General:
   a. For all types of 120V ac relays, provide surge protection across the coil of each relay.
   b. For all types of 24V dc relays, provide a free-wheeling diode across the coil of each relay.
2. General Purpose:
   a. Magnetic control relays.
   b. NEMA Type A300 Rated:
      1) 300 volts.
      2) 8 amps continuous (minimum).
      3) 7,200 volt-amperes make.
      4) 720 volt-amperes break.
   c. Plug-in type.
   d. LED indication for energization status.
   e. Coil Voltages: As required for the application.
   f. Minimum Poles: DPDT.
   g. Touch Safe Design: All connection terminals to be protected against accidental touch.

h. Enclose each relay in a clear plastic heat and shock-resistant dust cover.
i. Quantity and type of contact shall be as indicated on the Drawings or as needed for system compatibility.
j. Relays with screw-type socket terminals.
k. Provide additional (slave/interposing) relays when the following occurs:
    1) The number or type of contacts shown exceeds the contact capacity of the specified relays.
    2) Higher contact rating is required in order to interface with starter circuits or other equipment.
l. DIN rail mounting on 35-millimeters rail.
m. Ice cube type relays with retainer clips to secure relay in socket.
n. Integrated label holder for device labeling.
o. Manufacturers and Products:
    1) One of the following:
        a) Potter and Brumfield; Type KUMP.
        b) Eaton; D5PF.
        c) IDEC; RR series.
        d) Allen-Bradley; Type 700 H Series.
        e) Square D; Type K.
        f) “Or-equal.”

3. Latching:
    a. Magnetic latching control relays.
    b. NEMA Type B300 Rated:
        1) 300 volts.
        2) 10 amps continuous.
        3) 3,600 volt-amperes make.
        4) 320 volt-amperes break.
    c. Plug-in type.
    d. DIN rail mounting on 35-millimeters rail.
    e. Coil Voltage: As required for the application.
    f. Minimum Poles: 2PDT, as required for the application, plus 1 spare pole.
    g. Touch Safe Design: All connection terminals to be protected against accidental touch.
    h. Clear cover for visual inspection.
    i. Provide retainer clip to secure relay in socket.
    j. Manufacturers and Products:
        1) One of the following:
            a) Square D; Type 8501 Type K.
            b) IDEC; TWTD.
            c) “Or-equal.”
    k. Provide relays with push to test and manual override lever.

4. Time Delay:
   a. Provide time delay relays to control contact transition time.
   b. Contact Rating:
      1) 240 volts.
      2) 10 amps continuous.
      3) 3,600 volt-amperes make.
      4) 360 volt-amperes break.
   c. Coil Voltage: As required for the application.
   d. Provide pneumatic or electronic type with on-delay, off-delay, and on/off delay: For off delay use true power off time delay relays. Where the required timing range exceeds capability of the off delay relay use signal off delay where power loss will not cause undesirable operation or pneumatic time delay relays.
   e. Minimum Poles: 2PDT.
   f. Units include adjustable dial with graduated scale covering the time range in each case.
   g. Minimum Timing Range: 0.1 second to 10 minutes, or as required for the application.
   h. Manufacturers and Products:
      1) One of the following:
         a) IDEC; RTE series.
         b) Agastat; Type Series 7000 series (pneumatic).
         c) Allen-Bradley; Type 700HR Series.
         d) “Or-equal.”

G. Terminal Blocks:

1. Din rail mounting on 35-mm rail.
2. Suitable for specified AWG wire.
3. Rated for 15 amperes at 600 volts.
4. Screw terminal type.
5. Provide mechanism to prevent wire connection from loosening in environments where vibration is present. This mechanism shall not cause permanent deformation to the metal body.
6. Finger safe protection for all terminals for conductors.
7. Construction: Polyamide insulation material capable of withstanding temperature extremes from minus 40 degree C to 105 degrees C.
8. Terminals: Plainly identified to correspond with markings on the diagrams. Permanent machine printed terminal identification.
9. Disconnect type field signal conductor terminals with socket/screw for testing.
10. Identify terminals suitable for use with more than one conductor.

11. Position:
    a. So that the internal and external wiring does not cross.
    b. To provide unobstructed access to the terminals and their conductors.
12. Provide minimum 25 percent spare terminals.
13. Manufacturers and Products:
    a. One of the following:
        1) Phoenix Contact; UK5 Series.
        2) ABB/Entrelec; M4/8 Series.
        3) "Or-equal."
14. Wire Duct:
    a. Provide flame retardant plastic wiring duct, slotted with dust cover.
    b. Type:
        1) Wide slot.
        2) Narrow slot.
        3) Round hole.
    c. Manufacturer:
        1) The following:
            a) Panduit.
            b) "Or-equal."

H. Surge Protection Devices:

1. Control Panel Power:
    a. 120-Volt Control Power Source:
        1) Non-UPS Powered:
            a) Provide surge protection device (SPD) for panel power entrances:
                (1) Nominal 120V ac with a nominal clamping voltage of 200 volts.
                (2) Non-faulting and noninterrupting design.
                (3) A response time of not more than 5 nanoseconds.
            b) Control Panel Power System Level Protection, Non-UPS Powered:
                (1) Design to withstand a maximum 10 kA test current of an 8/20 µs waveform according to IEEE C62.41.1Category C Area.
                (2) For panels receiving power at 120V ac, provide surge protection at secondary of main circuit breaker.

(3) Provide both normal mode noise protection (line to neutral) and common mode (neutral to ground) surge protection.
(4) DIN rail mounting.
(5) Attach wiring to the SPD by means of a screw type cable-clamping terminal block:
(a) Gas-tight connections.
(b) The Terminal Block: Fabricated of nonferrous, non-corrosive materials.
(6) Visual status indication of MOV status on the input and output circuits.
(7) Dry contact rated for at least 250V ac, 1 amp for remote status indication.
(8) Meeting the following requirements:
(a) Response Time: Less than or equal to 100 ns.
(b) Attenuation: Greater than or equal to minus 40 dB at 100 kilovolt-hertz as determined by a standard 50 ohms insertion test.
(c) Safety Approvals:
(d) UL 1283 (EMI/RFI Filter).
(e) UL 1449 2nd Edition.
(9) Manufacturers:
(a) Phoenix Contact type SFP TVSS/Filter.
(b) Sola.
(c) "Or-equal."

b. 120-Volt Control Power Source: UPS powered.
1) Provide surge protection on the control power source at each panel containing power supplies, or electronic components including PLCs, I/O, HMI, and digital meters.
2) Location:
a) For panels with a UPS, install surge protection ahead of UPS and maintenance bypass switch. Surge protection is not required for 120V ac circuits that are only used for panel lights and receptacles.
b) For panels receiving power at 480V ac, provide surge protection on the 120V ac control power transformer secondary.
3) MCOV: 150V ac.
4) Surge Capability (8/20 microsecond wave): 10 kA.
5) Peak Let-through: 620V L-N, 850V L-G.

6) Manufacturers and Products:
a) One of the following:
(1) Phoenix Contact; Plugtrab PT series.
(2) MTL Surge Technologies; MA15 series.
(3) "Or-equal."

2. Instrument, Data and Signal Line Protectors (Traditional I/O) – Panel Mounted:
a. Surge Protection Minimum Requirements: Withstand a 10 kA test current of an 8/20 microsecond waveform in accordance with IEEE C62.41.1 Category C Area.
b. DIN rail mounting on 35 millimeters rail (except field mounted SPDs).
c. SPDs consisting of two parts:
1) A base terminal block.
2) A plug protection module:
a) Replacing a plug shall not require the removal of any wires nor interrupt the signal.
b) Base and plug coded to accept only the correct voltage plug.
d. SPD Manufacturers and Products:
1) One of the following:
a) Phoenix Contact; Plugtrab Series.
b) Bournes; Series 1800.
c) "Or-equal."

3. Instrument, data, and signal line protectors (traditional I/O)– field mounted:
a. Surge Protection Minimum Requirements: Withstand a minimum 10 kA test current of a 8/20 µs waveform in accordance with IEEE C62.41.1 Category C Area.
b. Manufacturers and Products:
1) One of the following:
a) Plugtrab; PT Series
b) MTL; TP48 Series.
c) "Or-equal."

I. Power Supplies:

1. Design power supply systems so that either the primary or backup supply can be removed, repaired, and returned to service without disrupting the system operation.
2. Convert 120V ac to 24V dc or other dc voltages required or as required for the application.
3. Provide backup 24V dc power supply units to automatically supply the load upon failure of the primary supply.

4. Provide power supply arrangement that is configured with several modules to supply adequate power in the event of a single module failure:
    a. Provide automatic switchover upon module failure.
    b. Alarm contacts monitored by the PLC.
5. Sized to provide 40 percent excess rated capacity.
6. UL 508C listed to allow full rated output without de-rating.
7. Provide fuse or short-circuit protection.
8. Provide a minimum of one set of dry contacts configured to change state on failure for monitoring and signaling purposes.
9. Output Regulation:
    a. Within 0.05 percent for a 10 percent line change or a 50 percent load change: With remote voltage sensing.
10. Operating Temperature Range: 0 degree C to 50 degrees C.
11. Touch Safe Design: All connection terminals to be protected against accidental touch.
12. DIN rail mounting on 35-millimeters rail.
13. Provide self-protecting power supplies with a means of limiting dc current in case of short circuit.
14. Manufacturers and Products:
    a. One of the following:
        1) Phoenix Contact; Quint series.
        2) IDEC; PS5R series.
        3) Sola.
        4) Allen-Bradley; Series 1606.
        5) “Or-equal.”

J. Intrinsic Safety Barriers:

1. Transformer Isolated Barrier:
    a. Containing a Transformer to Provide Complete:
        1) Isolation between the safe and hazardous areas for loop powered devices.
        2) Three-way isolation between the safe area, hazardous area and power supply powered devices.
    b. Resistor for current limitation.
    c. Fuses for short circuit protection.
    d. Provide barriers with pluggable connectors that are coded for easy replacement.
    e. Transmission error shall be less than or equal to 0.1 percent of full scale.
    f. DIN rail mounted on 35-millimeters DIN rail.

g. Approvals:
1) FM.
2) UL 913.

2. Types:
a. Switch Isolators:
1) Designed and approved for use with discrete inputs.
2) Supply Power: 120V ac.
3) Output to track input.
4) LED in the cover to indicate the status of the input.
5) Selector switch to change the logic of the input.
6) Input: Dry contact.
7) Output: SPDT relay.

b. Transmitter and converters for use with 4 mA to 20 mA signals without Hart® communications capability:
1) Designed and approved for use with 4 mA to 20 mA analog signals.
2) Designed for powering two- and/or three-wire transmitters in hazardous locations and repeating and/or generating the current to the safe area.
3) Supply Voltage: Loop Power.

c. Transmitter and converters for use with 4 mA to 20 mA signals with Hart® communications capability:
1) Designed and approved for use with 4 mA to 20 mA analog signals.
2) Designed for powering two-wire and/or three-wire transmitters in hazardous locations and repeating and/or generating the current to the safe area.
3) Transfer digital signals from the hazardous area to the safe area.
4) Complete bi-directional communication between a smart transmitter located in the field and the suitable equipment located in the safe area.
5) Supply Voltage: Loop Power.

3. Manufacturers and Products:
a. One of the following:
1) Phoenix Contact; MACX Series.
2) Pepperl+Fuchs.
3) “Or-equal.”

K. Limit Switches:

1. NEMA Type 4X.
2. AC contact rating 120 volts, 10A.
3. DC contact rating 125 volts, 0.4A.

4. Provide robust actuation mechanism not prone to degradation.
5. Provide complete actuator mechanism with all required hardware.
6. Allows for contact opening even during contact weld condition.
7. UL approved.
8. Operating Temperature Range: Minus 18 degrees C to plus 110 degrees C (0 degree F to 230 degrees F).
9. Manufacturers and Products:
    a. One of the following:
        1) Allen-Bradley; 802.
        2) Honeywell; HDLS.
        3) Omron; D4.
        4) Eaton; E47, E49, E50.
        5) ABB “or-equal.”
        6) “Or-equal.”

L. Current Switches:

1. Operate from 120V ac supply voltage.
2. One normally open and normally closed contacts.
3. Adjustable current setting.
4. Manufacturer: Zelio; RM35.

M. Isolation Transformer:

1. An isolation transformer shall be provided for all control panels as indicated on the Drawings.
    a. Minimum Size: 3 kVA.
    b. Shielded.
    c. Low noise.
    d. Mounted outside of the control enclosure when indicated on the Drawings.
2. The panel lights, convenience receptacle and environmental controls shall not be powered from the isolation transformer.
3. Manufacturers and Products:
    a. One of the following:
        1) Acme; T-3-53043-S.
        2) General Electric, “or-equal.”
        3) Jefferson, “or-equal.”

N. Ethernet Switches:

1. Unmanaged Ethernet Switches:
   a. Manufacturers and Products:
      1) One of the following:
         a) Allen-Bradley; 1783-US5T.
         b) Phoenix Contact; 2891673.
         c) "Or-equal."
   b. Properties:
      1) Power Supply:
         a) Provide redundant power supplies.
         b) 24V dc power supply.
         c) Alarm output indicating loss of power supply.
      2) Performance:
         a) 10/100/1000, Full/half-Duplex.
         b) MDI/MDI-X Auto-sensing.
      3) Environment:
         a) Operating Temperature Range: Minus 13 degrees F to 167 degrees F.
         b) Humidity: 15 percent to 95 percent, noncondensing.
      4) Connector Type:
         a) Copper: RJ-45.
      5) Mounting: Din Rail.

2.06 ACCESSORIES

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

B. Provide panels with an inside protective pocket to hold the panel drawings. Ship panels with one copy of accepted Shop Drawings including, but not limited to, schematic diagram, connection diagram, and layout drawing of control wiring and components in a sealed plastic bag stored in the panel drawing pocket.

C. Provide 15-inch floor stands or legs where needed or as indicated on the Drawings.

D. Provide a folding shelf for enclosures that contain programmable controllers. The shelf shall be mounted on the inside surface of the door, capable of supporting a laptop computer.

E. Provide nameplate to each panel as indicated on the Drawings:

1. Provide as specified in Section 16075, Electrical Identification, on all internal and external instruments and devices.
2. Provide a nameplate with the following markings that is plainly visible after installation:
    a. Manufacturer's name, trademark, or other descriptive marking by which the organization responsible for the panel can be identified.
    b. Supply voltage, phase, frequency, and full-load current.
    c. Power Source or Circuit ID.
    d. Short-circuit current rating of the panel based on one of the following:
        1) Short-circuit current rating of a listed and labeled assembly.
        2) Short-circuit current rating established utilizing an approved method.
3. Provide enclosures with a flange mounted disconnect that is interlocked with the doors.

F. Provide a window kit where indicated on the Drawings. The window shall meet the following requirements:

1. Safety plate glass.
2. Secured by rubber locking seal.
3. Allow full viewing of devices issuing visual process data or diagnostics.

G. Lighting:

1. Provide one luminaire for each section, on the interior of the panel, spaced evenly along the top-front of the enclosure door opening(s):
    a. Covered or guarded.
    b. Provide On-Off door-activated switches where indicated on the Drawings.
    c. Provide LED Lamp for Indoor Enclosures: Provide additional fixtures for every 36 inches of width.

H. Receptacles:

1. Provide one duplex receptacle located every 4-feet of enclosure width, spaced evenly along the back mounting panels.
2. GFCI, 125-volt, single-phase, 15-amp style plug.
3. Provide circuit breaker or fuse to limit receptacle draw to 5 amperes.

I. Grounding:

1. Provide the following:
   a. Grounding strap between enclosure doors and the enclosure.
   b. Equipment grounding conductor terminals.
   c. Provide equipment ground bus with lugs for connection of all equipment grounding wires.
   d. Bond multi-section panels together with an equipment grounding conductor or an equivalent grounding bus.
2. Identify equipment grounding conductor terminals with the word "GROUND," the letters "GND" or the letter "G," or the color green.
3. Signal (24V dc) Grounding: Terminate each drain wire of a signal (shielded) cable to a unique grounding terminal block, or common ground bus at the end of the cable as shown on the Loop Drawings.
4. Ensure the continuity of the equipment grounding system by effective connections through conductors or structural members.
5. Design so that removing a device does not interrupt the continuity of the equipment grounding circuit.
6. Provide an equipment-grounding terminal for each incoming power circuit, near the phase conductor terminal.
7. Size ground wires in accordance with NEC and UL Standards, unless noted otherwise.
8. Connect all exposed, noncurrent-carrying conductive parts, devices, and equipment to the equipment grounding circuit.
9. Connect the door stud on the enclosures to an equipment-grounding terminal within the enclosure using an equipment- bonding jumper.
10. Bond together all control panels both remote and local, processor racks, and conductive enclosures of power supplies and connect to the equipment grounding circuit to provide a common ground reference.

J. Provide sunshades for outdoor installations.

2.07 FINISHES

A. Finishes:

1. Metallic (nonstainless):
   a. Metal surfaces of panels shall be prepared by chemical cleaning and mechanical abrasion in accordance with the finish manufacturer's recommendations to achieve a smooth, well-finished surface.

b. Scratches or blemishes shall be filled before finishing. One coat of zinc phosphate shall be applied per the manufacturer's recommended dry film thickness, and allowed to dry before applying the finish coat.
c. Finish coat shall be a baked polyester urethane powder, aliphatic air-dry polyurethane, or epoxy enamel to meet NEMA rating specified application.
d. Exterior of enclosures located outdoors shall be UV resistant polyester powder coating. Total dry film thickness shall be 3 mils, minimum.

2. Stainless Steel: Stainless enclosures shall be provided with a number 4 brushed finish - not painted.

B. Colors:

1. Exterior color of panels mounted indoors shall be manufacturer's standard light gray.
2. Exterior of panels mounted outdoors shall be manufacturer's standard white.
3. Panel interiors shall be manufacturer's standard white.

2.08 SOURCE QUALITY CONTROL

A. As specified in 17050, Basic Measurement and Control Instrumentation Materials and Methods.

B. Factory calibrate each instrument with a minimum 3-point calibration or according to manufacturer's standard at a facility that is traceable to the NIST. Submit calibration data sheets to the Engineer at least 30 days before shipment of the instruments to the Project Site.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine the installation location for the instrument and verify that the instrument will work properly when installed.

1. Notify the Engineer promptly if any installation condition does not meet the instrument manufacturer's recommendations or specifications.

3.02 INSTALLATION

A. Install enclosures so that their surfaces are plumb and level within 1/8 inch over the entire surface of the panel; anchor securely to wall and structural supports at each corner, minimum. Direct attachment to dry wall is not permitted.

B. Install the enclosure per guidelines and submitted installation instructions to meet the seismic requirements at the Project Site.

C. Provide floor stand kits for wall-mount enclosures larger than 48 inches high.

D. Provide 3-1/2 inch high concrete housekeeping pads for free-standing enclosures.

E. Install gasket and sealing material under panels with floor slab cutouts for conduit: Undercoat floor mounted panels.

F. Provide a full size equipment-grounding conductor in accordance with NEC included with the power feeder. Terminate to the incoming power circuit-grounding terminal.

G. All holes for field conduits, etc., shall be cut in the field, there shall be no additional holes, factory cut holes, or hole closers allowed. Incorrect holes, additional holes, or miss-cut holes shall require that the entire enclosure be replaced.

H. Control panels that are adjacent to motor control centers shall be fully wired to the motor control centers using wireways integral to the motor control center or additional conduits as needed. These interconnections are not shown or reflected on the conduit schedule, but shall be shown on the Loop Drawings prepared by the Contractor.

I. Provide individually fused analog input module points with blown fuse indicator lights, mounted external of the module on the output terminal strip.

3.03 FIELD QUALITY CONTROL

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

3.04 CLEANING

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

3.05 PROTECTION

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

END OF SECTION

SECTION 17901
INSTRUMENT LIST

PART 1 GENERAL

1.01 SUMMARY

A. The Instrument list is not a take-off list. Refer to Drawings and Specifications for additional information. Where any discrepancies between this list and the P&ID drawings arise, the P&ID shall govern.

B. Abbreviations used in the Instrument Index are defined on the Drawings.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 INSTRUMENT LIST

A. Columns include the following:

1. Tag: Tag number is a unique number that identifies the instrumentation on the Drawings.
2. Description: Describes the instrument or device.
3. Size: Indicates the size of instrument to apply for flow meters and some others. This field does not apply to all instruments.
4. Output Type: For instrumentation that is monitored by the PLC or other devices the signal will be either 4 mA to 20 mA analog signal or dry contact for discrete signals. None indicates that the instrument is not interface to a PLC or other monitoring device.
5. Calibration: Instrumentation calibration is provided in engineering units. For analog signals, gauges, and rotometers a range will be provided. For discrete instruments a contact open or close above or below a value will be given. The Contractor shall coordinate Owner during construction on all calibration ranges indicated in the schedule.
6. Power Type: “Four-wire” indicates the analog instrument will be provided with a power source. “Two-wire” indicates the instrument will be loop powered from the PLC. “120V ac” indicates the signal will be 120V ac discrete signal. “None” indicates the instrument is mechanically indicated.
7. P&ID Drawing: Indicates which P&ID the instrument is shown.
8. Specification: Provides a reference to the instrumentation specification requirements.
9. Installation Details: Provides a reference to all applicable installation details.

3.02 SUPPLEMENT

A. The supplement listed below, following “End of Section,” is a part of this specification:

1. Instrument List.

END OF SECTION

LOOP NO	EQUIP TAG NO	LOOP TITLE	INSTRUMENT NAME	INSTRUMENT SPEC	INSTRUMENT RANGE	P+ID NO	INSTRUMENT DETAIL	NOTE
2004110	200_PIT_4110	Odor Control Fan Inlet	Pressure Transmitter	17405	0-120 PSI	088-I-001_D3704505	17309, 17380	Pressure lines from tap to instrument should include 15% slope
2004111	200_PDSH_4111	Odor Control Fan 1	Pressure Switch Differential	17403	3"-11" WC	088-I-001_D3704505	17304A	Pressure lines from tap to instrument should include 15% slope
2004112	200_PDSH_4112	Odor Control Fan 2	Pressure Switch Differential	17403	3"-11" WC	088-I-001_D3704505	17304A	Pressure lines from tap to instrument should include 15% slope
2004113	200_PIT_4113	Odor Control Fan Discharge	Pressure Transmitter	17405	0-120 PSI	088-I-001_D3704505	17309, 17380	Pressure lines from tap to instrument should include 15% slope

SECTION 17903
SCHEDULES: I/O LIST

PART 1 GENERAL

1.01 SUMMARY

A. The I/O list is not a take-off list. Additional information is as indicated on the Drawings and specified in the Contract Documents. Where any discrepancies between this list and the P&ID drawings arise, the P&ID shall govern.

B. Abbreviations used in the I/O list are defined on the Drawings.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 I/O LIST

A. Use the descriptions on the I/O list for development of Shop Drawings.

3.02 SUPPLEMENT

A. The supplement listed below, following “End of Section,” is a part of this specification:

1. I/O List.

END OF SECTION

PANEL NO	PLC NO	LOOP NO	EQUIP TAG NO	I/O TAG	LOOP TITLE	I/O TYPE	P+ID NO
200LCP0505	PLC-15	2004110	200PI4110	200PI4110_PRESSURE	Biofilter Odor Control Fans Inlet	AI	088-I-001_D3704505
200LCP0505	PLC-15	2004111	200PAH4111	200PAH4111_HIGH	Biofilter Odor Control Fan 1	NDI	088-I-001_D3704505
200LCP0505	PLC-15	2004111	200RE4111	200RE4111_INREMOTE	Biofilter Odor Control Fan 1	NDI	088-I-001_D3704505
200LCP0505	PLC-15	2004111	200OL4111	200OL4111_FAIL	Biofilter Odor Control Fan 1	NDI	088-I-001_D3704505
200LCP0505	PLC-15	2004111	200ON4111	200ON4111_RUNNING	Biofilter Odor Control Fan 1	NDI	088-I-001_D3704505
200LCP0505	PLC-15	2004111	200RUN4111	200RUN4111_RUNCMD	Biofilter Odor Control Fan 1	NDO	088-I-001_D3704505
200LCP0505	PLC-15	2004111	200SC4111	200SC4111_SPEEDCMD	Biofilter Odor Control Fan 1	NAO	088-I-001_D3704505
200LCP0505	PLC-15	2004111	200SI4111	200SI4111_SPEED	Biofilter Odor Control Fan 1	NAI	088-I-001_D3704505
200LCP0505	PLC-15	2004111	200VI4111	200VI4111_VIBRATE	Biofilter Odor Control Fan 1	AI	088-I-001_D3704505
200LCP0505	PLC-15	2004112	200PAH4112	200PAH4112_HIGH	Biofilter Odor Control Fan 2	NDI	088-I-001_D3704505
200LCP0505	PLC-15	2004112	200RE4112	200RE4112_INREMOTE	Biofilter Odor Control Fan 2	NDI	088-I-001_D3704505
200LCP0505	PLC-15	2004112	200OL4112	200OL4112_FAIL	Biofilter Odor Control Fan 2	NDI	088-I-001_D3704505
200LCP0505	PLC-15	2004112	200ON4112	200ON4112_RUNNING	Biofilter Odor Control Fan 2	NDI	088-I-001_D3704505
200LCP0505	PLC-15	2004112	200RUN4112	200RUN4112_RUNCMD	Biofilter Odor Control Fan 2	NDO	088-I-001_D3704505
200LCP0505	PLC-15	2004112	200SC4112	200SC4112_SPEEDCMD	Biofilter Odor Control Fan 2	NAO	088-I-001_D3704505
200LCP0505	PLC-15	2004112	200SI4112	200SI4112_SPEED	Biofilter Odor Control Fan 2	NAI	088-I-001_D3704505
200LCP0505	PLC-15	2004112	200VI4112	200VI4112_VIBRATE	Biofilter Odor Control Fan 2	AI	088-I-001_D3704505
200LCP0505	PLC-15	2004113	200PI4113	200PI4113_PRESSURE	Biofilter Odor Control Fans Outlet	AI	088-I-001_D3704505
200LCP0505	PLC-15	2004613	200OPW4613	200OPW4613_OPENCMD	Biofilter Water Panel	DO	088-I-001_D3704505
200LCP0505	PLC-15	2004614	200OPW4614	200OPW4614_OPENCMD	Biofilter Water Panel	DO	088-I-001_D3704505
200PCP4610	PLC-15	2004611	200FI4611	200FI4612_FLOW	Biofilter Water Panel	AI	088-I-001_D3704505