SECTION 14555

SHAFTLESS SCREW CONVEYOR SYSTEM

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes: Shaftless screw conveyors, associated slide gates, cake inlet and discharge chutes, supports, controls, and accessories.
   1. Equipment Tag Numbers:
      a. Cake Conveyor No. 1: 51-CNV-433.
      b. Cake Conveyor No. 2: 51-CNV-434.

B. All equipment shall conform to the requirements of Section 15050 except as modified herein.

C. 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 01140 - Work Restrictions.
      b. Section 01330 - Submittal Procedures.
      c. Section 01600 - Product Requirements.
      d. Section 01612 - Seismic Design Criteria.
      e. Section 01614 - Wind Design Criteria.
      f. Section 01660 - Testing, Training, and Commissioning.
      g. Section 01740 - Warranties and Bonds.
      h. Section 01782 - Operations and Maintenance Data.
      i. Section 09960 - High-Performance Coatings.
      j. Section 11380 - Dewatering Screw Press.
      k. Section 15050 - Basic Mechanical Materials and Methods.
      l. Section 15958 - Mechanical Equipment Testing.
      m. Section 16050 - General Requirements for Electrical Work.
      n. Section 16075 - Electrical Identification.
      o. Section 16222 - Low Voltage Motors up to 500 Horsepower.
      p. Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
      q. Section 17100 - Control Strategies.
      r. Section 17101-51 - Process Control Strategy - Solids Dewatering.
      s. Section 17950 - Testing, Calibration, and Commissioning.

D. Comply with the current provisions of the following standards except as modified herein:
   1. American Gear Manufacturers Association (AGMA).

2. Anti-Friction Bearing Manufacturers Association (AFBMA).
3. Conveyor Equipment Manufacturers Association (CEMA).

1.02 REFERENCES

A. American Iron and Steel Institute (AISI).

B. American Bearing Manufacturers Association (ABMA):
1. 9 - Load Ratings and Fatigue Life for Ball Bearings.
2. 11 - Load Ratings and Fatigue Life for Roller Bearings.

C. American Gear Manufacturer's Association (AGMA).

D. American National Standards Institute/American Society of Mechanical Engineers (ANSI/ASME).

E. American Society for Testing and Materials (ASTM):
1. A 48 - Standard Specification for Gray Iron Castings.
2. A 108 - Standard Specification for Steel Bars, Carbon, Cold-Finished, Standard Quality.
3. A 276 - Standard Specification for Stainless and Heat Resisting Steel Bars and Shapes.
4. A 283 - Specification for Low and Intermediate Tensile Strength Carbon Steel Plates.
5. A 743 - Standard Specification for Castings, Iron-Chromium, Iron-Nickel, Corrosion Resistant, for General Application.
6. E 10 - Test Method for Brinell Hardness of Metallic Materials.

F. National Electrical Manufacturer's Association (NEMA).

1.03 SYSTEM DESCRIPTION

A. General:
1. Two inclined shaftless screw conveyors to collect and transport dewatered cake, complete with all accessories and controls necessary to provide a complete, operational system in accordance with the Contract Documents.
2. The shaftless screw conveyor system equipment shall include, but not be limited to, the following items, all of which shall be supplied by the shaftless screw conveyor manufacturer:
   a. Spiral flighting.
   b. End shaft.
   c. Drive.
   d. Troughs and liners.
   e. Covers.
   f. Chutes.
   g. Hoppers.
   h. Conveyor supports.
   i. Zero speed switches.
   j. Safety accessories.
   k. Observation hatches.
3. The conveyors shall be suitable for both intermittent and continuous loading and operation.

4. Fabrication: All welds shall be continuous unless otherwise specified. Facing surfaces of bolted joints shall be shop primed. Facing surfaces of field-welded components shall be beveled and match marked.
5. Edge Grinding: Sharp corners of all cut and sheared edges shall be made smooth. Grind all welds smooth.
6. Controls and Control Strategy: As indicated in Specification Section 17101-51 and as shown on the Drawings.

B. Design Requirements and Design Criteria:
1. Base the standards for conveyor selection on these specifications and the operational experience of the manufacturer with shaftless screw conveyors and not standards developed for shafted screw conveyors.
2. Design the shaftless screw conveyor system to meet the following performance and design requirements:

Conveyor	**Cake Conveyor No. 1 Cake Conveyor No. 2**
Design capacity (min) - cu ft/hr	100
Conveyed material density - lbs/cu ft	65
Conveyed material solids concentration (min) - %	15
Conveyed material solids concentration (max) - %	40
Length	See Drawings
Incline angle (degrees)	25
Screw speed (max) - rpm	22
Maximum filling factor at design capacity (based on 100% being the circular area calculated from the screw outside diameter, not trough cross-sectional area) - %	45
Loss of volumetric capacity due to incline - %	50
Flight outside screw diameter (min) - inches	9
Inner spiral required	Yes
Outer spiral size (min) - inch x inch	2.5 x 0.75
Inner spiral size (min) - inch x inch	0.5 x 0.75
Spiral weight (min) - lb/ft	15.7
Trough width (min) - inches	10
Trough height (max) - inches	11.125
Trough thickness (min) - inches	3/16
Trough liner thickness (min) - inches	3/8
Cover thickness (min)	11 gauge
Drive end plate thickness (min) - inches	1/2
Non-drive end plate thickness (min) - inches	3/8
Location of drive	Pushing
Drive horsepower (min)	10
Reversing screw	No

3. The spiral flights shall be designed with the stability to prevent distortion and jumping in the trough.
4. The "spring effect" (maximum compression or elongation) of the spiral shall not exceed 0.10 inch per 1 foot of length at design load conditions when the following equation is used:

   Deflection = $7.2 \prod nr3P(b^2+h^2)/b^3h^3Gk$ where:

   k = (4c-1)/(4c-4) + 0.615/c
   c = 2r/b
   r = spiral radius
   n = number of pitches
   b = spiral width
   h = spiral thickness
   P = Load
   G = 11,000,000 psi
   (Mark's Handbook for Mechanical Engineers, latest edition)
5. In the extreme condition of start-up with 50-percent trough filling, at 250 percent of the motor nameplate horsepower, the maximum torque produced by the drive unit shall be not more than 75 percent of the torsional rating of the outermost fibers of the spiral flight.
6. The torque capacity of the drive unit shall be sufficient to start the conveyor with 100-percent trough loading.
7. At 100 percent of trough loading and operating, the maximum torque shall be not greater than 35 percent of the torsional yield strength rating of the spiral.

1.04 SUBMITTALS

A. In addition to the requirements of Section 01600, Section 17101-51, and Section 15050, submit information specified herein.

B. Installation List:
   1. To verify conformance with the specified Manufacturer Qualifications as specified in Article 1.04.
   2. Must be included with the Substitution Request Form as part of the Proposed Substitutes “Or Equal” Submittal, and the regular Shop Drawing Submittal in accordance with Section 01600.
   3. Include the following information as a minimum:
      a. Name and location of installation.
      b. Name and telephone number of person in direct responsible charge of the equipment.
      c. Month and year the equipment was placed in operation.
      d. Size of Equipment: Length and diameter of shaftless screw.
      e. Design capacity and corresponding filling factor.
      f. Indicate whether single or double (outer plus inner) spiral was used.
      g. Manufacturer of spiral.
      h. Location of Drive: Push system.
      i. Drive horsepower.
      j. Number of units installed.
      k. Service and material conveyed.
      l. Liner material.
   4. Substitution Request Form for Proposed Substitute “Or Equal” Submittal specified in Section 01600 must also include Shop Drawings for the equipment installations that satisfy the requirements of Manufacturer Qualifications

Article 1.04, Paragraph A.2.b of this Section. The Drawings shall also verify conformance with Article 1.04, Paragraph A.2.a.1 and Article 1.04, Paragraph A.2.a.2).

C. Product Data.

D. Shop Drawings:
   1. Detailed dimensional arrangement Drawings of the complete screw conveyor assemblies including locations of conveyors relative to locations of associated feed equipment, inlet and outlet chutes, and conveyor supports.
      a. Verify conformance to the dimensional constraints shown on the Drawings.
   2. Detailed drawings of system components including screw conveyors, motors, gear reducers, chutes, slide gates and operators, hoppers, supports, instrumentation, and accessories.
   3. Show locations of trough liner joints to verify conformance to special requirements indicated in the Contract Drawings.

E. Separate certification from the spiral manufacturer certifying that the spiral meets the minimum specified hardness and yield strength requirements and is crack-free as determined by a dye-penetrant examination.

F. Complete Bill of Materials and Part Numbers.

G. Calculations: Detailed calculations and design data verifying conformance with the Drawings and Specifications.
   1. Structural Calculations: Include the following to support structural adequacy of the shaftless screw conveyors and accessories, prepared and signed by a registered professional structural engineer in the State of California:
      a. Conveyor supports including member sizing and anchoring to concrete slabs and steel beams as shown on the Drawings. Support calculations shall also confirm compliance with the design criteria specified in Article 2.03, Paragraph D.2 and Article 2.03, Paragraph D.3.
      b. Support design for chutes, slide gates, and cylinder operators.
      c. Seismic design as specified in Section 01612.
   2. Mechanical calculations prepared and signed by a registered professional mechanical engineer to demonstrate the following:
      a. Volumetric capacity of each conveyor.
      b. Torque calculations and selection of the gear reducer size and motor horsepower.
      c. Compliance with each of the design requirements specified in Article 1.02, Paragraph B.5; Article 1.02, Paragraph B.6; Article 1.02, Paragraph B.7; Article 1.02, Paragraph B.8; and Article 2.03, Paragraph E.6.e.

H. Manufacturer's Installation Instructions.

I. Quality Control Submittals:
   1. Detailed Performance Test Procedures: Source quality control and field testing.
   2. Performance Test Data.
   3. Certificates.

J. Operation and Maintenance Manual.

K. Wiring Schematics.

L. Technician Qualifications Resume: Submit resume of technician(s) to perform Manufacturer's Field Services.

1.05 QUALITY ASSURANCE

A. Manufacturer Qualifications:
   1. Minimum 10 years experience in construction and manufacturing of shaftless screw conveyor systems substantially similar to equipment specified for the municipal wastewater treatment industry. Installation or reselling of shaftless screw conveyors shall not qualify as construction or manufacturing experience and will not be considered towards meeting experience requirements.
   2. Installation List: Submit evidence of satisfactory operation of equipment similar to the specified equipment in at least 10 separate facilities in North America in accordance with the following requirements:
      a. All equipment on the submitted installation list shall:
         1) Be in municipal wastewater industry application.
         2) Have the same spiral manufacturer and screw conveyor system manufacturer as proposed for this project.
         3) Have a minimum spiral diameter of 9 inches.
         4) Have a minimum spiral length of 40 feet.
         5) Be a conveyor separate from a dewatering unit.
      b. At least 3 of the installations shall also satisfy the following requirements:
         1) Years in Service: Minimum 3 years.
         2) Service: Dewatered municipal solids.
         3) Spiral: Double, consisting of an outer and inner spiral.
         4) Spiral Length: Minimum 40 feet.
         5) Spiral Diameter: Minimum 9 inches.
      c. Multiple equipment units at a plant shall be considered as one installation toward meeting the experience requirements.

B. Fulfillment of the specified experience requirements shall be a condition of acceptance.

C. The gear reducer/motor drive unit shall be manufactured in the U.S.

D. Manufacturer's shop welds, welding procedures, and welders: Qualified and certified in accordance with the requirements of ANSI/AWS D1.1, or ASME Boiler and Pressure Vessel Code Section IX.

E. Screw Conveyor System: Shop inspected, assembled, adjusted, and tested for proper fit before shipping.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Shaftless Screw Conveyor System:
   1. Factory assembled before shipment to ensure proper fit of all components.
   2. Ship equipment in the minimum practical number of pieces for field assembly by the CONTRACTOR.
   3. Follow the requirements of Section 01140.

B. Provide delivery, storage, handling, and any required periodic maintenance from delivery until start-up in accordance with manufacturer's recommendations, Section 01600, and Section 15050.

1.07 PROJECT CONDITIONS

A. As specified in Section 15050.

1.08 WARRANTY

A. Warrant equipment free of defects in material and workmanship for a period of 3 years from the date specified in Section 01740. Cover inspections, shipping, parts, and labor except for normal wear of the trough liner.

B. Manufacturer's warranty shall be issued in the OWNER's name.

1.09 MAINTENANCE

A. Spare Parts: Furnish the following spare parts packed and labeled for warehouse storage:

Item	Quantity
1. Trough Liners	1 set for each conveyor
2. Motor for Drive Unit	1 each size
3. Shaft Seals	1 set of all shaft seals for each conveyor

B. Special Tools: Furnish any special tools required for maintenance and disassembly of furnished equipment.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Manufacturers: One of the following, modified as necessary to meet the Specification requirements:
   1. Custom Conveyor Corporation, Rogers, MN.
   2. Spirac Incorporated, Peachtree City, GA.
   3. Or equal.

2.02 MATERIALS

A. Trough: AISI Type 316L stainless steel.

B. Drive and End Plates: AISI Type 316L stainless steel.

C. Covers: AISI Type 316L stainless steel.

D. Spiral Flights (certified by manufacturer): Cold-formed chrome alloy steel, Brinell 225 hardness (minimum), 80,000 psi yield strength (minimum), with inner and outer spirals.

E. Wear Liner: Ultra-high molecular weight polyethylene (UHMWPE) impregnated with a lubricating agent for increased anti-wearing.
   1. Density: 59 pounds per cubic foot, minimum.
   2. Hardness: 62 Shore D, minimum.

F. Chutes, Hoppers: AISI Type 316L stainless steel.

G. Supports: AISI Type 316L stainless steel.

H. Hardware, Fasteners, Lifting Lugs (for all components, including gates): Type 316 stainless steel.

I. Drive Shaft: AISI 1045.

J. Gate Material: AISI Type 316L stainless steel.

2.03 SHAFTLESS SCREW CONVEYOR COMPONENTS

A. Spiral:
   1. Design spiral flighting to convey material without a center shaft and with the stability to prevent distortion and jumping in the trough.
   2. The spiral flighting shall consist of an outer spiral and an inner spiral to increase the axial strength and capacity of the conveyor. A third backing spiral may be used to achieve the specified design requirements. The minimum spiral sizes and weight shall be as specified herein. Also, neither the outer nor the inner spiral shall exceed 3 inches in width. Single spirals of any size will not be accepted.
   3. The spiral flights shall be cold-formed in sections from continuous flat hot-rolled bar with 80,000 psi minimum yield strength and 225 minimum Brinell measured anywhere on the spiral. Sectional flighting formed from plate will not be accepted.
   4. The spiral flighting shall be concentric to within 2 millimeters +/-.
   5. The spirals shall be rolled in such a way as to limit “neckdown” of the outside edge of the cold rolled spiral to 10 percent of the thickness of the inside edge of the spiral. The spiral edges and faces shall be smooth in the as-rolled condition and not show cracks, roll forming or grinding marks.
   6. If any form of hold-down is required, provide such hold-down using liner under the lid. The use of hold-down bars will not be accepted.
   7. Spiral connections shall be welded according to AISC B-U3-GF (double V grove) and be full penetration welds. Flights shall be welded in a jig to ensure true alignment.
   8. The connection of the spiral to the drive system shall be through a properly reinforced flanged connection plate that is welded to the spiral forming a smooth and continuous transformation from the flange plate to the spiral. The drive shaft shall have a mating flange and shall be bolted to the spiral connection plate. Pipe connections will not be accepted. Additionally, a grease lubricated labyrinth seal shall be shaft mounted internally in the conveyor between the back plate and spiral coupling connection.
   9. A gland-packing ring consisting of two Teflon®-coated packing rings shall seal the drive shaft at its penetration through the end plate, along with a greased labyrinth sealing system.
   10. The conveyor manufacturer shall provide a separate Spiral Certification from the spiral manufacturer certifying that the spiral meets the minimum hardness

and yield strength requirements and is crack free as determined by a dye-penetrant examination.

B. Trough and Cover:
   1. Trough shall be the same as the dimensional standards of CEMA 300. Trough size, thickness, and material shall be as specified herein.
   2. Trough shall be U-shaped with stiffeners across the top, fastened to both sides of the trough to maintain trough shape and act as a face seal for each cover section. At filling openings, provide a trough stiffener on each side of opening.
   3. Apply a continuous neoprene gasket totaling one-half inch width to the entire top face of the trough top flange and stiffeners.
   4. Trough sections shall be joined using bolted flanged connections and neoprene gaskets.
   5. Equip each trough with filling and/or discharge openings as indicated in the Drawings. Each filling and discharge opening shall be flanged, suitable for connection to other devices such as slide gates, chutes, and hoppers.
      a. Discharge openings from conveyors shall have a length not less than 1.5 times the spiral pitch nor less than the dimension indicated on the Drawings.
      b. Discharge openings from conveyors shall have a width equal to the full width of the U-trough.
   6. Flare the trough immediately above top of liner at the locations of filling chutes where indicated on the Drawings.
   7. Provide each conveyor with a 4-inch flanged drain outlet located as shown on the Drawings.
   8. The portion of each trough that is not covered by a filling chute shall be covered by a bolted cover of a material identical to the trough.
   9. Cover sections shall be 5-foot length, maximum.
   10. Covers shall be bolted at 12-inch spacing maximum. To prevent unsafe access to the conveyors, quick opening covers will not be accepted.
   11. Where indicated on the Drawings, provide covers with stainless steel hinged observation hatches. At each hatch location, provide the cover with a stainless steel mesh guard to block access to the spiral.
   12. Where indicated on the Drawings, provide a 10-foot length of uncovered conveyor that is open to the atmosphere. At each opening location, provide a stainless steel mesh guard to block access to the spiral.

C. Trough Liner:
   1. Provide the conveyor trough with a wear liner fabricated of ultra high molecular weight polyethylene (UHMWPE) impregnated with a lubricating agent.
   2. Wear liner thickness shall be as specified herein.
   3. The liner shall be provided with a visual indication (using colors) of excess wear.
   4. Wear liner coefficient of thermal expansion shall match that of the trough material.
   5. Wear liner shall be the following type, or equal:
      a. DURAFLO SPX by SPIRAC, Inc.
      b. Polystone M.

6. The wear liner shall be furnished in maximum 4-foot long sections. Shorter liner sections will be required at some locations to provide liner joints at specific locations indicated on the Drawings.
7. Each liner section shall be held in place with a minimum of four Type 316L retainer bars permanently welded to the trough at 180 degrees along the trough. Fasteners that penetrate the trough will not be accepted.

D. Supports:
1. Provide conveyor supports fabricated of Type 316L stainless steel structural members. The support types and configurations shall be as shown on the Drawings. The conveyor manufacturer shall be responsible for sizing the support structural members and anchors and shall include all required bracing to meet the application and Specifications requirements. For support design, assume the conveyor trough is 100 percent full with material weighing 65 lb/cf.
2. All structural supporting members shall be designed such that the ratio of the unbraced length to least radius of gyration (slenderness ratio) shall not exceed 120 for any compression member and shall not exceed 240 for any tension member (of angles about Z-Z axis).
3. All structural members and connections shall be designed so that the unit stresses will not exceed the American Institute of Steel Construction (AISC) allowable stresses by more than 1/3 when subject to loading of twice the maximum design operating torque of the spiral conveyor drive motors.
4. At a minimum, each conveyor shall be provided with supports at each end, with intermediate supports as shown on the Drawings. If required, provide additional supports as determined by the calculations.
5. Design the supports to avoid interference with other equipment or equipment supports.
6. Conveyor support spacing shall not exceed 10 feet.
7. Supports shall be shop fabricated, assembled, fitted to the conveyor, and match marked with the associated conveyor segments prior to shipment to the job site.
8. All shop welding shall conform to the latest standards of the American Welding Society (AWS). All welds shall be ground smooth and passivated per project Specifications.

E. Drive:
1. Each spiral conveyor shall be driven by a constant-speed integral gear reducer/motor drive unit mounted to an adapter flange, which is in turn mounted to the end plate of the conveyor.
2. The adapter flange shall allow the leakage of any material from the conveyor trough to atmosphere rather than into the gear reducer/motor drive unit. Direct coupling of the gear reducer/motor drive unit to the end flange of the conveyor will not be accepted.
3. The drive unit shall be rigidly supported so there is no visible “wobble” movement under any operating condition.
4. The drive system shall be designed, at a minimum, to start the conveyor from a dead stop with the trough filled throughout its entire cross sectional area and length with partially dried and hardened dewatered material.
5. The drive unit shall be a hollow shaft mounted drive.
6. Gear Reducers:
   a. All gears shall be AGMA Class II, single, double, or triple reduction, helical gear units with high capacity roller bearings.

b. Bearings shall be designed for the thrust loads from the fully loaded startup condition and shall have an AFBMA B10 life of 30,000 hours minimum.
c. V-belt driven speed reducers or chain driven reducers will not be accepted.
d. The reducer shall be the standard air-cooled unit with no auxiliary cooling required.
e. The gear reducer shall be sized with a torque service factor of 1.5 times the absorbed power or 1.1 times the motor nameplate, at the driven shaft speed, whichever is greater.

7. Motor:
   a. Motor shall be as specified in Section 16222 except as modified herein.
   b. Motor horsepower for each conveyor shall be as specified herein.
   c. Constant speed, 480 V, 60 Hz, 3 phase.
   d. Maximum speed: 1,750 rpm.
   e. Ambient temperature (degrees C): 50.
   f. Service factor: 1.15.
   g. Insulation: Class F.
   h. Temperature rise under full load: Not to exceed that for Class B insulation.
   i. Enclosure: NEMA 4X for unclassified locations.
   j. Design B speed/torque characteristics.
8. Drive unit shall be manufactured by Nord, SEW Eurodrive; or equal.

2.04 CHUTES AND HOPPERS

A. This article applies to the cake inlet and outlet chutes.

B. Fabricated and provided by the shaftless screw conveyor system manufacturer.

C. Fabricated from the same material as the conveyor trough.

D. Construct of 3/16-inch wall thickness with 3/8-inch flanges for connection to conveyors and/or other chute sections. Provide chutes with external body reinforcing stiffeners as required.

E. Provide neoprene gaskets at flanged connections.

F. Where indicated on the Drawings, provide chutes with stainless steel hinged observation hatches. At each hatch location, provide a stainless steel mesh guard to block access to the spiral.

G. Provide each chute section with handles and lifting lugs for easy handling.

H. Provide chutes with flexible neoprene sections where shown on the Drawings. Attach neoprene chute section to stainless steel chute using stainless steel clamps.

I. Provide chutes with supports as required and as shown on the Drawings. Include chute support calculations with submittal for review by the ENGINEER.

2.05 CONTROLS

A. Refer to DIVISION 16 and DIVISION 17 for additional instrumentation and electrical requirements.

2.06 ACCESSORIES

A. Zero Speed Switch:
   1. Provide each shaftless screw conveyor unit with a zero speed switch located and mounted per the manufacturer's recommendations. Zero speed sensor to be of the non-contacting type using a probe with a pre-amplifier and main electronic assembly.
   2. Use a magnetic pick-up welded on the spiral flights to sense motion.
   3. Main electronic unit to operate on 120-V, single-phase, 60-Hz power supply.
   4. Switch shall be rated for NEMA 4X locations.
   5. Furnish and install all accessories required for a complete working system and coordinate requirements with the Electrical Drawings and Specification Section 17101-51.
   6. As manufactured by Milltronics model MFA 4p (Motion Fail Alarm) with MSP12 probe, or equal.

B. Emergency STOP Cable Switch:
   1. Furnish each shaftless screw conveyor with one cable-operated latching type emergency STOP safety switch.
   2. Hook safety switches to a cable running on both sides of the conveyor and provide accessories as required.
      a. Provide orange plastic coated safety cable and mount through eyebolts spaced no more than 10 feet.
   3. Switch shall be rated for the area classification indicated on the electrical drawings.
   4. Enclosure: NEMA 4X for unclassified locations.
   5. Safety switch as manufactured by Material Control, Inc.; Conveyor Components Company; or equal.
   6. Furnish and install all accessories required for a complete working system and coordinate requirements with the electrical Drawings and Specification Section 17050.

C. Lifting Lugs: Provide equipment and each disassemblable part weighing over 100 pounds with lifting lugs for easy handling.

D. Equipment Identification Plates: Securely mount a 16-gauge stainless steel identification plate on each shaftless screw conveyor unit in a readily visible location. For each conveyor, provide two such identification plates. The plate shall bear the 1/4-inch die-stamped equipment name and tag identification number listed in this Section or indicated on the Drawings.

E. Safety Signage: Provide signs as required by laws and regulations.

2.07 FINISHES

A. Surface preparation, factory prime, field prime, and finish coats as specified in Section 09960:
   1. Stainless steel components: Acid clean (passivate) all weld areas.
   2. Spiral: Shop primer coating following sandblasting.
   3. Torque bracket: Epoxy coating.
   4. Drive shaft: Rust inhibitor coating.

PART 3 EXECUTION

3.01 SOURCE QUALITY CONTROL

A. Factory Testing
   1. Perform testing to verify spiral hardness and tensile strength.
   2. Dye-penetrant examination of each spiral to verify spiral is crack-free.
   3. Factory inspect and fit shaftless screw conveyor system to ensure proper fit and consistency of all components. Inspect and adjust before shipment.

3.02 INSTALLATION

A. Install as indicated on the Drawings and in strict conformance with the manufacturer's installation instructions, shop drawings, and recommendations.

B. Prior to start-up, the equipment shall be inspected for proper alignment, quiet operation, proper connection, and satisfactory performance.

3.03 FIELD QUALITY CONTROL

A. Testing and Training: As specified in Section 01660, Section 15958, and herein.
   1. Conduct tests in presence of the ENGINEER.
   2. Conduct field tests in presence of and under direction of the manufacturer's representative.
   3. Test each piece of equipment and each system for satisfactory operation without excessive noise, vibration, overheating, etc.
   4. For Field Quality Control Test, use Level 3 Quality Control Test as specified in Section 15958.
   5. Check and adjust all equipment for misalignments, clearances, supports, and adherence to safety standards.

3.04 MANUFACTURER'S FIELD SERVICES

A. Coordinate field service work with the manufacturer's representative, OWNER, and ENGINEER prior to initiating such work.

B. CONTRACTOR shall furnish a qualified Manufacturer's Representative to provide manufacturer's field services as specified in Specification Section 01660.

C. Require manufacturer's representative to perform the following services as described below and as specified in Section 01660. The specified durations are the minimum required time on the job site. Additional services and/or longer durations shall be provided as needed at no cost to the OWNER to meet the required quality of work.
   1. Installation Assistance:
      a. Advise/observe the CONTRACTOR on the installation of the shaftless screw conveyors and accessories.
      b. Check and verify that installation of the shaftless screw conveyors and accessories is in accordance with the Drawings and manufacturer's installation instructions.
      c. Provide additional assistance as required.
   2. Installation Inspection: Two trips. 2 Workdays each trip.

3. Start-up/Testing Assistance: 5 Workdays.
    a. Prior to start-up, the equipment shall be inspected for proper alignment, operation and satisfactory performance.
    b. Provide additional start-up/testing assistance as required.
4. Training: Provide training as specified in Section 01660.
5. Provide separate classes for the operations staff and maintenance staff. Final Acceptance Checkout: 2 Workdays.
6. Post Start-up Checkout: 2 Workdays.

END OF SECTION

SECTION 14612

DAVIT CRANES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Portable davit cranes with worm gear hand winch.

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 01740 - Warranties and Bonds.
      b. Section 05120 - Structural Steel.
      c. Section 09960 - High-Performance Coatings.
      d. Section 11312K - Medium Capacity Submersible Pumps.
      e. Section 15050 - Common Work Results for Mechanical Equipment.

1.02 SYSTEM DESCRIPTION

A. Design requirements:
   1. Davit crane and hoist load capacity: 2,000 pounds, minimum.
   2. Boom reach: 45 to 81 inches.
   3. Minimum clearance under boom: 48 inches.
   4. CONTRACTOR shall coordinate the total lift required.
   5. Mount type: Deck mounted socket.

1.03 SUBMITTALS

A. Product data:
   1. Dimensional drawings or other construction details including materials of construction, equipment weights and equipment finishes.
   2. Manufacturer's installation instructions.

B. Shop drawings and calculations.
   1. Structural loads calculations for crane and supports stamped by an engineer registered in California.
   2. Anchor bolts design calculations and details as specified in Section 05120.

C. Certificate of testing to verify performance requirements of these Specifications.

D. Operation and maintenance manuals: Provide prior to installation of the system.

E. Warranties.

1.04 QUALITY ASSURANCE

A. The manufacturer of the equipment shall have successful operating installations of a similar type to the equipment specified at 5 or more separate facilities. Fulfillment of this experience requirement shall be a condition of acceptance.

1.05 WARRANTY

A. Provide a minimum 2-year manufacturer's warranty that shall commence in accordance with Section 01740.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Packing and Shipping: Unload and store cranes under direct supervision of manufacturer.

PART 2 PRODUCTS

2.01 MANUFACTURES

A. One of the following or equal:
   1. Thern, Series 5124.

2.02 PORTABLE DAVIT CRANE

A. Design davit crane in accordance with Specifications and Codes of the Steel Construction Manual.

B. The boom to be capable of rotating 360 degrees under load.

C. Boom to be capable of telescoping to 4 different lengths allowing the extension of the reach of the crane and the hook over the load. Boom to lock in place at each position with a locking pin.

D. Screw jack adjustment: Boom angle to be vertically adjustable with a ratchet style screw jack to increase lift height.

E. Locking pin adjustment: Boom angle to be vertically adjustable. Boom to lock in place at each position with a locking pin.

F. Provide a locking device to prevent boom swivel when desired.

G. Provide a tie off hook or location to tie off the load while lifting.

H. Crane and base to be constructed of stainless steel.

2.03 PORTABLE WINCH

A. Manufacture: One of the following or equal.
   1. Thern, Series 4WP2T8.

B. The winch shall have the following:
   1. Machine cut worm gears.
   2. Enclosed oil bath.
   3. Internal mechical brake.
   4. Pressure plate that applies pressure to drum to maintain informing cable winding.
   5. Mounting: Portable mount on the davit crane.
   6. Cast aluminum construction.

C. Electrical requirements:
   1. Portable Mount:
      a. 120 volt, single phase, 60 hertz TEFC motor sized for the largest lifting load.
      b. Power cord shall be minimum 16 feet long with pushbutton control on a 16-foot cord.
      c. Power cord shall have a plug connection.
   2. Fixed Mount:
      a. 460 volt, 3 phase, 60 hertz, TEFC motor sized for the lifting load.
      b. Provide a pushbutton control on a 16-foot cord.
      c. Power cord shall be hardwired.

2.04 CRANE ACCESSORIES

A. Provide 5/16 inch stainless steel cable with swivel hook. The CONTRACTOR shall coordinate the length of cable required. The hoisting cable shall be specifically designed for service loads specified.

B. Provide a flush stainless steel socket base or base mount by the same manufacturer as the davit crane.

C. Provide plastic base cover to keep water from collecting in base when crane is removed.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install per manufacturer’s written instruction.

B. CONTRACTOR shall coordinate the location of the socket base based on the location of the pump, deck opening and the boom reach.

3.02 FIELD TEST

A. After complete installation of the system, the equipment shall be tested to its rated capacity.
   1. Load and slings shall be provided by the crane manufacturer and removed when tests are complete.
   2. The equipment shall be operated through 3 complete lift and lowering cycles.
   3. No hoisting equipment shall be used until load testing is concluded.

B. Crane shall not be used by CONTRACTOR for the installation of equipment.

3.03 SCHEDULE

Location	Type	Base
Secondary Clarifier No. 1	Fixed mount	Base mount
Secondary Clarifier No. 2	Fixed mount	Base mount
Area 21	Portable mount	Socket
Area 23	Portable mount	Socket
Area 28	Portable mount	Socket

Notes:
1. For portable mount application provide one portable davit system. Provide a socket base for each of the pumps in the Area listed.
2. For fixed mount provide one each for each fixed mounted location. The fixed mount will be hardwired and will remain in place.

END OF SECTION

SECTION 14624

MONORAIL CRANE SYSTEM

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Complete monorail system, including trolley, hoist, monorail beams, end stops, connections to beams, and all accessories required for a complete system.

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 01600 - Product Requirements.
      b. Section 01612 - Seismic Design Criteria.
      c. Section 01660 - Testing, Training, and Commissioning.
      d. Section 05120 - Structural Steel.
      e. Section 09960 - High-Performance Coatings.
      f. Section 15050 - Common Work Results for Mechanical Equipment.
      g. Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
      h. Section 17710 - Control Systems - Panels, Enclosures, and Panel Components.

C. Inclusion of a specific manufacturer's name in the Specifications does not mean that the specific manufacturer's standard product will be acceptable. Specified manufacturer's or other manufacturer's standard product shall be modified as required to meet the Specifications.

1.02 REFERENCES

A. American National Standards Institute (ANSI):
   1. B30.11 - Safety Code for Underhung Cranes and Monorail Systems.
   2. B30.16 - Safety Code for Overhead Hoists.

B. American Institute of Steel Construction (AISC):
   1. Specifications for Design, Fabrication and Erection of Structural Steel for Buildings.

C. American Welding Society (AWS):
   1. D1.O - Code for Welding in Building Construction.
   2. D14.1 - Specifications for Welding Industrial and Mill Cranes.

D. Monorail Manufacturers' Association (MMA):
   1. Specifications for Underhung Cranes and Monorail Systems.

1.03 SYSTEM DESCRIPTION

A. Design Requirements:
   1. All components and materials of construction shall be suitable for installation in the electrical classification listed in the Table under Article 1.03, Paragraph B.
   2. Hoisting system shall be in accordance with ANSI B30.11, ANSI B30.16, and OSHA standards.
   3. Design monorail crane system for seismic design criteria as specified in Section 01612.

B. The monorail and hoist systems provided shall meet the following performance and design requirements:

Equipment Location	Dewatering Building	UV Facility	Maintenance Building
Equipment No.	51-HOI-431 51-HOI-432	31-HOI-241	06-HOI-841
Monorail Capacity	3T	1T	3T
Trolley and Hoist Capacity (each)	3T(1)	1T	3T
Motor hp (each)	3.5 hp	1 hp	3.5 hp
Minimum Vertical Hook Travel	20 feet	20 feet	10 feet
Service Classification	Class C, moderate service	Class C, moderate service	Class C, moderate service
Motor Electric Requirements	460 volt, 3 phase, 60 hertz	460 volt, 3 phase, 60 hertz	208 volt, 3 phase, 60 hertz
Electrical Classification	Per Specification 16050	Per Specification 16050	Per Specification 16050
Trolley and Hoist Control	Radio Remote Control	Pendant Pushbutton Station	Pendant Pushbutton Station

Notes:
(1) Two trolleys and hoists of 3T capacity each will be provided for the dewatering building monorail. The sum total of the loads to be lifted by the hoists shall not exceed 3T.

1.04 SUBMITTALS

A. Shop drawings:
   1. Drawings that include outline drawings, cut-away drawings, parts lists, material specification lists, and other information required to substantiate that proposed equipment complies with specified requirements.
   2. Include support types, sizes, spacing, bridging, connections, anchoring, and bearing plates.
   3. Erection instructions if needed.
   4. Substantiate that the monorail system will provide access to all required equipment by providing a CAD drawing showing the layout and limits of travel for the entire monorail system and all equipment needing monorail access.
      a. The CONTRACTOR shall provide the equipment manufacturer with CAD files of plan drawings for areas where the monorails will be installed for the development of the monorail layout drawings.
   5. Installation and checkout instructions including leveling, alignment, grouting, lubrication, and initial start-up procedures.
   6. Submit information specified in Section 15050.
   7. Submit design for monorail supports showing design calculations and support locations.

B. O&M Manuals.

C. Calculations for the complete monorail crane system signed and stamped by a professional engineer registered in the State of California for installation at the job site shall be submitted as part of shop drawings for approval. Refer to Section 01612 for seismic design criteria.

D. Compliance Certificate upon completion of field load testing.

1.05 CONTRACTOR'S QUALITY ASSURANCE

A. Installer Qualifications: Minimum 5 years experience in, and regularly engaged in, field installation of monorail hoist systems.

B. Unload, store, and install monorail system under direct supervision of manufacturer.

1.06 MAINTENANCE

A. Tools and Spare Parts: CONTRACTOR shall supply one complete set of special wrenches or other special tools necessary for the assembly, adjustment, and dismantling of the equipment at each location. All tools shall be of best quality and furnished in labeled toolboxes of suitable design.

B. For the monorail at each location, furnish a 1-year supply of lubricants, as well as spare parts as recommended by the manufacturer, such as bearings, drive belts, seals, washers, rings, and any other parts subject to wear or frequent replacement. All parts shall be properly labeled and identified with the name and number of the equipment to which they belong.

1.07 DELIVERY, HANDLING, AND STORAGE

A. Assemble, paint, test, and adjust monorail system in manufacturer's shop before shipment as far as practical.

PART 2 PRODUCTS

2.01 MONORAIL

A. Manufacturers: One of the following or equal:
   1. Ace Crane, Cudaby, CA.
   2. General Conveyor Inc, Corona, CA.
   3. Whiting Tram Beam.

B. Maximum Deflection of Monorail Beam: Maximum span of monorail beam divided by 450, but not to exceed 1-1/4 inches.

C. Maximum Lateral Deflection of Monorail Beam: Maximum span of monorail beam divided by 360 when subjected to a lateral load of 20 percent of the lifted load.

D. Stops and Bumpers: Adequate to absorb energy of and stop moving trolley at end of permitted travel.

E. Runway Track:
   1. The track shall be a fabricated section having a carbon content of 0.55 percent to 0.65 percent and a manganese content of 0.60 percent to 0.90 percent.
   2. Provide a continuous full penetration weld where the top flange and the web are joined and where the web and high carbon lower flange are joined. Provide an ultrasonic test certification upon request.
   3. Allowable stress in the lower load carrying (tension) flange: 20 percent of the ultimate tensile strength of the material used.
   4. Hardness of the lower load carrying (tension) flange: 195 Brinell minimum.
   5. Design lower flange to allow for tread wear without affecting the rated load carrying capacity. If a raised wear surface of at least 20 percent of the original flange thickness is NOT provided, the track supplier shall stipulate the amount of tread wear allowable before the rated capacity is infringed upon.
   6. The lower load carrying flange shall be 3-1/4 or 4-1/2 inches wide. It shall have a raised tread so as to maintain a flat, smooth contact surface with the wheels throughout its wear life.
   7. Turning Radius of Monorail: Not less than 4 feet.

F. Labeling: Paint hoist capacity on monorail with minimum 4-inch high letters and numbers where clearly visible from operating floor.

G. Coating: Provide prime coat, intermediate coat, and finish coat in accordance with requirements of Section 09960.

H. Length: As indicated on the Drawings.

I. Track Switches:
   1. The switch shall be patented track and shall be from the same manufacturer as the track.
   2. The 3-way and 2-way switches shall be constructed of an inner moving frame and an outer stationery frame.
   3. Standard 2-way and 3-way type track switches shall not be shifted with a trolley on the moveable track.
   4. The inner frame stops shall be adjustable. The frame shall be guided with anti-friction rollers.

5. The switch shall be manual with spring load throw switches. Outrigged chains with sheaves shall hang from the switch to allow the inner frame to be easily shifted from one position to another.
6. Means shall be provided to hold the moveable frame in a stationary position during passage of a trolley through the track switch.
7. Safety stops shall be present to prevent the trolley from rolling off the end of an open monorail track.

J. Anchor bolts: Stainless steel undercut anchors per Section 05120.

2.02 TROLLEY HOISTS

A. Manufacturers: One of the following or equal:
1. Cleveland Tram Rail.
2. P&H Hevi-Lift.
3. Yale.

B. Type: Combination electric motor-driven trolleys and hoists, single-speed with trolley cushioned start, including mechanical brake, electrical brake, and upper hoist limit stop and load limiting device,

C. Hoisting speed: 15 feet per minute.

D. Critical dimensions: Maximum allowable combined vertical height as measured from the top of the monorail beam to inside of hook in fully raised position.
1. UV Facility: 31 inches.
2. Dewatering Building: 43 inches.
3. Maintenance Building: 25 inches.

E. Trolleys wheels: Single-flanged; forged steel, hardened to 425 Brinell; fitted with anti-friction bearings with lifetime seals; suitable for adjustment to monorails.

F. Safety lugs: Add safety lugs to manufacturer's standard design.

G. Drive units: Specially designed for monorail service with cushioned stop holding brakes.

H. Hoisting drum: Steel or cast iron with machined, 1/2 rope diameter deep grooves; adequate to provide minimum 2 complete rope wraps on drum with hook in lowest position, and to accommodate full length of rope without overlapping when in highest position.

I. Hoist drive speed reducer: With heat-treated steel helical gears; oil-lubricated with oiltight cases; shafts running in anti-friction bearings.

J. Limit switches and overload device: Manufacturer's standard.

K. Hoisting rope: Specifically designed for specified service loads; preformed, improved plow steel with fiber core; double-reeved.

L. Hoisting block: Steel with forged or cast steel hook supported on ball or roller bearings for true vertical lift.

M. Hook: Safety type, able to rotate freely on bearing support with heavy-duty type safety latches.

N. Bottom block: Shrouded.

O. Coating: Provide prime coat, intermediate coat, and finish coat in as specified in Section 09960.

2.03 ELECTRIFICATION

A. Electrification type: Cable and spring-loaded swiveled cable reel-mounted on structure.

B. Cable run: From junction box to cable reel, then to control unit.

C. Alternative Electrification Type: Power rail enclosed conductor bar system (“hot rail”).

D. Contractors shall denote at time of bid which power system will be supplied for each monorail.

2.04 CONTROL

A. Control unit: Pendant pushbutton station:
   1. Pendant pushbutton station hanging from hoist to maximum 4 feet above operation floor.
   2. Control voltage: 120 volts alternating current, supplied from transformer on hoist.
   3. Pushbuttons: Momentary-contact, maintain-pressure, automatically de-energizing upon relaxation of pressure; number and functions as follows:
      a. Pushbuttons for hoisting: Two per hoist, 1 for each direction.
      b. Pushbuttons for trolley: Two per hoist, 1 for each direction.
   4. Enclosures for control unit, electrical control, and reel: NEMA 4X and to meet the requirements as specified in Sections 17050 and 17710.
   5. Control unit support: Steel cable.
   6. Control accessories:
      a. Geared limit switch able to limit up and down travel with second switch operated by hook to stop hoist when highest safe point is reached.
      b. Magnetic contactors for up and down operation and control.
   7. Junction boxes: Suitable for connection of field services with ground pads.

B. Control unit: Remote radio control:
   1. The monorail shall be operated from a radio remote controller. The radio remote controller shall operate in the 900 MHz range that complies with the Federal Communication Commission (FCC) Part 15 for license-free operation.
   2. The transmitters shall be handheld microprocessor-based 16 bit CRC for error-free operation. The transmitters shall have the following features:
      a. Internal antenna: 300 feet minimum range.
      b. Rubber rocker switches.
      c. Self-test LED providing transmitter and battery status.
      d. Operating temperature range between -20 and 160 degrees F.
      e. The units shall be battery operated with a nominal 200 hours life, and shall be provided with a battery charging station.

f. Each transmitter shall have a rotary switch installed on the front of the transmitter to select the appropriate trolley and hoist to operate.
g. Each transmitter shall have the ability to operate the dedicated trolley or operate both trolleys simultaneously.
h. The receivers shall differentiate between the transmitters by Frequency and internal FCFS (First Come First Serve) programming loaded into the receivers.
i. Controls on the face plate shall consist of the following:
    1) Trolley Selector Switch.
    2) OFF-Emergency Stop switch.
    3) ON/alarm LED.
    4) UP-DOWN switch for the hoist.
    5) FORWARD-REVERSE switch for the trolley.
j. The units shall be designed so that if the controls are released, the trolley ceases to function.
k. The transmitters shall be Remtron, Inc. “Command Pro #21T20” or approved equal.

3. A receiver shall be provided for each trolley and hoist with the following features:
    a. Surge suppressors, NEMA 4 package.
    b. Redundant safety circuits,
    c. 60 milliseconds response time,
    d. Self-test LED’s, operating temperature range between -20 and 160 degrees F,
    e. Input voltage of 115, single phase, 60 Hz.
    f. Provide all interfacing wiring required between the receiver and the trolley and hoist control system.
    g. Receivers shall be Remtron, Inc. “22 Series” or approved equal.

PART 3 EXECUTION

3.01 GENERAL

A. Equipment shall be coated in accordance with the requirement of Section 09960.

3.02 INSTALLATION

A. The hoisting equipment shall be installed by competent personnel who have at least 5 years experience in, and regularly engaged in, field installation of monorail hoist systems. All unloading, storage, and installation shall be done by, or under the direct supervision of, the manufacturer.

3.03 LOAD TESTING

A. After complete installation of the system, the equipment shall be tested with a load 25 percent above the rated capacity and a certificate shall be provided.

B. Load and slings shall be provided by the monorail system manufacturer and removed when the tests are completed.

C. The equipment shall be operated through a complete lift and lowering cycle and through complete travel of the trolley to determine that the equipment will perform the functions of hoisting, braking, and traveling, quietly, smoothly, and safely.

D. Any defects in the equipment shall be corrected.

E. Testing shall be done in the presence of a test certifier, an authorized representative of the monorail system manufacturer and the OWNER.

F. No hoisting equipment shall be used to handle any equipment until the load testing is concluded and a certificate has been provided.

G. Do not use the monorail crane system for construction.

3.04 MANUFACTURER'S FIELD SERVICES

A. Coordinate field service work with the manufacturer's representative, OWNER, and ENGINEER prior to initiating such work.

B. Require manufacturer's representative to perform the following services as described below and as specified in Specification Section 01660.
   1. Installation Inspection: 1 man-day.
      a. Check and verify that installation of the Monorail Hoist System is in accordance with the Drawings and manufacturer's installation instructions.
      b. Certify installation and assist with field-testing and start-up.

C. Require manufacturer's technical field representative to complete all certificates, reports, and forms in Specification Section 01600.

END OF SECTION

SECTION 15050

COMMON WORK RESULTS FOR MECHANICAL EQUIPMENT

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Basic design and performance requirements for mechanical equipment.

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 01600 - Product Requirements.
      b. Section 01610 - Project Design Criteria.
      c. Section 01612 - Seismic Design Criteria.
      d. Section 01660 - Testing, Training, and Commissioning.
      e. Section 01740 - Warranties and Bonds.
      f. Section 01770 - Closeout Procedures.
      g. Section 01782 - Operating and Maintenance Data.
      h. Section 03600 - Grouting.
      i. Section 05120 - Structural Steel.
      j. Section 09960 - High-Performance Coatings.
      k. Section 10400 - Signage.
      l. Section 15082 - Piping Insulation.
      m. Section 15958 - Mechanical Equipment Testing.
      n. Section 16950 - Field Electrical Acceptance Tests.
      o. Section 17950 - Testing Calibration and Commissioning.

1.02 REFERENCES

A. American Gear Manufacturer's Association (AGMA) Standards:
   1. 6001-E08 – Design and Selection of Components for Enclosed Gear Drives.

B. American Bearing Manufactures Association (ABMA) Standards:
   1. 9 - Load Ratings and Fatigue Life for Ball Bearings.
   2. 11 - Load Ratings and Fatigue Life for Roller Bearings.

C. American Petroleum Institute (API):
   1. 682 - Shaft Sealing Systems for Centrifugal and Rotary Pumps.

D. ASTM International (ASTM):
   1. A 36 - Standard Specification for Carbon Structural Steel.

2. A 48 - Standard Specification for Gray Iron Castings.
3. A 125 - Standard Specification for Steel Springs, Helical, Heat-Treated.
4. A 536 - Standard Specification for Ductile Iron Castings.
5. A 653 - Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process.
6. B 61 - Standard Specification for Steam or Valve Bronze Castings.
7. B 62 - Standard specification for Composition Bronze or Ounce Metal Castings.
8. B 505 - Standard Specification for Copper Alloy Continuous Castings.
9. B 584 - Standard Specification for Copper Alloy Sand Castings for General Applications.

E. Food and Drug Administration (FDA).

F. Hydraulic Institute (HI).

G. NSF International (NSF).

1.03 DEFINITIONS

A. Special tools: Tools that have been specifically made for use on unit of equipment for assembly, disassembly, repair, or maintenance.

B. Resonant frequency: That frequency at which a small driving force produces an ever-larger vibration if no dampening exists.

C. Rotational frequency: The revolutions per unit of time usually expressed as revolutions per minute.

D. Critical frequency: Same as resonant frequency for the rotating elements or the installed machine and base.

E. Peak vibration velocity: The root mean square average of the peak velocity of the vibrational movement times the square root of 2 in inches per second.

F. Rotational speed: Same as rotational frequency.

G. Maximum excitation frequency: The excitation frequency with the highest vibration velocity of several excitation frequencies that are a function of the design of a particular machine.

H. Critical speed: Same as critical frequency.

I. Free field noise level: Noise measured without any reflective surfaces (an idealized situation); sound pressure levels at 3 feet from the source unless specified otherwise.

J. Operating weight: The weight of unit plus weight of fluids or solids normally contained in unit during operation.

1.04 SYSTEM DESCRIPTION

A. General:
1. Provisions specified under each technical equipment specification prevail over and supersede conflicting provisions as specified in this Section.

2. Provide equipment and parts that are suitable for stresses, which may occur during fabrication, transportation, erection, and operation.
3. Provide equipment that has not been in service prior to delivery, except as required by tests.
4. Like parts of duplicate units are to be interchangeable.
5. When 2 or more units of equipment for the same purpose are required, provide products of same manufacturer.
6. Equipment manufacturer's responsibility extends to selection and mounting of gear drive units, motors or other prime movers, accessories, and auxiliaries required for proper operation.
7. When necessary, modify manufacturer's standard product to conform to specified requirements or requirements indicated on the Drawings and contained in Laws and Regulations.

B. Material requirements:
1. Comply with the American Recovery and Reinvestment Act (ARRA) provisions specified in Section 01600.
2. Materials: Suitable for superior corrosion resistance and for services under conditions normally encountered in similar installations.
3. Dissimilar metals: Separate contacting surfaces with dielectric material.

C. Power transmission systems:
1. Power transmission equipment: V-belts, sheaves, shaft couplings, chains, sprockets, mechanical variable-speed drives, variable frequency drives, gear reducers, open and enclosed gearing, clutches, brakes, intermediate shafting, intermediate bearings, and U-joints are to be rated for 24 hour-a-day continuous service or frequent stops-and-starts intermittent service, whichever is most severe, and sized with a minimum service factor of 1.5:
   a. Apply 1.5 service factor to nameplate horsepower and torque of prime source of power and not to actual equipment loading.
   b. Apply service factors higher than 1.5 when recommended for continuous 24 hour per day operation and shock loadings in accordance with AGMA 6001-E08, other applicable AGMA standards, or other applicable referenced standards.
   c. When manufacturer recommends service factor greater than 1.5, manufacturer's recommendation takes precedence.

D. Vibration:
1. Resonant frequency:
   a. For single speed equipment, ensure there are no natural resonant frequencies within 25 percent above or below the operating rotational frequencies or multiples of the operating rotational frequencies that may be excited by the equipment design.
   b. For variable speed equipment, ensure there are no natural resonant frequencies within 25 percent above or below the range of operating frequencies.
2. Design, balance, and align equipment to meet the vibration criteria specified in Section 15958.

E. Equipment mounting and anchoring:
   1. Mount equipment on cast iron or welded steel bases with structural steel support frames.
      a. Utilize continuous welds to seal seams and contact edges between steel members.
      b. Grind welds smooth.
   2. Provide bases and supports with machined support pads, dowels for alignment of mating of adjacent items, adequate openings to facilitate grouting, and openings for electrical conduits.
   3. Provide jacking screws in bases and supports for equipment weighing over 1,000 pounds.
   4. Anchorage of equipment to concrete: Perform calculations and determine number, size, type, strength, and location of anchor bolts or other connections.
   5. Provide bolt sleeves for anchor bolts for heavy equipment.
      a. Adjust bolts to final location and fill sleeve with non-shrink grout.
   6. Anchorage of equipment to metal supports: Perform calculations and determine number, size, type, strength, and location of bolts used to connect equipment to metal supports.
   7. Design equipment anchorage, supports, and connections for dead load, running loads, loads during start-up, seismic load, and other loads as required for proper operation of equipment.

F. Seismic design:
   1. Design equipment anchorage and related details for seismic design criteria as specified in Section 01612.
   2. For equipment with operating weight of 400 pounds or more, provide calculations for:
      a. Determine operating weight and centroid of equipment.
      b. Calculate forces and overturning moments.
      c. Calculate shear and tension forces in equipment anchorages, supports, and connections.
      d. Design equipment anchorage, supports, and connections based on calculated shear and tension forces.

G. Equipment units weighing 50 pounds or more: Provide with lifting lugs or eyes to allow removal with hoist or other lifting device.

1.05 SUBMITTALS

A. Product data:
   1. For each item of equipment:
      a. Design features.
      b. Load capacities.
      c. Efficiency ratings.
      d. Material designations by UNS alloy number or ASTM Specification and Grade.
      e. Data needed to verify compliance with the Specifications.
      f. Catalog data.
      g. Name plate data.
      h. Clearly mark submittal information to show specific items, materials, and accessories or options being furnished.

2. Gear reduction units:
    a. Engineering information in accordance with applicable AGMA standards.
    b. Gear mesh frequencies.

B. Shop drawings:
1. Letter or certificate signed by officer of company stating conformance with the ARRA requirements specified in Section 01600.
2. Drawings for equipment:
    a. Drawings that include outline drawings, cut-away drawings, parts lists, material specification lists, and other information required to substantiate that proposed equipment complies with specified requirements.
3. Outline drawings showing equipment, driver, driven equipment, pumps, seal, motor(s) or other specified drivers, variable frequency drive, shafting, U-joints, couplings, drive arrangement, gears, baseplate or support dimensions, anchor bolt sizes and locations, bearings, and other furnished components.
4. Installation and checkout instructions including leveling and alignment tolerances, grouting, lubrication requirements, and initial start-up procedures.
5. Wiring, control schematics, control logic diagrams and ladder logic or similar for computer based controls.
6. Recommended or normal operating parameters such as temperatures and pressures.
7. Alarm and shutdown setpoints for all controls furnished.

C. Calculations:
1. Calculations and other information to substantiate equipment base plates, supports, bolts, anchor bolts, and other connections meet minimum design strength requirements and seismic design criteria specified in Section 01612.
2. ABMA 9 or ABMA 11 L10 life for bearings calculation methods for drivers, pumps, gears, shafts, motors, and other driveline components with bearings.
3. Calculations and other information to substantiate that operating rotational frequencies meet the requirements of this Section.
4. Torsional analysis of power transmission systems: When torsional analysis specified in the equipment sections, provide:
    a. Sketch of system components identifying physical characteristics including mass, diameter, thickness, and stiffness.
    b. Results of analysis including first and second critical frequencies of system components and complete system.
5. Calculations shall be signed and stamped by a civil or structural engineer registered to practice in the state where the Project is located.

D. Quality control submittals:
1. Source quality control reports and certified test data as specified in Section 15958.
2. Submit factory test reports before shipment.
3. Certified static and dynamic balancing reports for rotating equipment.
4. Field quality control reports and test data as specified in Section 15958.
5. Start-up plan: Proposed plan for field-testing equipment as specified in Section 01660.
6. Certificate of Proper Installation: As specified in Section 01660.
7. Submit material test reports a specified in the equipment sections.

E. Operation and maintenance manuals:
   1. As specified in Section 01782.
   2. Submit prior to training of Owner's personnel.
   3. Make available at project site complete copy of manuals for use by field personnel and Engineer during start-up and testing of equipment.
   4. Include manufacturer and model number of every bearing; include calculated ball pass frequencies of the installed equipment for both the inner and outer raceways.
   5. Include motor rotor bar pass frequencies.

F. Project closeout documents: As specified in Section 01770.

1.06 QUALITY ASSURANCE

A. Manufacturer's field service:
   1. Furnish services of authorized representative specially trained in installation of equipment:
      a. Visit project site and perform tasks necessary to certify installation.
      b. Furnish Certificate of Proper Installation as specified in Section 01660.

1.07 DELIVERY, STORAGE, AND HANDLING

A. Packing and shipping:
   1. Equipment: Pack in boxes, crates, or otherwise protect from damage and moisture, dust, or dirt during shipment, handling, and storage.
   2. Bearings: Separately pack or otherwise suitably protect during transport.
   3. Spare parts: Deliver in boxes labeled with contents, equipment to which spare parts belong, and name of Contractor.

B. Storage:
   1. Equipment having bearings:
      a. Store in enclosed facilities.
      b. Rotate units at least once per month or more often as recommended by the manufacturer to protect rotating elements and bearings.
   2. Gear boxes: Oil filled or sprayed with rust preventive protective coating.

C. Protection:
   1. Equipment: Protect equipment from deleterious exposure.
   2. Painted surfaces: Protect against impact, abrasion, discoloration, and other damage.

1.08 SEQUENCING AND SCHEDULING

A. Equipment anchoring: Obtain anchoring material and templates or setting drawings from equipment manufacturers in adequate time for anchors to be cast-in-place when concrete is placed.

B. Coordinate details of equipment with other related parts of the Work, including verification that structures, piping, wiring, and equipment components are compatible.

C. General start-up and testing of equipment:
   1. Perform general start-up and testing procedures after operation and maintenance manuals for equipment have been received.
   2. Conduct functional testing of mechanical or electrical systems when each system is substantially complete and after general start-up and testing procedures have been successfully completed.
   3. Functional testing requirements as specified in Sections 01660, 15958, 16950, and 17950 and the equipment sections.

1.09 MAINTENANCE

A. Special tools:
   1. When specified, provide special tools required for operation and maintenance.
   2. Mark or tag and list such tools in maintenance and operations instructions. Describe use of each tool.

B. Spare belts:
   1. When spare belts are specified, furnish 1 spare belt for every different type and size of belt-driven unit:
      a. Where 2 or more belts are involved, furnish matched sets.
      b. Identify as to equipment, design, horsepower, speed, length, sheave size, and use.
      c. Package in boxes labeled with identification of contents.

C. Spare parts:
   1. Assume responsibility until turned over to Owner.
   2. Store in enclosed facilities.
   3. Furnish itemized list and match identification tag attached to every part.
   4. List parts by generic title and identification number.
   5. Furnish name, address, and telephone number of supplier and spare parts warehouse.

1.10 WARRANTY

A. Warrant the Work as specified in Sections 01740 and 01770.

PART 2 PRODUCTS

2.01 MATERIALS

A. Ferrous materials:
   1. Steel for members used in fabrication of assemblies: ASTM A 36.
   2. Iron castings: ASTM A 48, tough, close-grained gray iron, free from blowholes, flaws, and other imperfections.
   3. Ductile iron castings: ASTM A 536, Grade 65-45-12, free from flaws and imperfections.
   4. Galvanized steel sheet: ASTM A 653, minimum 0.0635 inch (16 gauge).
   5. Expanded metal: ASTM A 36, 13 gauge, 1/2-inch flat pattern expanded metal.

B. Nonferrous materials:
   1. Stainless steel: Type 304 or 316 as specified. Provide L grade where welding required.
   2. Bronze in contact with liquid: Composition of not more than 2 percent aluminum nor more than 6 percent zinc; UNS Alloy C83600, C92200 or C93700 in accordance with ASTM B 61, B 62, B 505, or B 584, when not specified otherwise.

C. Dielectric materials for separation of dissimilar metals:
   1. Neoprene, bituminous impregnated felt, heavy bituminous coatings, nonmetallic separators or washers, or other materials.

D. Anchors bolts: As specified in Section 05120; minimum 0.5-inch diameter.

E. Non-shrink grout: As specified in Section 03600.

2.02 SHAFT COUPLINGS

A. General:
   1. Type and ratings: Provide non-lubricated type, designed for not less than 50,000 hours of operating life.
   2. Sizes: Provide as recommended by manufacturer for specific application, considering horsepower, speed of rotation, and type of service.
   3. Use: Use of couplings specified in this Section does not relieve Contractor of responsibility to provide precision alignment of driver-driven units as required by equipment manufacturer and alignment criteria specified elsewhere in this Section.

B. Shaft couplings - close coupled: Shaft couplings for close coupled electric motor driven equipment 1/2 horsepower or larger and subject to sudden torque reversals or shock loading:
   1. Manufacturers: One of the following or equal:
      a. T.B. Woods, Dura-Flex, L-Jaw C-Jaw or G-Jaw.
      b. Lovejoy, S-Flex.
   2. Provide flexible couplings designed to accommodate angular misalignment, parallel misalignment, and end float.
   3. Manufacture flexible component of coupling from synthetic rubber, or urethane.
   4. Provide service factor of 2.5 for electric motor drives and 3.5 for engine drives.
   5. Do not allow metal-to-metal contact between driver and driven equipment.
   6. Examples of loads where sudden torque reversals may be expected:
      a. Reciprocating pumps, blowers, and compressors.
      b. Conveyor belts.
      c. Reversing equipment.

C. Shaft couplings - direct connected: Shaft couplings for direct connected electric motor driven equipment 1/2 horsepower or larger and subject to normal torque, non-reversing applications:
   1. Manufacturers: One of the following or equal:
      a. Rexnord - Falk.
      b. T.B. Woods, Dura-Flex, Sure-Flex or Form-Flex.
   2. Provide flexible couplings designed to accommodate shock loading, vibration, and shaft misalignment or offset.

3. Provide flexible connecting element of rubber and reinforcement fibers.
4. Connect stub shafts through collars or round flanges, firmly keyed to their shafts with neoprene cylinders held to individual flanges by through pins.

D. Spacer couplings: Where cartridge type mechanical seals or non-split seals are specified, provide a spacer type coupling of sufficient length to remove the seal without disturbing the driver or driven equipment unless noted otherwise in the individual equipment specifications.

E. Specialized couplings: Where requirements of equipment dictate specialized features, supply coupling recommended for service by manufacturer.

2.03 STUFFING BOX, SEAL CHAMBER, AND SHAFT SEALS

A. General:
1. Unless otherwise noted in the equipment section, provide cartridge type, double mechanical shaft seals for pumps.
2. Provide a stuffing box large enough for a double mechanical seal.
3. Where packing is specified, provide stuffing box large enough to receive a double mechanical seal.
4. Provide seal or packing flush connections, (3/4-inch size unless another size is indicated on the Drawings).
5. Provide and route leakage drain line to nearest equipment floor drain indicated on the Drawings.
6. For pumps with packing, design packing gland to allow adjustment and repacking without dismantling pump except to open up packing box.
7. Seal or packing flush requirements shall be in accordance with API Standard 682 requirements. Unless otherwise indicated, specified or required by the equipment and seal manufacturers, the following API flushing Plan arrangements shall be utilized as appropriate for the application:
   a. Single seal, clean water applications: Plan 11 (Discharge bypass to seal).
   b. Single seal, vertical pump applications: Plan 13 (Seal bypass to suction).
   c. Single seal, clean hot water (greater than 180 degrees Fahrenheit) applications: Plan 23 (Seal cooler and pumping ring).
   d. Single seal, solids, or contaminants containing water applications: Plan 32 (External seal water- see Carollo typical detail # M262).
   e. Double seal applications: Plan 54 (External seal water- see Carollo typical detail # M262).

B. Packing: When specified in the equipment section of the specifications, provide the following type of packing:
1. Wastewater, water, and sludge applications:
   a. Asbestos free.
   b. PTFE (Teflon®) free.
   c. Braided graphite.
   d. Manufacturers: One of the following or equal:
      1) Chesterton, 1400.
      2) John Crane Inc., equivalent product.
2. Drinking water service:
   a. Approved by the FDA or NSF.
   b. Asbestos free.

c. Material: Braided PTFE (Teflon®).
d. Manufacturers: One of the following or equal:
1) Chesterton, 1725.
2) John Crane, Inc., equivalent product.

C. Mechanical seals: Provide seal types specified in the equipment sections and as specified.
1. Provide seal types meeting the following requirements:
a. Balanced hydraulically.
b. Spring: Stationary, out of pumping fluid, Hastelloy C; Type Elgiloy or 17-7 PH stainless steel for split seals.
c. O-ring: Viton 747.
d. Gland: Type 316L stainless steel.
e. Set screws: Type 316L stainless steel.
f. Faces: Reaction bonded, Silicon Carbide.
g. Seal designed to withstand 300 pounds per square inch gauge minimum differential pressures in either direction; no requirement for seal buffer pressure to be maintained when pump is not operational even though process suction head may be present in pump.
2. Cartridge type single mechanical: Manufacturers: One of the following or equal:
a. Chesterton, S10.
b. John Crane, 5610 Series.
3. Cartridge type double mechanical: Manufacturers: One of the following or equal:
a. Chesterton, S20.
b. John Crane, 5620 Series.
4. Split face single mechanical: Manufacturers: One of the following or equal:
a. Chesterton, 442.
b. John Crane, 3740.

2.04 GEAR REDUCTION UNITS

A. Type: Helical or herringbone, unless otherwise specified.

B. Design:
1. Made of alloys treated for hardness and for severe service.
2. AGMA Class II service:
a. Use more severe service condition when such is recommended by unit's manufacturer.
3. Cast iron housing with gears running in oil.
4. Anti-friction bearings.
5. Thermal horsepower rating based on maximum horsepower rating of prime mover not actual load.
6. Manufactured in accordance with applicable AGMA standards.

C. Planetary gear units are not to be used.

2.05 BELT DRIVES

A. Sheaves:
1. Separately mounted on bushings by means of at least 3 pull-up bolts or cap tightening screws.
2. When 2 sheave sizes are specified, provide separate belts sized for each set of sheaves.

3. Statically balanced for all; dynamically balanced for sheaves that operates at peripheral speed of more than 5,500 feet per minute.
4. Key bushings to drive shaft.

B. Belts: Anti-static type when explosion-proof equipment or environment is specified.

C. Manufacturers: One of the following or equal:
1. Dodge, Dyna-V belts with matching Dyna-V sheaves and Taper-Lock bushings.
2. Wood's, Ultra-V belts with matching Sure-Grip sheaves and Sure-Grip bushings.

2.06 BEARINGS

A. Type: Oil or grease lubricated, ball or roller antifriction type, of standard manufacture.

B. Oil lubricated bearings: Provide either pressure lubricating system or separate oil reservoir splash type system:
1. Size oil lubrication systems to safely absorb heat energy generated in bearings when equipment is operating under normal conditions and with the temperature 15 degrees Fahrenheit above the maximum design temperature as specified in Section 01610.
2. Provide an external oil cooler when required to satisfy the specified operating conditions.
   a. Provide air cooled system if a water-cooling source is not indicated on the Drawings.
   b. Equip oil cooler with a filler pipe and external level gauge.

C. Grease lubricated bearings, except those specified to be factory sealed: Fit with easily accessible grease supply, flush, drain, and relief fittings.
1. Lubrication lines and fittings:
   a. Lines: Minimum 1/4-inch diameter stainless steel tubing.
   b. Multiple fitting assemblies: Mount fittings together in easily accessible location.
   c. Use standard hydraulic type grease supply fittings:
      1) Manufacturers: One of the following or equal:
         a) Alenite.
         b) Zurk.

D. Ratings: Rated in accordance with ABMA 9 or ABMA 11 L10 life for bearings rating life of not less than 50,000 hours:
1. Higher ratings, when specified in other Sections, supersede preceding requirement.

2.07 SAFETY GUARDS

A. Drive assemblies: Enclose sprockets, belts, drive chains, gearings, couplings, and other moving parts on drive assemblies in safety enclosures that are in compliance with applicable Laws and Regulations.

B. Shafts: Provide guards that protect personnel from rotating shafts or components within 7.5 feet of floors or operating platforms.

C. Hot surfaces: Insulate all surfaces with normal operating temperatures above 120 degrees Fahrenheit when surface is within 7.5 feet height from any operating floor or level; insulation thickness such that temperature is below 120 degrees Fahrenheit; cover insulation with moisture-proof protective jacket; insulation Type 3 and cover Type 5 as specified in Section 15082.

D. Guard requirements:
   1. Allow visual inspection of moving parts without removal.
   2. Allow access to lubrication fittings.
   3. Prevent entrance of rain or dripping water for outdoor locations.
   4. Size belt and sheave guards to allow for installation of sheaves 15 percent larger and addition of 1 belt.

E. Materials:
   1. Sheet metal: Carbon steel, 12 gauge minimum thickness, hot-dip galvanized after fabrication.
   2. Fasteners: Type 304 stainless steel.

2.08 SPRING VIBRATION ISOLATORS

A. Design requirements:
   1. Telescopic top and bottom housing with vertical stabilizers to resist lateral and vertical forces.
   2. Use steel coil springs.
   3. Design vibration isolators in accordance with seismic design criteria as specified in Section 01612.

B. Performance requirements: Minimum spring deflection of 1 inch under static load and capable of limiting transmissibility to 15 percent maximum at design operating load.

C. Manufacturers: One of the following or equal:
   1. California Dynamics Corporation, Type RJSD.
   2. Mason Industries, equivalent product.

D. Materials:
   1. Fabricate isolators using welded steel or shatterproof ductile iron in accordance with ASTM A 536 Grade CS-45-12.
   2. Spring steel: ASTM A 125.

2.09 WARNING SIGNS

A. Provide for equipment that starts automatically or remotely.

B. Material and size: Metal as specified in Section 10400.

C. Colors: Black lettering on yellow background.

D. Text: As specified in Section 10400.

2.10 FABRICATION

A. Structural steel members: As specified in Section 05120.

B. Nameplates:
   1. Engraved or stamped on Type 304 stainless steel and fastened to equipment at factory in an accessible and visible location.
   2. Indicate following information as applicable:
      a. Manufacturer's name.
      b. Equipment model number and serial number.
      c. Maximum and Normal rotating speed.
      d. Horsepower.
      e. Rated capacity.
      f. Service class per applicable standards.
   3. Nameplates for pumps: Include:
      a. Rated total dynamic head in feet of fluid.
      b. Rated flow in gallons per minute.
      c. Impeller, gear, screw, diaphragm, or piston size.
   4. Gear reduction units: Include:
      a. AGMA Class of service.
      b. Service factor.
      c. Input and output speeds.

C. Bolt holes in equipment support frames:
   1. Do not exceed bolt diameter by more than 25 percent, up to limiting maximum diameter oversize of 1/4 inch.

D. Shop finishing:
   1. Provide factory and field coating as specified in Section 09960. If not specified in Section 09960, provide coating as follows:
      a. Bases and support frames in contact with concrete or other material: Coat contacting surfaces with minimum of 2 coats of zinc chromate primer before installation or grouting.
      b. Shop primer for steel and iron surfaces, unless specified otherwise:
         1) Manufacturers: One of the following or equal:
            a) Ameron, Amercoat 185 Universal Primer.
            b) Cook, 391-N-167 Barrier Coat.
            c) Kop-Coat, Pug Primer.
            d) Tnemec, 37-77 Chem-Prime.
            e) Valspar, 13-R-28 Chromox Primer.
      c. Coat machined, polished, and nonferrous surfaces which are not to be painted with rust-preventive compounds:
         1) Manufacturers: One of the following or equal:
            a) Houghton, Rust Veto 344.
            b) Rust-Oleum, R-9.
      d. Coating for ferrous metal surfaces, except stainless steel: High solids polyamine epoxy.
      e. Finish painting of motors: Shop finish paint with manufacturer's standard coating, unless otherwise specified in Section 09960.

2.11 SOURCE QUALITY CONTROL

A. As specified in Section 15958 for testing requirements and the individual equipment sections of the Specifications.

PART 3 EXECUTION

3.01 EXAMINATION

A. Inspect all components for shipping damage, conformance to specifications, and proper torques and tightness of fasteners.

3.02 PREPARATION

A. Metal work embedded in concrete:
   1. Accurately place and hold in correct position while concrete is being placed.
   2. Clean surface of metal in contact with concrete immediately before concrete is placed.

B. Concrete surfaces designated to receive non-shrink grout:
   1. Heavy sandblast concrete surface in contact with non-shrink grout.
   2. Clean concrete surfaces of sandblasting sand, grease, oil, dirt, and other foreign material that may reduce bond to non-shrink grout.
   3. Saturate concrete with water. Concrete shall be saturated surface damp at time non-shrink grout is placed.

C. Field measurements:
   1. Prior to fabrication of equipment, take measurements for installation of equipment and verify dimensions indicated on the Drawings.
   2. Ensure equipment and ancillary appurtenances fit within available space.

3.03 INSTALLATION

A. Install equipment in accordance with manufacturer's installation instructions and recommendations.

B. Lubrication lines and fittings:
   1. Lines from fittings to point of use: Support and protect.
   2. Fittings:
      a. Bring fittings to outside of equipment in manner such that they are readily accessible from outside without necessity of removing covers, plates, housings, or guards.
      b. Mount fittings together wherever possible using factory-mounted multiple fitting assemblies securely mounted, parallel with equipment lines, and protected from damage.
      c. Fittings for underwater bearings: Bring fittings above water surface and mount on edge of structure above.

C. Alignment of drivers and equipment:
   1. Where drive motors or other drivers are connected to driven equipment by flexible coupling, disconnect coupling halves and align driver and equipment after complete unit has been leveled on its foundation.
   2. Comply with procedures of appropriate HI, AGMA Standards, alignment tolerances of equipment manufacturers and the following requirements to bring components into angular and parallel alignment:
      a. Maximum total coupling offset (not the per plane offset): Not to exceed 0.5 mils per inch of coupling length for spacer couplings based on coupling length (not dial separation).

b. Utilize jacking screws, wedges, or shims as recommended by the equipment manufacturer and as specified in the equipment sections.

3. Use reverse-indicator arrangement dial type or laser type alignment indicators: Mount indicators on the driver/coupling flange and equipment/coupling flange. Alignment instrumentation accuracy shall be sufficient to read angular and radial misalignment at 10 percent or less of the manufacturer's recommended acceptable misalignment.
4. Alignment and calculations shall include measurement and allowance for thermal growth, spacer coupling length, indicator separation, and axial spacing tolerances of the coupling.
5. When alignment satisfies most stringent tolerance of system components, grout between base and foundation.
   a. Allow minimum 48 hours for grout to harden.
   b. After grout hardens, remove jacking screws, tighten anchor bolts and other connections, and recheck alignment.
   c. Correct alignment as required.
6. After operational testing is complete, dowel motor or drivers and driven equipment.
   a. Comply with manufacturer's instructions.

D. Grouting equipment bases and baseplates with non-shrink grout:
1. Grout with non-shrink grout as specified in Section 03600.
2. Comply with equipment manufacturer's installation instructions for grouting spaces, and tolerances for level and alignments, both vertical and horizontal.
3. Grout after piping connections are complete and in alignment with no strain transmitted to equipment.
4. Grout base when equipment is leveled and in alignment.
5. Place grout, filling voids under equipment bases and other supports including recesses between anchor bolts and sleeves:
   a. Extend grout to edge of equipment bases or baseplates and bevel at 45 degrees around units.
   b. Grouts must be cut back to the lower edge of baseplates after reaching initial set.
      1) Provide a 45-degree angle cut back.
   c. Finish surfaces with slope that prevents ponding water within grouted areas.

E. Forms and head boxes for non-shrink grouts or non-shrink epoxy grouts:
1. As specified in Section 03600.

F. Special techniques: Use applicable special tools and equipment, including precision machinist levels, dial indicators, and gauges as required in equipment installations.

G. Tolerances:
1. Completed equipment installations: Comply with requirements for intended use and specified vibration and noise tolerances.

H. Warning signs: Mount securely with stainless fasteners at equipment that can be started automatically or from remote locations.

3.04 FIELD QUALITY CONTROL

A. Test equipment as specified in Section 15958 and the individual equipment section of the Specifications.

B. Perform operational testing as required by Section 01660.

3.05 MANUFACTURER'S REPRESENTATIVE

A. Field checkout: Before field-testing and start-up, provide services of factory-trained field service representative to certify the equipment has been installed, aligned, and checked in accordance with the manufacturer’s instructions and the Specifications.

B. Testing: Provide services of factory trained representative to observe and advise the Contractor during field quality control testing.

C. Training: When training is specified, provide services of factory-trained representative to perform training as specified in Section 01660.

END OF SECTION

SECTION 15052

COMMON WORK RESULTS FOR GENERAL PIPING

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Basic piping materials and methods.

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 01010 - Project Summary.
   b. Section 01140 - Work Restrictions.
   c. Section 01600 - Product Requirements.
   d. Section 01757 - Disinfection.
   e. Section 09960 - High-Performance Coatings.
   f. Section 13930 - Wet Pipe Fire Extinguishing System
   g. Section 15061 - Pipe Supports.
   h. Section 15062 - Preformed Channel Pipe Support System.
   i. Section 15063 - Non-Metallic Pipe Support System.
   j. Section 15082 - Piping Insulation.
   k. Section 15210 - Cast Iron Soil Pipe, ASTM A 74.
   l. Section 15211 - Ductile Iron Pipe, AWWA C151.
   m. Section 15230 - Plastic Piping and Tubing.
   n. Section 15281 - Copper Water Tube-Seamless, ASTM B 88.
   o. Section 15293 - Double Containment Piping.
   p. Section 15286 - Stainless Steel Pipe.
   q. Section 15814 - Fiberglass Reinforced Plastic Ductwork.
   r. Section 15956 - Piping Systems Testing.

1.02 REFERENCES

A. American Society of Mechanical Engineers (ASME):
1. B16.5 - Pipe Flanges and Flanged Fittings: NPS 1/2 Through 24.
2. B16.47 - Large Diameter Steel Flanges: NPS 26 Through NPS 60 Metric/Inch Standard.

B. American Water Work Association (AWWA):
1. C207 - Standard for Steel Pipe Flanges for Waterworks Services-Size 4 In. Through 144 In.

C. ASTM International (ASTM):
   1. A 193 - Standard Specification for Alloy-Steel and Stainless Steel Bolting Materials for High Temperature or High Pressure Service and Other Special Purpose Applications.
   2. A 194 - Standard Specification for Carbon and Alloy Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both.
   3. A 307 - Standard Specification for Carbon Steel Bolts and Studs, 60,000 PSI Tensile Strength.
   4. F 37 - Standard Test Methods for Sealability of Gasket Materials.

D. California Health and Safety Code.

1.03 DEFINITIONS

A. Buried pipe: Pipe that is buried in the soil, or cast in a concrete pipe encasement that is buried in the soil.

B. Exposed pipe: Pipe that is located aboveground, or pipe that is located inside a structure, supported by a structure, or cast into a concrete structure.

C. Underground piping: Piping actually buried in soil or cast in concrete that is buried in soil.

D. Underwater piping: Piping below tops of walls in basins or tanks containing water.

E. Wet wall: Wall with water on at least 1 side.

1.04 SUBMITTALS

A. Product data:
   1. Escutcheons.
   2. Flange bolts.
   3. Gaskets.
   4. Link -type seals.
   5. Certifications of compliance with reference standard for lead limits.

B. Letter or certificate signed by officer of company stating conformance with the ARRA requirements specified in Section 01600.

1.05 SYSTEM DESCRIPTION

A. Material Requirements:
   1. Comply with the American Recovery and Reinvestment Act (ARRA) provisions specified in Section 01600.

PART 2 PRODUCTS

2.01 ESCUTCHEONS

A. Material: Chrome-plated steel plate.

B. Manufacturers: One of the following or equal:
   1. Dearborn Brass Company, Model Number 5358.
   2. Keeney Manufacturing Company, Model Number 102 or Number 105.

2.02 LINK TYPE SEALS

A. Characteristics:
   1. Modular mechanical type, consisting of interlocking neoprene or synthetic rubber links shaped to continuously fill the annular space between the pipe and wall opening.
   2. Assemble links solely with stainless steel bolts and nuts to form a continuous rubber belt around the pipe.
   3. Provide a nylon polymer pressure plate with Type 316 stainless steel hardware. Isolate pressure plate from contact with wall sleeve.

B. Manufacturers: One of the following or equal:
   1. Calpico, Incorporated.
   2. Pipeline Seal and Insulator, Inc., Link-Seal.

2.03 FLANGE BOLTS

A. Ductile iron pipe:
   1. Bolts and nuts for ductile iron pipe flanges located indoors, outdoors above ground, or in dry vaults and structures and where pressures do not exceed 150 pounds per square inch shall be hot-dip galvanized carbon steel, ASTM A 307, Grade B.
   2. Bolts and nuts for ductile iron pipe flanges located indoors, outdoors above ground, or in dry vaults and structures where the pressures exceed 150 pounds per square inch shall be alloy steel, ASTM A 193, Grade B7.
   3. Bolts and nuts for ductile iron pipe flanges submerged in water or wastewater, buried, in wet vaults or structures, adjacent to wet walls, or above open water-containing structures shall be Type 316 stainless steel in accordance with ASTM A 193, Grade B8M for bolts and in accordance with ASTM A 194, Grade 8M for nuts.
   4. Bolts and nuts for buried ductile iron pipe flanges shall be Type 316 stainless steel in accordance with ASTM A 193, Grade B8M for bolts and in accordance with ASTM A 194, Grade 8M for nuts.
   5. Provide a washer for each nut. Washer shall be of the same material as the nut.
   6. Nuts shall be Heavy hex-head, Type 2H.
   7. Cut and finish flange bolts to project a maximum of 1/4 inch beyond outside face of nut after assembly.
   8. Tap holes for cap screws or stud bolts when used.

B. Plastic pipe:
   1. Bolts and nuts for flanges on plastic pipe located indoors, outdoors above ground, or in dry vaults and structures shall be Type 316 stainless steel in accordance with ASTM A 193, Grade B8M for bolts and in accordance with ASTM A 194, Grade 8M for nuts.
   2. Bolts and nuts for flanges on plastic pipe submerged in water or wastewater, buried, in wet vaults or structures, adjacent to wet walls, or above open water-containing structures and plastic pipe carrying corrosive chemicals shall

be-Type 316 stainless steel in accordance with ASTM A 193, Grade B8M for bolts and in accordance with ASTM A 194, Grade 8M for nuts.

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

C. Steel pipe:
1. Bolts and nuts for ASME B16.5 Class 150 flanges and AWWA C207 Class D flanges located indoors, outdoors above ground, or in dry vaults and structures shall be hot-dip galvanized carbon steel, ASTM A 307, Grade B.
2. Bolts and nuts for ASME B16.5 and B16.47 Class 300 flanges and AWWA C207 Class E and F flanges located indoors, outdoors above ground, or in dry vaults and structures in accordance with ASTM A 193, Grade B7 for bolts and in accordance with ASTM A 194, Grade 2H for nuts.
3. Bolts and nuts for flanges submerged in water or wastewater, buried, in wet vaults or structures, adjacent to wet walls, or above open water-containing structures shall be Type 316 stainless steel in accordance with ASTM A 193, Grade B8M for bolts and in accordance with ASTM A 194, Grade 8M for nuts.
4. Provide a washer for each nut. Washer shall be of the same material as the nut.
5. Nuts shall be Heavy hex-head, Type 2H.
6. Cut and finish flange bolts to project a maximum of 1/4 inch beyond outside face of nut after assembly.
7. Tap holes for cap screws or stud bolts when used.

D. Lubricant for stainless steel bolts and nuts:
1. Chloride-free.
2. Manufacturers: One of the following or equal:
   a. Huskey FG-1800.

2.04 GASKETS

A. Gaskets for non-steam cleaned ductile iron and steel piping:
1. Suitable for pressures equal to and less than 150 pounds per square inch gauge, temperatures equal to or less than 250 degrees Fahrenheit, and raw sewage service.
2. Gasket material:
   a. Neoprene elastomer with minimum Shore A hardness value of 70.
   b. Reinforcement: Inserted 13-ounce nylon fabric cloth for pipes 20-inch or larger.
   c. Thickness: Minimum 3/32-inch thick for less than 10-inch pipe; minimum 1/8 inch thick for 10-inch and larger pipe.
3. Manufacturers: One of the following or equal:
   a. Pipe less than 20 inches in diameter:
      1) Garlock, Style 7797.
      2) John Crane, similar product.
   b. Pipe 20 inches in diameter and larger:
      1) Garlock, Style 8798.
      2) John Crane, similar product.

B. Gaskets for steam cleaned non glass-lined ductile iron and steel piping:
   1. Suitable for pressures equal and less than 150 pounds per square inch gauge, temperatures equal or less than 360 degrees Fahrenheit, and raw sewage service.
   2. Material:
      a. Neoprene elastomer, compressed, non-asbestos fiber reinforcement.
   3. Manufacturers: One of the following or equal:
      a. Garlock, Bluegard 3300.
      b. John Crane, similar product.

C. Gaskets for steam cleaned glass lined ductile iron piping:
   1. Suitable for pressures equal and less than 150 pounds per square inch gauge, temperatures equal and less than 360 degrees Fahrenheit, and sludge service.
   2. Material:
      a. Teflon® gasketing with 1/16-inch sheet thickness each side (1/8 inch total sheet thickness), filled with corrugated or perforated Type 316 stainless steel ring and non-asbestos filler material with minimum 5/16-inch overall thickness.
   3. Manufacturers: One of the following or equal:
      a. Garlock, Style HP3561.
      b. John Crane, similar product.

D. Gaskets for flanged joints in polyvinyl chloride and polyethylene piping:
   1. Suitable for pressures equal to or less than 150 pounds per square inch gauge, with low flange bolt loadings, temperatures equal and less than 120 degrees Fahrenheit, and polymer, chlorine, caustic solutions, and other chemicals, except chemicals which liberate free fluorine including fluorochemicals and gaseous fluorine.
   2. Material: 0.125-inch thick Viton® rubber.
   3. Manufacturers: One of the following or equal:
      a. Garlock.
      b. John Crane, similar product.
   4. Liquefied petroleum, propane, and natural gas applications in black steel piping: Suitable for pressures equal to or less than 250 pounds per square inch gauge, temperatures equal to or less than 100 degrees Fahrenheit, and liquefied petroleum gas, propane gas, and natural gas application.
   5. Material:
      a. Microcellular Teflon® outer layers with rigid center layer.
      b. Sealability in accordance with ASTM F 37, less than 0.55 millimeters per hour leakage of iso-octane at 1,000 pounds per square inch gasket load and 9.8 pounds per square inch fluid pressure.
   6. Manufacturers: One of the following or equal:
      a. Garlock, Style 3545.
      b. John Crane, similar product.

E. Gaskets for flanged joints in low pressure air piping:
   1. Suitable for pressures equal to or less than 150 pounds per square inch gauge, temperatures equal to or less than 300 degrees Fahrenheit, and compressed air service.
   2. Material: EPDM elastomer, 1/8 inch thick, 60 Shore hardness, smooth surface.
   3. Manufacturers: One of the following or equal:
      a. Garlock, Style 8314.
      b. John Crane, similar product.

F. Gaskets for flanged joints in ductile iron or steel water piping:
   1. Suitable for hot or cold water, pressures equal to or less than 150 pounds per square inch gauge, temperatures equal to or less than 160 degrees Fahrenheit.
   2. Material:
      a. Neoprene elastomer, compressed, with non-asbestos fiber reinforcement.
      b. Teflon® ring; or Teflon® envelope with non-asbestos filler.
   3. Manufacturers: One of the following or equal:
      a. Garlock, Bluegard 3300.
      b. John Crane, similar product.

G. Provide gaskets suitable for the specific fluids and pressure and temperature conditions.

2.05 LEAD LIMITS

A. Comply with NSF 61.

B. Pipe, pipe or plumbing fittings or fixtures, solder, or flux used to convey water for human consumption shall be Lead-free as defined in Section 116875 of the California Health and Safety Code.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verification of existing conditions:
   1. Locate and expose existing structures, piping, conduits, and other facilities and obstructions that may affect construction of underground piping before starting excavation for new underground piping and appurtenances.
   2. Verify sizes, elevations, locations, and other relevant features of existing facilities and obstructions. Determine conflicts for the construction of the new underground piping and appurtenances.
   3. Make piping location and grade adjustments to resolve conflicts between new piping and existing facilities and obstructions.

3.02 INSTALLATION

A. General:
   1. Piping drawings:
      a. Except in details, piping is indicated diagrammatically. Not every offset and fitting, or structural difficulty that may be encountered has been indicated on the Drawings. Sizes and locations are indicated on the Drawings.
      b. Perform minor modifications to piping alignment where necessary to avoid structural, mechanical, or other type of obstructions that cannot be removed or changed.
         1) Modifications are intended to be of minor scope, not involving a change to the design concept or a change to the Contract Price or Contract Times.
   2. Piping alternatives:
      a. Provide piping as specified in this Section, unless indicated on the Drawings or specified otherwise.

b. Alternative pipe ratings:
   1) Piping with greater pressure rating than specified may be substituted in lieu of specified piping without changes to the Contract Price.
   2) Piping of different material may not be substituted in lieu of specified piping.
c. Valves in piping sections: Capable of withstanding specified test pressures for piping sections and fabricated with ends to fit piping.
d. For flanged joints, where 1 of the joining flanges is raised face type, provide a matching raised face type flange for the other joining flange.

3. Unless otherwise indicated on the Drawings, piping at pipe joints, fittings, couplings, and equipment shall be installed without rotation, angular deflection, vertical offset, or horizontal offset.

B. Wall and slab penetrations:
1. Provide sleeves for piping penetrations through aboveground masonry and concrete walls, floors, ceilings, roofs, unless specified or otherwise indicated on the Drawings.
2. For piping 1 inch in nominal diameter and larger, provide sleeves with minimum inside diameters of 1 inch plus outside diameter of piping. For piping smaller than 1 inch in nominal diameter, provide sleeve of minimum twice the outside diameter of piping.
   a. Arrange sleeves and adjacent joints so piping can be pulled out of sleeves and replaced without disturbing the structure.
   b. Cut ends of sleeves flush with surfaces of concrete, masonry, or plaster.
   c. Conceal ends of sleeves with escutcheons where piping runs through floors, walls, or ceilings of finished spaces within buildings.
   d. Seal spaces between pipes and sleeves with link-type seals when not otherwise specified or indicated on the Drawings.
3. Provide flexibility in piping connecting to structures to accommodate movement due to soil settlement and earthquakes. Provide flexibility using details indicated on the Drawings.
4. Core drilled openings:
   a. Do not damage or cut existing reinforcing bars, electrical conduits, or other items embedded in the existing concrete without acceptance by ENGINEER.
   b. Determine location of reinforcing bars or other obstructions with a non-destructive indicator device.
   c. Remove dust and debris from hole using compressed air.

C. Exposed piping:
1. Install exposed piping in straight runs parallel to the axes of structures, unless otherwise indicated on the Drawings:
   a. Install piping runs plumb and level, unless otherwise indicated on the Drawings.
      1) Slope plumbing drain piping with a minimum of 1/4 inch per foot downward in the direction of flow.
      2) Slope digester gas piping to drip traps or low-point drains at a minimum of 1/2 inch per foot where condensate flows against the gas, or at a minimum of 1/4 inch per foot where condensate flows with gas.
2. Install exposed piping after installing equipment and after piping and fitting locations have been determined.
3. Support piping: As specified in Sections 15061, 15062, and 15063:
   a. Do not transfer pipe loads and strain to equipment.

4. In addition to the joints indicated on the Drawings, provide unions, flexible couplings, flanged joints, flanged coupling adapters, and other types of joints or means which are compatible with and suitable for the piping system, and necessary to allow ready assembly and disassembly of the piping.
5. Assemble piping without distortion or stresses caused by misalignment:
    a. Match and properly orient flanges, unions, flexible couplings, and other connections.
    b. Do not subject piping to bending or other undue stresses when fitting piping.
    c. Do not correct defective orientation or alignment by distorting flanged joints or subjecting flange bolts to bending or other undue stresses.
    d. Flange bolts, union halves, flexible connectors, and other connection elements shall slip freely into place.
    e. Alter piping assembly to fit, when proper fit is not obtained.
    f. Install eccentric reducers or increasers with the top horizontal for pump suction piping.

D. Buried piping:
1. Bury piping with minimum 3-foot cover without air traps, unless otherwise indicated on the Drawings.
2. Where 2 similar services run parallel to each other, piping for such services may be laid in the same trench.
    a. Lay piping with sufficient room for assembly and disassembly of joints, for other structures, and to meet separation requirements of public health authorities having jurisdiction.
3. Laying piping:
    a. Lay piping in finished trenches free from water or debris. Begin at the lowest point with bell ends up slope.
    b. Place piping with top or bottom markings with markings in proper position.
    c. Lay piping on an unyielding foundation with uniform bearing under the full length of barrels.
    d. Where joints require external grouting, banding, or pointing, provide space under and immediately in front of the bell end of each section laid with sufficient shape and size for grouting, banding, or pointing of joints.
    e. At the end of each day's construction, plug open ends of piping temporarily to prevent entrance of debris or animals.
4. Concrete encase all buried pipe installed under concrete slabs or structures.

E. Venting piping under pressure:
1. Lay piping under pressure flat or at a continuous slope without air traps, unless otherwise indicated on the Drawings.
2. Install plug valves as air bleeder cocks at high points in piping.
    a. Provide 1-inch plug valves for water lines, and 2-inch plug valves for sewage and sludge lines, unless otherwise indicated on the Drawings.
3. Provide additional pipe taps with plug cocks and riser pipes along piping as required for venting during initial filling, disinfecting, and sampling.
4. Before piping is placed into service, close plug valves and install plugs. Protect plugs and plug valves from corrosion in as specified in Section 09960.

F. Condensate in foul air piping:
1. Slope foul air piping to low-point drains at minimum 1/4 inch per foot where condensate flows against the gas or 1/8 inch per foot where condensate flows with gas.

2. Install tapered filler pieces between flanges at high points of straight runs to provide for slope reversals.
    a. Do not subject piping to high stresses in order to change direction.
3. Provide pipe taps, threaded nipples, and 1-inch plug valves at low points in concrete utility boxes with lids.

G. Restraining piping:
1. Restrain piping at valves and at fittings where piping changes direction, changes sizes, and at ends:
    a. When piping is underground, use mechanical restraints or push-on restraints. Do not use thrust blocks.
    b. When piping is aboveground or underwater, use mechanical or structural restraints.
    c. Determine thrust forces by multiplying the nominal cross sectional area of the piping by design test pressure of the piping.
2. Provide restraints with ample size to withstand thrust forces resulting from test pressures:
    a. During testing, provide suitable temporary restraints where piping does not require permanent restraints.
3. Place concrete so piping joints, fittings, and other appurtenances are accessible for assembly and disassembly.
4. Provide underground mechanical restraints where specified in the Piping Schedule.

H. Connections to existing piping:
1. Expose existing piping to which connections are to be made with sufficient time to permit, where necessary, field adjustments in line, grade, or fittings:
    a. Protect domestic water/potable water supplies from contamination:
        1) Make connections between domestic water supply and other water systems in accordance with requirements of public health authorities.
        2) Provide devices approved by OWNER of domestic water supply system to prevent flow from other sources into the domestic supply system.
2. Make connections to existing piping and valves after sections of new piping to be connected have been tested and found satisfactory.
3. Provide sleeves, flanges, nipples, couplings, adapters, and other fittings needed to install or attach new fittings to existing piping and to make connections to existing piping.
4. For flanged connections, provide stainless steel bolts with isolation bushings and washers, and full-face flange gaskets.

I. Connections between ferrous and nonferrous metals:
1. Connect ferrous and nonferrous metal piping, tubing, and fittings with dielectric couplings especially designed for the prevention of chemical reactions between dissimilar metals.
2. Nonferrous metals include aluminum, copper, and copper alloys.

J. Flanged connections between dissimilar metals such as ductile iron pipe and steel pipe:
1. Provide stainless steel bolts with isolation bushings and washers, and full-face flange gaskets.

3.03 CLEANING

A. Piping cleaning:
   1. Upon completion of installation, clean piping interior of foreign matter and debris.
   2. Perform special cleaning when required by the Contract Documents.

B. Cleaning potable water piping:
   1. Flush and disinfect potable water piping as specified in Section 01757.

C. Cleaning air piping:
   1. Perform special cleaning of filtered air piping from the intake clean air plenums to the discharge points and high-pressure air piping.
      a. Protect surfaces from contamination.
   2. Special cleaning shall include wire brushing, power tool cleaning, wiping down with lint-free cloths, brooming, and vacuuming to remove rust, scale, weld spatter, dust, dirt, oil, and other matter deleterious to operation of the air system:
      a. Do not sandblast installed piping.
   3. To the greatest extent possible, clean piping immediately prior to final closure of piping systems:
      a. Enter piping, clean and wipe down surfaces, and vacuum out residue.
      b. Clean surfaces not accessible to this cleaning operation after installation within 6 hours preceding installation.
   4. Subsequent to cleaning, protect surfaces from contamination by dust, dirt, construction debris, and moisture, including atmospheric moisture:
      a. Whether or not pipe upstream has been cleaned, temporarily seal openings in partially completed work except when installation is actively in progress.
      b. When installation is actively in progress, seal openings at the end of each day's construction or when construction is temporarily stopped.
   5. Suspend cleaning and seal openings when inclement weather, including dust storms, is imminent.
   6. Use clean, dry air for testing the piping and other elements of the system.
   7. Prior to introduction of air to the system, blow piping clean.
      a. Blow with maximum discharge rate possible for minimum 4 hours, using new blowers or compressors and filters.
   8. Clean surfaces that become contaminated prior to acceptance.

3.04 PIPING SCHEDULE

A. Abbreviations:
   1. The following abbreviations used in the column of test method refer to the respective methods specified in Section 15956.

Abbreviation	Definition
AM	Air Method
GR	Gravity Flow Method
HH	High Head Method

Abbreviation	Definition
LH	Low Head Method
SC	Special Case

2. Abbreviations to designate piping include the following:

Abbreviation	Definition
BSP	Black Steel Pipe
CIP	Cast Iron Pipe
CISP	Cast Iron Soil Pipe
CPVC	Chlorinated Polyvinyl Chloride
CSP	Corrugated Steel Pipe
CUP	Copper Pipe
DIP	Ductile Iron Pipe
FRP	Fiberglass Reinforced Plastic Pipe
GSP	Galvanized Steel Pipe
HDPE	High Density Polyethylene
PE	Polyethylene
PP	Polypropylene
PVC	Polyvinyl Chloride
RCP	Reinforced Concrete Pipe
SST	Stainless Steel
STL	Steel
VCP	Vitrified Clay Pipe

3. Abbreviations to designate pipe lining include the following:

Abbreviation	Definition
CM	Cement Mortar
EC	Epoxy-Ceramic
GL	Glass Lined
PO	100% Solids Elastomeric Polyurethane

4. Abbreviations to designate pipe coating include the following:

Abbreviation	Definition
CM	Cement Mortar
EPU	High Solids Epoxy and Polyurethane System per Section 09960
HSE	High Solids Epoxy System per Section 09960
PE	Polyethylene Encasement per Section 15211
PTW	Plastic Tape Wrap
WAE	Waterborne Acrylic Emulsion per Section 09960

5. Abbreviations designate pipe service include the following:

Abbreviation	Definition
AA	Aeration Air
ALUM	Aluminum Sulfate or Polyaluminum Chloride
CHD	Chemical Drain or Vent
CN	Condensate Drain
CW	Cold Water
D	Drain
DEC	Decant
EEX	Engine Exhaust
FAD	Foul Air Duct
FAP	Foul Air Pipe
FBW	Filter Backwash
FE	Filter Effluent
FIL	Filtrate
FM	Force Main
FOR	Fuel Oil Return
FOS	Fuel Oil Supply
FSW	Fire Supply Water
HPA	High Pressure Air
HW	Hot Water
IRRIG	Irrigation
ML	Mixed Liquor
NG	Natural Gas
OOCR	Out-of-Compliance Return
PD	Plant Drain or Process Drain
PDFM	Plant Drain Force Main
POL	Polymer
PW	Plant Water or Utility Water
RAS	Return Activated Sludge
REW	Recycled or Reclaimed Water
RL	Refrigerant Liquid
RV	Refrigerant Vapor
SA	Sample Line
SC	Scum
SD	Storm Drain
SE	Secondary Effluent

Abbreviation	Definition
SEP	Septage
SHS	Sodium Hypochlorite Solution
SI	Secondary Influent
SPD	Sump Pump Discharge
SS	Sanitary Sewer
SSD	Structure Subsurface Drain
STW	Storm Water (Pumped)
TWAS	Thickened Waste Activated Sludge
V	Vent
VP	Vent Piping
W1	Potable Water For Human Consumption
W2	Non-Potable Water for Process
WAS	Waste Activated Sludge

1. Abbreviations designate pipe joints/fittings include the following:

Abbreviation	Definition
B&S	Butt and Strap
BF	Butt Fusion
FL	Flange
GE	Grooved End
RMJ	Restrained Mechanical Joint
RPO	Restrained Push-On
SCRD	Screwed
SF	Spot-Faced
SW	Socket Weld
WLD	Welded

2. Other Useful Abbreviations:

Abbreviation	Definition
<	Less Than
≤	Less Than or Equal To
>	Greater Than
≥	Greater Than or Equal To

(The PIPING SCHEDULE follows on the next pages).

PIPE SCHEDULE

Flow Stream Identifier	Service	Nominal Diameter (inches)	Materials	Class, Schedule, or Thickness	Joints/ Fittings	Test Pressure/ Method	Lining	Coating	Comments
AA	**Aeration Air (for Sludge Storage Tanks)**								
	Exposed	≤4	BSP	Sch. 40	WLD or FL	20 psig/AM	None	EPU	Note 1
	Exposed	>4	BSP	Sch. 40	WLD or FL	20 psig/AM	None	EPU	Note 1
	Submerged	All	316L SST	Sch. 10S	WLD or FL	20 psig/AM	None	None	
Acid Waste and Vent									
	Exposed	All	PP	Sch. 40	Electrofusion	TBD	None	None	
	Exposed	All	PP	Sch. 40	Electrofusion	TBD	None	None	
ALUM	**Aluminum Sulfate or Polyaluminum Chloride**								
	Exposed	All	CPVC	Sch. 80	SW or FL	125 psig/HH	None	WAE	
	Buried	All	PVC	Sch. 80	SW	125 psig/HH	None	None	Note 2
	Submerged	All	PVC	Sch. 80	SW	125 psig/HH	None	None	
CHD	**Chemical Drain or Vent**								
	Exposed	All	CPVC	Sch. 80	SW	25 psig/HH	None	WAE	
	Buried	All	CPVC	Sch. 80	SW	25 psig /HH	None	None	
	Submerged	All	CPVC	Sch. 80	SW	25 psig /HH	None	None	
CD	**Condensate Drain**								
	Exposed in Administration and Maintenance Buildings	<2	Copper	Type L	Soldered/Pressfit	10 psig/AM	None	None	
CW	**Cold Water**								
	Exposed	<2	Copper	Type L	Soldered/Pressfit	150 psig/HH	None	None	Note 3
	Buried	≤3	Copper	Type K	Soldered	150 psig/HH	None	PTW	Note 3

PIPE SCHEDULE

Flow Stream Identifier	Service	Nominal Diameter (inches)	Materials	Class, Schedule, or Thickness	Joints/ Fittings	Test Pressure/ Method	Lining	Coating	Comments
D	**Drain**								
	Exposed	<4	PVC	Sch. 80	SW	25 psig/HH	None	None	
	Exposed	≥4	DIP	Class 53	FL or GE	25 psig/HH	CM	EPU	
	Buried	4-18	PVC	AWWA C900/C905	Restrained	25 psig/HH	None	None	
	Buried	≥20	DIP	Class 53	RPO or RMJ	25 psig/HH	CM	PE	
	Submerged	<4	316L SST	Sch. 40S	FL or WLD	25 psig/HH	None	None	
	Submerged	≥4	DIP	Class 53	FL	25 psig/HH	CM	HSE	
DEC	**Decant**								
	Exposed	<4	PVC	Sch. 80	SW	25 psig/HH	None	WAE	
	Exposed	≥4	DIP	Class 53	FL or GE	25 psig/HH	CM	EPU	
	Buried	≥4	DIP	Class 53	RPO or RMJ	25 psig/HH	CM	PE	
Deionized Water									
	Exposed	All	LXT (Low-Extractable) PVC	Sch. 80	LXT one-step cement	50 psig/HH	None	None	Note 3
	Buried	All	LXT PVC	Sch. 80	LXT one-step cement	50 psig/HH	None	None	Note 3
EEX	**Engine Exhaust**								
	Exposed	All	SST	ASTM A358, Class 1, Type 321/347, Sch. 10S	FL or WLD	25 psig/AM	None	None	Note 1
FAD/FAP	**Foul Air Duct/Pipe**								
	All	All	FRP	Note 12	Contact molded/FL or B&S	5x Rated Press/AM	None	Note 12	

PIPE SCHEDULE

Flow Stream Identifier	Service	Nominal Diameter (inches)	Materials	Class, Schedule, or Thickness	Joints/ Fittings	Test Pressure/ Method	Lining	Coating	Comments
FBW	**Filter Backwash (Dewatering)**								
	Exposed	<4	304L SST	SCH 40S	WLD	50 psig/HH	None	None	
	Exposed	≥4	DIP	Class 53	GE or FL	50 psig/HH	CM	EPU	
	Buried	≥4	DIP	Class 53	RPO or RMJ	50 psig/HH	CM	PE	
	Submerged	≥4	DIP	Class 53	FL	50 psig/HH	CM	HSE	
FBW	**Filter Backwash (Tertiary Filters)**								
	Exposed	All	DIP	Class 53	SCRD	10 psig/LH	CM	EPU	
FD	**Floor Drain**								
	Exposed	All	DIP	Class 53	SCRD	10 psig/LH	CM	EPU	
	Buried	All	CISP	ASTM A 74	Push on	10 psig/LH	Bituminous	Bituminous	
FE	**Filter Effluent**								
	Exposed	All	DIP	Class 53	GE or FL	25 psig/HH	CM	EPU	
	Buried	All	DIP	Class 53	RPO or RMJ	25 psig/HH	CM	PE	
FIL	**Filtrate (Dewatering)**								
	Exposed	4-12	DIP	Class 53	GE	10 psi/LH	EC	EPU	
	Buried	4-12	DIP	Class 53	RPO or RMJ	10 psi/LH	EC	PE	
	Submerged	4-12	DIP	Class 53	FL	10 psi/LH	EC	HSE	
FM	**Force Main**								
	Exposed	All	DIP	Class 53	FL	50 psig/HH	EC	EPU	
	Buried	All	PVC	AWWA C900/C905	Restrained	50 psig/HH	None	None	

PIPE SCHEDULE									
Flow Stream Identifier	**Service**	**Nominal Diameter (inches)**	**Materials**	**Class, Schedule, or Thickness**	**Joints/ Fittings**	**Test Pressure/ Method**	**Lining**	**Coating**	**Comments**
FOR	**Fuel Oil Return**								
	Exposed	All	BSP	A53 Sch. 40, Pickled	Black Malleable Iron, 150 Pound, Pickled	125 psig/HH	None	None	
	Buried	All	BSP	A53 Sch. 40, Pickled	Black Malleable Iron, 150 Pound, Pickled	125 psig/HH	None	None	Note 2
FOS	**Fuel Oil Supply**								
	Exposed	All	BSP	A53 Sch. 40, Pickled	Black Malleable Iron, 150 Pound, Pickled	125 psig/HH	None	None	
	Buried	All	BSP	A53 Sch. 40, Pickled	Black Malleable Iron, 150 Pound, Pickled	125 psig/HH	None	None	Note 2
FSW	**Fire Supply Water**								
	Exposed	≥6	DIP	Class 53	RPO or RMJ	100 psig/HH	CM	EPU	Note 3
	Exposed	<6	Per Section 13930	Per Section 13930	Per Section 13930	Per Section 13930	Per Section 13930	Per Section 13930	Notes 3, 9
	Buried	≥4	DIP	Class 53	RPO or RMJ	100 psig/HH	CM	PE	Note 3
HPA	**High Pressure Air**								
	Exposed	<4	316L SST	Sch. 40S	WLD	225 psig AM	None	None	
HW	**Hot Water**								
	Exposed	<2	Copper	Type L	Soldered/Pressfit	150 psig/HH	None	None	Notes 3
	Buried	≤3	Copper	Type K	Soldered	150 psig/HH	None	PTW	Notes 3
IRRIG	**Irrigation**								
	Buried	All	Note 11	Note 11	Note 11	60 psig/HH	None	None	

PIPE SCHEDULE

Flow Stream Identifier	Service	Nominal Diameter (inches)	Materials	Class, Schedule, or Thickness	Joints/ Fittings	Test Pressure/ Method	Lining	Coating	Comments
ML	**Mixed Liquor**								
	Exposed	All	DIP	Class 53	GE or FL	50 psig/HH	CM	EPU	
	Buried	All	DIP	Class 53	RPO or RMJ	50 psig/HH	CM	PE	
NG	**Natural Gas**								
	Exposed in Administration and Maintenance Buildings	<3	BSP	Sch. 40S	Threaded	50 psig/AM	None	None	
	Exposed Elsewhere	<4	316 SST	Sch. 40S	WLD	100 psig/AM	None	None	
	Exposed Elsewhere	>4	316 SST	Sch. 20S	WLD	100 psig/AM	None	None	
	Buried	All	PE	ASTM D 2513, SDR 11	BF or SF	100 psig/AM	None	None	Note 5
OOCR	**Out-of-Compliance Return**								
	Exposed	>10	DIP	Class 53	FL	175 psig/HH	CM	EPU	
	Buried	>10	DIP	Class 53	RMJ or RPO	175 psig/HH	CM	PE	
	Submerged	>10	DIP	Class 53	FL	175 psig/HH	CM	HSE	
PD	**Plant Drain or Process Drain (Upstream of Plant Drain Pumps)**								
	Exposed	<4	PVC	Sch. 80	SW	10 psig/LH	None	WAE	
	Exposed	≥4	DIP	Class 53	FL or GE	10 psig/LH	CM	EPU	
	Buried	>4	PVC	AWWA C900/C905, SDR 18	Restrained	10 psig/LH	None	None	
	Submerged	<4	PVC	Sch. 80	SW	10 psig/LH	None	HSE	
	Submerged	≥4	DIP	Class 53	FL	10 psig/LH	CM	HSE	

PIPE SCHEDULE									
Flow Stream Identifier	**Service**	**Nominal Diameter (inches)**	**Materials**	**Class, Schedule, or Thickness**	**Joints/ Fittings**	**Test Pressure/ Method**	**Lining**	**Coating**	**Comments**
PDFM	**Plant Drain Force Main (Downstream of Plant Drain Pumps)**								
	Exposed	≥4	DIP	Class 53	FL or GE	50 psig/HH	CM	EPU	
	Buried	≥4	DIP	Class 53	RPO or RMJ	50 psig/HH	CM	PE	
	Submerged	≥4	DIP	Class 53	FL	50 psig/HH	CM	HSE	
POL	**Polymer**								
	Exposed	All	CPVC	Sch. 80	SW	125 psig/HH	None	WAE	Note 4
	Buried	All	PVC	Sch. 80	SW	125 psig/HH	None	None	Note 2
	Submerged	All	PVC	Sch. 80	SW	125 psig/HH	None	None	
PW	**Plant Water/Utility Water**								
	Exposed	<4	316 SST	Sch. 40S	WLD, FL	150 psig/HH	None	None	
	Exposed	≥4	DIP	Class 53	FL	150 psig/HH	CM	EPU	
	Buried	<4	PVC	Sch. 80	SW	150 psig/HH	None	None	
	Buried	≥4	DIP	Class 53	RMJ or RPO	150 psig/HH	CM	PE	
	Submerged	<4	316 SST	Sch. 40S	WLD, FL	150 psig/HH	None	None	
	Submerged	≥4	DIP	Class 53	FL or GE	150 psig/HH	CM	EPU	
RAS	**Return Activated Sludge**								
	Exposed	≥4	DIP	Class 53	FL or GE	50 psig/HH	CM	EPU	
	Buried	≥4	DIP	Class 53	RMJ or RPO	50 psig/HH	CM	PE	
	Submerged	≥4	DIP	Class 53	FL or GE	50 psig/HH	CM	HSE	
REW	**Recycled or Reclaimed Water (Downstream of Effluent Pumps)**								
	Exposed	>4	DIP	Class 53	FL	175 psig/HH	CM	EPU	
	Buried	≥4	DIP	Class 53	RMJ or RPO	175 psig/HH	CM	PE	
	Submerged	>4	DIP	Class 53	FL	175 psig/HH	CM	HSE	

PIPE SCHEDULE									
Flow Stream Identifier	**Service**	**Nominal Diameter (inches)**	**Materials**	**Class, Schedule, or Thickness**	**Joints/ Fittings**	**Test Pressure/ Method**	**Lining**	**Coating**	**Comments**
REW	**Recycled or Reclaimed Water (Upstream of Effluent Pumps)**								
	Exposed	≥4	DIP	Class 53	FL	25 psig/HH	CM	EPU	
	Buried	≥4	DIP	Class 53	FL	25 psig/HH	CM	PE	Note 6
	Submerged	≥4	DIP	Class 53	FL	25 psig/HH	CM	HSE	
RL	**Refrigerant Liquid**								
	Exposed	≤3	Copper	ASTM B 280	Soldered	150 psig/AM	None	None	
RV	**Refrigerant Vapor**								
	Exposed	≤3	Copper	ASTM B 280	Soldered	225 psig/AM	None	None	
SA	**Sample Line**								
	Exposed	All	CPVC	Sch. 80	SW	125 psig/HH	None	WAE	
	Buried	All	PVC	Sch, 80	SW	125 psig/HH	None	None	
	Submerged	All	PVC	Sch, 80	SW	125 psig/HH	None	None	
SC	**Scum**								
	Exposed	<4	316 SST	Sch. 40S	WLD	75 psig/HH	None	None	
	Exposed	≥4	DIP	Class 53	GE	75 psig/HH	EC	EPU	
	Buried	≥4	DIP	Class 53	RPO or RMJ	75 psig/HH	EC	PE	
	Submerged	<4	316 SST	Sch. 40S	WLD	75 psig/HH	None	None	
	Submerged	≥4	DIP	Class 53	FL	75 psig/HH	EC	HSE	

PIPE SCHEDULE									
Flow Stream Identifier	**Service**	**Nominal Diameter (inches)**	**Materials**	**Class, Schedule, or Thickness**	**Joints/ Fittings**	**Test Pressure/ Method**	**Lining**	**Coating**	**Comments**
SD	**Storm Drain (Gravity)**								
	Buried	≤18	PVC	AWWA C900/C905	Push on	5 psig/LH	None	None	
	Buried	>18	Corrugated HDPE	ASTM D 3350	Push on	15 psig/LH	None	None	
SE	**Secondary Effluent**								
	Exposed	≥4	DIP	Class 53	FL or GE	25 psig/HH	CM	EPU	
	Buried	≥4	DIP	Class 53	RPO or RMJ	25 psig/HH	CM	PE	
SEP	**Septage**								
	Exposed	≥4	DIP	Class 53	FL or GE, Long Radius	100 psig/HH	GL	EPU	
	Buried	≥4	DIP	Class 53	RPO or RMJ, Long Radius	100 psig/HH	GL	PE	
	Submerged	≥4	DIP	Class 53	FL, Long Radius	100 psig/HH	GL	HSE	
SHS	**Sodium Hypochlorite Solution**								
	Exposed	All	CPVC	Sch. 80	SW or FL	150 psig/HH	None	WAE	
	Buried	All	PVC	Sch. 80	SW	150 psig/HH	None	None	Note 2
SI	**Secondary Influent**								
	Exposed	≥4	DIP	Class 53	FL or GE	15 psig/LH	CM	EPU	
	Buried	≥4	DIP	Class 53	RPO or RMJ	15 psig/LH	CM	PE	
SPD	**Sump Pump Discharge**								
	Exposed	<4	CPVC	Sch. 80	SW or FL	25 psig/HH	None	WAE	
	Exposed	≥4	DIP	Class 53	FL or GE	25 psig/HH	CM	EPU	
	Buried	≤3	CPVC	Sch. 80	SW	25 psig/HH	None	None	

PIPE SCHEDULE									
Flow Stream Identifier	**Service**	**Nominal Diameter (inches)**	**Materials**	**Class, Schedule, or Thickness**	**Joints/ Fittings**	**Test Pressure/ Method**	**Lining**	**Coating**	**Comments**
	Buried	>4	PVC	AWWA C900/C905	Restrained	25 psig/HH	None	None	
	Submerged	<4	GSP	Sch. 40	SCRD	25 psig/HH	None	EPU	
	Submerged	≥4	DIP	Class 53	FL	25 psig/HH	None	HSE	
SS	**Sanitary Sewer**								
	Buried in Administration and Maintenance Buildings	<4	ABS	Sch. 40	SW	25 psig/HH	None	None	
	Buried Elsewhere	4-18	PVC	AWWA C900/C905	Restrained	25 psig/HH	None	None	
	Buried	>18	DIP	Class 53	RPO or RMJ	25 psig/HH	CM	PE	
SSD	**Structure Subsurface Drain**								
	Buried	All	PVC	SDR 26, Perforated	Push on	None	None	None	Note 10
STW	**Storm Water (Pumped)**								
	Exposed	≥4	DIP	Class 53	FL or GE	50 psig/HH	CM	EPU	
	Buried	≥4	PVC	AWWA C900/C905	Restrained	50 psig/HH	None	None	
TWAS	**Thickened Waste Activated Sludge (Downstream of Sludge Storage Tanks)**								
	Exposed	≥4	DIP	Class 53	FL or GE	100 psig/HH	GL	EPU	
	Buried	≥4	DIP	Class 53	RPO or RMJ	100 psig/HH	GL	PE	
	Submerged	≥4	DIP	Class 53	FL	100 psig/HH	GL	HSE	

PIPE SCHEDULE									
Flow Stream Identifier	**Service**	**Nominal Diameter (inches)**	**Materials**	**Class, Schedule, or Thickness**	**Joints/ Fittings**	**Test Pressure/ Method**	**Lining**	**Coating**	**Comments**
V	**Vent**								
	Exposed in Administration and Maintenance Buildings	≤4	ABS	Sch. 40	SW	10” WC/LP	None	None	
Vacuum Piping									
	Exposed	All	Copper	Type L	Soldered	TBD	None	None	Note 3
	Buried	All	Copper	Type L	Soldered	TBD	None	None	Note 3
VP	**(Process) Vent Piping**								
	Exposed	<4	316L SST	Sch. 40	WLD	50 psig/HH	None	None	
	Buried	<4	316L SST	Sch. 40	WLD	50 psig/HH	None	None	
	Submerged	<4	316L SST	Sch. 40	WLD	50 psig/HH	None	None	
W1	**Potable Water for Human Consumption**								
	Exposed	<4	GSP	Sch. 40	SCRD	100 psig/HH	None	EPU	Notes 3, 8
	Exposed	≥4	DIP	Class 53	FL or GE	100 psig/HH	CM	EPU	Notes 3, 8
	Buried	<4	CPVC	Sch. 80	SW	100 psig/HH	None	None	Note 3
	Buried	≥4	DIP	Class 53	RPO or RMJ	100 psig/HH	CM	PE	Note 3
	Submerged	<4	GSP	Sch. 40	SCRD	100 psig/HH	None	HSE	Note 3
	Submerged	≥4	DIP	Class 53	FL	100 psig/HH	CM	HSE	Note 3
W2	**Non-Potable Water for Process**								
	Exposed	<4	GSP	Sch. 40	SCRD	100 psig/HH	None	EPU	Notes 3, 8
	Exposed	≥4	DIP	Class 53	FL or GE	100 psig/HH	CM	EPU	Notes 3, 8
	Buried	<4	CPVC	Sch. 80	SW	100 psig/HH	None	None	Note 3

PIPE SCHEDULE

Flow Stream Identifier	Service	Nominal Diameter (inches)	Materials	Class, Schedule, or Thickness	Joints/ Fittings	Test Pressure/ Method	Lining	Coating	Comments
	Buried	≥4	DIP	Class 53	RPO or RMJ	100 psig/HH	CM	PE	Note 3
	Submerged	<4	GSP	Sch. 40	SCRD	100 psig/HH	None	HSE	Note 3
	Submerged	≥4	DIP	Class 53	FL	100 psig/HH	CM	HSE	Note 3
WAS	**Waste Activated Sludge**								
	Exposed	≥4	DIP	Class 53	FL or GE	100 psig/HH	EC	EPU	
	Buried	≥4	DIP	Class 53	RPO or RMJ	100 psig/HH	EC	PE	
	Submerged	≥4	DIP	Class 53	FL	100 psig/HH	EC	HSE	

Notes:

(1) Provide piping insulation in accordance with Section 15082.
(2) Provide engineered secondary containment piping system that consists of carrier piping and containment piping and in accordance with Section 15293.
(3) Disinfection of piping is required.
(4) Following pressure testing, dry neat polymer piping between tank/tote and polymer feed equipment with hot dry air prior to placing in service.
(5) Natural gas piping from Los Osos Valley Road up to and including the natural gas pressure regulating valve and meter will be furnished and installed by the utility provider. The CONTRACTOR shall provide excavation and backfill for the utility provider's installation of that piping. In addition, the natural gas system within the LOWRF downstream the pressure regulating valve and meter will be the sole responsibility of the CONTRACTOR. Refer to Section 01010 for additional information.
(6) Buried recycled water piping at locations other than the Effluent Pump Station.
(7) Buried recycled water piping at the Effluent Pump Station.
(8) Metallic piping shall not be provided within chemical containment areas. Provide PVC Sch. 80 piping instead .
(9) All Fire Supply Water piping components shall be in accordance with Section 13930, as indicated on the Drawings, and as approved by Fire Marshall.
(10) Provide perforated pipe with two rows of 1/2-inch diameter holes every 5 inches, parallel to pipe axis, and 120 degrees apart.
(11) Refer to landscaping drawings for requirements on irrigation pipes.
(12) As specified in Section 15814.

General Notes:

(A) All DIP and fabricated steel piping in buried applications shall be provided with corrosion protection and corrosion monitoring facilities.
(B) All buried piping under concrete slabs and/or structures shall be concrete encased.
(C) All buried piping shall have underground warning tape.
(D) Stainless steel piping shall not be lined or coated.
(E) Field welding of stainless steel piping will not be allowed.

END OF SECTION

SECTION 15053

SEISMIC RESTRAINTS FOR PIPING

PART 1 GENERAL

1.01 SUMMARY

A. This Section specifies seismic restraints for bracing all piping and ductwork.
   1. This Section does not include seismic restraints for fire sprinkler systems.

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 01410 - Code Requirements.
      b. Section 01612 - Seismic Design Criteria.
      c. Section 15052 - Common Work Results for General Piping.
      d. Section 15054 - Expansion Control for Piping.
      e. Section 15061 - Pipe Supports.

C. Operating Conditions:
   1. Seismic restraints specified in this Section are provided to resist pipe movements and loads that result from an earthquake or other seismic event.
   2. All piping systems shall be provided with seismic restraints conforming to governing state and local codes.
   3. Seismic restraints shall conform to guidelines given in the Sheet Metal and Air Conditioning Contractors' National Association (SMACNA) Seismic Restraint Manual for the Seismic Hazard Level specified in Section 01612 and, at a minimum, be consistent with requirements of governing state and local codes.
   4. In case of conflict, the more stringent requirements specified in Section 01612 or governing state or local code shall be followed.

D. Restraint Selection:
   1. Piping systems shall not be braced to dissimilar parts of a building or to dissimilar building systems that may respond in a different mode during an earthquake. Examples: wall and a roof; solid concrete wall and a metal deck with lightweight concrete fill.
   2. Restraints shall be sized to fit outside diameter of pipe, tubing, or, where specified, outside diameter of insulation.
   3. There shall be no contact between a pipe and restraint component of dissimilar metals. CONTRACTOR shall prevent contact between dissimilar metals when restraining copper tubing by using copper-plated, rubber, plastic or vinyl-coated, or stainless steel restraint components.

4. Branch lines shall not be used to brace main lines.
5. Seismic bracing shall not limit expansion and contraction of the piping system.

1.02 REFERENCES

A. American Institute of Steel Construction (AISC):
   1. Manual of Steel Construction, Allowable Stress Design - 9th Edition.

B. Metal Framing Manufacturers Association (MFMA):
   1. MFMA-2 - Metal Framing Standards Publication.
   2. MFMA-101 - Guidelines for the Use of Metal Framing.

C. American National Standard Institute or Manufacturer's Standardization Society (ANSI/MSS):
   1. SP-58 - Standard for Pipe Hangers and Supports - Materials, Design, and Manufacture.
   2. SP-69 - Standard for Pipe Hangers and Supports - Selection and Application.
   3. SP-89 - Standard for Pipe Hangers and Supports - Fabrication and Installation Practices.

D. American National Standard Institute/National Fire Protection Association:
   1. ANSI/NFPA 70.

E. National Fire Protection Association (NFPA):
   1. NFPA 13 - Installation of Sprinkler Systems.
   2. NFPA 14 - Standpipe and Hose Systems.

F. Sheet Metal and Air Conditioning Contractors' National Association (SMACNA):
   1. Seismic Restraint Guidelines for Mechanical Systems.

1.03 DEFINITIONS

A. Longitudinal Direction: Direction parallel to the pipe axis.

B. Lateral Direction: Direction perpendicular to the pipe axis.

1.04 DESIGN

A. Seismic restraint system shall be designed by the DESIGN PROFESSIONAL as required in Section 15061.

B. Seismic restraint details shall be designed in conjunction with preparation of pipe system hangers and drawings.

1.05 SUBMITTALS

A. Per Section 15061.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Standard pipe restraints and components shall be manufactured by Carpenter & Patterson, B-Line, Kin-Line, ITT Grinnell, Michigan, Pipe Shields Incorporated, Superstrut, Unistrut, or equal.

B. Pipe restraint materials, design, manufacture, testing, installation, and application shall conform to the requirements of MSS SP-58, MSS-SP-69, MSS-SP-89, MFMA-2, and MFMA-101.

2.02 MATERIALS

A. Unless otherwise specified, restraints, including braces, pipe and structural attachments, shall match the pipe support material as specified in Section 15061.

B. Nuts, bolts, and washers shall match materials specified for the nuts, bolts, and washers in Section 15061.

C. For corrosive areas specifically requiring fiberglass materials. In those areas, all pipe support, anchor, and brace components (not just fittings and accessories) shall be made of fiberglass.

2.03 THERMAL PIPE HANGER SHIELD

A. Thermal shields shall be provided at seismic restraint locations on pipe requiring insulation.

B. Thermal pipe hanger shields shall be as specified in Section 15061.

C. Stainless steel band clamps shall be provided on thermal shields at longitudinal pipe restraint locations.

PART 3 EXECUTION

3.01 PIPE RESTRAINT LOCATIONS

A. The first seismic restraint on a piping system shall be located not more than 10 feet from the main riser, entrance to a building or piece of equipment.

B. Cast iron pipe shall be braced on each side of a change in direction of 90 degrees or more. Joints in risers shall be braced or stabilized between floors.

C. No-hub and bell-and-spigot cast iron soil pipe shall be braced longitudinally every 20 feet and laterally every 10 feet.

D. Lateral bracing for one pipe section may also act as longitudinal bracing for the pipe section connected perpendicular to it, if the bracing is installed within 24 inches of the elbow or tee of the same size.

3.02 INSTALLATION

A. Rod stiffener assemblies shall be used at seismic restraints for hanger rods over 6 inches in length.

B. A minimum of two-rod stiffener clamps shall be used on any rod stiffener assembly.

C. Lateral and longitudinal bracing shall be installed between 45 degrees above and 45 degrees below horizontal, inclusive, relative to the horizontal centerline of the pipe.

D. Welded and bolted attachments to the building structural steel shall be in accordance with the requirements of the AISC Manual of Steel Construction.

E. There shall be no drilling or burning of holes in the building structural steel without approval of the Project Inspector.

F. Embedded anchor bolts shall be used instead of concrete inserts for seismic brace installations in areas below water surface or normally subject to submergence.

G. The CONTRACTOR shall install thermal pipe hanger shields on insulated piping at required locations during restraint installation.

H. Butt joint connections to pipe insulation shall be made at the time of insulation installation in accordance with the manufacturer's recommendations.

I. Restraint components in contact with plastic pipe shall be free of burrs and sharp edges.

J. Rollers shall roll freely without binding.

K. Plastic or rubber end caps shall be provided at the exposed ends of all framing channels that are located up to 7 feet above the floor.

3.03 INSPECTION AND CERTIFICATION

A. As required in Section 15061.

END OF SECTION

SECTION 15054

EXPANSION CONTROL FOR PIPING

PART 1 GENERAL

1.01 SUMMARY

A. This section addresses pipe anchorage, pipe guides, and expansion control by either expansion joints or pipe deflection.
   1. Provide expansion control for the piping scheduled in this Section.

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 01612 - Seismic Design Criteria.
      b. Section 09960 - High-Performance Coatings.
      c. Section 15052 - Common Work Results for General Piping.
      d. Section 15053 - Seismic Restraints for Piping.
      e. Section 15061 - Pipe Supports.
      f. Section 15120 - Piping Specialties.

C. Operating Conditions:
   1. Expansion control as specified in this Section shall be provided to control pipe movements and loads occurring as a result of pipeline temperature changes.
   2. Those piping systems listed in the following table shall be provided with expansion control conforming to good engineering practice:

Piping System	Minimum Temperature, degrees F	Maximum Temperature, degrees F
Engine Exhaust (EEX)	45	1,200
Aeration Air (AA)	45	300

D. Definitions:

Term	Definition
Expansion joint	Any device containing one or more bellows used to absorb dimensional changes

Term	Definition
Main anchor	An attachment between a structure and a pipe which must withstand the full pipeline thrust due to pressure, pipe bending, pipe compression, flow, spring forces, pipe and contents weight and other pipe forces
Intermediate anchor	An attachment between a structure and a pipe which withstands the same forces as a main anchor except the pressure forces
Sliding anchor	An attachment between a structure and a pipe which absorbs forces in one direction while permitting motion in another
Pipe guide	A device fastened to a structure, which permits the pipeline to move freely in only one direction, along the axis of the pipe
Pipe section	That portion of pipe between two anchors
Planar pipe guide	A device fastened to a structure, which permits transverse movement or bending of the pipeline in one plane
Lateral direction	Direction perpendicular to the pipe axis
Longitudinal direction	Direction parallel to the pipe axis

1.02 REFERENCES

A. American Institute of Steel Construction (AISC):
   1. Manual of Steel Construction, Allowable Stress Design - 9th Edition.

B. Expansion Joint Manufacturers Association (EJMA):
   1. EJMA-93 - Standards of the Expansion Joint Manufacturers Association, Inc., Sixth Edition, 1993.
   2. EJMA-85 - A Practical Guide to Expansion Joints, Copyright 1985, Expansion Joint Manufacturers Association, Inc.

1.03 DESIGN

A. The expansion control system shall be designed by the DESIGN PROFESSIONAL as required in Section 15061.

B. Expansion control details shall be designed in conjunction with preparation of pipe system hangers and seismic restraint systems drawings.

1.04 DESIGN GUIDELINES

A. The DESIGN PROFESSIONAL shall use the following guidelines:
   1. The difference between the minimum and maximum temperatures scheduled.
   2. Published coefficients of thermal expansion for pipe materials shall be used for the listed temperature range.
      a. The source of the coefficients of expansion used in the calculations shall be included with the data provided as Product Data.

3. Expansion control systems shall be designed for maximum reliability. Unless otherwise indicated on the Drawings, "L," "U," or "Z" bends shall be employed to control expansion in preference over expansion joints.
4. Expansion control systems using pipe bends shall be designed to limit bending stress in the pipe associated with deflection at the worst-case temperature difference.
    a. The maximum allowable bending stress shall be 1/3 of the yield stress for the pipe material.
    b. If loading conditions or uncertainties warrant, a lower allowable stress value shall be used.
    c. A recognized pipe bending stress calculation method and documentation supporting its use shall be provided as Product Data.
5. The requirements set forth in Section 15120 shall prevail if expansion joints are used. Expansion control design for expansion joints shall conform to the guidelines given in the Standards of The Expansion Joint Manufacturers Association, Inc. (EJMA).
6. If the DESIGN PROFESSIONAL chooses to use expansion control or pipe support methods that involve higher loading on the structure than are indicated on the Drawings, the ENGINEER shall be notified. The requested loads shall be listed and the DESIGN PROFESSIONAL will redesign the structure as necessary at the CONTRACTOR's expense.
7. The test pressures listed in the Piping Schedule of Section 15052 shall be used when calculating pressure forces.
8. Pipe guides or planar pipe guides shall be provided to control the movement of pipes when "L," "U," or "Z" bends are used for expansion control.
    a. The guides shall be located as indicated in EJMA standards.
    b. An alternative recognized standard may be used for this purpose only upon approval by the ENGINEER.
9. Recommended main anchor locations are shown on the Drawings.
    a. Intermediate anchors shall be provided as needed.
    b. Maximum forces that the structure can withstand at the main anchor points are noted on the Drawings.
    c. Anchors shall be designed to attach to the structure and solidly to the pipe.
    d. Pipe clamps or U-bolts are not allowed unless they are designed to withstand the forces imposed upon the anchor and have stops welded to the pipe so that the pipe cannot slip in the anchor.
10. Anchors and guides shall be coordinated with the pipe support system specified in Section 15061 and seismic restraints specified in Section 15053.
11. The design of the expansion control, pipe supports, and seismic restraints for the listed piping systems shall be integrated to provide maximum flexibility for maintenance access to equipment, appurtenances such as valves, etc., and to the pipe itself.
12. The piping layout indicated shall be reviewed in relation to surrounding structures, adjacent piping, and equipment before selecting the anchors, guides, and expansion control method to be used at each point.
13. There shall be no metal-to-metal contact between a pipe and restraint component of dissimilar metals.
14. Branch lines shall not be used to anchor main lines.

15. For elevated pipe sections, fabricated support frames, or other appropriate structures shall be designed to withstand the specified loads plus gravity and seismic loads.
16. The supports shall be designed to provide access to equipment, walkways, gates, and other piping.

1.05 SUBMITTALS

A. Per Section 15061.

PART 2 PRODUCTS

2.01 MATERIALS

A. Unless otherwise specified, anchors, and guides, including braces, pipe and structural attachments, and shall match the pipe support material specified in Section 15061.

B. Nuts, bolts, and washers shall match materials specified for the nuts, bolts, and washers in Section 15061.

C. Supports cast integrally with cast iron fittings are specifically prohibited for use in any application where shear forces may be imposed on the support.

D. For corrosive areas specifically requiring fiberglass materials. In those areas, all pipe support, anchor, and brace components (not just fittings and accessories) shall be made of fiberglass.

PART 3 EXECUTION

3.01 EXPANSION CONTROL SCHEDULES

A. Anchor, guide, and expansion joint locations shall be indicated on the piping layout drawings per Section 15052.

B. Schedules shall be prepared as specified below.
   1. Anchors:
      a. The anchor schedule shall list as a minimum:
         1) Anchor Point Label.
         2) Pipe Size and Service.
         3) Contract Drawing Number.
         4) Layout Drawing Number.
         5) Forces.
         6) Load, pounds.
         7) Direction.
         8) Anchor Description.
         9) Remarks.
   2. Guides:
      a. The guide schedule shall list as a minimum:
         1) Guide Label.
         2) Pipe Size and Service.

3) Contract Drawing Number.
4) Layout Drawing Number.
5) Guide Description.
6) Remarks.

3. Expansion Joints:
   a. The expansion joint schedule shall list as a minimum:
      1) Expansion Joint Label.
      2) Pipe Size and Service.
      3) Contract Drawing Number.
      4) Layout Drawing Number.
      5) Movement, inches:
         a) A - Lateral movement.
         b) B - Compression movement.
         c) C - Extension movement.
         d) D - Angular movement.
      6) Maximum Spring Force, pounds.
      7) Test Pressure, psig.
      8) Pressure Force, pounds.
      9) Total Forces.
      10) Load, pounds.
      11) Direction.
      12) Expansion Joint Description.
      13) Special Features.
      14) Remarks.

3.02 INSTALLATION

A. The CONTRACTOR shall install the expansion control system in accordance with the Drawings required in Section 15052.

B. Welded and bolted attachments to the building structural steel shall be in accordance with the requirements of the AISC Manual of Steel Construction.
   1. There shall be no drilling or burning of holes in the building structural steel without approval of the ENGINEER.

C. Unless otherwise specified, embedded anchor bolts shall be used instead of concrete inserts, wedge anchors, expansion anchors, adhesive, or other non-embedded type of anchor for expansion control installations in areas below water surface or normally subject to submerging.

D. The CONTRACTOR shall install thermal pipe hanger shields on insulated piping at required locations during guide installation.

E. Butt joint connections to pipe insulation shall be made at the time of insulation installation in accordance with the manufacturer's recommendations.

F. Anchors shall be directly connected to the pipe by welding or another acceptable, positive means.

G. Components in contact with plastic pipe shall be free of burrs and sharp edges.

H. Rollers shall roll freely without binding.

I. Plastic or rubber end caps shall be provided at the exposed ends of all framing channels that are located up to 7 feet above the floor.

3.03 INSPECTION AND CERTIFICATION

A. As required in Section 15061.

END OF SECTION

SECTION 15061

PIPE SUPPORTS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Supports for pipe, fittings, valves, ductwork, and appurtenances.

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 01612 - Seismic Design Requirements.
      b. Section 05120 - Structural Steel.
      c. Section 09960 - High-Performance Coatings.
      d. Section 15052 - Common Work Results for General Piping.
      e. Section 15053 - Seismic Restraints for Piping.
      f. Section 15054 - Expansion Control for Piping.
      g. Section 15062 - Preformed Channel Pipe Support System.
      h. Section 15063 - Non-Metallic Pipe Support System.
      i. Section 15812 - Metal Ductwork.
      j. Section 15814 - Fiberglass Reinforced Plastic Ductwork.
      k. Section 15820 - Flexible Ductwork.
      l. Section 16070 - Hangers and Supports.

1.02 REFERENCES

A. American National Standard Institute or Manufacturer's Standardization Society (ANSI/MSS):
   1. SP-58 - Standard for Pipe Hangers and Supports - Materials, Design, and Manufacture.
   2. SP-69 - Standard for Pipe Hangers and Supports - Selection and Application.

B. American Society for Testing Materials (ASTM):
   1. ASTM B633 - Specification for Electrodeposited Coatings of Zinc on Iron and Steel.
   2. ASTM A123 - Specification for Zinc (Hot-Galvanized) Coatings on Products Fabricated from Rolled, Pressed, and Forged Steel Shapes, Plates, Bars and Strip.

3. ASTM A653 – Specification for Steel Sheet, Zinc-Coated by the Hop-Dip Process.
4. ASTM A1011 – Specification for Steel, Sheet, Hot-Rolled, Carbon, Structural High-Strength Low-Alloy and High-Strength Low-Alloy with Improved Formability.

C. National Fire Protection Association (NFPA):
1. NFPA 13 – Standard for the Installation of Sprinkler Systems.

1.03 SYSTEM DESCRIPTION

A. CONTRACTOR shall provide final design, inspection, and certification for supports, seismic restraints, and provisions for control of expansion for this project.
1. The design of these systems shall be the product of a qualified professional engineer licensed to practice in the State of California retained by CONTRACTOR, (hereinafter and in all referenced sections the DESIGN PROFESSIONAL).
2. The hanger and support design drawings and calculations shall be prepared and signed by the DESIGN PROFESSIONAL and shall bear the DESIGN PROFESSIONAL's registration seal.
3. The DESIGN PROFESSIONAL shall obtain and maintain professional liability insurance in the amount of $1,000,000 per incident with a $1,000,000 aggregate to be in effect the project duration plus 1 year.
4. DESIGN PROFESSIONAL shall have no less than 5 years of experience in type of piping work required for this project.
5. These requirements, however, shall not be construed as relieving CONTRACTOR of overall responsibility for this portion of the work.

B. In some cases, pipe/ductwork supports and expansion controls are shown on the Drawings. In other cases, they are not shown, but are required. In general, seismic restraints are not shown, but are required. CONTRACTOR is responsible to supply complete pipe/ductwork supports, seismic restraints, and expansion control systems whether they are shown on the Drawings or not.

1.04 DEFINITIONS

A. Buried pipe: Pipe that is buried in the soil, or cast in a concrete pipe encasement that is buried in the soil.

B. Exposed pipe: Pipe that is located above ground, or pipe that is located inside a structure, supported by a structure, or cast into a concrete structure.

C. Underground piping: Piping actually buried in soil or cast in concrete that is buried in soil.

D. Submerged piping: Piping below tops of walls in basins or tanks containing water.

E. Wet wall: Wall with water on at least 1 side.

1.05 DESIGN/PERFORMANCE REQUIREMENTS

A. The pipe/duct system drawings shall show the hanger and support locations as well as the details of the seismic restraints and expansion control systems.

B. The pipe hanger and support system shall be coordinated with the seismic restraint specified under Section 15053 and the expansion control system specified under the provisions of Section 15054.

C. Design supports to limit pipe/ductwork deflection to L/240, and a spacing not to exceed 10 feet on center.

D. The CONTRACTOR shall coordinate the design of the hanger and support system with the design of the electrical support systems in Section 16070.

E. Refer to Sections 15812, 15814, and 15815 for additional requirements for the design of ductwork support systems.

F. The CONTRACTOR shall select pipe hangers and supports as specified in this Section and elsewhere in the Specifications or Drawings. Selections shall be based upon the pipe support classifications specified in MSS-SP69, the piping insulation thickness specified in Section 15082, and any special requirements that may be specified in other sections of the Specifications or Drawings.

G. The CONTRACTOR shall review the piping/ductwork layout in the in relation to the surrounding structure and adjacent piping, ductwork, electrical support systems, and equipment before selecting the type of support to be used at each hanger point.

H. Where shown on the Drawings, supports are provided as guidance and may not meet minimum requirements. The CONTRACTOR shall provide, at no additional cost to the OWNER, additional pipe supports as necessary and required by the Specifications. Supports shown on the Drawings shall be provided and shall be incorporated into the overall hanger and support system design.

I. Hangers and supports used in fire protection piping systems shall be listed and labeled by Underwriters Laboratories (UL).

1.06 SUBMITTALS

A. DESIGN PROFESSIONAL Qualifications:
   1. Education, proof of registration, and previous experience in performing this type of work.
   2. Documentation shall be sufficient to demonstrate compliance with requirements of this Section.

B. Calculations:
   1. Calculations and other information to substantiate supports meet minimum design strength requirements and seismic bracing.
   2. Seismic loads shall be as specified in Section 01612.
   3. Calculations shall be sealed by the DESIGN PROFESSIONAL.

C. Product Data:
   1. Manufacturer’s data sheets on each product used.
   2. Preparation instructions and recommendations by Manufacturer.
   3. Storage and handling requirements.
   4. Installation methods.

D. Shop Drawings:
   1. Include schedule, indicating where supports will be installed, where seismic bracing will be installed, and drawings of pipe support system components and seismic bracing.
   2. Piping and ductwork layout drawings, including supports, seismic restraints, and details of the expansion control systems.
   3. Shop drawings shall be sealed by the DESIGN PROFESSIONAL.

E. Inspection Reports:
   1. Inspection reports shall be sealed by the DESIGN PROFESSIONAL.

F. Final Inspection Report:
   1. Final Inspection report shall be sealed by the DESIGN PROFESSIONAL.

PART 2 PRODUCTS

2.01 MATERIALS

A. Pipe Supports:
   1. Outdoor Areas: Areas exposed to natural outdoor environment or under canopies:
      a. Stainless Steel: Type 316.
   2. Submerged locations, above water level inside water bearing structures and pipe supports for all stainless steel piping regardless of location.
      a. Stainless Steel: Type 316.
   3. Indoor Areas:
      a. Inside Administration and Maintenance Buildings: Hot-Dip Galvanized Steel. Hot-dip galvanize pipe support after fabrication per ASTM A123.
      b. All Other Indoor Areas: Stainless Steel type 316.
   4. All stainless steel supports:
      a. Shop-fabricate. At the shop, perform pickling and passivation on all surfaces inside and out.
      b. Field welding is prohibited unless specifically approved by the OWNER. If field welding is allowed, all field welds shall be passivated in the field.
   5. Plastic, Aluminum, FRP and Other Miscellaneous Materials: Use where specifically indicated on the Drawings.

B. Concrete Anchors:
   1. As specified in Section 05120.

C. Fasteners:
   1. Stainless Steel Supports:
      a. Type 316 stainless steel in accordance with ASTM A 193, Grade B8M for bolts and in accordance with ASTM A 194, Grade 8M for nuts.
   2. Hot-Dip Galvanized Supports:
      a. Hot-dip galvanized ASTM A 307 steel, or ASTM A 36 meeting the mechanical requirements of ASTM A 307.
   3. Plastic, Aluminum, FRP Supports:
      a. Type 316 stainless steel in accordance with ASTM A 193, Grade B8M for bolts and in accordance with ASTM A 194, Grade 8M for nuts.

2.02 PIPE SUPPORTS

A. Concrete Inserts for Pipes under 30-Inch Diameter: ANSI/MSS SP-69 Type 18. Minimum 1,140 pounds capacity with 5/8-inch diameter rod.
   1. Manufacturers: One of the following or equal:
      a. Anvil, Figure 282.
      b. Carpenter and Paterson, Figure CP-109.

B. Concrete Inserts for Pipe 30-Inch Diameter and Larger: Hot-dip galvanized steel body with 3/4-inch diameter National Coarse zinc plated square nut, anchor insert to steel concrete reinforcement.
   1. Manufacturers: One of the following or equal:
      a. Connection Specialties, Inc., Model 6MD350.

C. Hanger Rods: Sized to match suspended pipe hanger, or as indicated on the Drawings.
   1. Manufacturers: One of following or equal:
      a. Anvil, Figure 140.
      b. Bergen-Paterson, Part 5000.
      c. B-Line Systems, Inc., Figure B3205.

D. Hanger Rods, Continuously Threaded: Sized to match suspended pipe hanger, or as indicated on the Drawings.
   1. Manufacturers: One of the following or equal:
      a. Anvil, Figure 146.
      b. Bergen-Paterson, Part BP-5006.

E. Eye Bolts: Welded and rated equal to full-load capacity of rod.

F. Welded Eyebolt Rod:
   1. Manufacturers: One of the following or equal:
      a. Anvil, Figure 278.
      b. Bergen-Paterson, Part 5004.
      c. B-Line Systems, Inc., Figure B3210.

G. Adjustable Ring Hangers: ANSI/MSS SP 69 Type 7.
   1. Manufacturers: One of the following or equal:
      a. Anvil.
      b. B-Line Systems, Inc., Figure B3172.

H. Adjustable Clevis Hangers: ANSI/MSS PS 69, Type 1.
   1. Manufacturers: One of the following or equal:
      a. Anvil, Figure 260.
      b. Bergen-Paterson, Part 6750.
      c. B-Line systems, Inc., Figure B3100 or B3105.

I. Adjustable Clevis Hangers for Insulated Pipe: Oversize.
   1. Manufacturers: One of the following or equal:
      a. Anvil, Figure 300.
      b. Bergen-Paterson, Part 6754.
      c. B-Line Systems, Inc. Figure B3108.

J. Brackets: ANSI/MSS SP-69 Type 32 with back plate; rated for 1,500 pounds.
   1. Manufacturers: One of the following or equal:
      a. Anvil, Figure 195.
      b. B-Line Systems, Inc., Figure B3066.

K. Brackets, Heavy Duty: ANSI/MSS SP 69 Type 33 with back plate; rated for 3,000 pounds.
   1. Manufacturers: One of the following or equal:
      a. Anvil, Figure 199.
      b. B-Line Systems, Inc., Figure B3067.

L. Standard U-bolt: ANSI/MSS SP-69 Type 24.
   1. Manufacturers: One of the following or equal:
      a. Anvil, Figure 137.
      b. Bergen-Paterson, Part 6510.
      c. B-Line Systems, Inc., Figure B3188.

M. Riser Clamps: ANSI/MSS SP-69 Type 8.
   1. Manufacturers: One of the following or equal:
      a. Anvil, Figure 261.
      b. Bergen-Paterson, Part 6302.
      c. B-Line Systems, Inc., Figure B3373.

N. Pipe Clamps: ANSI/MSS SP 69 Type 4.
   1. Manufacturers: One of the following or equal:
      a. Anvil, Figure 212.
      b. Bergen-Paterson, Part 6100.
      c. B-Line Systems, Inc., Figure B3140.

O. Adjustable Offset Pipe Clamp:
   1. Manufacturers: One of the following or equal:
      a. Anvil, Figure 100.
      b. B-Line Systems, Inc., Figure B3149.

P. Offset Pipe Clamp:
   1. Manufacturers: One of the following or equal:
      a. Anvil, Figure 103.
      b. B-Line Systems, Inc., Figure B3148.

Q. Floor Stand or Stanchion Saddles: ANSI/MSS SP-69 Type 37. Provided with U-bolt hold down yokes.
   1. Manufacturers: One of the following or equal:
      a. Anvil, Figure 259.
      b. Bergen-Paterson, Part 6652.
      c. B-Line Systems, Inc., Figure B3090.

R. Spring Supports:
   1. Manufacturers: One of the following or equal:
      a. Bergen-Paterson, Part 3200.
      b. Anvil, Figure B-268.

S. One Hole Pipe Clamps:
   1. Manufacturers: One of the following or equal:
      a. Anvil, Figure 126.
      b. Carpenter and Paterson, Figure 237.

T. Welded Beam Attachment:
   1. Manufacturers: One of the following or equal:
      a. Anvil, Figure 66.
      b. Bergen-Paterson, Part 1047.
      c. B-Line Systems, Inc., Figure B3083.

U. Heavy Pipe Clamp:
   1. Manufacturers: One of the following or equal:
      a. Anvil, Figure 216.
      b. Bergen-Paterson, Part 6101.

V. Pipe Roll with Stand:
   1. Manufacturers: One of the following or equal:
      a. Anvil, Figure 271.
      b. B-Line Systems, Inc., Figure B3117SL.

W. Anchor Bolts, Flush Shells, Powder Actuated Fasteners, and Concrete Anchors: As specified in Section 05120.

PART 3 EXECUTION

3.01 INSTALLATION

A. Properly support, suspend, or anchor exposed pipe, fittings, valves, ductwork, and appurtenances to prevent sagging, overstressing, or movement of piping; and to prevent thrusts or loads on or against connected pumps, blowers, and other equipment. Not all supports are shown on the Drawings. Provide supports shown in addition to the requirements herein.

B. Pipe supports shown on the Drawings do not show required seismic bracing. Provide seismic bracing as required.

C. Carefully determine locations of inserts. Anchor to formwork prior to placing concrete.

D. Use flush shells only where indicated on the Drawings.

E. Do not use anchors relying on deformation of lead alloy.

F. Do not use stud type powder actuated fasteners for securing metallic conduit or steel pipe larger than 1 inch to concrete, masonry, or wood.

G. Suspend pipe hangers from hanger rods. Secured with double nuts.

H. Install continuously threaded hanger rods only where indicated on the Drawings.

I. Use adjustable ring hangers; or adjustable clevis hangers, for 6-inch and smaller diameter pipe.

J. Use adjustable clevis hangers for pipe larger than 6 inches in diameter.

K. Secure pipes with galvanized double-nutted U-bolts or suspend pipes from hanger rods and hangers.

L. Support Spacing:
   1. Support 2-inch and smaller piping on horizontal and vertical runs at maximum 5 feet on center, unless otherwise specified.
   2. Support larger than 2-inch piping on horizontal and vertical runs at maximum 10 feet on center, unless otherwise specified.
   3. Support exposed polyvinyl chloride and other plastic pipes at maximum 5 feet on center, regardless of size.
   4. Support tubing, copper pipe and tubing, fiber-reinforced plastic pipe or duct, and rubber hose and tubing at intervals close enough to prevent sagging greater than 1/4 inch between supports.

M. Install Supports at:
   1. Bends.
   2. Both sides of flexible pipe connections.
   3. Base of risers.
   4. Floor penetrations.
   5. Connections to pumps, blowers, and other equipment.
   6. Valves and appurtenances.

N. Securely anchor plastic pipe, valves, and headers to prevent movement during operation of valves.

O. Anchor plastic pipe between expansion loops and direction changes to prevent axial movement through anchors.

P. Provide ductile iron elbows or tees supported from floors with base fittings where indicated on the Drawings.

Q. Support base fittings with metal supports or when indicated on the Drawings, concrete piers.

R. Size hanger rods, supports, clamps, anchors, brackets, and guides in accordance with ANSI/MSS SP 58 and SP 69.

S. Do not use chains, plumbers' straps, wire, or similar devices for permanently suspending, supporting, or restraining pipes.

T. Support plumbing drainage and vents in accordance with Uniform Plumbing Code.

U. Supports, Clamps, Brackets, and Portions of Support System Bearing Against Copper Pipe: Copper-plated, copper throughout, or isolated with neoprene or polyvinyl chloride tape.

V. Where pipe is insulated, install oversized supports and hangers.

W. Install insulation shield in accordance with ANSI/MSS SP 69, Type 40. Shield shall be galvanized steel unless specified elsewhere.

X. Install riser clamps at floor penetrations and where indicated on the Drawings.

Y. Paint or coat support system components as specified in Section 09960.

3.02 INSPECTION

A. The DESIGN PROFESSIONAL shall inspect piping/ductwork support installation, seismic restraints, and expansion control systems.
   1. DESIGN PROFESSIONAL shall inspect the work at not more than monthly intervals and submit inspection reports indicating progress of the work.
   2. Upon construction completion, but prior to beneficial occupancy of piping systems by OWNER, the DESIGN PROFESSIONAL shall conduct a detailed final inspection and submit final report certifying all work is complete and in accordance with applicable requirements.
   3. All reports shall bear DESIGN PROFESSIONAL's registration seal and signature in accordance with the laws, rules, and regulations of the state.

END OF SECTION

SECTION 15062

PREFORMED CHANNEL PIPE SUPPORT SYSTEM

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes: Preformed channel pipe support system consisting of preformed channels, fittings, straps, and fasteners engineered to support piping.

B. Hanger and Support Selection:
   1. The CONTRACTOR shall cause the pipe hangers and supports to be designed by the DESIGN PROFESSIONAL as required in 15061.
   2. The pipe hanger and support system shall be coordinated with the seismic restraint specified under Section 15053 and the expansion control system specified under the provisions of Section 15054.

C. 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 01612 - Seismic Design Requirements.
      b. Section 05120 - Structural Steel.
      c. Section 09960 - High-Performance Coatings.
      d. Section 15052 - Common Work Results for General Piping.
      e. Section 15053 - Seismic Restraints for Piping.
      f. Section 15054 - Expansion Control for Piping.
      g. Section 15061 - Pipe Supports.

1.02 REFERENCES

A. American Institute of Steel Construction (AISC).

B. American Iron and Steel Institute (AISI).

C. American National Standard Institute/Manufacturer's Standardization Society (ANSI/MSS):
   1. SP-58 - Pipe Hangers and Supports - Materials, Design, and Manufacture.
   2. SP-69 - Pipe Hangers and Supports - Selection and Application.

1.03 SYSTEM DESCRIPTION

A. Design Criteria:
   1. Provide design of the support system per Section 15061.

2. Include live, dead, and seismic loads associated with piping, valves, and appurtenances. Consider the content of the pipes in load calculations.
3. Minimum Gauge Thickness: 12 gauge.
4. Allowable Stress of Channels:
   a. Steel Channels: The lesser of 25,000 pounds per square inch, or 0.66 times yield stress of steel.
   b. Stainless Steel Channels: 0.66 times the yield stress of the stainless steel alloy.
5. Maximum Deflection: 1/240 of span.
6. Allowable Column Loads: As recommended by manufacturer in published instruction for column's unsupported height and "K" value for calculating effective column length of not less than 1.0.
7. Future Loads:
   a. Support systems indicated on the Drawings may include spaces intended to accommodate future pipes.
   b. Assume such spaces are occupied by 6-inch diameter ductile iron pipes. Only the number of pipes that would physically fit into the space need be considered.
   c. Include the weight of the pipe contents in determining future loads. Assume pipe contents are water.
8. Seismic Design Criteria: As specified in Sections 15053 and 15061 and as specified for mechanical equipment.
9. Spacing of Supports: As required to comply with design requirements but not more than 5 feet.

B. Materials:
   1. Refer to Section 15061.

1.04 SUBMITTALS

A. As required by Sections 15052 and 15061.

1.05 QUALITY ASSURANCE

A. Design Preformed Channel Pipe Support System for Loads in Accordance with Applicable Provisions of:
   1. AISC Manual of Steel Construction.
   2. AISI Cold-Formed Steel Design Manual.

B. Product Standards:
   1. Pipe Support Components: Conform to MSS SP-69.
   2. Pipe Support Materials: Conform to MSS SP-58.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Fabricate preformed channel pipe support system using, as a minimum, parts specified below and meeting the requirements specified under Design Criteria.
   1. Manufacturers: One of the following or equal:
      a. Unistrut, Series P1000 or P1001; P5500 or P5501, as indicated on the Drawings.

b. Allied Support Systems, Power Strut, Figure PS-200 or PS-200 2TS; PS-150 or PS-150 2TS.
c. B-Line Systems, Inc., Channel Type B22 or B22A; B12 or B12A.

2.02 MATERIALS

A. Unless otherwise specified, restraints, including braces, pipe and structural attachments, shall match the pipe support material as specified in Section 15061.

B. Nuts, bolts, and washers shall match materials specified for the nuts, bolts, and washers in Section 15061.

2.03 ACCESSORIES

A. Preformed Channel Concrete Inserts: Minimum 12 inches long.
1. Manufacturers: One of the following or equal:
a. Unistrut, Series P-3200.
b. Allied Support Systems, Figure 282.
c. B-Line Systems, Series B32I.

B. 90-Degree Angle Fittings:
1. Manufacturers: One of the following or equal:
a. Unistrut, P1026.
b. Allied Support Systems, Power Strut, P603.

C. Pipe Straps:
1. For Pipes 8 Inches in Diameter and Smaller: Use 2-piece universal strap with slotted hex head screw and nut.
a. Manufacturers: One of the following or equal:
1) Unistrut, Series P1109 through P1126.
2) Allied Support Systems, PS1100.
3) B-Line Systems, Inc., Series B2000.
2. For Pipes Greater than 8 Inches in Diameter: Unless different material is otherwise indicated on the Drawings or specified, use 1-piece, 1-inch wide by 1/8-inch, thick steel strap, hot-dip galvanized after fabrication.
3. For Stainless Steel Pipes: Use type of strap required for the pipe sizes specified above, but use Type 304 stainless steel materials.

D. Touch-Up Paint Galvanized Surfaces:
1. Manufacturers: One of the following or equal:
a. Galvinox, Galvo-Weld.

E. Touch-Up Paint for Painted Surfaces: Same formulation as factory paint.

2.04 FABRICATION

A. Hot-dip galvanize support system components after fabrication to required length and shape.

B. Do not galvanize or paint stainless steel components.

PART 3 EXECUTION

3.01 INSTALLATION

A. Properly support, suspend, or anchor exposed pipe, fittings, valves, and appurtenances to prevent sagging, overstressing, or movement of piping; and to prevent thrusts or loads on or against connected pumps, blowers, and other equipment. Not all supports are shown on the Drawings. Provide supports shown in addition to the requirements herein.

B. Pipe supports shown on the Drawings do not show required seismic bracing. Provide seismic bracing as required.

C. Carefully determine locations of inserts. Anchor to formwork prior to placing concrete.

D. Use flush shells only where indicated on the Drawings.

E. Do not use anchors relying on deformation of lead alloy.

F. Do not use stud type powder actuated fasteners for securing metallic conduit or steel pipe larger than 1 inch to concrete, masonry, or wood.

G. Suspend pipe hangers from hanger rods. Secured with double nuts.

H. Install continuously threaded hanger rods only where indicated on the Drawings.

I. Use adjustable ring hangers; or adjustable clevis hangers, for 6-inch and smaller diameter pipe.

J. Use adjustable clevis hangers for pipe larger than 6 inches in diameter.

K. Secure pipes with galvanized double-nutted U-bolts or suspend pipes from hanger rods and hangers.

L. Support Spacing:
   1. Support 2-inch and smaller piping on horizontal and vertical runs at maximum 5 feet on center, unless otherwise specified.
   2. Support larger than 2-inch piping on horizontal and vertical runs at maximum 10 feet on center, unless otherwise specified.
   3. Support exposed polyvinyl chloride and other plastic pipes at maximum 5 feet on center, regardless of size.
   4. Support tubing, copper pipe and tubing, fiber-reinforced plastic pipe or duct, and rubber hose and tubing at intervals close enough to prevent sagging greater than 1/4 inch between supports.

M. Install Supports at:
   1. Horizontal bends.
   2. Both sides of flexible pipe connections.
   3. Base of risers.
   4. Floor penetrations.
   5. Connections to pumps, blowers, and other equipment.
   6. Valves and appurtenances.

N. Securely anchor plastic pipe, valves, and headers to prevent movement during operation of valves.

O. Anchor plastic pipe between expansion loops and direction changes to prevent axial movement through anchors.

P. Provide ductile iron elbows or tees supported from floors with base fittings where indicated on the Drawings.

Q. Support base fittings with metal supports or when indicated on the Drawings, concrete piers.

R. Size hanger rods, supports, clamps, anchors, brackets, and guides in accordance with ANSI/MSS SP 58 and SP 69.

S. Do not use chains, plumbers' straps, wire, or similar devices for permanently suspending, supporting, or restraining pipes.

T. Support plumbing drainage and vents in accordance with Uniform Plumbing Code.

U. Supports, Clamps, Brackets, and Portions of Support System Bearing Against Copper Pipe: Copper-plated, copper throughout, or isolated with neoprene or polyvinyl chloride tape.

V. Where pipe is insulated, install oversized supports and hangers.

W. Install insulation shield in accordance with ANSI/MSS SP 69, Type 40. Shield shall be galvanized steel unless specified elsewhere.

X. Install riser clamps at floor penetrations and where indicated on the Drawings.

Y. Paint or coat support system components as specified in Section 09960.

3.02 INSTALLATION

A. As required by Section 15061.

END OF SECTION

SECTION 15063

NON-METALLIC PIPE SUPPORT SYSTEM

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes: Non-metallic pipe support system including the following:
   1. Channel framing, and components.
   2. Pipe clamps.
   3. Fittings.
   4. Fasteners.

B. Hanger and Support Selection:
   1. The CONTRACTOR shall cause the pipe hangers and supports to be designed by the DESIGN PROFESSIONAL as required in 15061.
   2. The pipe hanger and support system shall be coordinated with the seismic restraint specified under Section 15053 and the expansion control system specified under the provisions of Section 15054.

C. 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 01600 - Product Requirements.
      b. Section 01612 - Seismic Design Requirements.
      c. Section 05120 - Structural Steel.
      d. Section 09960 - High-Performance Coatings.
      e. Section 15050 - Common Work Results for Mechanical Equipment.
      f. Section 15052 - Common Work Results for General Piping.
      g. Section 15053 - Seismic Restraints for Piping.
      h. Section 15054 - Expansion Control for Piping.
      i. Section 15061 - Pipe Supports.

1.02 REFERENCES

A. American Society for Testing Materials (ASTM):
   1. E 84 - Test Method for Surface Burning Characteristics of Building Materials.

1.03 SYSTEM DESCRIPTION

A. Design Requirements:
   1. Provide design of the support system per Section 15061.

2. Include live, dead, and seismic loads associated with piping, valves, and appurtenances. Consider the content of the pipes in load calculations.
3. Maximum Allowable Deflection: 1/240 of span.
4. Allowable Column Loads: As recommended by manufacturer in published instruction for column's unsupported height and "K" value for calculating effective column length of not less than 1.0.
5. Future Loads:
   a. Support systems indicated on the Drawings may include spaces intended to accommodate future pipes.
   b. Assume such spaces are occupied by 6-inch diameter ductile iron pipes. Only the number of pipes that would physically fit into the space need be considered.
   c. Include the weight of the pipe contents in determining future loads. Assume pipe contents are water.
6. Seismic Design Criteria: As specified in Section 15053 and 15061 and as specified for mechanical equipment.
7. Spacing of Supports: As required to comply with design requirements but not more than 5 feet.

1.04 SUBMITTALS

A. As required by Sections 15052 and 15061.

1.05 QUALITY ASSURANCE

A. Supply all materials from a single manufacturer with sole responsibility for the pipe support system.

B. The supplied system including pipe clamps shall be interchangeable with industry standard 1-5/8-inch steel and fiberglass channel framing systems.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Comply with Sections 01600 and 15050.

1.07 WARRANTY

A. As specified in Section 15050 unless noted otherwise.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. One of the following or equal:
   1. StrutTech, Redmond, Washington.
   2. Unistrut, Wayne, Michigan.

2.02 MATERIALS

A. Nuts, bolts, and washers shall match materials specified for the nuts, bolts, and washers in Section 15061.

B. Fiberglass Resin: Corrosion-resistant premium-grade vinylester.

C. Injection Molded Components: Polyurethane thermoplastics.

D. Flame Spread of Fiberglass:
   1. Vinylester Fiberglass (Series VF): Class 1, ASTM E 84.
   2. Polyurethane: V-O UL 94V.

E. Physical Properties of Fiberglass:

	Longitudinal	**Transverse**
Tensile Strength	37,500 psi	10,000 psi
Tensile Modules	3.0×10^6 psi	1.0×10^6 psi
Flexural Strength	37,500 psi	14,000 psi
Flexural Modules	2.0×10^6 psi	1.0×10^6 psi
Compressive Strength	37,500 psi	20,000 psi
Shear Strength	6,000 psi	5,500 psi
Izod Impact	30-foot psi	5-foot psi

F. Surface Veil: Fiberglass channel shall have polyester surface veil over 100 percent of the surface to provide protection against degradation from ultraviolet light.

G. Touch-Up Resin:
   1. Manufacturers: One of the following or equal:
      a. Krylon, 7006-Satin Polyurethane Clear Finish.

H. Concrete Anchors:
   1. As specified in Section 05120.

I. Fasteners:
   1. Type 316 stainless steel in accordance with ASTM A 193, Grade B8M for bolts and in accordance with ASTM A 194, Grade 8M for nuts.

2.03 COMPONENTS

A. Channel Framing:
   1. All channel framing shall be supplied with integral notches 1 inch on center.
   2. Locate notches on interior flange to prevent slippage of pipe clamps and fittings after installation.

B. Pipe Clamps:
   1. Adjustable Type: Non-metallic and non-conductive.
   2. Fixed Type:
      a. Pipe clamps for pipe less than 6 inches in diameter shall be non-metallic and non-conductive.
      b. Pipe clamps for pipe equal to and greater than 6 inches in diameter shall be fiberglass.

C. Channel Fittings:
   1. Make fittings and post bases from glass-filled polyurethane or polyester.

D. Fasteners:
   1. Make fasteners from one of the following materials:
      a. Glass-filled polyurethane.
      b. Vinylester fiberglass.

PART 3 EXECUTION

3.01 INSTALLATION

A. Properly support, suspend, or anchor exposed pipe, fittings, valves, and appurtenances to prevent sagging, overstressing, or movement of piping; and to prevent thrusts or loads on or against connected pumps, blowers, and other equipment. Not all supports are shown on the Drawings. Provide supports shown in addition to the requirements herein.

B. Pipe supports shown on the Drawings do not show required seismic bracing. Provide seismic bracing as required.

C. Carefully determine locations of inserts. Anchor to formwork prior to placing concrete.

D. Use flush shells only where indicated on the Drawings.

E. Do not use anchors relying on deformation of lead alloy.

F. Do not use stud type powder actuated fasteners for securing metallic conduit or steel pipe larger than 1 inch to concrete, masonry, or wood.

G. Suspend pipe hangers from hanger rods. Secure with double nuts.

H. Install continuously threaded hanger rods only where indicated on the Drawings.

I. Use adjustable ring hangers; or adjustable clevis hangers, for 6-inch and smaller diameter pipe.

J. Use adjustable clevis hangers for pipe larger than 6 inches in diameter.

K. Secure pipes with galvanized double-nutted U-bolts or suspend pipes from hanger rods and hangers.

L. Support Spacing:
   1. Support 2-inch and smaller piping on horizontal and vertical runs at maximum 5 feet on center, unless otherwise specified.
   2. Support larger than 2-inch piping on horizontal and vertical runs at maximum 10 feet on center, unless otherwise specified.

3. Support exposed polyvinyl chloride and other plastic pipes at maximum 5 feet on center, regardless of size.
4. Support tubing, copper pipe and tubing, fiber-reinforced plastic pipe or duct, and rubber hose and tubing at intervals close enough to prevent sagging greater than 1/4 inch between supports.

M. Install Supports at:
1. Horizontal bends.
2. Both sides of flexible pipe connections.
3. Base of risers.
4. Floor penetrations.
5. Connections to pumps, blowers, and other equipment.
6. Valves and appurtenances.

N. Securely anchor plastic pipe, valves, and headers to prevent movement during operation of valves.

O. Anchor plastic pipe between expansion loops and direction changes to prevent axial movement through anchors.

P. Provide ductile iron elbows or tees supported from floors with base fittings where indicated on the Drawings.

Q. Support base fittings with metal supports or when indicated on the Drawings, concrete piers.

R. Size hanger rods, supports, clamps, anchors, brackets, and guides in accordance with ANSI/MSS SP 58 and SP 69.

S. Do not use chains, plumbers' straps, wire, or similar devices for permanently suspending, supporting, or restraining pipes.

T. Support plumbing drainage and vents in accordance with Uniform Plumbing Code.

U. Supports, Clamps, Brackets, and Portions of Support System Bearing Against Copper Pipe: Copper-plated, copper throughout, or isolated with neoprene or polyvinyl chloride tape.

V. Where pipe is insulated, install oversized supports and hangers.

W. Install insulation shield in accordance with ANSI/MSS SP 69, Type 40. Shield shall be galvanized steel unless specified elsewhere.

X. Install riser clamps at floor penetrations and where indicated on the Drawings.

Y. Paint or coat support system components as specified in Section 09960.

3.02 INSTALLATION

A. As required by Section 15061.

END OF SECTION

SECTION 15075

EQUIPMENT IDENTIFICATION

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Equipment nameplates.
   2. Special items.

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 01410 - Regulatory Requirements.
      c. Section 01600 - Product Requirements.
      d. Section 01740 - Warranties and Bonds.
      e. Section 01770 - Closeout Procedures.
      f. Section 09960 - High-Performance Coatings.

1.02 SUBMITTALS

A. Submit as specified in Section 01330.

B. Submit following:
   1. Product data.
   2. Samples.
   3. Manufacturer's installation instructions.
   4. Submit following as specified in Sections 01740 and 01770:
      a. Warranty.

1.03 QUALITY ASSURANCE

A. Regulatory requirements: Comply with Air Pollution Control District regulations and federal lead content laws.

PART 2 PRODUCTS

2.01 EQUIPMENT NAMEPLATES

A. Material and fabrication:
   1. Stainless steel sheet engraved or stamped with text, holes drilled, or punch for fasteners.

B. Fasteners:
   1. Number 4 or larger oval head stainless steel screws or drive pins.

C. Text:
   1. Manufacturer’s name, equipment model number and serial number, identification tag number; and when appropriate, drive speed, motor horsepower with rated capacity, pump rated total dynamic head, and impeller size.

2.02 SPECIAL ITEMS

A. In addition, special coating of following items will be required:

Item	Color
Valve handwheels and levers	Red
Hoist hooks and blocks	Yellow and black stripes
Steel guard posts	In accordance with standard details

B. Paint minimum 2 inches high numbers on or adjacent to accessible valves, pumps, flowmeters, and other items of equipment which are indicated on the Drawings or in Specifications by number.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify satisfactory conditions of substrate for applying identification.

B. Verify that conditions are satisfactory for installation and application of products as specified in Section 01600.

3.02 PREPARATION

A. Prepare and coat surfaces as specified in Section 09960.

B. Prepare surface in accordance with product manufacturer's instructions.

END OF SECTION

SECTION 15076

PIPE IDENTIFICATION

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Pipe identification including the following:
   1. Pipe identification by color and legend.
   2. Underground warning tape.
   3. Tracer wire.
   4. Witness markers.
   5. Valve identification.

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 01600 - Product Requirements.
      c. Section 01770 - Closeout Procedures.
      d. Section 09960 - High-Performance Coatings.

1.02 REFERENCES

A. American Society of Mechanical Engineers (ASME):
   1. A13.1 - Scheme for the Identification of Piping Systems.

1.03 SUBMITTALS

A. Submit as specified in Section 01330.

B. Submit following:
   1. Product data.
   2. Samples.
   3. Manufacturer's installation instructions.
   4. Submit following as specified in Section 01770:
      a. Operation and Maintenance Data.
      b. Warranty.

PART 2 PRODUCTS

2.01 ABOVEGROUND AND IN-CHASE PIPE IDENTIFICATION

A. Manufacturers:
   1. One of the following or equal:
      a. Seton, Opti Code Pipe Markers.
      b. Lab Safety Supply.
      c. Marking Services, Inc.

B. Materials:
   1. Pipe markers: Self-adhesive vinyl, suitable for outdoor application from -40 degrees to 180 degrees Fahrenheit; in accordance with ASME A13.1 requirements.
      a. Lettering:

Nominal Pipe Diameter	Lettering Size
Less than 1.5	1/2 inch
1.5 inches to 2 inches	3/4 inch
2.5 inches to 6 inches	1-1/4 inches
8 inches to 10 inches	2-1/2 inches
Over 10 inches	3-1/2 inches

      b. Marker colors:

Service	Lettering	Background
Flammables, chemicals, toxics	Black	Yellow
Water, nontoxic solutions or low hazard liquids	White	Green
Nonflammable or nontoxic gases	White	Blue
Fire quenching fluids (foam, fire water, CO_2 Halon)	White	Red

   2. Coating: As specified in Section 09960.
   3. Pipe identification tags: Aluminum or stainless steel with stamped-in 1/4-inch high identifying lettering.
   4. Pipe identification tag chains: Aluminum or stainless steel.
   5. Snap-on markers: Markers with 3/4-inch high letters for 3/4- to 4-inch pipe or covering, or 5-inch high letters for 5-inch or larger pipe or cover, as manufactured by one of following:
      a. Brady Bradysnap-On B-915.
      b. Seton Setmark.

2.02 BURIED PIPELINE IDENTIFICATION

A. Underground warning tape:
   1. Manufacturer: One of the following or equal:
      a. Seton Name Plate Company, Branford, CT.
      b. T. Christy Enterprises, Inc.
   2. Material:
      a. Polyethylene tape for prolonged underground use.

b. Minimum tape thickness: 4 mils.
c. Overall tape width: 6 inches.
d. Message: “CAUTION” with the name of the service followed by “LINE BURIED BELOW” in black lettering on colored background in accordance with approved APWA colors.
1) Water: Blue.
2) Sewer: Green.
3) Telephone: Orange.
4) Gas and other services: Yellow.

B. Tracer wire:
1. Manufacturers: One of the following or equal:
a. Kris-Tech Wire.
b. Corrpro.
2. Materials: One of the following or equal:
a. Solid copper conductor with 30-mil HMWPE.
b. 10-gauge or thicker wire.
c. Match insulation color to the color of the pipe being installed.

C. Witness markers:
1. Manufacturers: One of the following or equal:
a. Carsonite Composites, Utility Marker.
b. Hampton Technical Associates, Inc.
2. Materials:
a. Glass fiber and resin reinforced thermosetting composite material.
b. UV resistant.
3. Constructed as a single piece.
4. Pointed at the bottom end.
5. Information to be included on the marker:
a. “Caution” (type of service) “Pipeline”.
b. Phone number for Underground Service Alert.
c. Phone number for OWNER in case of emergency.
d. Station number.
e. Offset:
1) Only provide offset if marker is not directly over the pipe.
f. Name of appurtenance or fitting (e.g. 45, BO, ARV etc.)

2.03 VALVE IDENTIFICATION

A. The CONTRACTOR shall furnish and install tags for all valves and gates required for the Work.
1. Tags shall be 2-inch diameter round, stainless steel or brass for buried applications.
2. Tags shall be furnished with a non-corrosive metal wire suitable for attaching the tag to the operator base.
3. Tags shall be stamped in 1/4-inch high letters:
a. Tags shall not be attached in such a way as to inhibit the operation of the valve or gate.
4. Buried valve tags shall be secured to concrete s with the specified valve or gate number.
5. Submit 2 samples of the type of tag proposed and the manufacturer’s standard color chart and letter styles to the ENGINEER for review.

6. Manufacturer: The following or equal:
   a. Seton Name Plate Company, Branford, CT.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify satisfactory conditions of substrate for applying identification.

B. Verify that conditions are satisfactory for installation and application of products as specified in Section 01600.

3.02 PREPARATION

A. Prepare and coat surfaces as specified in Section 09960.

B. Prepare surface in accordance with product manufacturer's instructions.

3.03 ABOVE GROUND AND IN-CHASE PIPING IDENTIFICATION

A. Identify exposed piping, valves, and accessories, and piping, valves, and accessories in accessible chases with lettering or tags designating service of each piping system with flow directional arrows and color code.

B. Color code:
   1. Paint all piping with colors as selected by OWNER.

C. Lettering and flow direction arrows:
   1. Stencil lettering on painted bands or use snap-on markers on pipe to identify pipe. When stenciling, stencil 3/4-inch high letters on 3/4- through 4-inch pipe or coverings, or 5-inch high letters on 5-inch and larger pipe or coverings.
   2. Provide lettering and flow direction arrows near equipment served, adjacent to valves, both sides of walls and floors where pipe passes through, at each branch or tee, and at intervals of not more than 50 feet in straight runs of pipe.

D. Where scheduled, space 6-inch wide bands along stainless steel pipe at 10-foot intervals and other pipe at 5-foot intervals.

E. Label chemical tank fill pipelines at locations which are visible from chemical fill stations.

F. Metal tags:
   1. Where outside diameter of pipe or pipe covering is 5/8 inch or smaller, provide metal pipe identification tags instead of lettering.
   2. Fasten pipe identification tags to pipe with chain.
   3. Where tags are used, color code pipe as scheduled.

3.04 BURIED PIPING IDENTIFICATION

A. Underground warning tape:
   1. Place continuous run of warning tape in pipe trench, 12 inches above the pipe.

B. Tracer wire:
   1. Install on all non-metallic pipe.
   2. Install an electrically continuous run of tracer wire along the entire length of the pipe with wire terminations in valve boxes, vaults, or structures.
   3. Install tracer wire on top of the pipe and secure to pipe with tape a minimum of every 10 feet.
   4. Where approved by the ENGINEER, splice sections of wire together using approved direct bury wire nuts.
      a. Twisting the wires together is not acceptable.

C. Witness markers:
   1. Install over pipe in unpaved open-space areas at intervals not greater than 200 feet.
   2. Place markers at appurtenances located in unpaved areas.
   3. Embed markers at least 18 inches into the soil.

3.05 APPLICATION

A. Identify piping with legend markers, directional arrow markers, and number markers; use self-adhesive arrow roll tape to secure ends of piping markers and indicate flow direction.

B. Provide legend markers, directional arrow markers, and number markers where piping passes through walls or floors, at piping intersections and at maximum 15-foot spacing on piping runs.

C. Provide piping marker letters and colors as scheduled.

D. Place markers on piping so they are visible from operator's position in walkway or working platform near piping. Locate markers along horizontal centerline of pipe, unless better visibility is achieved elsewhere.

3.06 PIPING COLOR CODE AND MARKER SCHEDULE

Service Fluid	Pipe Color	Marker Legend
Aeration Air (Sludge Storage)	Light Green	AA
Aluminum Sulfate or Polyaluminum Chloride	Yellow	ALUM
Chemical Drain	Charcoal	CHD
Cold Water	Blue	CW
Condensate Drain	Charcoal	CD
Decant	Dark Brown	DEC
Drain	Charcoal	D
Engine Exhaust	Yellow	EEX
Filter Backwash	Light Brown	FBW
Filter Effluent	Light Brown	FE
Filtrate	Light Brown	FIL

Service Fluid	Pipe Color	Marker Legend
Fire Supply Water	Red	FSW
Floor Drain	Charcoal	FD
Force Main	Dark Brown	FM
Foul Air Duct	Yellow	FAD
Foul Air Pipe	Yellow	FAP
Fuel Oil Return	Orange	FOR
Fuel Oil Supply	Orange	FOS
Hot Water	Light Blue	HW
Irrigation	Purple	IRRIG
Mixed Liquor	Dark Brown	ML
Natural gas	Red	NG
Non-Potable Water	Light Blue	W2
Out-of-Compliance Return	Dark Brown	OOCR
Plant Drain or Process Drain	Charcoal	PD
Plant Drain Force Main	Charcoal	PDFM
Plant Water or Utility Water	Dark Blue	PW
Polymer	Orange	POL
Potable Water	Light Blue	W1
Recycled/Reclaimed Water	Purple	REW
Refrigerant Liquid	Yellow	RL
Refrigerant Vapor	Yellow	RV
Return Activated Sludge	Dark Brown	RAS
Roof Drain	Charcoal	RD
Sample Line	Dark Blue	SA
Sanitary Sewer	Charcoal	SS
Scum	Dark Brown	SC
Secondary Effluent	Dark Blue	SE
Secondary Influent	Dark Blue	SI
Septage	Dark Brown	SEP
Sodium Hypochlorite Solution	Yellow	SHS
Storm Drain	Charcoal	SD
Storm Water (pumped)	Charcoal	STW
Sump Pump Discharge	Dark Brown	SPD

Service Fluid	Pipe Color	Marker Legend
Thickened Waste Activated Sludge	Dark Brown	TWAS
Vent	Yellow	V
Vent Piping	Yellow	VP
Waste Activated Sludge	Dark Brown	WAS

Letters	Color of Pipe	Color of Bands	Color of Letters
AA	Light Green	Dark Green	Black
ALUM	Orange	Yellow	Black
CHD	Charcoal	None	White
CW (return)	Light Brown	Red	White
CW (supply)	Light Brown	Dark Gray	White
CD	Charcoal	None	White
D	Charcoal	None	White
DEC	Dark Brown	None	White
EEX	Yellow	Black	Black
FAD	Yellow	Black	Black
FAP	Yellow	Black	Black
FBW	Light Brown	None	Black
FD	Charcoal	None	White
FE	Light Brown	None	Black
FIL	Light Brown	None	Black
FM	Dark Brown	None	White
FOR	Orange	None	Black
FOS	Orange	None	Black
FSW	Red	None	Black
HW (return)	Light Blue	Black	Black
HW (supply)	Light Blue	White	Black
IRRIG	Purple	None	White
ML	Dark Brown	None	White
NG	Red	Yellow	White
PD	Charcoal	None	White
PDFM	Charcoal	None	White

Letters	Color of Pipe	Color of Bands	Color of Letters
POL	Orange	Dark Green	Black
PW	Dark Blue	None	White
RAS	Dark Brown	None	White
RD	Charcoal	None	White
REW	Purple	None	White
RL	Yellow	White	Black
RV	Yellow	Black	White
SA	Dark Blue	Black	White
SC	Dark Brown	None	White
SD	Charcoal	None	White
SE	Dark Blue	None	White
SEP	Dark Brown	None	White
SHS	Yellow	Dark Green	Black
SI	Dark Blue	None	White
SPD	Dark Brown	None	White
SS	Charcoal	None	White
STW	Charcoal	None	White
TWAS	Dark Brown	None	White
V	Yellow	Black	White
VP	Yellow	Black	White
W1	Light Blue	White	Black
W2	Light Blue	Dark Gray	Black
WAS	Dark Brown	None	White

END OF SECTION

SECTION 15082

PIPING INSULATION

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Insulation for piping and related systems.

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 09960 - High-Performance Coatings.
   b. Section 15052 - Common Work Results for General Piping.
   c. Section 15075 - Equipment Identification.

1.02 REFERENCES

A. ASTM International (ASTM):
1. A 53 - Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded, and Seamless.
2. C 177 - Standard Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded-Hot-Plate Apparatus.
3. C 518 - Standard Test Method for Steady-State Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus.
4. C 533 - Standard Specification for Calcium Silicate Block and Pipe Thermal Insulation.
5. C 547 - Standard Specification for Mineral Fiber Pipe Insulation.
6. C 552 - Standard Specification for Cellular Glass Thermal Insulation.
7. C 795 - Standard Specification for Thermal Insulation for Use in Contact with Austenitic Stainless Steel.
8. C 929 - Standard Practice for Handling, Transporting, Shipping, Storage, Receiving, and Application of Thermal Insulation Materials for Use in Contact with Austenitic Stainless Steel.
9. C 1136 - Standard Specification for Flexible, Low Permeance Vapor Retarders for Thermal Insulation.
10. D 1784 - Standard Specification for Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds.
11. D 2310 - Standard Classification of Machine-Made "Fiberglass" (Glass-Fiber-Reinforced-Thermosetting-Resin) Pipe.
12. E 84 - Standard Test Method for Surface Burning Characteristics of Building Materials.
13. E 96 - Standard Test Methods for Water Vapor Transmission of Materials.

1.03 DEFINITIONS

A. Buried: Piping that is installed below buildings, foundations, or finish grade, either in soil or encased in concrete in soil.

B. Concealed: Piping above suspended ceilings and within walls, partitions, shafts, or service spaces and spaces not normally exposed to view but not buried.

C. Exterior: Piping that is installed under canopies, outside a building or within a pipe trench or tunnel.

D. Flame spread and smoke density: Burning characteristics determined in accordance with ASTM E 84. No units apply to value.

E. Interior: Piping that is installed inside a building.

F. K factor: Thermal conductivity determined in accordance with ASTM C 177 or C 518 and expressed in units of BTU-inch/hour-square feet-degrees Fahrenheit.

G. Mineral fiber: Fibers manufactured of glass, rock, or slag processed from a molten state, with or without a binder.

H. Water vapor permeance: Water vapor transmission determined in accordance with ASTM E 96 and expressed in units of perm-inch.

1.04 SUBMITTALS

A. Product data:
   1. Insulation properties: Include K factor, thickness, density, operating temperature limits, tensile strength, compressive strength, moisture absorption, flame spread, and smoke developed in accordance with ASTM E 84 and corrosivity to stainless steel piping in accordance with ASTM C 795.
   2. Jacket properties: Include covering material, cover thickness, tensile strength, tear strength, permeability in accordance with ASTM E 96, flame spread, and smoke developed in accordance with ASTM E 84, closure type or devices, and accessories.
   3. Insulating blankets: Include materials, performance characteristics, method of attaching to equipment, listing of locations where insulating blankets will be installed.

B. Manufacturer's application instructions: Include assembly and application drawings and detailed instructions.

C. Laboratory report: Provide certified laboratory report stating that insulation is not manufactured using chlorinated polymers and does not contain chlorides, bromides, sulfates, or fire-rated materials.

1.05 REGULATORY REQUIREMENTS

A. Projects located in California comply with California Energy Commission Energy Efficiency Standards for Residential and Non-Residential Buildings.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Store insulation materials and accessories under cover and protected from moisture.

B. Handle and store insulation for use on stainless steel in accordance with ASTM C 929.

1.07 SEQUENCING AND SCHEDULING

A. Pressure test piping and complete application of coating system before applying insulation.

B. When piping is to be heat traced, install and functionally test heat tracing before installation of insulation.

C. Before beginning installation of piping insulation, verify that the ENGINEER has accepted piping tests, pipe coating applications, and heat tracing tests.

PART 2 PRODUCTS

2.01 PIPE INSULATION, GENERAL REQUIREMENTS

A. Insulation thicknesses: Provide insulation thickness in inches in accordance with the following table. Insulation thickness shown is nominal. Manufacturing tolerance of 15 percent variation is permissible.

Required Insulation Thicknesses (inches)					
Service Temperature Range as Designated in Insulation Schedule at End of this Section	**Nominal Pipe Diameters**				
	1 inch & less	**1.25 to 2 inch**	**2.5 to 4 inch**	**5 to 10 inch**	**Over 10 inch**
Above 200 degrees Fahrenheit	2.0	2.5	3.0	3.5	3.5
100 to 200 degrees Fahrenheit	1.5	1.5	1.5	2.0	2.5
40 to 100 degrees Fahrenheit	0.5	1.0	1.0	1.5	2.0
Below 40 degrees Fahrenheit	1.0	1.0	1.5	2.0	2.0
Heat Traced Pipes	1.0	1.0	1.0	1.5	2.0
Aeration Air Pipes	0.5	0.5	1.0	1.0	1.0

2.02 PIPE INSULATION

A. Insulation types: Provide in accordance with the insulation types listed and scheduled.

B. Insulation, Type 1:
   1. Insulation material: Closed cell elastomeric insulation.
   2. Manufacturers: One of the following or equal:
      a. Armstrong World Industries, AP Armaflex.
      b. Apache Products Company, ISO-25.
   3. Minimum temperature range: Minus 40 degrees F to plus 220 degrees F.

4. K factor at 75 degrees F: Not more than 0.27 BTU-inch/hour-square feet-degrees F.
5. Fire ratings:
   a. Flame spread: 25 or less.
   b. Smoke density: 50 or less for insulation thicknesses up to 1.5 inches.
6. Joints: Seal with manufacturer's recommended contact adhesive to form continuous water barrier.

C. Insulation, Type 2:
1. Insulation material: Preformed mineral fiberglass insulation made from glass fibers bonded with a thermosetting resin.
   a. In accordance with ASTM C 547, Class 1.
   b. Provide with factory installed vapor barrier.
      1) Material: White kraft paper bound to aluminum foil in accordance with ASTM C 1136, Type I.
      2) Longitudinal lap seals: Pressure-sensitive, self-sealing longitudinal lap strip with factory applied adhesive.
      3) Circumferential butt seals: 4-inch wide tape or similar properties or 4-inch wide overlap with adhesive seal.
      4) Vapor barrier permeability: 0.02 perms or lower.
      5) Vapor barrier flame spread rating: 25 or less.
2. Minimum temperature range: Minus 0 degrees F to plus 850 degrees F.
3. K factor at 75 degrees F: Not more than 0.23 BTU-inch/hour-square feet-degrees F.
4. Maximum moisture absorption, volume percent: 5.
5. Manufacturers: One of the following or equal:
   a. Owens-Corning Fiberglas Corp.
   b. Johns Manville
   c. Knauf Fiber Glass.

D. Insulation, Type 3:
1. Insulation material: Rigid cellular glass in accordance with ASTM C 552, Type II.
2. Temperature range: Minus 450 degrees F to plus 900 degrees F.
3. K factor at 75 degrees F: Not more than 0.32 BTU-inch/hour-square feet-degrees F.
4. Minimum average density: 7.5 pounds per cubic foot.
5. Maximum moisture absorption, volume percent: 5.
6. Minimum compressive strength: 87 pounds per square inch.
7. Moisture permeability: 0.00 perm-inch.
8. Manufacturers: One of the following or equal:
   a. Pittsburgh Corning Corporation, Foamglas.
   b. Cell-U-Foam Corporation, Ultra-CUF.

E. Insulation, Type 4:
1. Insulation material: Asbestos free, rigid calcium silicate in accordance with ASTM C 533; Type I for process temperatures up to 1,200 degrees F.
2. K factor at 500 degrees F: 0.55 for Type I.
3. Maximum average (dry) density: 14.5 pounds per cubic foot.
4. Compressive strength: 100 pounds per square inch, to produce a 5 percent compression.

5. Manufacturers: One of the following or equal: In accordance with ASTM C 533 Type I:
    a. Industrial Insulation Group, LLC, Thermo-12 Gold.
6. Insulation material: Asbestos free, rigid calcium silicate in accordance with ASTM C 533; Type II for process temperatures above 1,200 degrees F.
7. K factor at .67 degrees F: 700.
8. Maximum average (dry) density: 18 pounds per cubic foot.
9. Compressive strength: 450 pounds per square inch, to produce a 5 percent compression.
10. Manufacturers: One of the following or equal: In accordance with ASTM C 533 Type II:
    a. Super Caltemp Gold 1700.

2.03 INSULATION JACKETS

A. Jacket, Type 1:
1. Material: 28 ounces per square yard polyvinyl chloride on polyester fabric; total thickness 0.028 inches minimum.
2. Fire rating: 25 maximum flame spread, smoke developed 50 or less.
3. Color: As selected by the ENGINEER from manufacturer's standard colors.
4. Overlap: 1-inch minimum at joints and fittings.
5. Joint seal: Self-sealing lap tape.
6. Fittings: Factory made with full thickness insulation.
7. Manufacturers: One of the following or equal:
    a. Accessible Products, Techlite Insulation, 379 SSL Series.

B. Jacket, Type 2:
1. Material: Ultraviolet resistant polyvinyl chloride jacketing, 20 mil minimum thickness.
2. Fire rating: 25 maximum flame spread, smoke developed 50 or less.
3. Color: White.
4. Overlap: 1-inch minimum at joints and fittings.
5. Joint seal: PVC solvent welded or adhesive as recommended by the manufacturer.
6. Fittings: Factory made with full thickness insulation.
7. Manufacturers: One of the following or equal:
    a. Johns Manville, Zeston 2000 PVC.
    b. Proto Corp., LoSMOKE PVC.
    c. Speedline Smoke Safe PVC Jacketing System.
    d. Knauf Covering System.

C. Jacket, Type 3:
1. Material: Aluminum, Alloy 5005; 0.016-inch (26 gauge) minimum thickness.
2. Overlap: Overlap circumferential joints 4 inches minimum; overlap longitudinal joints 1-inch minimum; longitudinal joints oriented to minimize water entry.
3. Bands: 0.5 inch wide, 0.0508 inch (16 gauge) thick aluminum, same alloy as jacket or 0.0179 inch thick Type 304 stainless steel; install on 18 inch centers, uniformly spaced and at all fitting joints.
4. Joint seal: Apply waterproof adhesive at joints and overlaps.
5. Fittings: Custom fit of same materials.
6. Manufacturers: One of the following or equal:
    a. Childers Products.
    b. Premetco International.

2.04 VAPOR BARRIERS

A. Vapor barrier, Type 1:
   1. Material: White kraft paper bound to aluminum foil in accordance with ASTM C 1136, Type 1.
   2. Permeability: 0.02 perms or lower.
   3. Maximum flame spread rating: 25.
   4. Edge seal: Pressure sensitive tape lap seal.
   5. Circumferential joints: 4 inch wide tape or 4 inch overlap with adhesive seal.

B. Vapor barrier, Type 2:
   1. Material: Mastic.
   2. Manufacturers: One of the following or equal:
      a. Benjamin Foster, No. 30-76.
      b. Insul-Coustic, No. I.C.-580.
      c. Foster Products, 36-10/46-10 Weatherite.
      d. Childers Products CP10/11 Vi-Acryl.

2.05 RELATED MATERIALS

A. Cover adhesive: Premium adhesive as recommended by the insulation cover supplier for heavy-duty service in corrosive, wet environments. Standard duty adhesives are not permitted.

2.06 REMOVABLE INSULATING BLANKETS

A. In piping systems specified to be insulated, use removable insulating blankets for valves, meters, strainers, filters, catalytic converters, engine exhaust silencers, and other in-line piping appurtenances and equipment requiring periodic servicing.

B. Size limits: Use removable insulating blankets for equipment and piping appurtenances 3-inch in nominal size and larger. Insulate equipment and piping appurtenances less than 3-inch with molded sections of insulation or by field cutting insulation to conform to the shape of the component and to fit tightly around the component.

C. Manufacturers: One of the following, or equal:
   1. Pittsburgh Corning, Temp-Mat.
   2. Accessible Products, Thermazip 2000 Jacket.
   3. Thermal Energy Products, Inc., Energy Wrap.

D. Low temperature insulating blankets rated up to 800 degrees F:
   1. Use: For service temperatures up to 800 degrees F.
   2. Insulation: Fiberglass fiber, K factor 0.27 at 75 degrees F.
   3. Cover: 17-ounce fabric with both sides covered with silicone impregnated glass cloth suitable for temperatures up to 800 degrees F.
   4. Cover fasteners: Use one of the following systems:
      a. Grommets in the blanket and stainless steel wire; or
      b. 1-inch wide straps with stainless steel rectangular ring buckles and Velcro on strap tail.

E. High temperature insulating blankets rated up to 1,400 degrees F:
   1. Rated for sustained service temperatures up to 1,400 degrees F.

2. Insulation: Ceramic fiber, K factor 0.50 at 600 degrees F, insulation material suitable for up to 2,300 degrees F, thickness to match adjacent piping insulation specified thickness.
3. Cover: 17-ounce silicone impregnated fiberglass cloth suitable for temperatures up to 1,400 degrees F.
4. Cover fasteners: Use one of the following systems:
   a. Grommets in the blanket and stainless steel wire; or
   b. 1-inch wide straps with stainless steel rectangular ring buckles and Velcro on strap tail.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verification of conditions: Before installing insulation, verify satisfactory completion of pressure tests of piping systems and functional tests of heat tracing equipment.

B. Examine piping surfaces and verify that surfaces are dry and free of loose scale, rust, dirt, oil, or water before applying insulation. When specified, paint or coat pipe surfaces as specified in Section 09960 before installing insulation.

C. Examine insulation materials and accessories before installation. Do not install insulation and jackets that have been damaged or insulation that has become wet due to exposure to water.

3.02 INSTALLATION

A. Install insulation and jacket materials in accordance with manufacturer's written instructions.

B. Apply insulation in smooth, clean manner with tight and finished smooth joints. Fit insulation tightly against surfaces. Insulate each continuous run of pipe with full-length sections of insulation with a single piece cut to length to complete the run of pipe. Do not use cut pieces or scraps to complete the installation.

C. Butt longitudinal and circumferential insulation joints firmly together.

D. Maintain the integrity of vapor barrier jacketing. Do not use staples to hold vapor barrier overlaps in place.

E. Apply sealant or cement when previous applications of adhesives and cement have thoroughly dried.

F. Apply insulation to permit expansion or contraction of pipelines without damage to insulation or jacketing.

G. Fittings:
   1. Insulate fittings by covering with mitered sections of insulation or utilize factory-made prefabricated fitting shapes.
   2. Terminate preformed pipe jackets or covering at sufficient distance from flanges to permit removal of bolts.
   3. Overlap flange and flanged fitting insulation on adjacent pipe covering by at least 2 inches.

H. Valves:
   1. Insulate valves 3-inch in nominal size and larger with removable insulating blankets.
   2. Size blanket to extend up to packing gland only so that replacement of packing does not require removal of insulating blanket.

I. Provide continuous insulation through and over pipe supports and provide protection saddles at supports.

J. Extend insulation against insulation end protection shields or covers so that insulation voids do not exist and provide watertight end seals and covers where insulation terminates.

K. Insulate pipeline strainers to permit removal of strainer basket without disturbing insulation on strainer body.

L. Provide continuous pipe insulation and covering through sleeves or openings in walls and floors. When buried pipe enters a building through a below grade wall or slab penetration, begin insulation system on interior side of penetration.

M. Apply premolded pipe insulation with extended legs when used on pipe traced with either tubing or electric cable type.

N. Thermally isolate all insulation closure locations (end caps, transitions, etc.) Type 1 or 2 jacket installation on piping with potential reach temperatures greater than 150 degrees Fahrenheit.

O. Apply piping identification on jackets as specified in Section 15075.

3.03 INSULATION SCHEDULE

Service Designation (1)	Location(2)	Insulation Type(3)	Jacket Type(3)	Service Temp. °F(4)	Vapor Barrier
HVAC Refrigerant	Interior or Exterior	1	2	Below 40	Required
Aeration Air (AA)(6)	Interior or Exterior	2	1	Use thickness established in Table in Article 2.01	Required
Engine Exhaust	Interior	4	3	Note 5	None

Notes:
1. Refer to Piping Schedule in Section 15052 for service designations.
2. Insulation jackets are not required for interior installations that are concealed. See definitions for description of concealed locations.
3. CONTRACTOR may select from options listed.
4. Unless noted otherwise, use service temperature range provided in this table to establish insulation thickness as required by Table in Article 2.01 Paragraph A.
5. Service temperature based on engine rating. Use Type I calcium silicate for exhaust temperatures up to 1,000 degrees F, use Type II calcium silicate for exhaust temperatures above 1,000 degrees F.
6. Install insulation on all aeration air piping on the discharge side of blowers up to 10 feet above floor slab. Insulation is not required for aeration air piping that is installed higher than 10 feet above the floor slab. Insulation is not required for aeration air piping on the suction side of blowers.

END OF SECTION

SECTION 15084

DUCTWORK INSULATION

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: External thermal insulation for metal air ductwork systems.

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 01410 - Regulatory Requirements.

1.02 REFERENCES

A. ASTM International (ASTM):
   1. E 84 - Standard Test Method for Surface Burning Characteristics of Building Materials.
   2. G 21 - Standard Practice for Determining Resistance of Synthetic Polymeric Materials to Fungi.

B. Sheet Metal and Air Conditioning Contractor's National Association (SMACNA).

C. California Code of Regulations (CCR):
   1. Title 24 - Building Standard Code.

1.03 SUBMITTALS

A. Manufacturer's product literature including product specifications and installation recommendations.

B. Certification of compliance with CCR Title 24 energy and approval by the California Energy Commission.

1.04 QUALITY ASSURANCE

A. Comply with SMACNA ducting construction standards and the specified requirement, whichever is more stringent.

B. Compliance with CCR Title 24.

PART 2 PRODUCTS

2.01 EXTERNAL DUCTWORK INSULATION

A. Manufacturers: One of the following or equal:
   1. Owens Corning, SoftR Duct Wrap.
   2. Johns Manville Microlite Duct Wrap.

B. External ductwork insulation: Flexible blanket type glass fiber factory-laminated to reinforced foil kraft vapor barrier facing with 2-inch stapling and topping flange on one edge, conforming to the following requirements:
   1. Thickness: As required to achieve the following R-values:
      a. For ducting exterior to weather-protected spaces, provide 3 inches minimum thickness to meet an installed value of R8; provide additional weatherproof exterior barrier covering.
      b. For interior ducting in ceiling plenums, attics, or other unconditioned spaces provide 2 inches minimum thickness to meet an installed value of R8**.**
   2. Temperature range: 40 to 250 degrees Fahrenheit.
   3. Density: 1.5 pounds per cubic foot.
   4. Moisture absorption: Less than 3 percent.
   5. Thermal conductivity: 0.25 Btu-inch per hour per square foot per degree Fahrenheit at 75 degrees Fahrenheit.
   6. Fire hazard classification in accordance with ASTM E84:
      a. Flame spread: 25.
      b. Smoke developed: 50.

C. Seaming tape: UV resistant with properties in accordance with mechanical code as specified in Section 01410.

PART 3 EXECUTION

3.01 EXTERNAL DUCTWORK INSULATION

A. Provide external ductwork insulation on round ducts carrying conditioned air passing through outdoor or unconditioned spaces or as indicated on the Drawings.

B. Apply external duct insulation with edges tightly butted and secured by 3 wraps of 1/2-inch wide polypropylene strapping tape every 12 inches.

C. Seal seams with 4-inch wide tape with ends of the tape overlapping at least 4 inches.

D. When underside of horizontal ducts exceeds 24 inches in width, additionally secure insulation by mechanical fasteners. Install 1 mechanical fastener for every 2 square feet of duct surface.

E. Seal duct penetrations with a piece of the same facing material as the duct and install with the same vapor barrier adhesive. Extend external insulation and vapor barrier through all duct sleeves.

END OF SECTION

SECTION 15110

COMMON WORK RESULTS FOR VALVES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Basic requirements for valves.

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 09960 - High-Performance Coatings.
      c. Section 15211 - Ductile Iron Pipe, AWWA C151.

1.02 REFERENCES

A. American Water Works Association (AWWA):
   1. C111/A21.11 - Standard for Rubber-Gasket Joints for Ductile-Iron Pressure Pipe Fittings.

B. ASTM International (ASTM):
   1. A 126 - Standard Specification for Gray Iron Casting for Valves, Flanges, and Pipe Fittings.
   2. A 167 - Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip.
   3. A 536 - Standard Specification for Ductile Iron Castings.

C. NSF International (NSF):
   1. 61 - Drinking Water System Components - Health Effects.

D. Society for Protective Coatings (SSPC):
   1. SP 7 - Brush-Off Blast Cleaning.
   2. SP 10 - Near-White Blast Cleaning.

1.03 DESIGN REQUIREMENTS

A. Pressure rating:
   1. Suitable for service under minimum working pressures of 150 pounds per square inch gauge.
   2. When a piping system is specified in the Piping Schedule to be tested at a pressure greater than 150 pounds per square inch gauge, provide valves for

that piping system with design working pressure which is sufficient to withstand the test pressure.

B. Valve to piping connections:
   1. Valves 3-inch nominal size and larger: Flanged ends.
   2. Valves less than 3-inch nominal size: Screwed ends.
   3. Plastic valves in plastic piping:
      a. Up to 2.5 inches: Provide solvent or heat welded unions.
      b. 3 inches and above: Provide solvent or heat welded flanges.

1.04 SUBMITTALS

A. Submit as specified in Section 01330.

B. Product data:
   1. Submit the following information for each valve:
      a. Valve type, size, pressure rating, Cv factor.
      b. Coatings.
      c. Power valve actuators:
         1) Information on valve actuator including size, manufacturer, model number, limit switches, mounting; and motor enclosure, seating and unseating torque coefficient, dynamic torque, and bearing friction for calculation of maximum operating torque.
         2) Complete wiring diagrams and control system schematics.
      d. Manual valve actuators:
         1) Information on valve actuator including size, manufacturer, model number.
      e. Certified drawings with description of component parts, dimensions, weights, and materials of construction.
      f. Certifications of reference standard compliance:
         1) Submit certification that the valves and coatings are suitable in potable water applications in accordance with NSF 61.
      g. Clearly mark submittal information to show specific items, materials, and accessories or options being furnished.
      h. Factory test data.

C. Operation and maintenance data:
   1. Furnish bound sets of installation, operation, and maintenance instructions for each type of manual valve 4 inch in nominal size and larger, and all non-manual valves. Include information on valve operators in operation and maintenance instruction manual.

1.05 QUALITY ASSURANCE

A. Manufacturer qualifications:
   1. Valves manufactured by manufacturers whose valves have had successful operational experience in comparable service.

1.06 DELIVERY STORAGE AND HANDLING

A. Protect valves and protective coatings from damage during handling and installation; repair coating where damaged.

PART 2 PRODUCTS

2.01 MATERIALS

A. Stainless steel: In accordance with ASTM A 167, Type 316, or Type 304, UNS Alloy S31600 or S30400.

B. Valve and operator bolts and nuts:
   1. Fabricated of stainless steel for the following installation conditions:
      a. Submerged in sewage or water.
      b. In an enclosed space above sewage or water.
      c. In structures containing sewage or water, below top of walls.
      d. At openings in concrete or metal decks.
   2. Where dissimilar metals are being bolted, use stainless steel bolts with isolation bushings and washers.
   3. Underground bolts: Low-alloy steel in accordance with AWWA C111/A21.11.

C. Bronze and brass alloys: Use bronze and brass alloys with not more than 6 percent zinc and not more than 2 percent aluminum in the manufacture of valve parts; UNS Alloy C83600 or C92200 unless specified otherwise.

D. Valve bodies: Cast iron in accordance with ASTM A 126, Class 30 minimum or ductile iron in accordance with ASTM A 536, Grade 65-45-12 minimum unless specified otherwise.

2.02 INTERIOR PROTECTIVE LINING

A. When specified in the particular valve specification, provide valves with type of protective lining specified in the particular valve Specification.

B. Apply protective lining to interior, non-working surfaces, except stainless steel surfaces.

C. Lining types:
   1. Fusion bonded epoxy:
      a. Manufacturers: One of the following or equal:
         1) 3-M Company, ScotchKote 134; certified to NSF 61 for drinking water use.
      b. Clean surfaces in accordance with SSPC SP 7 or SP 10, as recommended by epoxy manufacturer.
      c. Apply in accordance with manufacturer's published instructions.
      d. Lining thickness: 0.010 to 0.012 inches except that:
         1) Lining thickness in grooves for gaskets: 0.005 inches.
         2) Do not coat seat grooves in valves with bonded seat.
      e. Quality control:
         1) Lining thickness: Measured with a non-destructive magnetic type thickness gauge.
         2) Verify lining integrity with a wet sponge-testing unit operating at approximately 60 volts, or as recommended by the lining manufacturer.
         3) Consider tests successful when lining thickness meets specified requirements and when no pinholes are found.

4) Correct defective lining disclosed by unsuccessful tests, and repeat test.
5) Repair pinholes with liquid epoxy recommended by manufacturer of the epoxy used for lining.

2. High solids epoxy:
   a. Product equivalent to high solids epoxy specified in Section 09960.
      1) Certified in accordance with NSF 61 for drinking water use.
      2) Interior: Coat valve interior with manufacturer's equivalent high performance high solids epoxy coating system with a certifiable performance history for the service conditions and as approved by the ENGINEER. Manufacturer shall provide for approval, coating information sufficient to allow ENGINEER to assess equivalence to the specified high solids epoxy coating specified in Section 09960.
   b. Clean surfaces to meet SP-7 or SP-10, or as recommended by coating manufacturer.
   c. Quality control: After coating is cured, check coated surface for porosity with a holiday detector set at 1,800 volts, or as recommended by coating manufacturer.
      1) Repair holidays and other irregularities and retest coating.
      2) Repeat procedure until holidays and other irregularities are corrected.

2.03 UNDERGROUND VALVES

A. Provide underground valves with flanged, mechanical, or other type of joint required for the type of pipe to which the valve is to be connected.

B. Coating and wrapping:
   1. After installation, encase valves in 2 layers of polyethylene wrap as specified for ductile iron piping in Section 15211.
      a. Ascertain that polyethylene wrapping does not affect operation of valve.

2.04 STEAM VALVES

A. Valves in steam or steam condensate piping: Ductile iron body in accordance with ASTM A 536, Grade 65-45-12 minimum or cast steel or forged steel.

2.05 VALVE BOXES

A. Provide cast-iron valve boxes at each buried valve to access valve and valve operators.

B. Do not support boxes on valve, valve operator, or pipe.

C. Boxes:
   1. 2-piece, fabricated of cast iron; provide cover, with asphalt varnish or enamel protective coating.
   2. Adjustable to grade, install centered around the upper portions of the valve and valve operator.

D. Manufacturers: One of the following or equal:
   1. Tyler Pipe Industries, Inc.
   2. Neenah Foundry Company.

2.06 VALVE OPERATORS

A. Valve operator "Open" direction: Open counterclockwise.

B. Provide valves located below operating level or deck with extensions for key operation or floor stands and handwheels.

C. Provide manually operated valves located not more than 6 feet above the operating level with tee handles, wrenches, or handwheels.
   1. Make the valve operator more conveniently accessible by rolling valves, located more than 5 feet but less than 6 feet above the operating level, toward the operating side.
   2. Secure tee handles and wrenches to the valve head or stem, except where a handle or wrench so secured constitutes a hazard to personnel; in which case, stow handle or wrench immediately adjacent to the valve on or in a suitable hanger, bracket, or receptacle.

D. Fit valves located more than 6 feet above operating level with chain operated handles or valve wheels.
   1. Chains: Sufficient length to reach approximately 4 feet above the operating level.
   2. Where chains constitute a nuisance or hazard to operating personnel, provide holdbacks or other means for keeping the chains out of the way.

E. Provide an operator shaft extension from valve or valve operator to finished grade or deck level when buried valves, and other valves located below the operating deck or level, are specified or indicated on the Drawings to be key operated; provide 2 inch square AWWA operating nut, and box and cover as specified, or a cover where a box is not required.

PART 3 EXECUTION

3.01 EXAMINATION

A. Preparation prior to installation:
   1. Install valves after the required submittal on installation has been accepted.
   2. Determine after flanged valves and flanged check valves are selected, the face-to-face dimensions of flanged valves and flanged check valves.

B. Fabricate piping to lengths taking into account the dimensions of flanged valves and flanged check valves.

3.02 INSTALLATION

A. Provide incidental work and materials necessary for installation of valves including flange gaskets, flange bolts and nuts, valve boxes and covers, concrete bases, blocking, and protective coating.

B. Where needed, furnish and install additional valves for proper operation and maintenance of equipment and plant facilities under the following circumstances:
   1. Where such additional valves are required for operation and maintenance of the particular equipment furnished by CONTRACTOR.
   2. Where such additional valves are required as a result of a substitution or change initiated by CONTRACTOR.

C. Install valves with their stems in vertical position above the pipe, except as follows:
   1. Butterfly valves, gate valves aboveground, globe valves, ball valves, and angle valves may be installed with their stems in the horizontal position.
   2. Install buried plug valves with geared operators with their stems in a horizontal position.

D. Install valves so that handles clear obstructions when the valves are operated from fully open to fully closed.

E. Place top of valve boxes flush with finished grade or as otherwise indicated on the Drawings.

F. Valves with threaded connections:
   1. Install valves by applying wrench on end of valve nearest the joint to prevent distortion of the valve body.
   2. Apply pipe joint compound or Teflon® tape on external (male) threads to prevent forcing compound into valve seat area.

G. Valves with flanged connections:
   1. Align flanges and gasket carefully before tightening flange bolts.
   2. When flanges are aligned, install bolts and hand tighten.
   3. Tighten nuts opposite each other with equal tension before moving to next pair of nuts.

H. Valves with soldered connections:
   1. Do not overheat connection to prevent damage to resilient seats and metal seat rings.
   2. Position valves in full open position before starting soldering procedure.
   3. Apply heat to piping rather than to valve body.

END OF SECTION

SECTION 15111

BALL VALVES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Metal body ball valves and plastic body ball valves.

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 13447 - Electric Motorized Actuators.
      c. Section 15052 - Common Work Results for General Piping.
      d. Section 15110 - Common Work Results for Process Valves.

1.02 REFERENCES

A. American Society of Mechanical Engineers (ASME):
   1. B16.1 - Gray Iron Pipe Flanges and Flanged Fittings: Classes 25, 125, and 250.
   2. B16.5 - Pipe Flanges and Flanged Fittings: NPS 1/2 through 24.

B. American Water Works Association (AWWA):
   1. C507 - Standard for Ball Valves 6 Inch Through 48 Inch.

C. ASTM International (ASTM):
   1. A 48 - Standard Specification for Gray Iron Castings.
   2. A 216 - Standard Specification for Steel Castings, Carbon, Suitable for Fusion Welding, for High-Temperature Service.
   3. A 351 - Standard Specification for Castings, Austenitic, for Pressure-Containing Parts.

1.03 SYSTEM DESCRIPTION

A. General: Unless otherwise indicated on the Drawings use:
   1. Metal body ball valves on metallic pipelines.
   2. Plastic body ball valves on plastic pipelines.

B. Do not use metal body ball valves in sodium hypochlorite or sodium bisulfite systems.

1.04 SUBMITTALS

A. Shop drawings: Submit the following information as specified in Sections 01330 and 15110:
   1. Product data.
   2. Certificates:
      a. Metal body ball valves: 6 inches and larger only. Submit affidavit of compliance in accordance with AWWA C507.
   3. Operation and maintenance data.

PART 2 PRODUCTS

2.01 METAL BODY BALL VALVES, LESS THAN 6 INCH SIZE

A. Manufacturers: One of the following, or equal:
   1. Apollo Valves as manufactured by Conbraco Industries, Inc.
   2. Metso Automation/Jamesbury.
   3. NIBCO, Inc.
   4. Flow-Tek, Inc.

B. General:
   1. Type: Non-lubricated, full port and capable of sealing in either direction.
   2. End connections:
      a. Threaded or solder ends for sizes 3-inch and smaller.
      b. Class 150 flanged for sizes larger than 3 inch.
         1) Flanges: In accordance with ASME B16.1 standards.
   3. Stem packing: Manually adjustable while valve is under pressure.
   4. Shafts:
      a. Rigidly connected to the ball by a positive means.
         1) Design connection to transmit torque equivalent to at least 75 percent of the torsional strength of the shaft.
   5. Handles: Stainless steel latch lock handle with vinyl grip and stainless steel nut designed to open and close the valve under operating conditions.
   6. Temperature limits: Suitable for operation between minus 20 and 350 degrees Fahrenheit.

C. Materials:
   1. Valves in copper lines: Bronze body.
   2. Valves in steel and ductile iron piping: Ductile iron or cast steel body.
   3. Valves in stainless steel piping: Stainless steel body, material type to match piping material as specified in Section 15052.
   4. Ball: Type 304 or 316 stainless steel, Type 316 in digester gas applications.
   5. Seats: PTFE.
   6. Stem seals: PTFE or Viton®.
   7. Bearings: Self-lubricated, corrosion resistant material that will not contaminate potable water.
   8. Valves for combustible fluid applications (digester gas, natural gas, fuel oil, etc.) must be of fire safe design.

2.02 PLASTIC BODY BALL VALVES

A. Manufacturers: One of the following or equal:
   1. Asahi America.
   2. Chemtrol Division, NIBCO, Inc.
   3. Plast-O-Matic Valves, Inc.

B. General:
   1. Type: Non-lubricated and capable of sealing in either flow direction.
   2. End connections: True union; solvent or heat welded to piping.
   3. Operator handle: Lever.
   4. Stem extension:
      a. Where indicated on the Drawings.
      b. One-piece, non-supported, wall mounted with collar where valve handle should be extended away from the valve for out-of-reach locations.
      c. Same material as the valve body.

C. Materials:
   1. Body: Polyvinyl chloride (PVC) or Chlorinated polyvinyl chloride (CPVC) to match piping material.
   2. Ball: PVC or CPVC to match piping material.
   3. Seats: PTFE (Teflon®).
   4. O-rings: FKM (Viton®).

PART 3 EXECUTION

3.01 INSTALLATION

A. General: Install each type of valve in accordance with manufacturers' printed instructions.

B. Special techniques:
   1. PVC or CPVC ball valves for hypochlorite service:
      a. Provide valve with factory drilled 0.125-inch hole in the upstream side of the ball.
      b. Provide an engraved plastic tag permanently attached to the valve stem stating "One side of ball drilled for hypochlorite service."

END OF SECTION

SECTION 15112

BUTTERFLY VALVES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Butterfly valves.

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 01757 - Disinfection.
   c. Section 09960 - High-Performance Coatings.
   d. Section 13446 - Manual Actuators.
   e. Section 13447 - Electric Motorized Actuators.
   f. Section 15110 - Common Work Results for Valves.
   g. Section 15211 - Ductile Iron Pipe, AWWA C151.

1.02 REFERENCES

A. American Society of Mechanical Engineers (ASME):
1. B16.1 - Cast Iron Pipe Flanges and Flanged Fittings, Classes 25, 125 and 250.
2. B16.5 - Pipe Flanges and Flanged Fittings, NPS 1/2 through NPS 24.

B. American Water Works Association (AWWA):
1. C110 - Standard for Ductile-Iron and Gray-Iron Fittings.
2. C504 - Rubber-Seated Butterfly Valves.
3. C540 - Standard for Power-Actuating Devices for Valves and Sluice Gates.
4. C550 - Protective Interior Coatings for Valves & Hydrants.
5. C606 - Standard for Grooved and Shouldered Joints.

C. ASTM International (ASTM):
1. A 126 - Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings.
2. A 216 - Standard Specification for Steel Castings, Carbon, Suitable for Fusion Welding, for Higher-Temperature Service.
3. A 276 - Standard Specification for Stainless Steel Bars and Shapes.

4. A 351 - Standard Specification for Castings, Austenitic, for Pressure-Containing Parts.
5. A 395 - Standard Specification for Ferritic Ductile Iron Pressure-Retaining Castings for Use at Elevated Temperatures.
6. A 479 - Standard Specification for Stainless Steel Bars and Shapes for Use in Boilers and Other Pressure Vessels.
7. A 515 - Standard Specification for Pressure Vessel Plates, Carbon Steel, for Intermediate - and Higher-Temperature Service.
8. A 516 - Standard Specification for Pressure Vessel Plates, Carbon Steel, for Moderate - and Lower-Temperature Service.
9. A 536 - Standard Specification for Ductile Iron Castings.
10. A 564 - Standard Specification for Hot-Rolled and Cold-Finished Age-Hardening Stainless Steel Bars and Shapes.
11. A 582 - Standard Specification for Free-Machining Stainless Steel Bars
12. B 584 - Standard Specification for Copper Alloy Sand Castings for General Applications.
13. D 429 - Standard Test Methods for Rubber Property-Adhesion to Rigid Substrate.

D. Compressed Gas Association (CGA):
1. Standard G-4.1 - Cleaning Equipment for Oxygen Service.

E. NSF International (NSF):
1. Standard 61 - Drinking Water System Components - Health Effects.

F. United States Code of Federal Regulations (CFR):
1. 21 - Food and Drugs.

1.03 SYSTEM DESCRIPTION

A. Design requirements:
1. General purpose AWWA butterfly valves:
   a. Design standard: Provide valves designed and manufactured in accordance with AWWA C504.
   b. Class:
      1) Provide butterfly valves in accordance with AWWA Class 150B, unless otherwise specified.
      2) Provide butterfly valves in accordance with AWWA Class 250B in piping systems with test pressure greater than 150 pounds per square inch and less than 250 pounds per square inch.
2. High pressure butterfly valves:
   a. Piping systems designed for operating pressures greater than 250 pounds per square inch and less than 450 pounds per square inch: Provide ASME B16.5, Class 300 high pressure valves.
3. Industrial class butterfly valves:
   a. Industrial class butterfly valves capable of 150 pounds per square inch leak tight shut off.
4. Stainless steel butterfly valves:
   a. Stainless steel butterfly valves capable of a minimum of 100 pounds per square inch leak tight shut off and with special cleaning, packaging, and handling.

B. Usage:
   1. Provide and install butterfly valve types as outlined in the Butterfly Valve Application Schedule at the end of this Section.

C. Design requirements for all butterfly valves with power actuating devices:
   1. Design valves and actuators for maximum operating torque, in accordance with and using safety factors required in AWWA C540, using the following values:
      a. Maximum water velocity: 16 feet per second with valve fully open.
      b. Maximum pressure differential across the closed valve equal to the pressure class designation.
      c. Coefficient for seating and unseating torque, dynamic torque, and bearing friction in accordance with valve manufacturer's published recommendations.
   2. Valve disc: Seat in an angular position of 90 degrees to the pipe axis and rotate an angle of 90 degrees between fully open and fully closed positions:
      a. Do not supply valves with stops or lugs cast with or mechanically secured to the body of the valve for limiting the disc travel.
   3. Unacceptable thrust bearings: Do not provide valves with thrust bearings exposed to the fluid in the line and consisting of a metal bearing surface in rubbing contact with an opposing metal bearing surface.

D. Performance requirements:
   1. Tight shutoff at the pressure rating of the valve with pressure applied in either direction.
   2. Suitable for the following service conditions:
      a. Throttling.
      b. Frequent operation.
      c. Operation after long periods of inactivity.
      d. Installation in any position and flow in either direction.

1.04 SUBMITTALS

A. Shop drawings: Submit the following information as specified in Sections 01330 and 15110:
   1. Product data:
      a. For general purpose AWWA butterfly valves, include description of the method of attachment of the disc edge to the valve disc.
   2. Certificates:
      a. General purpose AWWA butterfly valves:
         1) Proof-of-design tests: Certified statement that proof-of-design tests were performed and all requirements were successfully met.
         2) Affidavit of compliance attesting valves provided comply with all provisions in accordance with AWWA C504.
      b. Interior epoxy coatings: Affidavit of compliance attesting that epoxy coatings applied to interior surfaces of butterfly valves comply with all provisions in accordance with AWWA C550.
      c. Certification, for all valves and coatings in contact with potable water, that the products used are suitable for contact with drinking water in accordance with NSF Standard 61.
   3. Operation and Maintenance Data.

PART 2 PRODUCTS

2.01 GENERAL PURPOSE AWWA BUTTERFLY VALVES

A. Manufacturers: One of the following or equal:
   1. DeZurik/Sartell Model BAW.
   2. Henry Pratt Company.

B. Valve body:
   1. Material: Cast iron, ASTM A 126, Grade B, or ductile iron, ASTM A 536, Grade 65-45-12.
   2. Body design:
      a. Flanged body valves:
         1) Usage: Comply with limitations specified in the Butterfly Valve Application Schedule.
         2) Flanges: In accordance with ASME B16.1 Class 125 flanges for Class 150B valves, in accordance with ASME B16.1 Class 250 flanges for Class 250B valves.
      b. Mechanical joint body valves:
         1) Usage: Comply with limitations specified in the Butterfly Valve Application Schedule.
         2) Mechanical joint design: In accordance with AWWA C110.
         3) When mechanical joint body valves are used, incorporate valve into thrust restraint analysis as specified in Section 15211. Utilize test pressure on one side of valve and zero pressure on the opposite side of the valve. Restrain pipe joints on both sides of valve as determined by thrust analysis calculations.
      c. Wafer body valves:
         1) Usage: Comply with installation limitations specified in the Butterfly Valve Application Schedule.
         2) Body design: Lugged design with boltholes drilled and tapped to accept flange bolts. Wafer body valves that are installed by mating between flanges are not acceptable.
         3) Locate lugged style valves in piping systems such that when the valve is operated, the opening of the valve disc will not interfere with, nor be impaired by, adjacent piping, fittings, valves, equipment, or other installations.
      d. Grooved end body valves:
         1) Usage: Butterfly valves with grooved ends may be used in piping systems specified in the Piping Schedule to have grooved end joints. Comply with additional limitations specified in the Butterfly Valve Application Schedule.
         2) Grooved end joint design: In accordance with AWWA C606.

C. Disc:
   1. Material: Cast iron or ductile iron with Type 316 stainless steel edge that matches seat in valve body.
   2. Secure valve disc to shaft by means of smooth-sided, taper or dowel pins, Type 316 stainless steel, or Monel.
   3. Extend pins through shaft and mechanically secure in place.

D. Shaft and bearings:
   1. Shaft design:
      a. Valves 20-inch and less: 1 piece, through disc design.
      b. Valves greater than 20-inch size: 2 piece, stub shaft design.
   2. Shaft seal: Vee type, chevron design.
   3. Shaft material for Class 150B valves: Type 316 stainless steel, ASTM A 276.
   4. Shaft material for Class 250B valves: Type 17-4 pH stainless steel, ASTM A 564.
   5. Shaft bearings: Self-lubricating sleeve type:
      a. Valves 20-inch and less: Nylatron.
      b. Valves greater than 20-inch size: Teflon® with stainless steel or fiberglass backing.

E. Seats:
   1. Seat materials:
      a. In low-pressure air applications: EPDM.
      b. In all other applications: NBR or natural rubber
   2. For valves 20 inches in nominal size and smaller, bond or vulcanize seat into the valve body.
   3. For valves 24 inches in nominal size and larger, retain seats mechanically or by adhesive:
      a. Mechanical retainage: Retain seat by a clamping ring with segmented clamping ring locks with adjusting locking screws.
         1) Clamping ring, ring locks, and adjusting locking screws: Type 316 stainless steel.
         2) Provide means to prevent ring locks and screws used to retain seats from loosening due to vibration or cavitation.
      b. Adhesive retainage: Inset the seat within a groove in the valve body and retain in place with epoxy injected behind the seat so that the seat expands into the body.
      c. Do not provide valves with seats retained by snap rings or spring-loaded retainer rings.
   4. Resilient seat: Withstand 75 pound per inch pull when tested in accordance with ASTM D 429, Method B.

F. Valve packing:
   1. Valves 4 inch to 48 inch nominal size: Self-adjusting V-type packing or chevron-type packing. NBR or EPDM to match seat material.
   2. Valves 54 inch nominal size and larger: Adjustable V-type packing with bronze packing gland or self-adjusting V-type packing. NBR or EPDM to match seat material.

2.02 HIGH PRESSURE BUTTERFLY VALVES

A. Manufacturers: One of the following or equal:
   1. DeZurik.
   2. Crane Flowseal.
   3. Neles-Jamesbury.

B. Valve body:
   1. Material: Carbon steel ASTM A 515 or A 516, Grade 70, or ASTM A 216, WCB.
   2. Body design: Flanged, in accordance with ASME B16.5, Class 300 dimensions. Wafer and lugged style valves may not be used for high-pressure service.

C. Disc:
   1. Offset disc.
   2. Material: Type 316 stainless steel, ASTM A 351, Grade CF-8M.

D. Shaft and bearings:
   1. Shaft: Type 316 stainless steel, ASTM A 479 or Type 17-4 PH stainless steel, ASTM A 564.
   2. Shaft bearings: Self-lubricating sleeve type; Teflon® with stainless steel or fiberglass backing.

E. Disc pins: Secure valve disc to shaft by means of solid, smooth-sided, taper or dowel pins, Type 316 stainless steel or Monel:
   1. Extend pins through shaft and mechanically secure in place.

F. Seats:
   1. Material: Teflon®, or Teflon® with titanium back-up ring.
   2. Seat retainer ring:
      a. If used on sizes above 20-inch: Type 316 stainless steel with stainless steel fasteners.
      b. Type 316 stainless steel for digester gas applications.
      c. For all such valves, bond the seat to the retention ring.

G. Valve shaft packing: Teflon®, chevron type design. Field adjustable and field replaceable.

2.03 INDUSTRIAL CLASS BUTTERFLY VALVES

A. Manufacturers: One of the following or equal:
   1. SPX/DeZurik Style BOS.
   2. Tyco-Keystone Figure AR2.

B. Valve body:
   1. Pressure rating: 150 pounds per square inch, minimum.
   2. Material: Cast iron, ASTM A 126, Class B or Ductile Iron, ASTM A 395, Grade 60/40/18.
   3. Body design: Lugged style body with drilled and tapped boltholes in accordance with ASME B16.1, Class 125 and Class 150 flange drilling dimensions.

C. Disc:
   1. Materials:
      a. Air and water service: Cast iron, ASTM A 126, Class B or Ductile Iron, ASTM A 536, Grade 65/45/12 or Type 316 stainless steel, ASTM A 351, Grade CF8M.
      b. Natural gas and digester gas service: Type 316 stainless steel, ASTM A 351, Grade CF8M.
   2. Disc edge: Nickel-plated when cast iron or ductile iron disc is used.

D. Shaft and bearings:
   1. Shaft: Type 316 stainless steel, ASTM A 276 or Type 416 stainless steel, ASTM A 582 / A 582M.
   2. Shaft bearings: Self-lubricating sleeve type, Teflon® with stainless steel or fiberglass backing.

E. Disc pins: Secure valve disc to shaft by means of solid, smooth-sided, taper or dowel pins, Type 316 stainless steel:
   1. Extend pins through shaft and mechanically secure in place.

F. Seats:
   1. Material:
      a. Natural gas applications: Neoprene or Buna N.
      b. All other applications: EPDM.
   2. Seat retention ring, if used on larger sizes: Type 316 stainless steel or bronze, ASTM B 584, with stainless steel fasteners. For all such valves, bond the seat to the retention ring.

G. Valve shaft packing:
   1. Natural gas applications: Neoprene or Buna N.
   2. All other applications: EPDM or Teflon®.

2.04 THERMOPLASTIC BUTTERFLY VALVES (1-1/2 TO 16-INCHES)

A. Manufacturers: One of the following, or equal:
   1. ASAHI, Type 56.
   2. Hayward.

B. Valve Body:
   1. Material: PVC, CPVC, PVDF.
   2. Body Design: Lugged, wafer style body with drilled and tapped bolt holes to match ASME/ANSI B 16.1, Class 125 and Class 150 flanged drilling dimensions.

C. Disc:
   1. Disc shall be offset.
   2. Material: PVC, CPVC, PVDF.

D. Stem and stem older:
   1. Stem: Type 316 stainless steel.
   2. Stem holder: Type 304 stainless steel.

E. Seats:
   1. Material: EPDM or as required to be compatible with the service fluid.
   2. O-rings: EPDM or as required to be compatible with the service fluid.

2.05 BUTTERFLY VALVE ACTUATORS

A. Motorized actuators are specified in Section 13447. Additional requirements for manual actuators are specified in Section 13446.

B. Manual actuators for aboveground valves, 4 inches in nominal size and smaller for liquid service, and 10 inches in nominal size and smaller for aeration air service.
   1. For valves operating at pressures up to and including 250 pounds per square inch, provide hand lever type with locking device so that the valve can be locked in any position with a wing nut.
      a. Locking device: Rigid, allowing no vibration or chattering of the valve.
      b. Hand lever: 12 inches long, with handgrip.
   2. For valves operating at pressures above 250 pounds per square inch, provide totally enclosed worm gear actuator mounted on the valve.

C. Manual actuators for aboveground valves in nominal sizes and in service applications other than specified above, except for valves 30 inches and larger.
   1. For valves operating at pressures up to and including 250 pounds per square inch, provide either a totally enclosed worm gear actuator or a totally enclosed traveling nut actuator mounted on the valve.
   2. For valves operating at pressures above 250 pounds per square inch, provide totally enclosed worm gear actuator mounted on the valve.

D. Manual actuators for aboveground valves 30 inches in nominal size and larger, all pressures.
   1. Provide totally enclosed worm gear actuator mounted on the valve.

E. Manual actuators for buried or submerged valves, all sizes, and pressures.
   1. Provide totally enclosed travelling nut actuator mounted on the valve.
   2. Actuators for buried or submerged valves: Hermetically sealed and grease packed.
   3. For buried valves, provide 2-inch square AWWA nut on enclosed actuator.
   4. For buried valves, provide extension stem, valve box, and valve box cover as specified in Section 15110.
   5. For submerged valves, provide extension stem as indicated on the Drawings.

F. Position indication:
   1. For all aboveground worm gear or traveling nut manual actuators, provide position indication on the actuator enclosure.

G. Limit switches: Provide limit switches on manually actuated valves where indicated on the Drawings:
   1. Limit switches: Heavy-duty, industrial grade, oiltight, with not less than 2 auxiliary contacts.
   2. Rating: Rated for 10 amps, 120 volts alternating current.
   3. Enclosure: NEMA Type 4X enclosure and with stainless steel levers and arms. Provide switch with NEMA Type 7 enclosure when switch is located within areas with NEC Class 1, Division 1 or Class 1, Division 2 designations as indicated on the Drawings.

2.06 COATING

A. Shop coat interior and exterior metal surfaces of valves, except as follows:
   1. Interior machined surfaces.
   2. Surfaces of gaskets and elastomeric seats and stem seals.
   3. Bearing surfaces.
   4. Stainless steel surfaces and components.

B. Coating material for potable water applications:
   1. Formulate coating material from materials in accordance with CFR 21.

C. Field applied coatings:
   1. Additional coating of the valve exterior will be required to match the epoxy or epoxy/polyurethane paint system as specified in Section 09960.
      a. When shop applied finish coating matches field applied coating on adjacent piping, touch up shop coating in damaged areas in accordance with instructions recommended by the paint manufacturer.

b. When shop applied coating does not match field coating on adjacent piping, or when damage has occurred to the shop applied coating that requires more than touchup, blast clean valve surfaces or utilize other surface preparation recommended by the manufacturer of the coating material and apply the coating system used for coating adjacent piping.

D. Surface coatings:
1. Interior surfaces, except for valves used in low-pressure air service: High solids epoxy.
2. Interior surfaces of valves used in low-pressure air service: High temperature coating for range of 150 to 350 degrees Fahrenheit, as specified in Section 09960.
3. Exterior surfaces of valves, actuators, and accessories:
   a. Submerged valves: High solids epoxy.
   b. Buried valves: Coal tar epoxy.
   c. Other valves: High solids epoxy with polyurethane topcoat.
4. Polished and machined surfaces: Apply rust-preventive compound.

E. Coating materials:
1. High solids epoxy and coal tar epoxy:
   a. Products: As specified in Section 09960:
      1) Coating product in contact with potable water must be in accordance with AWWA C550 and NSF 61.
2. High temperature coating: As specified in Section 09960 and in accordance with AWWA C550.
3. Rust-preventive compound: One of the following or equal:
   a. Houghton, Rust Veto 344.
   b. Rust-Oleum, R-9.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install valves with valve shafts horizontal, unless a vertical shaft is required to suit a particular installation, and unless a vertical shaft is indicated on the Drawings.

B. Install pipe spools or valve spacers in locations where butterfly valve disc travel may be impaired by adjacent pipe lining, pipe fittings, valves, or other equipment.

3.02 BUTTERFLY VALVE APPLICATION SCHEDULE

A. Acceptable butterfly valve types and body styles are listed in the Butterfly Valve Application Schedule provided at the end of this Section. Furnish and install butterfly valves in accordance with this Schedule.

BUTTERFLY VALVE APPLICATION SCHEDULE	
Valve Type and Style	**Acceptable Applications**
General Purpose AWWA Butterfly Valves – Flanged Body Design	Aboveground or submerged in the following service applications only: - Acceptable in all service applications except oxygen and ozone service and high-pressure service. - May be used in buried applications when required by the specified piping system.
General Purpose AWWA Butterfly Valves – Mechanical Joint Body Design	Buried in the following service applications only: - Acceptable in all service applications except oxygen and ozone service and high-pressure service.
General Purpose AWWA Butterfly Valves – Lugged Body Design	Aboveground in the following service applications only: - Aeration Air Systems
General Purpose AWWA Butterfly Valves – Wafer (not lugged) Body Design	Not allowed.
General Purpose AWWA Butterfly Valves – Grooved End Body Design	Aboveground, in sizes 20-inch and less, with piping system test pressure less than 100 psi, and in the following service applications only: - Acceptable in all service applications, except oxygen and ozone service, where piping for that service is specified in the Piping Schedule to have grooved end joints.
High Pressure Butterfly Valves – Flanged Body Design	Service applications with piping system test pressure greater than 250 psi. Acceptable in aboveground and buried installations.
High Pressure Butterfly Valves – Wafer or Lugged Wafer Body Design	Not allowed.
Industrial Class Butterfly Valves – Lugged Body Design	Aboveground in the following service applications only: - Aeration Air Systems - Natural Gas Systems - - Chilled and Hot Water Systems
Industrial Class Butterfly Valves – Wafer (not lugged) Body Design	Not allowed.
Stainless Steel Butterfly Valves - Lugged Body Design	Aboveground in the following service applications only: - Oxygen Systems - Ozone Systems
Stainless Steel Butterfly Valves – Wafer (not lugged) Body Design	Not allowed.

END OF SECTION

SECTION 15114

CHECK VALVES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Swing.
   2. Cushioned swing.
   3. Plastic swing check.
   4. Flapper type.
   5. Plastic ball check valves.
   6. Inline check valves.

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 09960 - High-Performance Coatings.
      c. Section 15110 - Common Work Results for Valves.

1.02 REFERENCES

A. American Society of Mechanical Engineers (ASME):
   1. B16.1 - Gray Iron Pipe Flanges and Flanged Fittings: Classes 25, 125, and 250.

B. American Water Works Association (AWWA):
   1. C508 - Standard for Swing-Check Valves for Waterworks Service 2 Inch Through 24 Inch (50-mm Through 600-mm) NPS.

C. ASTM International (ASTM):
   1. A 126 - Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings.
   2. A 313 - Standard Specification for Stainless Steel Spring Wire.
   3. A 536 - Standard Specification for Ductile Iron Castings.
   4. B 582 - Standard Specification for Nickel-Chromium-Iron-Molybdenum-Copper Alloy Plate, Sheet, and Strip.
   5. B 584 - Standard Specification for Copper Alloy Sand Castings for General Applications.

D. NSF International (NSF):
   1. 61 - Drinking Water System Components - Health Effects.

1.03 SYSTEM DESCRIPTION

A. Design requirements:
   1. Check valves: When not otherwise specified as indicated on the Drawings, provide check valves suitable for service as follows:
      a. In either horizontal or vertical position.
      b. Suitable for service working pressures up to150 pounds per square inch gauge.

1.04 SUBMITTALS

A. Submit the following information as specified in Sections 01330 and 15110:
   1. Product data.
   2. Certificates:
      a. General purpose AWWA check valves:
         1) Affidavit of compliance attesting valves provided comply with all provisions in accordance with AWWA C508.
   3. Operation and maintenance data.

PART 2 PRODUCTS

2.01 SWING CHECK VALVES

A. Valves 1/4 inch through 3 inches:
   1. Manufacturers: One of the following or equal:
      a. Crane Valve Company, Number 36.
      b. Lunkenheimer Company, Figure 554Y.
   2. Valve design:
      a. Threaded joints.
      b. Y-pattern body with integral seat.
      c. Hinged disc.
      d. Access to valve seat for regrinding without disassembly of piping.
   3. Materials:
      a. Body, cap, hinge, and disc: Bronze.

B. Valves 4 inches through 24 inches:
   1. Manufacturers: One of the following or equal:
      a. Kennedy, Figure 106LW.
      b. Mueller Company, Model A-2600.
      c. M&H, Model 159.
   2. Valve design:
      a. In accordance with AWWA C508.
      b. Constructed to permit top entry and removal of internal components without removing the valve.
      c. Equipped with outside lever and weight.
   3. Materials:
      a. Body: Cast iron, ASTM A 126 Class B.
      b. Disc:
         1) 4-inch valves: Bronze.
         2) 6 inches and larger valves: Bronze faced.
      c. Hinge pins: Stainless steel.

2.02 CUSHIONED SWING CHECK VALVES

A. Manufacturers: One of the following or equal:
   1. Crispin, Series SWC-BD.
   2. APCO, Air Cushioned Swing-Check, Series 6000B.

B. Valve design:
   1. Counter-weighted.
   2. Rubber seated and driptight.
   3. Totally enclosed hydraulic dampening chambers with adjustment for closing speed.

C. Materials:
   1. Valve body, cover, and disc: Cast iron, ASTM A 126, Class B.
   2. Disc seat: EPDM.
   3. Shaft: Stainless steel.
   4. Cushion cylinder: Corrosion resistant metal.
   5. Disc ring seat: Stainless steel.
   6. Seat pins and lock screws: Stainless steel.

2.03 PLASTIC SWING CHECK VALVES FOR CHEMICAL SERVICES

A. Manufacturers: One of the following or equal:
   1. ASAHI.
   2. Spears.

B. Valve Design:
   1. Top entry swing check type, solid thermoplastic construction having no metal to media contact, suitable for horizontal and vertical installations .
   2. All valve components shall be replaceable .
   3. Viton® O-ring sealed drain plug to allow quick-flush of any accumulated debris from bottom of value .
   4. Flanged ANSI Class 125 end connections .
   5. External lever and weight to assist the disc in closing faster.

C. Materials:
   1. Body: Polyvinyl chloride (PVC) or Chlorinated polyvinyl chloride (CPVC) to match piping material.
   2. Valve: Polyvinyl chloride (PVC) or Chlorinated polyvinyl chloride (CPVC) to match piping material.
   3. Seal: Viton®.
   4. All other components shall match the material used for valve body, except bolts, nuts, and washers, which shall be Type 304 stainless steel.

2.04 FLAPPER TYPE CHECK VALVES

A. Manufacturers: One of the following or equal:
   1. Crane Company, Crane Valve Group, Duo Chek Check Valves.
   2. Techno Corporation, equivalent product.

B. Valve design:
   1. Spring-assisted dual valve plates with metal hinge. Springs designed to close valve plates upon flow reversal.

2. Replaceable elastomeric seal secured to valve plates with clamp plates and fasteners.
3. Valve seats integral with valve body. Eliminate leakage when valve plates are fully closed with elastomeric seal in full contact with valve seat.
4. Wafer style valve body.
5. Stops on valve shaft which prevent valve plates from opening more than 90 degrees from closed position.

C. Valve design:
1. Dual valve plates with replaceable elastomeric member which acts as both a hinge and a seal.
2. Elastomeric member secured to valve plates with clamping plates and fasteners.
3. Full port, seatless design. Eliminate leakage when valve plates are fully closed with elastomeric member in full contact with interior surface of valve port.
4. Wafer style valve body.

D. Materials:
1. Body: Cast iron.
2. Valve plates: Bronze.
3. Seal: EPDM.
4. Trim: Type 316 stainless steel.
5. Spring: Type 316 stainless steel.

2.05 PLASTIC BALL CHECK VALVES

A. Manufacturers: One of the following or equal:
1. Chemtrol Division of Nibco.
2. R. G. Sloane Company, Inc.

B. Valves: Ball type:
1. Polyvinyl chloride (PVC) or Chlorinated polyvinyl chloride (CPVC) to match piping material.
2. Double or single union-type end connections.
3. Seals: Viton®.

2.06 INLINE CHECK VALVES

A. Manufacturers: One of the following or equal:
1. Tide Flex, CheckMate®.

B. Design:
1. Maximum downstream head:20 feet.
2. With internal pressure 1 to 2 inches w.c. above backpressure, bill of valve opens, allowing flow.
3. With backpressure 1 to 2 inches w.c. above internal pressure, bill of valve closes, preventing backflow.
4. Suitable for sewage and storm water applications.
5. Slip-in body.

C. Materials of construction:
   1. Single piece elastomer construction with internal polyester fabric reinforcing all vulcanized into a composite material.
      a. Internal reinforcing sufficient to maintain structural integrity under the specified operating conditions.
      b. Exterior applications require coating for UV protection and to resist pest gnawing.
   2. Elastomeric material: EPDM.
   3. Expansion clams: 316 Stainless Steel.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install valves as specified in Section 15110 and the manufacturer's instructions.

B. Flapper type check valves:
   1. Install with proper orientation of flow direction arrow on valve body.
   2. When installed in horizontal pipelines, mount with shaft on vertical locations.
   3. When mounted in a vertical pipeline, directly downstream of an elbow, mount with the shaft perpendicular to the outermost portion of the elbow.
   4. Mount on downstream side of discharge silencer when used on positive displacement and centrifugal blowers.

3.02 ADJUSTING

A. Adjust cushioned swing check valves in the field by means of external adjustment devices to minimize pressure surges.

B. Adjust weight on swing check valves to affect proper closing action on equipment shutdown.

END OF SECTION

SECTION 15115

GATE, GLOBE, AND ANGLE VALVES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Gate, globe, angle, plug disc and plain hose valves, and yard hydrants.

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 15110 - Common Work Results for Valves.

1.02 REFERENCES

A. American Society of Mechanical Engineers (AMSE).

B. American Water Works Association (AWWA):
   1. C 509 - Resilient-Seated Gate Valves for Water Supply Service (Includes Addendum C509a-95).
   2. C515 - Standard for Reduced-Wall, Resilient-Seated Gate Valves for Water Supply Services.
   3. C 550 - Protective Interior Coatings for Valves and Hydrants.

C. ASTM International (ASTM):
   1. B 98 - Standard Specification for Copper-Silicon Alloy Rod, Bar, and Shapes.

1.03 SUBMITTALS

A. Shop drawings: Submit the following information as specified in Sections 01330 and 15110:
   1. Product Data.
   2. Certificates:
      a. General purpose AWWA gate valves:
         1) Proof-of-Design Tests: Certified statement that proof-of-design tests were performed and all requirements were successfully met.
         2) Affidavit of compliance attesting valves provided in accordance with all provisions of AWWA C515.

b. Interior epoxy coatings: Affidavit of compliance attesting that epoxy coatings applied to interior surfaces of valves and hydrants comply in accordance with all provisions of AWWA C550.

3. Operation and Maintenance Data.

PART 2 PRODUCTS

2.01 GATE VALVES

A. Gate valves aboveground:

1. Valves less than 3 inches in size for clean water and air service:
   a. Manufacturers: One of the following or equal:
      1) Crane, Figure 431.
      2) Jenkins, Figure 47.
      3) Lunkenheimer Company, Figure 2151.
   b. Design:
      1) Size and configuration: Indicated on the Drawings.
      2) Manufacturer's standard bronze, solid wedge disc, rising stem, screwed end, Class 150 pounds.
2. Valves 3 inches in size and larger:
   a. Manufacturers: One of the following or equal:
      1) M&H/Kennedy Valve Company.
      2) Mueller.
      3) American Flow Control, Series 2500.
   b. Design:
      1) Size, material, configuration: Indicated on the Drawings.
      2) Resilient wedge type in accordance with AWWA C515.
      3) Flange, iron body, and bonnet rated for 200 pound working pressure.
         a) Provide O-ring seal between valve body and bonnet.
      4) Ductile or cast iron wedge encapsulated in nitrile rubber and capable of sealing in either flow direction.
      5) Bronze stem with double or triple O-ring or braided packing stem seals.
      6) Rising stem configuration with handwheel diameter sized to allow opening of valve with no more than a 40-pound pull.
      7) Coat interior and exterior surfaces of valve body and bonnet with fusion-bonded epoxy in accordance with AWWA C550.

B. Gate valves underground:

1. Manufacturers: One of the following or equal:
   a. M&H/Kennedy Valve Company.
   b. Mueller Company.
   c. American Flow Control.
2. Design:
   a. Size, material, configuration: Indicated on the Drawings.
   b. Resilient wedge type in accordance with AWWA C515.
   c. Stem:
      1) Iron body, resilient seat, non-rising stem, double O-ring stem seal.
      2) Rising stem configuration with handwheel diameter sized to allow opening of valve with no more than a 40-pound pull.

d. Ductile or cast iron wedge encapsulated in nitrile rubber and capable of sealing in either flow direction.
e. Bronze stem with double or triple O-ring or braided packing stem seals.
f. Coat interior and exterior surfaces of valve body and bonnet with fusion-bonded epoxy in accordance with AWWA C550.
g. Valve operator: Provide standard AWWA 2-inch operating nut, matching valve key, and valve box for operating stem.

2.02 GLOBE AND ANGLE VALVES

A. General purpose globe and angle valves:
1. Valves 3 inches and smaller:
a. Manufacturers: One of the following or equal:
1) Except in welded steel piping:
a) Crane, No. 1 Globe or No. 2 Angle.
b) Lunkenheimer Company Figure No. 2140 Globe or No. 2141 Angle.
2) In Welded steel piping:
a) Crane, No. 351.
b) Lunkenheimer Company, Figure No. 1123; or equal with flanged ends.
b. Design:
1) Size and configuration: Indicated on the Drawings.
2) Valve: Class 125 threaded ends, rated for 250 degrees Fahrenheit at pressure of 170 pounds per square inch.
2. Valves larger than 3 inches:
a. Manufacturers: One of the following or equal:
1) Crane, No. 351.
2) Lunkenheimer Company, Figure No. 1123.
b. Design:
1) Size and configuration: Indicated on the Drawings.
3. Plug disc globe valves: for throttling or for severe service.
a. Manufacturers: One of the following or equal:
1) Crane, No. 212P or No. 384P.
2) Lunkenheimer Company, 72-PS or 73-PS1.
b. Design:
1) Size and configuration: Indicated on the Drawings.
2) Material: Iron body stainless steel trimmed plug type seat and disc.

2.03 NEEDLE VALVES

A. Manufacturers: One of the following or equal:
1. Powell, Figure No. 180.
2. Lunkenheimer Company, Figure No. 906-BS or No. 907-BS.
3. Crane No. 88 or No. 89.

B. Design:
1. Size and configuration: Indicated on the Drawings.

2.04 HOSE VALVES AND YARD HYDRANTS

A. Hose valves:
   1. Manufacturers:
      a. Globe threaded valve: One of the following or equal:
         1) Crane, No. 7TF.
         2) Stockham, Figure No. B22T.
      b. Angle threaded valve: One of the following or equal:
         1) Crane, No. 17TF.
         2) Stockham, Figure No. B222T.
   2. Design:
      a. Size and configuration: Indicated on the Drawings.
      b. Valve: Globe or angle valve with threaded ends.
      c. Disc: Renewable, made of Teflon or Buna-N.
      d. Threaded ends rated for a pressure of 200 pounds per square inch.

B. Freezeless yard hydrant:
   1. Manufacturers: One of the following or equal:
      a. Kupferle Foundry Company.
         1) #1 Total Eclipse Yard Hydrant - 3/4 inch and 1 inch.
      b. Murdock Company:
         1) #M-75 – 3/4 inch or #M100 - 1 inch.
      c. Zurn Company:
         1) #1385 - 3/4 inch or 1 inch.
   2. Design:
      a. Self draining, non-freezing, compression type.
         1) Inlet connection size: Indicated on the Drawings.
         2) Outlet connection size: Indicated on the Drawings.
         3) Materials:
            a) Exterior casing pipe material: Indicated on the Drawings.
            b) Interior operating rod material: Indicated on the Drawings.
            c) Casing guard material: Indicated on the Drawings.
            d) Principal interior operating parts material: brass and/or bronze and removable from yard hydrant for servicing without excavation.
         4) Provide 4 Spoke, Ball Wheel Handle operated.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install valves as specified in Section 15110 and manufacturer's instructions.

B. Mount yard hydrants on minimum 1-inch supply pipe or size indicated on the Drawings.

C. Set yard and post hydrants in 4 cubic feet of 3/4 inch minimum crushed stone surrounding valve body to allow for proper drainage.
   1. Install in accordance with AWWA recommendations for hydrants.

END OF SECTION

SECTION 15116

PLUG VALVES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Non-lubricated.

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 09960 - High-Performance Coatings.
      c. Section 15110 - Common Work Results for Valves.

1.02 REFERENCES

A. American Water Works Association (AWWA):
   1. C517 - Resilient-Seated Cast Iron Eccentric Plug Valves.

B. ASTM International (ASTM):
   1. A 126 - Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings.
   2. A 536 - Standard Specification for Ductile Iron Castings.

1.03 SUBMITTALS

A. Shop drawings: Submit the following information as specified in Sections 01330 and 15110:
   1. Product data.
   2. Operation and maintenance data.

PART 2 PRODUCTS

2.01 NON-LUBRICATED PLUG VALVES

A. Manufacturers: One of the following or equal:
   1. DeZurik, "PEC."
   2. Clow Valve.

B. Design:
   1. Type: Non-lubricated eccentric type, in accordance with AWWA C517.
   2. Plug face: Resilient material that operates satisfactorily at a temperature of 180 degrees Fahrenheit continuous and 215 degrees Fahrenheit intermittent, except for valves in compressed air or digester gas service.
      a. Valves in compressed air service: Resilient material suitable for continuous duty at 250 degrees Fahrenheit.
      b. Valves in digester gas service: Resilient material suitable for petroleum or digester gas at continuous duty at 180 degrees Fahrenheit.
   3. Compression washer: Provide flat compression washer made of Teflon®, or of a material having equal physical characteristics on valve stem between plug and bonnet.
   4. Stem seals: Provide stem seals serviceable without unbolting the valve bonnet assembly.
   5. Clearly mark valves to indicate their open and closed positions.
   6. Provide valves with ends as required by piping details indicated on the Drawings.

C. Materials:
   1. Body and plug: ASTM A 126, Class B, cast-iron or ASTM A 536, Grade 65-45-12, with plug face of neoprene or Buna N material suitable for the intended service as specified under paragraph "Design" above.
   2. Body seats in valves 3 inch size and larger: Provide with overlay of not less than 90-percent nickel and minimum thickness of 1/8 inch on surfaces contacting the plug face.
   3. Stem bearing and bottom bearing: Type 316 stainless steel.
   4. Internal parts, except the body and plug: Type 316 stainless steel, Monel, or nickel.
   5. Exposed nuts, bolts, and washers: Zinc plated. Exception: Exposed nuts, bolts, and washers for buried service: Stainless steel.

2.02 PLUG VALVES FOR CHEMICAL SERVICES

A. Provide plug valves for chemical services where specifically indicated on the Drawings.

B. Manufacturers: One of the following or equal:
   1. DeZURIK.
   2. The valve manufacturer shall have a minimum of 7 years experience in the manufacturing of cylindrical eccentric plug valves for similar service. The manufacturer shall be ISO 9000 certified. Successful experience data and certifications shall be furnished upon request.

C. Non-lubricated eccentric type.

D. Design:
   1. Suitable for service under minimum working pressure of 150 pounds per square inch gauge.
   2. Service:
      a. Valves will be located on drain lines from chemical storage areas.

b. Valves are expected to be normally exposed to light concentration solution of stored chemicals.
c. Valve may occasionally be exposed to the chemical solution at its maximum concentration listed herein (such as in the case of a chemical spill):
    1) Phosphoric Acid: Up to 10-percent solution by weight.

3. Plug Face:
    a. EPDM material.
4. Provide 316 stainless steel cup at bottom bearing area to stop media from leaking into journal area.
5. Provide multiple v-ring type stem seals externally adjustable without removing the bonnet or actuator from the valve under the specified rated pressure. Packing shall be TFE material.
6. The interference between the plug face and body seat, with the plug in the closed position, shall be externally adjustable in the field with the valve in the line under the specified rated pressure.
7. Clearly mark valves to indicate their open and closed positions.
8. Provide valves with ends as required by piping details indicated on the Drawings.
9. Port areas for valves through 20 inches shall be at least 80 percent of full pipe area.
10. Valves and gear actuators:
    a. Valves and gear actuators shall have seals on all shafts and gaskets on the valve and actuator covers to prevent the entry of water.
    b. All submerged or buried valve actuators shall be completely packed with lubricant to eliminate all voids.
    c. Actuator mounting brackets for buried or submerged service shall be totally enclosed and shall have gasket seals on all units. Units with aluminum housings are not acceptable.
    d. Worm gear actuators shall be Limitorque Model HBC-4 Series or DeZURIK G series.
    e. Valve actuators shall be tested and certified per the requirements of AWWA C504. All actuators shall be factory mounted and tested by the valve manufacturer prior to shipment.
    f. All gearing shall be enclosed in a cast iron housing and be suitable for running in a lubricant with elastomeric lip seals provided on all shafts to prevent entry of dirt and water into the actuator. Seals shall be located outside the bearings. The actuator shaft and the quadrant shall be supported on permanently lubricated bronze or ball bearings.
    g. Units with aluminum housings are not acceptable.
    h. Aboveground actuators shall clearly indicate valve position and an adjustable stop shall be provided to set closing torque. Stops shall be capable of withstanding 300 foot-pounds of input torque.
    i. Valve packing adjustment on non-submerged valves shall be accessible without removing the actuator from the valve.
    j. Rim pull shall not exceed 80 pounds at the valve design pressure.
    k. Handwheel diameter shall be no greater than twice the diameter of the gear sector.
    l. Valve to actuator or nut connection to valve plug shall have a hex, square, or splined shaft to mate with an approved square nut or actuator. Pinned valve shafts are not acceptable.
    m. All exposed nuts, bolts, springs, and washers for valves and gear actuators in buried or submerged service shall be stainless steel.

E. Materials:
   1. Body: ASTM A 126 Class B cast iron with plug face of material suitable for the intended service, as specified in Article 2.03 Paragraph D of this Section. Body shall be soft rubber-lined.
   2. Plug: Stainless steel.
   3. Body Seats in Valves 3 Inches in Size and Larger: Provide with overlay of not less than 90-percent nickel and minimum thickness of 1/8 inch on surfaces contacting the plug face.
   4. Stem Bearing and Bottom Bearing: Stainless steel Type 316. Provide 316 stainless steel cup at bottom bearing area to stop media from leaking into journal area.
   5. Internal Parts, Except the Body and Plug: Type 316 stainless steel, Monel, or nickel.
   6. Exposed Nuts, Bolts, and Washers: Zinc plated. Exception: Exposed nuts, bolts, and washers for buried service: Stainless steel.
   7. Bonnet: Stainless steel.

2.03 VALVE OPERATORS

A. Furnish valves with an operating wrench or worm gear operator:
   1. Equip valves 4 inch nominal size and smaller with a lever operator.
   2. Equip valves 6 inch nominal size and larger with a worm gear operator.

2.04 COATING

A. Coat interior metal surfaces as specified in Section 15110.

B. Coat exterior metal surfaces as specified in Section 09960.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install valves as specified in Section 15110 and the manufacturer's instructions.

B. Install valve so that valve stem is in horizontal position.

C. Unless otherwise directed, observe the following rules for installation of eccentric plug valves on sewage, grit, sludge, or other liquid systems containing solids, silt, or fine sand:
   1. Install valves so that in closed position the pressure in the pipeline applies a seating head on the valves, except as noted in Item 4 below.
   2. In vertical pipelines, install valve with the seat side up.
   3. In horizontal pipelines, the plug shall swing upwards when opening, to permit flushing out of solids.
   4. Orient the valve to prevent the valve body from filling up with solids, when closed. However, when the pressure differential through the valve exceed 25 psi, the higher pressure for valves without worm gear, electric, or air operators, shall be through the valve, to force the plug against the seat.
   5. For special applications, or when in doubt, consult with the manufacturer prior to installation.

END OF SECTION

SECTION 15117

SPECIALTY VALVES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Backflow preventers.
   2. Field irrigation valves.
   3. Float valves.
   4. Hydrostatic pressure relief valves.
   5. Solenoid valves.
   6. Plastic body diaphragm valves.
   7. Tubing valves.
   8. Corporation stops.
   9. Curb stops.
   10. Cocks.

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 15110 - Common Work Results for Valves.

1.02 REFERENCES

A. American Society of Civil Engineers (ASCE):
   1. 25 - Earthquake-Actuated Automatic Gas Shutoff Devices.

B. American Society of Mechanical Engineers (ASME):
   1. B16.42 - Ductile Iron Pipe Flanges and Flanged Fittings: Classes 150 and 300.

C. American Water Works Association (AWWA):
   1. C511 - Standard for Reduced Pressure-Principle Backflow-Prevention Assembly.
   2. C800 - Underground Service Line Valves & Fittings (Also Included: Collected Standards For Service Line Materials).

D. ASTM International (ASTM):
   1. A 48 - Standard Specification for Gray Iron Castings.
   2. A 126 - Standard Specification for Gray Iron Casting for Valves, Flanges, and Pipe Fittings.

3. A 276 - Standard Specification for Stainless Steel Bars and Shapes.
4. A 536 - Standard Specification for Ductile Iron Castings.
5. B 584 - Standard Specification for Copper Alloy Sand Castings for General Application.

E. National Electrical Manufacturers Association (NEMA):
1. 250 - Enclosures for Electrical Equipment (1000 V Maximum).

1.03 DEFINITIONS

A. NEMA Type 4 enclosure in accordance with NEMA 250.

1.04 SUBMITTALS

A. Shop drawings: Submit the following information as specified in Sections 01330 and 15110:
1. Product data.
2. Operation and maintenance data.

B. Certificates:
1. Recertification of all new backflow preventers after installation, start-up and testing.

1.05 QUALITY ASSURANCE

A. Manufacturer qualifications: Manufactured by manufacturers whose valves have had successful operational experience in comparable service.

1.06 DELIVERY STORAGE AND HANDLING

A. Protect valves from damage during handling and installation.

PART 2 PRODUCTS

2.01 BACKFLOW PREVENTERS

A. Manufacturers: One of the following or equal:
1. Febco backflow prevention:
   a. Model 825Y for 1/2-inch through 2-inch.
   b. Model 825YD for sizes larger than 2-inch.
2. Zurn/Wilkins:
   a. Model 975XL for 1/2-inch through 2-inch.
   b. Model 975 for sizes 2 1/2 inch, 3 inch, 8 inch, and 10 inch.
   c. Model 375 and 375DA for sizes 4 inch and 6 inch.
3. Watts regulator: Series 909.

B. Design: Reduced pressure chamber type in accordance with AWWA C511.

C. Include shutoff valves at each end of backflow preventer with properly located test cocks.

D. Shutoff valves:
   1. Backflow preventers 2-inch and smaller: Provide with full-port, quarter turn, resilient seated ball valves.
   2. Backflow preventers larger than 2-inch: Provide with resilient seated, outside stem and yoke gate valves.

2.02 FIELD IRRIGATION VALVES

A. As indicated on the landscaping drawings.

2.03 FLOAT VALVES

A. Manufacturers: One of the following or equal:
   1. Cla-Val Company, Number 124.
   2. GA Industries, Figure 54.

B. Float valves: Pilot controlled, diaphragm, or piston actuated from hydraulic pressure of liquid flowing through valve.

C. Design:
   1. Valves: Single seated. Open wide when the float is at low level, and close driptight at high level.
   2. Float level: Adjustable in the field.

2.04 HYDROSTATIC PRESSURE RELIEF VALVES

A. Flap gate type:
   1. Manufacturers: One of the following or equal:
      a. Clow Corporation.
      b. Neenah Foundry Company.
   2. Design:
      a. Provide valves with vertical seat design and offset single pivoted hinge.
      b. Valve components: Flap gate, body with flanged end, hinge pin, and gate seat ring.
      c. Design valve so that flap gate begins to open at a head of 1/3 the inner diameter of the valve body.
      d. Cement and mechanically retain gate seat ring in place.
   3. Materials:
      a. Flap gate and body: Cast iron in accordance with ASTM A 126 Class B or bronze in accordance with ASTM B 584 UNS Number C84400.
      b. Hinge pin: Bronze of the type specified in the preceding subparagraph or stainless steel in accordance with ASTM A 276 Type 304.
      c. Gate seat ring: EPDM.

B. Pop-up type:
   1. Manufacturers: One of the following or equal:
      a. Clow Corporation.
      b. Neenah Foundry Company.
   2. Design:
      a. Design valve to begin opening at a maximum head of 9 inches.
      b. Integrally cast locking lugs into body.
         1) Prevent groundwater pressure from separating the cover and strainer from the body.

c. The cover and the strainer shall be easily removed by release from the locking lugs.
d. Provide lead seats, poured and peened into grooves on the underside of cover and top of body.
1) Machine seats to form lead-to-lead contact when the cover is in closed position.
3. Materials:
a. Cover, body, and strainer: Cast-iron in accordance with ASTM A 126, Class B.

2.05 SOLENOID VALVES

A. 2-way solenoid valves:
1. Manufacturers: One of the following or equal:
a. Automatic Switch Company, Series 8210.
b. Skinner Electric Valve Division, Series C.

B. 3-way solenoid valves:
1. Manufacturers: One of the following or equal:
a. Automatic Switch Company, Series 8320.
b. Skinner Electric Valve Division, Type A4.

C. 4-way solenoid valves:
1. Manufacturers: One of the following or equal:
a. Automatic Switch Company, Bulletin 8344.
b. Skinner Electric Valve Division, Series V9.

D. Design:
1. Valves: Suitable for service under the following conditions:
a. Fluid: Tertiarily treated wastewater (Title 22 compliant plant effluent).
b. Temperature of fluid: 80 degrees Fahrenheit.
c. Piping test pressure: 175 pounds per square inch gauge.
2. Unless otherwise indicated on the Drawings, provide valves that:
a. Minimum NEMA Type 4 enclosure.
b. 120 VAC operation.
c. Suitable for use as indicated on the Drawings.
d. Minimum Class F coil insulation.
3. 2-way valves: Furnish with openings of size equal to or larger than the nominal size designation of the valve.
4. Furnish with manual/bypass operators.

E. Materials:
1. Body: Brass or bronze.
2. Seats: Resilient material.

2.06 PLASTIC BODY DIAPHRAGM VALVES

A. Type of service: Use plastic body diaphragm valves in the following services:
1. Sodium hypochlorite.

B. Manufacturers: One of the following or equal:
1. Simtech.
2. Chemtrol.

C. Materials:
   1. Body: CPVC or PVC with reinforcing ribs at body and end connections to match piping material.
   2. Diaphragm: Unless otherwise specified below, provide 2 diaphragm layers - Teflon® diaphragm with EPDM backing or other material suitable for the intended use.
      a. For sodium hypochlorite service: 3 diaphragm layers, Teflon® (PTFE), PVDF, and ethylene-propylenediene (EPDM) or Viton® backing cushion.
   3. Bonnet: Reinforced polypropylene with cast iron or silicon bronze drive nut, double lead acme stem threads, acrylic protective cap and visual position indicator.
      a. Adjustable travel stop: Stainless steel.
      b. Compressor: PVDF or cast iron.
   4. Handwheel: Polypropylene.
   5. Sleeve: Bronze or cast iron.
   6. Stem: Stainless steel.
   7. Bolt, nut, and washer: Stainless steel.
   8. Thrust bearing: Teflon® disc or carbon steel.
   9. End connector: CPVC or PVC to match piping material.
   10. End connector seal (flange gasket): Suitable for the intended use unless otherwise specified below.
      a. For sodium hypochlorite service: Hypalon 1/8-inch thick gaskets.
   11. O-rings: Viton®.
   12. Position indicator: Carbon steel.

D. Valve design:
   1. End connections: Flanged.
   2. Operator handle: Handwheel, with position indicator and adjustable travel stop to prevent overtightening. Provide acrylic stem cap.
   3. Diaphragm valves: Weir type.
   4. Pressure: 150 pound per square inch gauge at 70 degrees Fahrenheit.

E. Stem extension:
   1. Where indicated on the Drawings.
   2. With wall support for wall mounting where valve handle should be extended away from the valve for out-of-reach locations.
   3. Same material as the valve body

F. Electric actuator:
   1. Manufacturers: One of the following or equal:
      a. Asahi/America.
      b. Barton/ITT Fluid Technology Corporation.
      c. Gemu.
   2. General:
      a. Reversing type motor.
      b. Suitable for 115 volt, 1 phase, 60 hertz power supply.
      c. Travel stop limit switches with remote valve open and closed status indication.
      d. Brushless, capacitor-run motors with integral thermal overload protection and auto reset.
      e. Permanently lubricated gear train.
      f. Visual position indicator.
      g. Declutchable manual override.

3. Materials:
    a. Actuator housing: Aluminum.
    b. Output shaft: Stainless steel.
    c. Electrical housing: NEMA Type 4.
    d. Enclosure: NEMA Type 4.
    e. Thermally bonded epoxy powder coating with stainless steel trim.

2.07 CORPORATION STOPS

A. Type: In accordance with AWWA C800.
    1. Manufacturers: One of the following or equal:
        a. Ford.
        b. Mueller Company.

2.08 CURB STOPS

A. Manufacturers: One of the following or equal:
    1. Ford.
    2. Mueller Company.

B. Description: Round way solid tee head stops.

2.09 COCKS

A. Gauge cock:
    1. Manufacturers: One of the following or equal:
        a. Lunkenheimer Company, Figure 1178 or Figure 1180.

B. Air cock:
    1. Manufacturers: One of the following or equal:
        a. Whitey Research Tool Company, Model B-42S4.
        b. Hoke, Inc., 7122G4B.

C. Plug cock:
    1. Manufacturers: One of the following or equal:
        a. Lunkenheimer Company, Figure 454.
    2. Design: Plug cocks: Bronze, straightway pattern complete with lever.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install as specified in Section 15110 in accordance with manufacturer's published instructions.

B. Backflow preventers:
    1. Install with a minimum clearance of 12 inches and with maximum clearance of 30 inches between the relief port and the floor or finished grade.
    2. Install with sufficient side clearance for access for testing and maintenance.
    3. Recertify all new backflow preventers after installation, start-up, and testing.

C. Plastic body diaphragm valves for sodium hypochlorite service:
   1. When valves are installed horizontally, install valves with valve stem position rotated as necessary such that no internal valve obstruction prevents the passage of vapors traveling along the top of adjacent piping from traveling through the valve.

D. Flow control valves:
   1. Install orifice in accordance with manufacturer's requirements.

END OF SECTION

SECTION 15118

PRESSURE REDUCING AND PRESSURE RELIEF VALVES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Pressure reducing and pressure relief valves for water, sludge, and chemical service.

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 15110 - Common Work Results for Valves.

1.02 REFERENCES

A. American Society of Mechanical Engineers (ASME):
   1. B16.42 - Ductile Iron Pipe Flanges and Flanged Fittings: Classes 150 and 300.

B. ASTM International (ASTM):
   1. A 48 - Standard Specification for Gray Iron Castings.
   2. A 536 - Standard Specification for Ductile Iron Castings.

C. Underwriters Laboratories, Inc. (UL)

1.03 SUBMITTALS

A. Shop drawings: Submit the following information as specified in Sections 01330 and 15110:
   1. Product Data.
   2. Operation and Maintenance Data.

PART 2 PRODUCTS

2.01 WATER PRESSURE REDUCING VALVES

A. Water pressure reducing valves, 2 1/2 inches and smaller:
   1. Manufacturers: One of the following or equal:
      a. Watts Regulator, Series 223.
      b. Wilkins, 500 Series.

2. Direct operated, single seat type pressure reducing valve.
3. Materials:
    a. Body and spring cover: Bronze.
    b. Valve seat: Series 300 stainless steel.
    c. Diaphragm: Buna Nitrile or EPDM.
    d. Disk: Buna Nitrile or EPDM.

B. Water pressure reducing valves, 3 inches and larger:
1. Manufacturers: One of the following, or equal:
    a. Watts ACV Series 115.
    b. Cla-Val Model 90-01.
2. Design:
    a. Pilot controlled, hydraulically operated, diaphragm actuated, globe patterned valve.
    b. Rated for 125 pounds per square inch gauge.
    c. Pilot line: Equipped with a strainer.
    d. Flanges: 150 pound rating, in accordance with ASME B16.42.
3. Materials:
    a. Body and cover: Cast iron ASTM A 48 or Ductile Iron ASTM A 536.
    b. Valve trim: Bronze.
    c. Pilot control: Cast bronze with Series 303 stainless steel trim.
    d. Diaphragm: Nylon reinforced Buna N, Neoprene, or EPDM.

2.02 WATER PRESSURE RELIEF VALVES

A. Water pressure relief valves:
1. Manufacturers: One of the following, or equal:
    a. Watts ACV Series 116.
    b. Cla-Val Model 50-01.
2. Design:
    a. Pilot controlled, hydraulically operated, diaphragm actuated, globe patterned valve.
    b. Rated for 125 pounds per square inch gauge.
    c. Pilot line: Equipped with a strainer.
    d. End connections:
        1) 2 1/2 inch and smaller: Screwed.
        2) 3 inch and larger: 150 pound rated flanges in accordance with ASME B16.42.
3. Materials:
    a. Body and cover: Cast iron ASTM A 48 or Ductile Iron ASTM A 536.
    b. Valve trim: Bronze.
    c. Pilot control: Cast bronze with Series 303 stainless steel trim.
    d. Diaphragm: Nylon reinforced Buna N, EPDM, Neoprene.

2.03 SLUDGE PRESSURE RELIEF VALVES

A. Sludge pressure relief valves:
1. Manufacturers: One of the following or equal:
    a. GA Industries, Inc., Figure Number 525-RD.
    b. Valve and Primer Corporation.
2. Component elements: Include body, disc, seating face, shaft, attached counterweight arms and lever, and cushion chamber.

3. Design:
    a. Provide valves that open immediately when the system pressure exceeds the load setting of the counterweights, and close slowly at an adjustable speed upon return of system pressure to normal.
    b. Set counterweights to open and relieve at a pressure 10 pounds per square inch greater than the pressure developed by the pump under normal operating conditions.
    c. Cushion chamber: Attached externally to the side of the valve body and constructed with a piston operating in a chamber with valve operation without hammering action:
        1) Cushioning:
            a) By oil stored in an oil reservoir attached by piping and fittings to the cushion chamber.
            b) Provide anti-freeze hydraulic oil as required.
        2) Design cushion chamber to allow adjustment of closing speed.
4. Materials:
    a. Body: Heavy cast iron or cast steel.
    b. Disc: Welded steel.
    c. Seating face: Rubber, EPDM, Viton®.
    d. Shaft and cushion chamber: Bronze or steel.

2.04 PRESSURE RELIEF VALVES FOR CHEMICAL SERVICE

A. Manufacturers: One of the following or equal:
    1. Plast-O-Matic, Series RVT.
    2. Asahi/America.

B. Materials:
    1. Valve body: CPVC or PVC to match piping material.
    2. U-cup seals:
        a. Polymer service: Viton®.
        b. Hypochlorite service: Viton®.
        c. Caustic service: EPDM.
        d. Aluminum Sulfate: EPDM.
    3. Adjusting bolt, locknut, control spring and fasteners: stainless steel.

C. Design:
    1. Pressure rating: Not less than 150 pounds per square inch.
    2. In-line or angle pattern design, size as indicated on the Drawings.
    3. End connections:
        a. 1 inch and smaller: Threaded.
        b. Larger than 1 inch: Flanged.
    4. Relief set point:
        a. Externally adjustable without removing valve from piping system.
        b. Set valve to open at 10 pounds per square inch more than pump discharge pressure at operating point, or as indicated on the Drawings.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install in accordance with Section 15110.

END OF SECTION

SECTION 15119

AIR AND VACUUM RELIEF VALVES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Air release valves, air and vacuum valves, and air vents.

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 15110 - Common Work Results for Valves.

1.02 REFERENCES

A. American Society of Mechanical Engineers (ASME).
   1. B16.1 - Gray Iron Pipe Flanges and Flanged Fittings: Classes 25, 125, and 250.
   2. B16.5 Pipe Flanges and Flanged Fittings: NPS 1/2 through 24.

B. American Water Works Association (AWWA).

C. ASTM International (ASTM):
   1. A 126 - Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings.
   2. A 240 - Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications.
   3. A 270 - Standard Specification for Seamless and Welded Austenitic Stainless Steel Sanitary Tubing.
   4. B 584 - Standard Specification for Copper Alloy Sand Castings for General Applications.

1.03 SUBMITTALS

A. Shop drawings: Submit the following information as specified in Sections 01330 and 15110:
   1. Product data.
   2. Operation and maintenance data.

PART 2 PRODUCTS

2.01 AIR RELEASE VALVES, WATER SERVICE

A. Manufacturers: One of the following or equal:
   1. Valve and Primer Corporation, APCO ARV, Series 200.
   2. Multiplex Manufacturing Company, Crispin PL Series.

B. Design:
   1. Pressure rating: 150 pounds per square inch gauge.
   2. Inlet: Screwed, 2-inch.
   3. Orifice size: 1/4 inch diameter.

C. Materials:
   1. Valve body: Cast iron.
   2. Float and internal trim: Type 316 stainless steel.
   3. Seat or valve plunger: Buna-N.

2.02 AIR RELEASE VALVES, SEWAGE SERVICE

A. Manufacturers: One of the following or equal:
   1. Valve and Primer Corporation, APCO Series 400 SARV.
   2. Multiplex Manufacturing Company, Crispin Series S.

B. Design:
   1. Operation: Release accumulated air in sewage pipelines operating under pressure. After entrained air escapes through the orifice, the orifice is plugged by a needle mounted on a compound lever mechanism.
   2. Internal components removable through top cover without removing valve from pipeline.
   3. Pressure rating: 150 pounds per square inch..
   4. Connections: Threaded, 2-inch diameter inlet and threaded, 1-inch diameter outlet.

C. Accessories:
   1. Inlet shutoff valve. Utilize eccentric plug valve.
   2. 2 blowoff valves for backflushing.
   3. 10 feet of hose with quick disconnect couplings.

D. Materials:
   1. Body: Cast iron.
   2. Float: Type 316 stainless steel.
   3. Needle: Buna-N.

2.03 AIR AND VACUUM VALVES, SEWAGE SERVICE

A. Select type of sewage-service air and vacuum release valve from the 2 options provided. Furnish only 1 style of air and vacuum release valve for the entire project.
   1. Option 1: Float activated air and vacuum release valve.
   2. Option 2: Anti-surge type air and vacuum release valve.

B. Option 1: Float activated air and vacuum release valves.
   1. Manufacturers: One of the following or equal:
      a. Multiplex Manufacturing Company, Crispin SA Series.
      b. Valve and Primer Corporation, APCO Series 401 SAVV.
   2. Design:
      a. Operation: Release air from pipeline as pipeline is filled and allow air to enter pipeline as pipeline is drained.
      b. Internal components removable through top cover without removing valve from pipeline.
      c. Pressure rating: 150 pounds per square inch.
   3. Accessories:
      a. Inlet shutoff valve. Utilize eccentric plug valve.
      b. 2 blowoff valves for backflushing.
      c. 10 feet of hose with quick disconnect couplings.
   4. Connections: 2-inch threaded inlet and 1-inch threaded outlet.
   5. Materials:
      a. Body: Cast iron.
      b. Float: Type 316 stainless steel.
      c. Seat: Buna-N.

C. Option 2: Anti-surge type air and vacuum release valve.
   1. Manufacturers: One of the following or equal:
      a. International Valve Marketing Company, Vent-O-Matt series RGX.
   2. Design:
      a. Operation: Release air from pipeline as pipeline is filled and allow air to enter pipeline as pipeline is drained. Design valve to react immediately to break vacuum upon pipeline drainage or liquid column separation by the full opening of the orifice.
      b. Design: Consisting of a tubular chamber with a hollow, direct acting float, solid cylindrical orifice control float, woven dirt inhibitor screen, and rubber seats.
      c. Surge alleviation: Integral surge alleviation mechanism that operates automatically to limit transient pressure rise or shock. Induce operation of anti-surge mechanism by closure due to high velocity air discharge or the subsequent rejoining of separated liquid columns.
      d. Control discharge of pressurized air by the seating and unseating of a small orifice on a seal affixed to the control float. Provide a nozzle with a flat seating land surrounding the orifice to prevent damage to the seal.
      e. Internal components removable through top cover without removing valve from pipeline.
   3. Connections: Flanged connections conforming to ASME B16.1 Class 250 and ASME B16.5 Class 300 standards.
   4. Performance: Leaktight past the orifice seal at operating pressures to 200 pounds per square inch gauge.
   5. Materials:
      a. Body: Type 316 stainless steel.
      b. Float: HDPE.
      c. Seats: EPDM.

2.04 COMBINATION AIR VALVES - SEWAGE SERVICE

A. Manufacturers: One of the following or equal:
   1. Valve and Primer Corporation, APCO Series 440 SCAV.
   2. Multiplex Manufacturing Company, Crispin Series US.

B. Design:
   1. Operation: Automatic exhaust and intake of large quantities of air during filling and draining of pipelines, respectively, and release of accumulated air while pipeline is under pressure.
   2. Design: Utilize compound lever system in conjunction with large and small orifices.
   3. Internal parts removable through top cover without removing valve from pipeline.
   4. Pressure rating: 150 pounds per square inch.
   5. Connections: 2-inch threaded inlet and 1-inch threaded outlet.
   6. Accessories:
      a. Inlet shutoff valve.
      b. 2 blowoff valves for backflushing.
      c. 10 feet of hose with quick disconnect couplings.

C. Materials:
   1. Body: Cast iron.
   2. Float: Type 316 stainless steel.
   3. Needle: Buna N.

2.05 DEGASSING VALVE FOR SODIUM HYPOCHLORITE SERVICE

A. Manufacturers: One of the following or equal:
   1. Plast-O-Matic, DGV.
   2. Primary Fluid Systems.

B. Materials:
   1. Body: PVC, CPVC, or PVDF to match piping material.
   2. Elastomers: EPDM.
   3. Rating: 100 pounds per square gauge.
   4. Connection: 1/4 inch NPT minimum.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install as specified in Section 15110 and manufacturer's instructions.

B. Install air release valves and air and vacuum valves with suitable discharge lines to nearest drainage system.

END OF SECTION

SECTION 15120

PIPING SPECIALTIES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Piping specialties including:
   1. Flexible rubber connections.
   2. Bellows type expansion joints.
   3. Slip type expansion joints.
   4. Rubber expansion joints.
   5. Vibration control joints.
   6. Transition fittings.
   7. Sight glasses.
   8. Spray nozzles.
   9. Flexible connectors for chemical services.

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 17401 - Pressure/Vacuum Measurement - Diaphragm and Annular Seals.
      b. Section 17402 - Pressure/Vacuum Measurement - Instrument Valves.
      c. Section 17404 - Pressure/Vacuum Measurement - Gauges.
      d. Section 17409 - Pressure Measurement/Vacuum - Manometers.
      e. Section 17602 - Temperature Measurement - Temperature Gauge.

1.02 REFERENCES

A. American Society of Mechanical Engineers (ASME):
   1. B16.5 - Pipe Flanges and Flanged Fittings: NPS 1/2 through NPS 24.

B. American Water Works Association (AWWA):
   1. C110 - Standard for Ductile-Iron and Gray-Iron Fittings.
   2. C151 - Standard for Ductile-Iron Pipe, Centrifugally Cast.

C. ASTM International (ASTM):
   1. A 148 - Standard Specification for Steel Castings, High-Strength, for Structural Purposes.
   2. A 536 - Standard Specification for Ductile Iron Castings.

1.03 SUBMITTALS

A. Product data:
   1. Manufacturer's certificate attesting successful performance of specified tests.
   2. Shop drawings detailing dimensions and materials.
   3. Manufacturer's published installation instructions.
   4. Operation and maintenance manuals.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Bellows type expansion joints and vibration control joints:
   1. Protect joints against damage during packing, shipping, and installation, and also during pressure test.
   2. Lock expansion joints against movement until pressure tests are completed.
   3. Replace damaged expansion joints with new and undamaged expansion joints.

PART 2 PRODUCTS

2.01 FLEXIBLE RUBBER CONNECTIONS

A. Manufacturers: One of the following or equal:
   1. Mercer Rubber Company, Type 150 Vibraflex.
   2. Red Valve Company, Inc., Part Number P-5.

B. Provide flexible rubber connections with 3/8 inch thick EPDM rubber tube with full-faced flanged ends suitable to withstand a pressure of 150 pounds per square inch gauge.

C. Provide complete flexible rubber connections, including galvanized retaining rings and control rods.

2.02 BELLOWS TYPE EXPANSION JOINTS

A. Expansion joints for general service:
   1. Expansion joints: Flexible bellows type with equalizing rings, except as otherwise specified or indicated on the Drawings.
   2. Manufacturers:
      a. Expansion joints: One of the following or equal:
         1) Flexonics, Inc., Controlled Flexing Expansion Joint.
         2) Flex-Weld, Inc., Keflex, Series 308.
      b. Pipe alignment guides: One of the following or equal:
         1) Flexonics, Inc.
         2) Flex-Weld, Inc.
      c. Intermediate supports: Provide with protective saddles. One of the following or equal:
         1) Unistrut Corporation, Roller-type.
         2) Bergen-Paterson Pipe Support Corp.
   3. Design:
      a. Expansion joint rating: 150 pounds per square inch gauge, at 400 degrees Fahrenheit.
      b. Bellows: Laminated stainless steel, equipped with a self-draining liner guide.

c. Axial travel of expansion joints: Not less than 1.50 inches.
d. Ends: 150 pound ASME flanges, or plain suitable for welding connections, as required for piping in which installed.

2.03 SLIP TYPE EXPANSION JOINTS

A. PVC expansion joints:
1. Flexible bellows type with equalizing rings.
2. Manufacturers: One of the following or equal:
a. Flo Control, Flo-Span.
b. Chemtrol.
3. Materials: PVC with EPDM O-ring.
4. Design:
a. 150-pound-per-square-inch pressure rating.
b. Double O-ring seal.
c. Axial travel: Not less than 1.5 inches.
d. Ends: 150 pound ASME flanges, or plain end suitable for solvent welding connections.

2.04 RUBBER EXPANSION JOINTS

A. Manufacturers: One of the following or equal:
1. Mercer Rubber Company, Style 500 or 700.
2. Red Valve Company, Inc., Type J-1.

B. Provide rubber expansion joints complete with control units and split retaining rings.

C. Design:
1. Material: Neoprene rubber, reinforced with embedded steel rings, and a strong synthetic fabric.
2. Expansion rings, suitable for pressures of at least 125 pounds per square inch gauge, except as follows:
a. Expansion joints in pump suction piping and where indicated on the Drawings suitable for minimum 90 pounds per square inch gauge pressure, and minimum 30 inches mercury vacuum.
b. Split retaining rings, galvanized.
c. Ends of expansion joints, 150-pound ASME flanges with drilling to match that of the piping.

D. Rubber expansion joints for blowers: Butyl type rubber formulated for service application and for maximum temperature of 250 degrees Fahrenheit, suitable for minimum 40 pounds per square inch gauge pressure, and minimum 15 inches mercury vacuum.

2.05 VIBRATION CONTROL JOINTS

A. Manufacturers:
1. Braided bronze flexible vibration joints 2 inches and less in size: One of the following or equal:
a. Flexonics, Inc., Type Vibra Sorber.
b. Flex-Weld, Inc., Keflex, Type KFCB.

2. Flexible vibration joints larger than 2 inches: One of the following or equal:
   a. Flexonics, Inc., Type TCS.
   b. Flex-Weld, Inc., Keflex, Series 151-TR-1215.
3. Corrugated stainless steel with stainless steel braid flexible vibration joints: One of the following or equal:
   a. Flexonics, Inc., Type FCS.
   b. Flex-Weld, Inc., Keflex, Type USFNSS-31.

B. Design:
1. Flexible vibration joints 2 inches and smaller: Braided bronze, suitable for pressures of not less than 250 pounds per square inch gauge.
2. Flexible vibration joints larger than 2 inches: Flexible bellows type, suitable for pressures of not less than 150 pounds per square inch gauge, at 70 degrees Fahrenheit, except as follows:
   a. Provide vibration joints in piping subject to test pressures higher than 150 pounds per square inch gauge, suitable for such higher pressures.
   b. Bellows: Stainless steel, equipped with a stainless steel liner.
   c. Ends: ASME Class 150 flanges.
3. Vibration joints in high-pressure air piping and in digester gas piping: Corrugated Type 316 stainless steel with stainless steel braid, suitable for pressures of not less than 150 pounds per square inch gauge.
   a. Ends: ASME Class 150 flanges.

C. Protection: Protect vibration absorbers against end loading and torsional stresses by anchoring attached piping.

2.06 TRANSITION FITTINGS

A. Manufacturers: One of the following or equal:
1. Spears.

B. Materials:
1. Slip socket: Schedule 80 PVC.
2. Collar: Type 316 stainless steel.
3. Threaded insert: Brass or Type 316 stainless steel as required.

2.07 SIGHT GLASSES

A. Assembly: Body casting with ASME standard adapter flanges, borosilicate Pyrex™ glass section, cleaning assembly with scalloped neoprene wipers, operating rod and handle, packing gland with packing and suitable adapter, and cock with solvent hand pump.

B. Suitable for a minimum pressure of 30 pounds per square inch gauge.

C. Manufacturers: One of the following or equal:
1. EIMCO Process Machinery Division of Envirotech Corporation.
2. Ernst, Type K2 or K3 Cleanable Sight Glass.

2.08 SPRAY NOZZLES

A. Manufacturer: One of the following or Equal:
1. Spraying Systems Co; No. 22561 – Foam Control Nozzle.

B. Design:
   1. Operating pressure 10 pounds per square inch gauge, at which pressure each nozzle discharges not less than 2.0 gallons per minute, nor more than 3.0 gallons per minute.
      a. Spray: Flat, heavy sheet, fan with uniform distribution.
      b. Nominal spray angel at 10 psi: 130 degrees.
      c. Spray deflection with a replaceable deflector insert free to rotate away from the orifice opening and mechanically locked in place and counterweighted.
   2. Spray nozzles structurally suitable for pressure up to 200 pounds per square inch gauge.
   3. Nozzles, easy flush type.
   4. Provide split eye connector for mounting on spray header.

C. Materials:
   1. Spray nozzles: Leaded bronze.
   2. Nozzles provided with 1/4 inch national pipe thread, and the orifice diameter not less than 1/4 inch.
   3. Replaceable spray deflector: Neoprene rubber.

2.09 FLEXIBLE CONNECTORS FOR CHEMICAL SERVICES

A. Manufacturers: One of the following or equal:
   1. Saint-Gobain Flexible Components Series TWOB.

B. Design:
   1. Type 316 or Type 321 stainless steel braided TFE hose and Type 316 or Type 321 stainless steel flanged ends.
   2. Rated for 150 psig at 125° F minimum.
   3. Minimum Length: 12 inches.
   4. Lap-joint flange retainers:
      a. Flare-Thru” design that protects flanges from process fluid.
      b. Kynar or polypropylene as suitable for each application.

C. Install where indicated on the Drawings to provide flexibility at piping connections to chemical storage tanks/totes or other fixed components.

2.10 DIAPHRAGM SEALS

A. As specified in Section 17401.

2.11 INSTRUMENT VALVES

A. As specified in Section 17402.

2.12 PRESSURE GAUGES

A. As specified in Section 17404.

2.13 MANOMETERS

A. As specified in Section 17409.

2.14 THERMOMETERS

A. As specified in Section 17602.

PART 3 EXECUTION

3.01 INSTALLATION

A. Expansion control joints:
   1. Install bellows type expansion control joints at piping connections to mechanical equipment to prevent damaging stresses due to normal expansion and contraction with temperature changes in piping and connected equipment.
   2. Install bellows type expansion joints so as to allow 2-1/4 inch expansion per 100 linear feet of piping.
   3. Install expansion joints adjacent to an anchor, and provide 1 concentric guide on piping within 12 pipe diameters, but not more than 5 feet, from the end of the joint opposite the anchor.
      a. Locate a similar guide approximately 30 diameters but not more than 10 feet from the first.
   4. For expansion joints not installed adjacent to an anchor provide 2 concentric guides similarly located at each end of the joint.
   5. Provide control rods and additional guides where indicated on the Drawings, but at no greater intervals than recommended by the joint manufacturer in published instructions.
   6. Space intermediate supports a minimum of 10 feet, and tack weld the protective saddles to the pipe.

B. Vibration control joints:
   1. Install vibration control joints at piping connections to or from mechanical equipment to prevent transmitting equipment vibration through the piping system.

C. Transition couplings:
   1. Application:
      a. Use transition couplings with function and design similar to flexible couplings and flanged coupling adapters for connecting piping having different outside diameters.
   2. Install transition-coupling products specifically designed and manufactured for that application.

D. Spray nozzles:
   1. Install spray nozzles so that the flat spray is 90 degrees to the water surface.
   2. Mount at the elevations shown on the Drawings.

END OF SECTION

SECTION 15121

PIPE COUPLINGS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Dismantling joints.
   2. Grooved joint couplings.
   3. Flanged coupling adapters.
   4. Flexible couplings.
   5. Restrained flange coupling adapters.

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 09960 - High-Performance Coatings.
      b. Section 15052 - Common Work Results for General Piping.

1.02 REFERENCES

A. American National Standards Institute (ANSI).

B. American Society of Mechanical Engineers (ASME):
   1. B31.1 - Power Piping.
   2. B31.9 - Building Services Piping.

C. American Water Works Association (AWWA):
   1. C111 - Standard for Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings.
   2. C207 - Standard for Steel Pipe Flanges for Waterworks Service - Sizes 4 In. Through 144 In.
   3. C606 - Standard for Grooved and Shouldered Joints.

D. ASTM International (ASTM):
   1. A 36 - Standard Specification for Carbon Structural Steel.
   2. A 53 - Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless.
   3. A 193 - Standard Specification for Alloy Steel and Stainless Steel Bolting Materials for High Temperature or High Pressure Service and Other Special Purpose Applications.

4. A 351 - Standard Specification for Castings, Austenitic, for Pressure-Containing Parts.
5. A 449 - Standard Specification for Hex Cap Screws, Bolts and Studs, Steel, Heat Treated, 120/105/9 ksi Minimum Tensile Strength, General Use.
6. A 536 - Standard Specification for Ductile Iron Castings.
7. A 576 - Standard Specification for Steel Bars, Carbon, Hot-Wrought, Special Quality.
8. D 2000 - Standard Classification System for Rubber Products in Automotive Applications.
9. F 593 - Standard Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs.

E. NSF International (NSF).
1. 61 - Drinking Water System Components - Health Effects.

1.03 SUBMITTALS

A. Shop drawings, detailing dimensions, and materials.

B. Piping layout drawings: Coordinate preparation of required piping layout drawings such that coupling center sleeve sizes are clearly indicated on the Drawings.

C. Manufacturer's published installation instructions.

PART 2 PRODUCTS

2.01 PIPE COUPLINGS FOR DUCTILE IRON PIPING

A. Dismantling joints:
1. Manufacturers: One of the following or equal:
   a. Romac Industries, Inc., Style DJ400.
   b. Smith-Blair, Inc., Series 975.
2. Materials:
   a. Flanged spool:
      1) C207 Schedule 40 steel pipe in accordance with ASTM A 53 for sizes 3 inches to 12 inches.
      2) Steel for pipe in accordance with ASTM A 36 for sizes 14 inches to 72 inches.
   b. End ring and body:
      1) For sizes 3 inches to 12 inches, ductile iron in accordance with ASTM A 536.
      2) For sizes 14 inches to 72 inches, steel in accordance with ASTM A 36 or A 53.
   c. Follower ring: Ductile iron in accordance with ASTM A 536 or steel in accordance with ASTM A 36 or A 576.
   d. Bolts and hex nuts:
      1) Aboveground: High strength, low alloy steel in accordance with AWWA C111.
      2) Buried and underwater: Type 316 stainless steel bolts in accordance with ASTM F 593.
   e. Tie rods: High tensile steel in accordance with ASTM A 193 Grade B7.

3. Flange design: Class D steel ring flange in accordance with AWWA C207, compatible with ANSI Class 125 and 150 bolt circles.
4. Coating and lining: Manufacturer's standard fusion bonded epoxy, NSF 61 certified.
    a. As specified in Section 09960.

B. Flanged coupling adapters: 12-inch size and smaller.
1. Manufacturers: One of the following or equal:
    a. Dresser, Inc., Style 227.
    b. Romac Industries, Inc., Style FCA501.
    c. Smith-Blair, Inc., Series 912.
2. Materials:
    a. Flanged body: Ductile iron in accordance with ASTM A 536.
    b. Follower ring: Ductile iron in accordance with ASTM A 536.
    c. Bolts and hex nuts:
        1) Aboveground: High strength, low alloy steel in accordance with AWWA C111.
        2) Buried and underwater: Type 316 stainless steel bolts in accordance with ASTM F 593.
3. Flange design: Class D steel ring flange in accordance with AWWA C207 compatible with ANSI Class 125 and 150 bolt circles.
4. Coating and lining: Manufacturer's standard fusion bonded epoxy, NSF 61 certified.

C. Flanged coupling adapters: Greater than 12-inch size:
1. Manufacturers: One of the following or equal:
    a. Dresser, Inc., Style 128-W.
    b. Romac Industries, Inc., Style FC400.
    c. Smith-Blair, Inc., Series 913.
2. Materials:
    a. Flange and flanged body: Ductile iron or low carbon steel having a minimum yield strength of 30,000 pounds per square inch.
    b. Follower ring: Low carbon steel having a minimum yield strength of 30,000 pounds per square inch.
    c. Bolts and hex nuts:
        1) Aboveground: High strength, low alloy steel in accordance with AWWA C111.
        2) Buried and underwater: Type 316 stainless steel bolts in accordance with ASTM F 593.
3. Flange design: Class D steel ring flange in accordance with AWWA C207 compatible with ANSI Class 125 and 150 bolt circles.
4. Coating and lining: Manufacturer's standard fusion bonded epoxy, NSF 61 certified.

D. Flexible couplings:
1. Manufacturers: One of the following or equal:
    a. Dresser, Inc., Style 253.
    b. Romac Industries, Inc., Style 501.
    c. Smith-Blair, Inc., Series 441.
2. Materials:
    a. Center rings: Ductile iron in accordance with ASTM A 536.
    b. Follower rings: Ductile iron in accordance with ASTM A 536.

c. Bolts and hex nuts:
   1) Aboveground: High strength, low alloy steel in accordance with AWWA C111.
   2) Buried and underwater: Type 316 stainless steel in accordance with ASTM F 593.

3. Coating and lining: Manufacturer's standard fusion bonded epoxy, NSF 61 certified.
4. Center sleeve dimensions: Provide center sleeves with lengths in accordance with following table:

Nominal Pipe Size	Sleeve Length
3 inch and smaller	Manufacturer's standard
4 inch through 8 inch	7 inches
10 inch through 14 inch	12 inches
Greater than 16 inch	Use steel flexible coupling per Pipe Couplings for Steel Piping

E. Restrained flange coupling adapter:
1. Manufacturers: One of the following or equal:
   a. Romac Industries, Inc., Style RFCA.
   b. Star Pipe Products, 3200 StarFlange.
2. Materials:
   a. Flange and flanged body: Ductile iron in accordance with ASTM A 536.
   b. Follower ring: Lug type restraint system.
      1) Follower ring: Ductile iron in accordance with ASTM A 536.
      2) Restraining lugs: Ductile iron in accordance with ASTM A 536.
         a) Designed to contact the pipe and apply forces evenly.
      3) Restraining bolts:
         a) Ductile iron in accordance with ASTM A 536.
         b) Bolt heads shall be designed to twist off when the proper torque has been applied.
   c. Bolts and hex nuts:
      1) Aboveground: High strength, low alloy steel in accordance with AWWA C111.
      2) Buried and underwater: Type 316 stainless steel bolts in accordance with ASTM F 593.
3. Flange design: Class D steel ring flange in accordance with AWWA C207 compatible with ANSI Class 125 and 150 bolt circles.
4. Coating and lining: Manufacturer's standard fusion bonded epoxy, NSF 61 certified.
5. Angular deflection: Restrained flange coupling adapter must allow angular deflection after assembly.

F. Grooved joint couplings:
1. Manufacturers:
   a. Victaulic Company, Series 31 or equal.
2. Materials:
   a. Housings: Ductile iron in accordance with ASTM A 536.
   b. Gasket:
      1) FlushSeal® type, or equal. Elastomer in accordance with ASTM D 2000.
      2) EPDM.

c. Bolts and nuts: Electroplated steel in accordance with ASTM A 449.
d. Coating: As specified in Section 09960.

3. For use with rigid or flexible radius grooved components in accordance with AWWA C606.
4. For connection to IPS steel pipe sizes, Victaulic Style 307.

2.02 PIPE COUPLINGS FOR STEEL PIPING

A. Dismantling joints:
1. Manufacturers: One of the following or equal:
   a. Romac Industries, Inc., Style DJ400.
   b. Smith-Blair, Inc., Series 975.
2. Materials:
   a. Flanged spool:
      1) C207 Schedule 40 pipe in accordance with ASTM A 53 for sizes 3 inches to 12 inches.
      2) Steel for pipe in accordance with ASTM A 36 or A 53 for sizes 14 inches to 72 inches.
   b. End ring and body:
      1) For sizes 3 inches to 12 inches, ductile iron in accordance with ASTM A 536.
      2) For sizes 14 inches to 72 inches, steel in accordance with ASTM A 36.
   c. Follower ring: Ductile iron in accordance with ASTM A 536 or steel in accordance with ASTM A 36 or A 576.
   d. Bolts and hex nuts:
      1) Aboveground: High strength, low alloy steel in accordance with AWWA C111.
      2) Buried and underwater: Type 316 stainless steel bolts in accordance with ASTM F 593.
   e. Tie rods: High tensile steel in accordance with ASTM A 193 grade B7.
3. Flange design: Class D steel ring flange in accordance with AWWA C207 compatible with ANSI Class 125 and 150 bolt circles.
4. Coating and lining: Fusion bonded epoxy certified in accordance with NSF 61.

B. Flanged coupling adapters:
1. Manufacturers: One of the following or equal:
   a. Dresser, Inc., Style 128-W.
   b. Romac Industries, Inc., Style FCA501 (10 inch and smaller) or Style FC400 (12 inch and larger).
   c. Smith-Blair, Inc., Series 913.
2. Materials:
   a. Flange and flanged body: Ductile iron or low carbon steel having a minimum yield strength of 30,000 pounds per square inch.
   b. Follower ring: Low carbon steel having a minimum yield strength of 30,000 pounds per square inch.
   c. Bolts and hex nuts:
      1) Aboveground: High-strength, low-alloy steel in accordance with AWWA C111.
      2) Buried and underwater: Type 316 stainless steel bolts in accordance with ASTM F 593.

3. Flange design: Class D steel ring flange in accordance with AWWA C207 compatible with ANSI Class 125 and 150 bolt circles.
4. Coating and lining: Manufacturer's standard fusion bonded epoxy, NSF 61 certified.

C. Flexible couplings:
1. Manufacturers: One of the following or equal:
   a. Dresser, Inc., Style 38.
   b. Smith-Blair, Inc., Series 411.
   c. Romac Industries, Inc., Style 511 or Style 400.
2. Materials:
   a. Center sleeve and follower flanges: Ductile iron or low carbon steel having a minimum yield strength of 30,000 pounds per square inch.
   b. Bolts and hex nuts:
      1) Aboveground: High strength, low alloy steel in accordance with AWWA C111.
      2) Buried and underwater: Type 316 stainless steel bolts in accordance with ASTM F 593.
3. Coating and lining: Manufacturer's standard fusion bonded epoxy, NSF 61 certified.
4. Center sleeve dimensions: Provide center sleeves with lengths in accordance with following table:

Nominal Pipe Diameter	Sleeve Length
2-1/2 inch and smaller	Manufacturer's standard
3 inch through 6 inch	7 inch
8 inch through 14 inch	7 inch
Greater than 14 inches	10 inch

D. Restrained flange coupling adapters:
1. Manufacturers: One of the following or equal:
   a. Romac Industries, Inc., Style RFCA.
   b. Star Pipe Products, 3200 StarFlange.
2. Materials:
   a. Flange and flanged body: Ductile iron in accordance with ASTM A 536.
   b. Follower ring: Lug type restraint system.
      1) Follower ring: Ductile iron in accordance with ASTM A 536.
      2) Restraining lugs: Ductile iron in accordance with ASTM A 536.
         a) Designed to contact the pipe an apply forces evenly.
      3) Restraining bolts: Ductile iron in accordance with ASTM A 536. Bolt heads shall be designed to twist off when the proper torque has been applied.
   c. Bolts and hex nuts:
      1) Aboveground: High-strength, low-alloy steel in accordance with AWWA C111.
      2) Buried and underwater: Type 316 stainless steel bolts in accordance with ASTM F 593.
3. Flange design: Class D steel ring flange in accordance with AWWA C207 compatible with ANSI Class 125 and 150 bolt circles.
4. Coating and lining: Manufacturer's standard fusion bonded epoxy certified in accordance with NSF 61.

E. Grooved joint couplings:
   1. Model numbers from one manufacturer are shown to indicate type only. Equivalent products of other manufacturers may be submitted for approval.
   2. Coating: As specified in Section 09960.
   3. Sizes through 12 inch:
      a. Rigid type:
         1) Housings shall be cast with offsetting angle-pattern bolt pads to provide rigidity and system support and hanging in accordance with ASME B31.1 and B31.9.
         2) 2 inch through 6 inch: Installation-ready, for direct stab installation without field disassembly, with grade EHP gasket rated to plus 250 degrees Fahrenheit.
         3) Manufacturer: One of the following or equal:
            a) Victaulic Style 107.
            b) Victaulic Zero-Flex Style 07.
      b. Flexible type:
         1) For use in locations where vibration attenuation and stress relief are required.
         2) Three flexible couplings may be used in lieu of a flexible connector.
         3) The couplings shall be placed in close proximity to the source of the vibration.
         4) Manufacturer: The following or equal:
            a) Victaulic Style 77.
      c. Flange adapter:
         1) Flat face, ductile iron housings with elastomer pressure responsive gasket, for direct connection to ANSI Class 125 or 150 flanged components.
         2) Manufacturer: The following or equal:
            a) Victaulic Style 741.

2.03 PIPE COUPLINGS FOR STAINLESS STEEL PIPING

A. Flexible couplings:
   1. Manufacturers: One of the following or equal:
      a. Dresser, Inc., Style 38.

B. Grooved joint couplings:
   1. Manufacturers: One of the following or equal
      a. Victaulic Company.
   2. Materials:
      a. Housings:
         1) Ductile iron in accordance with ASTM A 536.
         2) Stainless steel in accordance with ASTM A 351.
      b. Gasket: Elastomer in accordance with ASTM D 2000.
      c. Bolts and nuts:
         1) Electroplated steel in accordance with ASTM A 449.
         2) Stainless steel in accordance with ASTM F 593.
   3. Rigid type:
      a. Victaulic Style 89 and W89 (ductile iron housings).
      b. Victaulic Style 489 (stainless steel housings).
   4. Flexible type: Victaulic Style 77S.

2.04 GASKETS FOR FLEXIBLE COUPLINGS AND FLANGED COUPLING ADAPTERS

A. Provide gasket materials for piping applications as follows:
   1. Low-pressure and high-pressure air, steam, hot water: EPDM.
   2. All other piping applications: EPDM.

2.05 EXTERIOR COATINGS FOR UNDERGROUND AND SUBMERGED APPLICATIONS

A. Manufacturers: One of the following or equal:
   1. Tapecoat Company, Inc., T.C. Mastic.
   2. Kop-Coat Company, Inc., Bitumastic Number 50.

B. Thickness: Minimum 0.040 inch.

PART 3 EXECUTION

3.01 INSTALLATION

A. In underground and underwater installations, coat the exterior of coupling with a protective coating after installation.

B. Joints and flexible connections shall be installed centered with no angular deflection unless otherwise indicated on the Drawings.

C. Flexible couplings and flange coupling adapters: Install with gap between pipe ends in accordance with the following table unless a greater gap is indicated on the Drawings. Maximum gap tolerance shall be within 1/8 inch.
   1. Install flexible coupling with pipe gap located in middle of center sleeve.
   2. Install flanged coupling adapter with end of plain end pipe in middle of flanged coupling body.

Center Ring Length	Gap Dimension and Tolerance
4 inch through 6 inch	3/8 inch
7 inch	5/8 inch
10 inch and greater	7/8 inch

D. Provide harnesses (tie-downs) for flexible couplings unless otherwise indicated on the Drawings with a written note.
   1. Design harnesses (tie-downs) for the test pressures as specified in the Piping Schedule in Section 15052.

E. Grooved joint couplings:
   1. Grooved joints shall be installed in accordance with the manufacturer's latest published installation instructions.
   2. Grooved ends shall be clean and free from indentations, projections, and roll marks in the area from pipe end to groove.
   3. Gaskets shall be of an elastomer grade suitable for the intended service, and shall be molded and produced by the coupling manufacturer.
   4. The grooved coupling manufacturer's factory trained representative shall provide on-site training for CONTRACTOR's field personnel in the use of grooving tools and installation of grooved joint products. The representative

shall periodically visit the jobsite and review CONTRACTOR is following best recommended practices in grooved product installation. (A distributor's representative is not considered qualified to conduct the training or jobsite visit(s).)

END OF SECTION

SECTION 15122

FIRE HYDRANTS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Barrel type fire hydrants.

1.02 REFERENCES

A. American Water Works Association (AWWA):
   1. C503-05 Wet-Barrel Fire Hydrants.
   2. C104-08 Cement–Mortar Lining for Ductile Iron Pipe and Fittings for Water.

B. San Luis Obispo County 2011 Public Improvement Standards.

C. Cal Fire/SLO County Fire Department Fire Prevention:
   1. Exhibit 3.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Manufacturers: One of the following or equal:
   1. Clow Valve Company, Wet Barrel Hydrant: F960.
   2. Mueller Company, approved alternate.
   3. Kennedy, approved alternate.

2.02 MATERIALS

A. Fire hydrants:
   1. Wet barrel in accordance with type AWWA C 503-05 and SLO County 2011 Public Improvement Standard Drawings W-2 and W-3, as complemented and modified in this Section.
   2. Provide hydrants with ground level break-off feature and manufactured such that the valve stem will not be bent when the hydrant is damaged or broken at or near the ground level.
   3. When shut, provide valves that remain reasonably tight when the upper portion of the barrel is broken off.
   4. Diameter of the main valve opening: Not less than 4 inches.
   5. Inlet connection: 6-inch diameter mechanical joint for ductile iron pipe.
   6. Provide two 2-1/2-inch hose nozzles and one 4-inch pumper nozzle facing the street.
      a. Provide nozzles with hose caps chained to the hydrant barrel.
      b. Nozzle threads: National standard hose thread.
   7. Color of hydrant above ground: Chrome Yellow.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install hydrants with proper extension so that branch pipe to hydrant and supply main are at the same elevation.

B. Attach auxiliary 6-inch gate valves by mechanical joint at least 18 inches from the hydrant joint, and attach piping ductile-iron to the supply. Ensure valve box does not interfere with concrete curb.

C. Firmly set hydrants on a bed of coarse gravel.

D. CONTRATOR shall install bollards per Cal Fire/SLO County Fire Department Fire Prevention: Exhibit 3.

END OF SECTION

SECTION 15125

STRAINERS AND FILTERS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Strainers and filters.

1.02 REFERENCES

A. ASTM International (ASTM):
   1. A 126 - Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings.
   2. A 420 - Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Low-Temperature Service.

B. Society of Automotive Engineers (SAE).

1.03 SUBMITTALS

A. Shop drawings detailing dimensions and materials.

B. Manufacturer's published installation instructions.

C. Operation and Maintenance Manuals.

PART 2 PRODUCTS

2.01 Y-TYPE STRAINERS

A. Y-type strainers 4 inches and larger in diameter:
   1. Materials:
      a. Bodies: Cast iron or semi-steel.
      b. Ends: Flanged.
      c. Screens: Brass or Type 304 stainless steel.
   2. Suitable for following minimum pressure conditions:
      a. Steam service: 250 pounds per square inch gauge.
      b. Water, oil, and gas service: 200 pounds per square inch gauge.
   3. Perforated screens:
      a. Openings: 0.045 inch.
      b. Active screen opening to pipe area ratio: 2.8, minimum.
      c. Free area: 37 percent minimum.
   4. Manufacturers: One of the following or equal:
      a. Armstrong International Inc., Code A1.
      b. ITT/Hoffman, 460 Series.

B. Y-type strainers less than 4 inches in diameter:
   1. Materials:
      a. Bodies: Cast iron or semi-steel.
      b. Ends: Flanged or threaded.
      c. Screen: Brass or Type 304 stainless steel.
   2. Suitable for minimum pressure of 250 pounds per square inch gauge.
   3. Screens: Perforations: 1/32 inch.
   4. Manufacturers: One of the following or equal:
      a. Fisher Controls Company, Fisher Type 260C.
      b. Armstrong, equivalent model.

2.02 BASKET TYPE STRAINERS

A. Provide basket type strainers single or duplex as indicated on the Drawings.

B. Materials:
   1. Bodies: Cast iron or cast steel.
   2. Baskets: Low-zinc bronze or stainless steel.

C. Pressure rating:
   1. Plant Water Service in Sludge Storage Tanks: 200 pounds per square inch gauge, minimum
   2. All Other Locations and Services: 125 pounds per square inch gauge, minimum.

D. Connections: Threaded or flanged, as required.

E. Covers:
   1. For strainers 6 inches and smaller in size, secured by yokes or similar quick opening devices.
   2. For strainers larger than 6 inches in size, bolted or hinged and bolted with slotted washers so that bolts or nuts need not be completely removed to open the strainer.
   3. Provide lifting eyes on covers weighing more than 50 pounds.

F. Baskets:
   1. Screen: Mesh or perforated sheet.
   2. Openings: 3/16-inch.
   3. Free area: Not less than 30 percent.
   4. Free area to pipe ratio: Not less than 3.

G. Provide duplex strainers with tapered plug transfer valve or with gate type transfer valves.
   1. Where action on 2-valve actuators is required to transfer operation from one chamber to the other, provide actuators mechanically linked for simultaneous operation.

H. Manufacturers:
   1. Single basket strainers: One of the following or equal:
      a. Fluid Engineering, Series 528B.
      b. Mueller Steam Specialty.

2. Double basket strainers: One of the following or equal:
   a. Fluid engineering, Series 534 for sizes 1-1/2 inch to 8 inch, and Series 424 for sizes 10 inch and larger.
   b. Mueller Steam Specialty.
3. Basket strainers for chemical service:
   a. Dual or simplex as indicated on the Drawings; baskets and bodies PVC; gaskets Viton® or EPDM as required for the chemical service; basket mesh size to be specified by the ENGINEER during shop drawing review.
   b. Manufacturer: Hayward.

2.03 Y STRAINERS FOR CHEMICAL SERVICE

A. Materials:
   1. Bodies: PVC or CPVC to match piping material.
   2. Baskets: PVC or CPVC to match piping material.
   3. Seals:
      a. Aluminum Sulfate Service: EPDM.
      b. Sodium Hypochlorite Service: Material compatible with the fluid.

B. Connections:
   1. Inlet and Outlet: Union.

C. Screens: Perforations: Not greater than 1/32 inch.

D. Manufacturers: One of the following or equal.
   1. Hayward.
   2. Asahi-America, Inc.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install in accordance with the manufacturer's recommendations.

END OF SECTION

SECTION 15128

FORCE BALANCED DUCTILE IRON BALL-TYPE FLEXIBLE EXPANSION JOINTS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Force balanced ductile iron ball-type flexible expansion joints.

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 15052 - Common Work Results for General Piping.
   b. Section 15211 - Ductile Iron Pipe, AWWA C151.

1.02 REFERENCES

A. American Water Works Association (AWWA):
1. C110 - Ductile-Iron and Gray-Iron Fittings.
2. C111 - Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings.
3. C153 - Ductile-Iron Compact Fittings for Water Service.
4. C210 - Liquid-Epoxy Coating Systems for the Interior and Exterior of Steel Water Pipelines.
5. C213 - Fusion Bonded Epoxy Coating for the Interior and Exterior of Steel Water Pipelines.

B. ASTM International (ASTM).
1. A 536 - Standard Specification for Ductile Iron Castings.

C. NSF International:
1. 14 - Plastics Plumbing System Components and Related Materials.
2. 61 - Drinking Water System Components - Health Effects.

1.03 SYSTEM DESCRIPTION

A. Design requirement:
1. Performance requirements:
   a. Joints capable of angular deflecting and expanding or contracting simultaneously without leakage.
   b. Angular deflection: Capable of providing a minimum angular deflection from centerline at each ball joint as follows:
      1) 3 to 12-inch pipe: 20 degrees.
      2) 14 to 18-inch pipe: 15 degrees.

c. Axial movement capacity: Unless otherwise indicated on the Drawings, factory pre-set axial movement to reserve 50 percent of the total axial movement capacity for expansion and 50 percent of the total axial movement capacity for compression. Provide one or more expansion sleeves to provide a total axial movement:
   1) 2-inch through 3-inch: Total of 4 inches minimum expansion and compression,
   2) 4-inch: Total of 6 inches minimum expansion and compression
   3) 6-inch through 12-inch: Total of 8 inches minimum expansion and compression.
   4) 18-inch: Total of 10 inches minimum expansion and compression.
d. Working pressure rating:
   1) Sizes:
      a) 2-inch: 150 psi.
      b) 3-inch through 12-inch: 350 psi.
      c) 14-inch and larger: 250 pounds per square inch.

1.04 SUBMITTALS

A. Product Data:
   1. Manufacturer's certificate attesting successful performance of specified tests.
   2. Shop drawings detailing dimensions and materials. Provide weights for each size of force balanced ball type flexible expansion joint used on the Project.
   3. Manufacturer's published installation instructions.
   4. Operation and maintenance manuals.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Protect sliding and rotating surfaces against damage during packing, shipping and installation.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. 2-inch: One of the following or equal:
   1. EBAA Iron, Inc., Force Balanced Flex-Tend Model 4402F20B.

B. 14-inch: One of the following or equal:
   1. 14-inch: EBAA Iron, Inc., Force Balanced Flex-Tend Model 4414F20B.

2.02 MATERIALS

A. Ductile iron: Material properties in accordance with ASTM A 536 with wall thickness meeting requirements of AWWA C153.

B. Gaskets:
   1. At ball joints and sleeves: EPDM.
   2. At flanged end connections: As specified in Section 15052.
   3. At mechanical joint end connections: As specified in Section 15211.

C. Bolts and nuts:
   1. At flanged end connections: As specified in Section 15052.

2.03 MANUFACTURED UNITS

A. Consist of 2 ball and socket type joints with a expansion unit located between the 2 ball joints. The ball and socket ends shall be integrally cast with the expansion unit.

B. End connections:
   1. Flange end connections in accordance with the dimensional requirements of AWWA C110 with the addition of an O-ring groove.

C. NSF compliance requirements for installation of forced balanced ball-type flexible expansion joints in potable water systems: Lining, gasket material, lubricants, and other wetted components shall be certified to meet requirements of NSF Standard No. 61 and health effects portion of NSF Standard No. 14.

2.04 FINISHES

A. Coat external surfaces as follows:
   1. Buried installations: External fusion-bonded epoxy in accordance with AWWA C210, coating by Manufacturer. Wrap fitting with polyethylene in same manner as for ductile iron pipe as specified in Section 15211.
   2. Aboveground installations: Field apply coating system as specified in Section 15052 for the piping system.

B. Line all internal wetted surfaces and seal contact surfaces with a minimum of 15 mils of fusion-bonded epoxy in accordance with AWWA C213. Holiday test epoxy lining with a 1,500-volt spark test in accordance with AWWA C213.

2.05 SOURCE QUALITY CONTROL

A. Pressure test to rated working water pressure before shipment.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install force balance ductile iron ball-type flexible expansion joints in accordance with manufacturer's published instructions to meet minimum expansion and contraction values as specified or as indicated on the Drawings.

END OF SECTION

SECTION 15130

STATION MONITORS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Standpipe mounted station monitors for wash-down of the Stormwater Retention Basin.

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 09960 - High-Performance Coatings.

C. Inclusion of a specific manufacturer's name in the Specifications does not mean that the specific manufacturer's standard product will be acceptable. Specified manufacturer's or other manufacturer's standard product shall be modified as required to meet the Specifications.

1.02 DESIGN REQUIREMENTS

A. Design for a minimum water stream reach of 140 feet when operated at a design rating of 300 gallons per minute at 100-psi line pressure.

1.03 SUBMITTALS

A. Product Data:
   1. Catalog cuts.
   2. Nomographs and other performance data.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. One of the following or equal:
   1. Stang Industrial Products, Corona, CA: Model 925000-71.

2.02 COMPONENTS

A. Monitor:
   1. 3-inch ANSI 150 pound flanged inlet.

2. 2-1/2-inch discharge.
3. Fabricated from Schedule 40 heavy wall seamless pipe. Pressure tested to a minimum 300 psi.
4. Horizontal and vertical motion shall be accomplished by a single tiller bar handle with PVC grip.
5. Horizontal and vertical joints shall be capable of being locked at any position.
6. Swivel joints shall be double sealed and contain two rows of Type 440C stainless steel ball bearings. Provisions shall be made for external lubrication of the swivels through zerk fittings.
7. Redial forces shall be completely balanced through a single sweeping water way. No division and re-mating of the waterway shall be allowed.
8. Mount to facilitate ease of operation from the adjacent sidewalk for wash-down of the basin. Orientation shall be subject to ENGINEER's approval.

B. Nozzle:
1. Straight stream tapered nozzle.
2. Molded from rigid Polyurethane.
3. Designed for a burst pressure of 200 psi.
4. Inlet: 2-1/2 inch threaded NH metal insert.
5. Outlet: Aluminum orifice insert available in various diametrical increments.
6. The nozzle shall incorporate straightening vanes to prevent breakup of the water stream within the reach required.

2.03 FINISHES

A. Undercoat and paint in accordance with Section 09960.

PART 3 EXECUTION

3.01 INSTALLATION

A. Provide, store, and install monitor stations in accordance with the recommendations of the manufacturer.

END OF SECTION

SECTION 15210

CAST IRON SOIL PIPE, ASTM A 74

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Cast iron soil piping and acid resistant cast iron soil piping.

1.02 REFERENCES

A. ASTM International (ASTM):
   1. A 74 - Standard Specification for Cast Iron Soil Pipe and Fittings.
   2. A 888 - Standard Specifications for Hubless Cast Iron Soil Pipe and Fittings for Sanitary and Storm Drain, Waste, and Vent Pipe Applications.
   3. C 564 - Standard Specification for Rubber Gaskets for Cast Iron Soil Pipe and Fittings.

1.03 SUBMITTALS

A. Shop drawings:
   1. Layout drawings.
   2. Joints.
   3. Fittings and specials.
   4. Structure and pipe connections.

B. Product data:
   1. Gaskets.

C. Test results.

PART 2 PRODUCTS

2.01 MATERIALS

A. Cast iron soil piping, underground:
   1. Cast iron soil pipe underground: Bell-and-spigot service weight cast iron soil pipe in accordance with ASTM A 74.
   2. Make joints by using positive double seal compression type gaskets in accordance with ASTM C 564.
   3. Pipe and fittings shall be marked with the collective trademark of the Cast Iron Soil Pipe Institute.

B. Cast iron soil piping, aboveground:
   1. Piping: As specified for cast iron soil piping underground, or "No Hub" cast iron soil pipe and fittings:
      a. Couplings for no hub cast iron soil piping: Consisting of a stainless steel corrugated shield and clamp assembly over a molded 1-piece neoprene sealing sleeve, in accordance with ASTM A 888.

2. Threaded joints: American standard taper screw threads, cut clean and made up with Teflon tape or an acceptable paste thread compound applied to the male threads only.
3. Pipe and fittings shall be marked with the collective trademark of the Cast Iron Soil Pipe Institute.

C. Acid resistant cast iron piping:
1. Manufacturers: One of the following or equal:
   a. The Duriron Company, Inc., Dayton, Ohio.
   b. Provide substitutes from other manufacturers with same chemical properties and weight equal or heavier than the weight of Duriron piping.
2. Make joints of stainless steel mechanical connectors with Teflon and neoprene liner, or with rope packing recommended by manufacturer.
3. Joints and fittings used for digester gas piping: Split flange type.

2.02 FABRICATION

A. Lining and coating:
1. Line cast iron soil pipe and fittings inside and coat outside with bituminous coating.

PART 3 EXECUTION

3.01 INSTALLATION

A. Cast iron soil piping:
1. Encase in concrete underground cast iron soil piping under structures.
   a. Encase pipe as indicated on the Drawings.
2. Support aboveground horizontal cast iron soil piping at not more than 5-foot spacing.
3. Aboveground vertical cast iron soil piping:
   a. Install vertical piping in chases in the wall where the wall is plastered; where the wall is not plastered, vertical piping may be installed in chases in the wall or may be run exposed.
   b. Support vertical pipes at the base and at each floor.
4. Fittings:
   a. Make junctions with sanitary tees or with wyes, with brass screw plug cleanouts at accessible locations at changes in direction.
   b. Make changes in pipe size with reducing fittings.
   c. Make changes in direction by use of 45-degree wyes, half wyes, long sweep 1/4 bends, 1/5, 1/6, 1/8, or 1/16 bends, except that sanitary tees may be used on vertical stacks; short 1/4 bends or elbows 3 inches in size or larger may be used on soil or waste lines where the change in direction of flow is from horizontal to vertical, and on the discharge from water closets.
   d. Cleanouts: Same size as the pipe, except that cleanout plugs larger than 4 inches will not be required.

B. Acid-resistant cast iron piping:
1. Where rope packing is used, caulk packing into half the depth of the hub.
   a. Ram packing well in accordance with manufacturer's published instructions.

b. After ramming, fill the joints with lead and caulk in accordance with the manufacturer's published instructions.
c. Preheat hubs before pouring lead.

2. Do not use hemp packing and jute packing for joints of acid resistant piping.

END OF SECTION

SECTION 15211

DUCTILE IRON PIPE, AWWA C151

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Ductile iron pipe, joints, fittings, gaskets, and pipe linings and coatings.

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 09960 - High-Performance Coatings.
      b. Section 13112 - Pipeline Corrosion Monitoring Facilities.
      c. Section 15052 - Common Work Results for General Process Piping.
      d. Section 15121 - Pipe Couplings and External Joint Restraints.

1.02 REFERENCES

A. American Society of Mechanical Engineers (ASME):
   1. B16.1 - Gray Iron Pipe Flanges and Flanged Fittings: Classes 25, 125, and 250.

B. American Water Works Association (AWWA):
   1. C104 - Standard for Cement-Mortar Lining for Ductile-Iron Pipe and Fittings.
   2. C105 - Polyethylene Encasement for Ductile-Iron Pipe Systems.
   3. C110 - Standard for Ductile-Iron and Gray-Iron Fittings.
   4. C111 - Standard for Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings.
   5. C115 - Flanged Ductile Iron Pipe with Ductile-Iron or Gray-Iron Threaded Flanges.
   6. C150 - Standard for Thickness Design of Ductile-Iron Pipe.
   7. C151 - Standard for Ductile-Iron Pipe, Centrifugally Cast.
   8. C600 - Installation of Ductile Iron Water Mains and Their Appurtenances.
   9. C606 - Standard for Grooved and Shouldered Joints.

C. American Welding Society (AWS):
   1. D11.2 - Guide for Welding Iron Castings.

D. ASTM International (ASTM):
   1. A 47 - Standard Specifications for Ferritic Malleable Iron Castings.
   2. A 183 - Standard Specifications for Carbon Steel Track Bolts and Nuts.

3. A 536 - Standard Specifications for Ductile Iron Castings.
4. C 283 - Standard Test Methods for Resistance of Porcelain Enameled Utensils to Boiling Acid.
5. D 792 - Standard Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement.

E. Ductile Iron Pipe Research Association (DIPRA):
1. Thrust Restraint Design Manual.

F. NACE International (NACE):
1. SP0188 - Discontinuity (Holiday) Testing of New Protective Coatings on Conductive Substrates.

G. National Association of Pipe Fabricators, Inc. (NAPF):
1. 500-03 - Surface Preparation Standard for Ductile Iron Pipe and Fittings in Exposed Locations Receiving Special External Coatings and/or Special Internal Linings.

H. Society for Protective Coatings (SSPC):
1. PA-2 - Measurement of Dry Coating Thickness With Magnetic Gages.

1.03 SYSTEM DESCRIPTION

A. Thrust restraint system design:
1. Design restrained joint thrust restraint system.
2. Determine the length of pipe that must be restrained on each side of the focus of a thrust load in accordance with the procedures and criteria established by the DIPRA Thrust Restraint Design Manual as specified in Piping Schedule in Section 15052 and the following additional criteria:
   a. Design pressure: Test pressure.
   b. Laying condition: Type 5 in accordance with AWWA C150.
   c. Soil designation: Silt 1 as defined by DIPRA.
   d. Unit friction resistance: Based upon polyethylene encasement of pipe.
   e. Safety factor: 1.5 (for thrust restraint calculations only).

1.04 SUBMITTALS

A. Product data: Photographs, drawings, and descriptions of fittings, gaskets, couplings, grooving of pipe and fittings, pipe linings, and coatings.

B. Shop drawings:
1. Detailed layout drawings showing alignment of pipes, location of valves, fittings, and appurtenances, types of joints, connections to structures, and thrust restraint system layouts.
2. Thrust restraint systems: Calculations and layout for restrained joint thrust restraint systems.

C. Design calculations:
1. Calculations for thrust restraint system design.

D. Test reports:
   1. Manufacturer's test reports for polyurethane**,**ceramic epoxy, and glass lining certifying successful performance of holiday detection tests.
      a. This documentation shall identify each piece by mark designation, and show the actual test results during the final inspection by the manufacturer prior to shipment.
      b. Acceptance criteria for glass lining shall be as specified under Field Quality Control.
   2. Manufacturer’s test results for glass lined pipe-certifying compliance with specified material requirements for glass lining.
   3. Submit Coating Manufacturer’s Technical Representative’s reports.

1.05 QUALITY ASSURANCE

A. Qualifications:
   1. Lining manufacturers: For piping specified to receive glass or epoxy lining, use only a lining manufacturer having a minimum of 5 years experience supplying this type of product to the wastewater and water industry.
   2. Welded on outlets: The pipe manufacturer shall have a minimum of 5 years experience in the fabrication and testing of outlets of similar size and configuration similar to those used on the Project.

B. Pre-installation meeting:
   1. Arrange for Coating Manufacturer’s Technical Representative to attend preconstruction conferences, and to make periodic visits to factory or shop to inspect surface preparation of pipe, fittings, and accessories; and to inspect application of linings to interior and coatings to exterior of pipe, fittings, and accessories.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Block piping and associated fittings for shipment to prevent damage to coatings and linings.

B. Carefully handle piping and associated fittings during loading, unloading, and installation.
   1. Do not drop piping material from cars or trucks.
   2. Lower piping by mechanical means.
   3. Do not drop or pound pipe to fit grade.

C. Ceramic epoxy, glass, polyurethane lined pipe and fittings must be handled only from the outside.
   1. No forks, chains, straps, hooks, or other lifting device shall be placed inside the pipe or fittings for lifting, positioning, or laying.

D. Protect gaskets and polyethylene encasement from long-term exposure to sunlight.

E. Store piping, fittings, and other accessories such that they do not accumulate and hold rainwater, dirt, and debris.

PART 2 PRODUCTS

2.01 MANUFACTURED UNITS

A. Ductile iron piping:
   1. Typical type:
      a. In accordance with AWWA C150 and AWWA C151.
      b. Pressure class or special thickness class as indicated in the Piping Schedule provided in Section 15052.
   2. Type with screw-on flanges:
      a. In accordance with AWWA C115 with minimum special thickness Class 53 wall thickness as required for screw-on flanges.
      b. Special thickness class as indicated in the Piping Schedule as specified in Section 15052.
   3. Type with grooved couplings:
      a. Special thickness class as indicated in the Piping Schedule as specified in Section 15052.

B. Joints:
   1. Flanged joints:
      a. Screw-on flanges: Comply with the diameter, thickness, drilling, and other characteristics in accordance with ASME B16.1. In addition, comply with the following requirements:
         1) Ductile iron.
         2) Long hub, threaded, and specially designed for ductile iron pipe.
         3) After attaching to pipe, machine flange face to make pipe end and flange even and perpendicular to the axis of the pipe.
      b. Bolt holes on flanges: 2-holed and aligned at both ends of pipe.
      c. Cap screw or stud bolt holes: Tapped.
      d. Bolts and nuts: As specified in Section 15052.
      e. Gaskets: Standard styrene butadiene copolymer (SBR) unless specified otherwise in Section 15052.
   2. Grooved joints: In accordance with AWWA C606, as complemented and modified below, radius-cut type, with following components:
      a. Couplings: Rigid type, cast from ductile iron in accordance with ASTM A 536, Grade 65-45-12, or malleable iron in accordance with ASTM A 47, Grade 32510.
      b. Bolts and nuts: In accordance with ASTM A 183, Grade 2.
      c. Gaskets: Capable of being applied on surface of piping with cavities to provide for an improved seal with the internal piping pressure. Material to be used for following services:
         1) For liquid service: EPDM.
         2) For air service: Fluoroelastomer.
         3) For hot water service: EPDM.
      d. Fittings: In accordance with AWWA C606, rigid radius-cut groove:
         1) Center-to-center dimensions: In accordance with AWWA C110.
         2) Wall thickness and other characteristics: In accordance with AWWA C606.
      e. Flanged unit connections: Flanged to grooved joint adapters or a long enough spool with one end flanged and the other end grooved to prevent interference with the operation of adjacent valves, pumps, or other items.
   3. Mechanical joints: In accordance with AWWA C111.

4. Push-on rubber gasket joints: In accordance with AWWA C111.
5. Integrally restrained mechanical joints:
   a. Application:
      1) Where designation Mech Rest.
      2) MJ is specified in the Piping Schedule provided in Section 15052, supply a restrained mechanical joint piping system, which includes restrained mechanical joints where necessary based upon thrust calculations.
      3) Standard mechanical joints as specified above can be used where thrust calculations demonstrate restraint is not required.
   b. Design:
      1) Integral retainer weldment type or lugged type joint with Type 304 stainless steel rods and nuts.
      2) Restrained mechanical joints of the configuration which utilizes a gripping or friction force for restraint will not be acceptable.
   c. Manufacturers: Where restrained mechanical joints are required, use one of the following or equal:
      1) American Cast Iron Pipe Company, MJ Coupled Joint.
      2) Pacific States Cast Iron Pipe Company, Lock Mechanical Joint.
      3) Griffin Pipe Products Co., Bolt-Lok.
6. Integrally restrained push-on joints:
   a. Application:
      1) Where designation restrained push-on is specified in the Piping Schedule provided in Section 15052, supply a restrained push-on joint piping system, which includes restrained push-on joints where necessary based upon thrust calculations.
      2) Standard push-on rubber gasket joints as specified above can be used where thrust calculations demonstrate restraint is not required.
   b. Design:
      1) Restrained push-on joints of the configuration which utilizes a gripping or friction force for restraint will not be acceptable.
      2) Suitable for the following working pressures:
         a) For 4- through 24-inch pipe: 350 pounds per square inch gauge.
         b) For 30- through 54-inch pipe: 250 pounds per square inch gauge.
   c. Manufacturers: One of the following or equal:
      1) United States Pipe and Foundry Company, TR Flex.
      2) Pacific States Cast Iron Pipe Company, Thrust Lock.
      3) American Cast Iron Pipe Company, Flex Ring or Lok-Ring.
      4) Griffin Pipe Products Co., Snap-Lok.
   d. Limit buried joints to half the manufacturer's published allowable angular joint deflection for purposes of pipeline alignment and elimination of fittings.

C. Fittings:
   1. Ductile iron in accordance with AWWA C110. Compact style fittings conforming to AWWA C153/ANSI ANSI A 21.53 shall not be used.
   2. Joint type: Same as that of the associated piping as specified in Section 15052.
   3. Plain end-to-flanged joint connectors using setscrews are not acceptable.

D. Welded-on outlets:
   1. Provide welded-on outlets as indicated on the Drawings.
   2. Fabrication:
      a. Welded-on outlets shall be fabricated by the pipe manufacturer at the same facility where the pipe is produced.
      b. Application is limited to branch outlets having a nominal diameter not greater than 70 percent of the nominal diameter of the main line pipe or 36 inches.
      c. Parent pipe and branch outlet candidate pipe shall be centrifugally cast ductile iron pipe designed in accordance with AWWA C150 and manufactured in accordance with AWWA C151. Minimum classes for parent and outlet pipe:
         1) Sizes 4- through 54-inch: Special Thickness Class 53.
         2) Sizes 60- through 64-inch: Pressure Class 350.
      d. Electrodes for reinforcing welds:
         1) Manufacturers: One of the following or equal:
            a) NCO Alloys, Ni-Rod 55-0 flux cored wire.
            b) INCO Alloys, Ni-Rod 55 welding electrode.
            c) Stoody Castweld, Ni 55-0 flux cored wire.
            d) INCO Alloys, Ni-Rod 44 Filler Metal.
         2) Carbon steel electrodes are not acceptable.
   3. Pressure rating:
      a. Welded-on outlets 6- through 30-inch: Rated for a working pressure of 250 pounds per square inch.
      b. Welded-on outlets 36-inch and larger: Rated for 200 pounds per square inch.
      c. Welded-on outlets of all diameters and configurations:
         1) Have a minimum safety factor of 2.0 based on proof of design hydrostatic test results.
         2) The CONTRACTOR shall, at the request of ENGINEER, provide the manufacturer’s representative proof test data confirming the design, hydrostatic test results, and safety factors.
   4. Source quality control:
      a. Branch outlets shall be subjected to an air pressure test of at least 15 pounds per square inch.
         1) Air leakage is not acceptable.
         2) Any leakage shall be detected by applying an appropriate foaming solution to the entire exterior surface of the weldment and adjoining pipe edges or by immersing the entire area in a vessel of water and visually inspecting the weld surface for the presence of air bubbles.
         3) Hydrostatic testing to 500 pounds per square inch on each branch outlet can be used in lieu of air testing.
         4) Any weldment that shows any signs of leakage shall be repaired and retested in accordance with the manufacturer's written procedures.
      b. Pipe manufacturer shall have a fully documented welding quality assurance system and maintain resident quality assurance records in accordance with AWS D11.2.
      c. Pipe manufacturer shall maintain appropriate welding procedure specification, procedure qualification, and welder performance qualification test records as well as appropriate air-test logs documenting air-leakage tests on all welded-on outlet pipes furnished to the Project.

E. Pipe linings:
   1. Cement-mortar lining:
      a. In accordance with AWWA C104, apply cement-mortar on clean bare metal surfaces. Extend to faces of flanges, ends of spigots, and shoulders of hubs.
      b. Minimum lining thickness: Standard in accordance with AWWA C104.
      c. Type of cement: Type V.
   2. Asphaltic seal coat:
      a. Apply over cement mortar linings and to outside surface of pipes that will not receive another coating. Apply in accordance with AWWA C151.
   3. Elastomeric polyurethane (100 percent solids) lining:
      a. As specified in Section 09960.
   4. Ceramic epoxy lining:
      a. Manufacturers: One of the following or equal:
         1) PROTECTO 401.
         2) SP-2000W.
      b. Material: Amine cured Novolac epoxy containing at least 20 percent by volume of ceramic quartz pigment.
      c. Minimum dry film thickness (DFT): 40 mills.
      d. Application:
         1) The lining shall only be applied by a manufacturer-authorized representative with no less than 5 years of experience in applying the specified material.
         2) The application of the lining shall be preformed in accordance with manufacturer's published specifications.
         3) Pipe and fittings shall be delivered to application facility with no interior lining.
         4) Interior of pipe shall be abrasive blasted per manufacturer's specifications.
      e. Coverage:
         1) Gasket and spigot ends-on joints: Provide 6 mils minimum and 10 mils maximum coverage using joint compound as specified by the manufacturer for the gasket area and spigot ends.
         2) Mechanical joints: Extend lining from spigot end to edge of gauging ring.
         3) Number of coats: As recommended by the lining manufacturer.
      f. Source quality control:
         1) Test pipe and fitting lining with a magnetic film thickness gauge. Perform testing in accordance with the method outlined in SSPC PA-2 Film Thickness Rating.
         2) Test lining integrity of pipes using a holiday detection testing instrument set at the voltage as specified by the coating manufacturer:
            a) Repair all holidays with joint compound in accordance with the recommendations of the coating manufacturer, and re-test.
         3) Discard piping or reline piping when pinholes or discontinuities are found.
   5. Glass lining:
      a. Manufacturers: One of the following or equal:
         1) Water Works Manufacturing, Ferrock MEH-32 Lining.
         2) Vitco Corporation, SG-14 Lining.

b. Material: Special glasses and inorganic materials suited for lining of sewage, sludge, and scum piping with the following characteristics:
   1) Thickness: 0.008 to 0.012 inch.
   2) Hardness: 5 to 6 on the Mohs Scale.
   3) Density: 2.5 to 3.0 grams per cubic centimeter, measured in accordance with ASTM D 792.
   4) Thermal shock resistance: Capable of withstanding 350 degrees Fahrenheit change from 430 degrees Fahrenheit to 80 degrees Fahrenheit without crazing, blistering, or spalling.
   5) Gloss retention: Capable of retaining gloss after immersion in an 8 percent sulfuric acid solution at 148 degrees Fahrenheit for 10 minutes.
   6) Weight loss: Maximum 3 milligrams per square inch when tested in accordance with ASTM C 283.

c. Fabrication:
   1) Use piping that is suitable for glass lining with minimum Class 53 wall thickness after application of glass lining.
   2) Machine interior of pipe. Bore or grit blast in accordance with NAPF 500-03 prior to application of glass lining.
   3) Screw factory assembled flanges on pipe, align boltholes, and flange faces, unless otherwise specified.
   4) Apply lining to surfaces free of chemicals.
   5) Place piping in furnaces specially designed for heating piping until glass melts and fuses with an integral molecular bond to the base metal.

F. Coatings:
   1. Asphalt varnish: Factory applied.
   2. Primer:
      a. Factory applied for field coating.
      b. Compatible with materials as specified in Section 09960.

2.02 POLYETHYLENE ENCASEMENT

A. 2 layers of linear low-density polyethylene (LLDPE) film, minimum thickness of 8 mils in accordance with AWWA C105; or

B. Single layer of high-density, cross-laminated polyethylene (HDCLPE) film, minimum thickness of 4 mils in accordance with AWWA C105.

2.03 CORROSION MONITORING FACILITIES

A. Provide joint bonding as specified in Section 13112.

PART 3 EXECUTION

3.01 INSTALLATION

A. General:
   1. Install ductile iron piping in accordance with AWWA C600, modified as specified in Section 15052.
   2. For underground piping, the trenching, backfill, and compaction: As specified in Section 02318.

B. Polyethylene encasement:
   1. Wrap all buried ductile iron pipe and fittings in 2 layers of loose polyethylene wrap in accordance with AWWA C105.
   2. Polyethylene encasement shall be continuous and terminated neatly at connections to below grade equipment or structures.
   3. At wall penetrations, extend encasement to the wall and neatly terminate.
   4. At slab penetrations, extend encasement to 2 inches below the top of slab and neatly terminate.
   5. When rising vertically in unimproved areas, extend encasement 6 inches above existing grade and neatly terminate.
   6. Repair tears and make joints with 2 layers of plastic tape.
   7. All work shall be inspected prior to backfilling of pipe and associated items.

C. Joints:
   1. Install types of joints as specified in the piping schedule provided in Section 15052.
   2. Mechanical joints are not acceptable in above ground applications.
   3. Field closure for restrained push-on pipe:
      a. Locate field closures in areas where thrust calculations demonstrate restraint is not required.
   4. Grooved joints:
      a. Install piping with grooved joints where specified in the piping schedule as specified in Section 15052 or indicated on the Drawings.
      b. Assemble grooved joints in accordance with manufacturer's published instructions.
      c. Support grooved-end pipe in accordance with manufacturer's published instructions.
         1) Install at least 1 support between consecutive couplings.

D. Tapping ductile iron pipe:
   1. Direct tapping of ductile iron pipe may be performed but is limited to the following conditions:
      a. Maximum allowable tap diameter by pipe diameter and pressure class:

Pipe Size (inches)	**Pressure Class**				
	150	**200**	**250**	**300**	**350**
	Maximum Allowable Direct Tap Size (inches)				
3	-	-	-	-	3/4
4	-	-	-	-	3/4
6	-	-	-	-	1
8	-	-	-	-	1
10	-	-	-	-	1
12	-	-	-	-	1-1/4
14	-	-	1-1/4	1-1/2	1-1/2
16	-	-	1-1/2	2	2
18	-	-	2	2	2
20	-	-	2	2	2
24	-	2	2	2	2

b. The maximum allowable tap diameter for pipelines greater than 24 inches is 2 inches.
c. Two layers of 3-mil thread sealant are required to minimize the torque required to effect a watertight connection.

2. Direct tapping of glass lined ductile iron pipe may be performed only when approved in writing by the ENGINEER. Direct tapping of glass lined pipe shall be performed in accordance with the above conditions for tapping ductile iron pipe in addition to the following conditions:
   a. Drilling and tapping shall be performed using a hole saw.
      1) Use of a large drill bit is not acceptable.
   b. As the hole saw approaches the glass lining, lessen the inward pressure to avoid excess chipping or cracking of the lining.
   c. Minor chipping or spalling of the glass lining shall be repaired using an epoxy resin “glass repair kit” provided by the fabricator.
      1) Manufacturers: One of the following or equal:
         a) Devoe - Devran 224 HS.
         b) Sherwin-Williams Co. – Sher-Tile High Solids Epoxy.
      2) Repair kit use is only allowed for areas of damage less than 1/2 inch in diameter.
         a) Larger areas of damage will require replacement.
      3) Surface shall be prepared and repair kit shall be applied in accordance with manufacturer and/or fabricator’s instructions.

3.02 CORROSION MONITORING FACILITIES

A. Bond all pipe joints and associated fittings to provide electrical continuity. Install dielectric insulating fittings and corrosion monitoring facilities as indicated on the Drawings and specified in Section 13112.

3.03 FIELD QUALITY CONTROL

A. Testing ductile iron piping:
   1. Test as specified in Section 15052.
   2. Do not test sections longer than 1/2 mile in total pipe length.

B. Repair damaged cement mortar lining to match quality, thickness, and bonding of original lining in accordance with AWWA C104.
   1. When lining cannot be repaired or repairs are defective, replace defective piping with undamaged piping.

C. Verify that interior surfaces of glass lined pipe and fittings have continuous coverage:
   1. Verify with low voltage wet sponge holiday detector in accordance with NACE SP0188.
   2. Discard glass lined ductile iron piping and fittings with voids or casting anomalies. that exceed the maximum non-visible pinholes allowances below:

Diameter	Maximum Pinholes	
	Fittings	Pipe (per 20-foot length of pipe)
4- to 8-inch	3-5	10-12

Diameter	Maximum Pinholes	
	Fittings	**Pipe (per 20-foot length of pipe)**
10- to 18-inch	5-8	18-20
20-inch and Larger	8-10	25-28

3. Discard lined piping and fittings found to have pinholes, crazing, or fish scales, which expose the metal substrate.

END OF SECTION

SECTION 15230

PLASTIC PIPING AND TUBING

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Plastic pipe, tubing, and fittings.

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 09960 - High-Performance Coatings
   b. Section 15052 - Common Work Results for General Piping.
   c. Section 15211 - Ductile Iron Pipe, AWWA C159.
   d. Section 15956 - Piping Systems Testing.

1.02 REFERENCES

A. American Society of Mechanical Engineers (ASME):
1. B16.12 - Cast Iron Threaded Drainage Fittings.

B. ASTM International (ASTM):
1. A 536 - Standard Specification for Ductile Iron Castings.
2. D 1248 - Standard Specification for Polyethylene Plastics Extrusion Materials For Wire and Cable.
3. D 1784 - Standard Specification for Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds.
4. D 1785 - Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80 and 120.
5. D 1869 - Standard Specification for Rubber Rings for Asbestos-Cement Pipe.
6. D 2412 - Standard Test Method for Determination of External Loading Characteristics of Plastic Pipe by Parallel-Plate Loading.
7. D 2466 - Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 40.
8. D 2467 - Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80.
9. D 2513 - Standard Specification for Thermoplastic Gas Pressure Pipe, Tubing and Fittings.
10. D 2564 - Standard Specification for Solvent Cements for Poly(Vinyl Chloride) (PVC) Plastic Piping Systems.
11. D 2665 - Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Drain, Waste, and Vent Pipe and Fittings.

12. D 2855 - Standard Practice for Making Solvent-Cemented Joints with Poly (Vinyl Chloride)(PVC) Pipe and Fittings.
13. D 3034 - Standard Specification for Type PSM Poly(Vinyl Chloride) (PVC) Sewer Pipe and Fittings.
14. D 3212 - Standard Specification for Joints for Drain and Sewer Plastic Pipes Using Flexible Elastomeric Seals.
15. D 3261 - Standard Specification for Butt Heat Fusion Polyethylene (PE) Plastic Fittings for Polyethylene (PE) Plastic Pipe and Tubing.
16. D 3350 - Standard Specification for Polyethylene Plastic Pipes and Fittings Materials.
17. D 4101 - Standard Specification for Polypropylene Injection and Extrusion Materials.
18. F 438 - Standard Specification for Socket-Type Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 40.
19. F 439 - Standard Specification for Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 80.
20. F 441 - Standard Specification for Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Pipe, Schedules 40 and 80.
21. F 477 - Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe.
22. F 493 - Standard Specification for Solvent Cements for Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Pipe and Fittings.
23. F 645 - Standard Guide for Selection, Design and Installation of Thermoplastic Water-Pressure Piping Systems.
24. F 679 - Standard Specification for Poly(Vinyl Chloride) (PVC) Large-Diameter Plastic Gravity Sewer Pipe and Fittings.
25. F 714 - Standard Specification for Polyethylene (PE) Plastic Pipe (SDR-PR) Based on Outside Diameter.

C. American Water Works Association (AWWA):
1. C900 - Standard for Polyvinyl Chloride (PVC) Pressure Pipe and Fabricated Fittings, 4 Inches to 12 Inches (100 mm Through 300 mm), for Water Transmission Distribution.
2. C950 - Standard for Polyvinyl Chloride (PVC) Pressure Pipe and Fabricated Fittings, 14 Inches to 48 Inches (350 mm Through 1,200 mm), for Water Transmission and Distribution.

D. NSF International (NSF).

E. Plastics Pipe Institute (PPI):
1. TR 31 - Underground Installation of Polyolefin Piping.

1.03 ABBREVIATIONS

A. ABS: Acrylonitrile-butadiene-styrene.

B. CPVC: Chlorinated polyvinyl chloride.

C. DR: Dimension ratio.

D. DWV: Drain, waste, and vent.

E. ID: Inside diameter of piping or tubing.

F. NPS: Nominal pipe size followed by the size designation.

G. NS: Nominal SIZE of piping or tubing.

H. PE: Polyethylene.

I. PP: Polypropylene.

J. PVC: Polyvinyl chloride.

K. SDR: Standard dimension ratio; the outside diameter divided by the pipe wall thickness.

1.04 SUBMITTALS

A. Product data: Describe materials, pipe, fittings, gaskets, and solvent cement.

B. Polyethylene pipe submittals: Include:
   1. Product data.
   2. Installation equipment including details on fusion machine used to join polyethylene pipe sections.
   3. Qualifications of installation crew for use of the fusion machine used for joining polyethylene pipe.

C. Manufacturer's Published Installation Instructions.

D. Certificates:
   1. Submit manufacturer's certificate attesting that plastic pipe, tubing, and fitting types meet specified requirements:
      a. PVC gravity sewer piping: In accordance with ASTM D 3034 or ASTM F 679, as applicable.
   2. Manufacturer's certification of date of manufacture of plastic pipe and tubing for each lot delivered.
   3. Copies of solvent cement manufacturer's report and certification in accordance with ASTM D 2564 for PVC piping, and ASTM F 493 for CPVC piping.

1.05 QUALITY ASSURANCE

A. Fusion machine technician qualifications: 1-year experience in the installation of similar PE piping systems from the same manufacturer.

B. Plastic pipe in potable water applications: Provide pipe and tubing bearing NSF seal.

C. Mark plastic pipe with nominal size, type, class, schedule, or pressure rating, manufacturer and all markings required in accordance with ASTM and AWWA standards.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Protect piping materials from sunlight, scoring, and distortion.

B. Do not allow surface temperatures on pipe and fittings to exceed 120 degrees Fahrenheit.

C. Store and handle PE pipe and fittings as recommended by manufacturer in published instructions.

PART 2 PRODUCTS

2.01 MATERIALS

A. Extruding and molding material: Virgin material containing no scrap, regrind, or rework material except where permitted in the referenced standards.

B. Fittings: Same material as the pipe and of equal or greater pressure rating, except that fittings used in drain, waste, and vent piping systems need not be pressure rated.

C. Unions 2-1/2 inches and smaller: Socket end screwed unions. Make unions 3 inches and larger of socket flanges with 1/8-inch full-face soft Viton® gasket.

2.02 PVC PIPING, SCHEDULE TYPE

A. Materials:
   1. PVC Pipe: Designation PVC 1120 in accordance with ASTM D 1785 and appendices:
      a. Pipe and fittings: Extruded from Type I, Grade 1, Class 12454-B material in accordance with ASTM D 1784.
      b. PVC Pipe: Schedule 80 unless otherwise indicated in Section 15052 or on the Drawings.
   2. Fittings:
      a. Supplied by pipe manufacturer.
      b. Pressure fittings: In accordance with ASTM D 2466 or ASTM D 2467.
      c. DWV fittings: In accordance with ASTM D 2665.
   3. Solvent cement: In accordance with ASTM D 2564:
      a. Chemical service: For CPVC or PVC pipe in chemical service, provide the following primer and cement, or equal:
         1) Primer: IPS Corp Type P70.
         2) Cement: IPS Corp Type 724 cement or another cement certified by the manufacturer for chemical service.

2.03 PVC PIPING, CLASS TYPE

A. PVC pipe, Class Type: In accordance with AWWA C900/C905, Pressure Class 150 unless otherwise specified in Section 15052 or indicated on the Drawings.
   1. Fittings: Ductile iron fittings as specified in Section 15211, sized for the dimensions of the pipe being used.
   2. Joint design: Push-on or mechanical joint type as identified in Piping Schedule.
   3. Gaskets: EPDM in accordance with ASTM D 1869 or ASTM F 477.

2.04 PVC GRAVITY SEWER PIPING

A. Materials:
   1. Polyvinyl chloride (PVC) gravity sewer pipe and fittings: In accordance with ASTM D 3034 for piping NPS 15 and smaller diameter, and to ASTM F 679 for piping NPS 18 and larger diameter:
      a. Referenced standards apply as complemented and modified in this Section.
      b. Fittings: Supplied by the pipe manufacturer.
   2. PVC compounds: Class Number 12454-C, in accordance with ASTM D 1784:
      a. Stabilizers, antioxidants, lubricants, colorants, and other additives and fillers: Not to exceed 10 parts by weight per 100 of PVC resin in the compound.
   3. Pipe NPS 15 and smaller diameter: Wall thickness SDR 26:
      a. Joints: Push-on joints in accordance with ASTM D 3212.
   4. Pipe NPS 18 and larger diameter:
      a. PVC compound: Cell classification 12454-C in accordance with ASTM D 1784.
      b. Minimum wall thickness: Thickness T-1 in accordance with Table 1 in ASTM F 679.
      c. Joints: Integral bell gasketed joints in accordance with ASTM F 679.
      d. Bell: Fabricated from pipe sections, thickness of the wall of the bell equivalent to the pipe wall thickness.
      e. Gasket ring: Locked into the bell.
      f. Spigot end of the pipe: Marked by the manufacturer to identify the final in-place position of the spigot in the bell.
   5. Fittings, including wyes, tees, elbow caps, plug adapters, and manhole waterstops: Same wall thickness as the pipe:
      a. Fittings: Factory molded with joints and gaskets equal to those of the pipe.
   6. Gasket: EPDM in accordance with ASTM D 3212 or ASTM F 477:
      a. Keep rubber gasket in place during pipe joining.
   7. Gasket for connection to manhole: Stainless steel clamp with gasket or similar device to seal the penetration.

2.05 CPVC PIPING

A. Materials:
   1. CPVC pipe: Schedule 40 or Schedule 80, as specified in Section 15052 or as indicated on the Drawings, in accordance with ASTM F 441 and Appendix, CPVC 4120:
      a. Pipe: Extruded from Type IV, Grade 1, Class 23447 material in accordance with ASTM D 1784.
      b. Manufacturers: One of the following or equal:
         1) Charlotte Pipe and Foundry Company.
         2) Eslon Thermoplastics, Inc.
         3) Harvel Plastics, Inc.
   2. Fittings: In accordance with ASTM F 438 or ASTM F 439 for pressure fittings, as appropriate to the service and pressure requirement:
      a. Fittings: Supplied by the pipe manufacturer.
      b. Manufacturers: One of the following or equal:
         1) Colonial Engineering.

2) Eslon Thermoplastics, Inc.
3) Chemtrol.
4) Spears Manufacturing Company; or equal.

3. Solvent cement: In accordance with ASTM F 493:
   a. For CPVC pipe in chemical service, utilize IPS Corp Type 724 cement or another cement certified by the manufacturer for high strength hypochlorite service.

2.06 PP PIPING

A. Materials:
   1. Pipe: Schedule 40 dimensions, extruded from Type I-19509 material in accordance with ASTM D 4101.
   2. Fittings: Molded from the same material and same laying length in accordance with ASME B 16.12:
      a. Fittings: Manufactured by pipe manufacturer.
   3. Join piping and fittings by the use of electrofusion.

2.07 POLYETHYLENE PIPING FOR UNDERGROUND GAS DISTRIBUTION

A. Manufacturers: One of the following or equal:
   1. DuPont.
   2. Amsted Industries, Inc., Plexco.

B. Manufactured in accordance with ASTM D 2513 using a compound in accordance with ASTM D 1248, PE 2306/2406:
   1. SDR: Maximum of 11.

C. Fittings: In accordance with ASTM D 2513 for socked fusion joints, and ASTM D 3261 for butt fusion joints.

2.08 HIGH DENSITY POLYETHYLENE PIPING FOR STORM DRAIN

A. General:
   1. Pipe and fittings: Corrugated High-density polyethylene.
   2. Pipe shall have a smooth interior and annular exterior corrugations.

B. Manufacturers: One of the following or equal:
   1. Advanced Drainage Systems, ADS.
   2. Southeast Culvert Inc.

C. Materials:
   1. Polyethylene: In accordance with ASTM D 3350.

D. Fittings:
   1. Conform to ASSHTO M294 or ASTM F2306.

E. Joints:
   1. Watertight seal in accordance with AASHTO M294 or ASTM F2306.
   2. Gaskets: ASTM F477.
   3. Bells formed integrally with the pipe.

F. Accessories:
   1. In-line Drop Manhole:
      a. Manufacturer: Nyloplast Inline Drains, or equal.
      b. Size: 30-inch diameter.
      c. Inline Drain shall be constructed of PVC and shall conform to ASTM D1784 cell class 12454.
      d. The inline drain must form a watertight seal with the specified drainage line material. Tightness of the joint shall conform to ASTM D3212.
      e. The flexible elastomeric seals shall conform to ASTM F477.
      f. The pipe spigot shall be joined to the inline drain body by use of a swage mechanical joint.
      g. The ductile iron dome grate cover for the in-line drop manhole shall be provided by the same manufacturer.
      h. Metal used to manufacture the dome grate cover shall conform to ASTM A536 grade 70-50-05 for ductile iron.
      i. The done grate cover shall be coated per Section 09960.

2.09 ABS PIPING

A. General:
   1. Pipe and fittings: Acrylonitrile-butadiene-styrene.
   2. Dimensions of pipe and fittings: Based on controlled outside diameter in accordance with ASTM F 628.
   3. Piping shall be provided in lengths of 10 feet or 20 feet as required.
   4. Pipe shall be tested and listed in accordance with ANSI/NSF Standard 14.

B. Materials:
   1. Cellular core co:-extruded ABS drain, waste and vent pipe shall be made in accordance with ASTM F 628 from a compound conforming to a minimum cell classification of 42222 as defined by ASTM D396 or PVC Pipe: Schedule 40 unless otherwise indicated on the Drawings.
   2. Fittings:
      a. Shall conform to ASTM D 2661 and be manufactured from virgin rigid ABS compounds with a Cell class of 32222 as indentified in ASTM D 3965.
      b. Supplied by pipe manufacturer.
   3. Solvent cement: In accordance with ASTM D 2235.
      a. E-Z Weld ABS or similar.

C. Manufacturers: One of the following or equal:
   1. Charlette Pipe.
   2. IPEX Drainaway®.

2.10 SOURCE QUALITY CONTROL

A. PVC piping, Schedule Type:
   1. Mark pipe and fittings in accordance with ASTM D 1785.

B. PVC piping, Class Type:
   1. Test pipe to withstand, without failure, 600 pounds per square inch gauge, hydrostatic pressure for a minimum of 5 seconds.
   2. Test integral bell with the pipe.

C. PVC gravity sewer piping:
   1. Mark pipe and fittings in accordance with ASTM D 3034. Also mark the production control code on pipe and fittings.

D. CPVC piping:
   1. Mark pipe and fittings in accordance with ASTM F 441.

PART 3 EXECUTION

3.01 INSTALLATION

A. General:
   1. Where not otherwise specified, install piping in accordance with ASTM F 645, or manufacturer's published instructions for installation of piping, as applicable to the particular type of piping.
   2. Provide molded transition fittings for transitions from plastic to metal or IPS pipe. Do not thread plastic pipe.
   3. Locate unions where indicated on the Drawings, and elsewhere where required for adequate access and assembly of the piping system.
   4. Provide serrated nipples for transition from plastic pipe to rubber hose.

B. Installation of PVC piping, Schedule Type:
   1. Solvent weld joints in accordance with ASTM D 2855:
      a. For PVC pipe in chemical service use IPS Corp. Type 724 cement in accordance with manufacturer's instructions.
   2. Install piping in accordance with manufacturer's published instructions.

C. Installation of PVC piping, Class Type:
   1. Install piping in accordance with the Appendix of AWWA C900 complemented with manufacturer's published instructions.

D. Installation of PVC gravity sewer piping:
   1. Install piping in accordance with manufacturer's published instructions, as modified and complemented in this Section.
   2. Install pipe and fittings not later than 4 months after their manufacture.
   3. Provide for contraction and expansion at joints with a gasket ring.
   4. Provide plugs or caps for stubs and branch pipes left unconnected to laterals.
   5. Lubricate and assemble joints in accordance with the pipe manufacturer's published instructions.
   6. Make connections to manholes with a manhole gasket that prevents infiltration and exfiltration through the penetrations:
      a. Provide opening for connection large enough to allow subsequent grouting around the manhole gasket.
      b. Grout around the manhole gasket and seal the opening.

E. Installation of CPVC piping:
   1. Clean dirt and moisture from pipe and fittings.
   2. Bevel pipe ends in accordance with manufacturer's instructions with chamfering tool or file. Remove burrs.
   3. Use solvent cement and primer formulated for CPVC:
      a. For CPVC pipe in chemical service use IPS Corp. Type 724 cement in accordance with manufacturer's instructions.

4. Use primer on pressure and non-pressure joints.
5. Do not solvent weld joints when ambient temperatures are below 40 degrees Fahrenheit or above 90 degrees Fahrenheit unless solvent cements specially formulated for these conditions are utilized.

F. Installation of PP piping:
1. Install piping in accordance with manufacturer's published instructions.
2. For acid waste and vent service, provide traps, tailpiece, and strainer on exposed piping under sinks. Mechanically join these items; do not fuse or glue.

G. Installation of PE piping for underground gas distribution:
1. Socket fuse joints for piping equal or less than NPS 2.
2. Butt fuse joints for piping larger than NPS 2.
3. Install piping in accordance with requirements of the gas utility company and with manufacturer's published instructions.

H. Installation of HDPE piping:
1. Install piping as recommended in manufacturer's published instructions.

I. Installation of ABS Pipe:
1. Install piping as recommended in the manufactures' published instructions and local code requirements.
   a. Buried pipe shall be installed in accordance with ASTM D 2321 and ASTM F 1668.
2. The system shall be protected from chemical agents, fire stopping materials, tread sealant, or other aggressive chemical agents not compatible with ABS compounds.
3. Transition joints between ABS and PVC shall be in accordance with ASTM D 3138.

3.02 FIELD QUALITY CONTROL

A. Leakage test for PVC piping, Class Type:
1. Polyvinyl chloride (PVC) piping, Class Type: Subject to visible leaks test and to pressure test with maximum leakage allowance, as specified in Section 15956.
2. Pressure test with maximum leakage allowance: Perform test after backfilling:
   a. Pressure: 125 pounds per square inch, gauge.
   b. Maximum leakage allowance as follows, wherein the value for leakage is in gallons per 100 joints per hour:

NPS, Inches	**1-1/2**	**2**	**2-1/2**	**3**	**4**	**6**	**8**	**10**	**12**
Leakage	0.41	0.52	0.63	0.76	0.98	1.45	1.88	2.35	2.80

B. Leakage test for HDPE piping:
1. Pressure test with maximum leakage allowance: Perform test prior to backfilling (cover pipe at intervals and/or curves if necessary to hold pipe in place during testing):
   a. Pressure: As specified in Section 15052 or 125 pounds per square inch, gauge.
   b. Test with water as test medium.
   c. Remove all free air from test section and raise pressure at steady rate to test pressure.

d. Apply and allow initial test pressure to stand without makeup pressure for 3 hours to allow for diametric expansion or pipe stretching to stabilize.
e. After stabilization period, return to test pressure and hold for 3 hours.
f. Amount of makeup water allowable for expansion during pressure test in accordance with PPI Technical Report TR 31-88.
g. No visual leaks or pressure drops allowed during final test period.

C. Mandrel tests for PVC gravity sewer and HDPE piping:
1. Perform initial mandrel test:
   a. After cleaning and completion of other tests.
   b. After placement and compaction of backfill.
   c. Before construction of pavement or surfacing.
   d. Not sooner than 30 days after pipe installation.
   e. Not later than 60 days after installation.
2. Perform final verification mandrel test:
   a. Not sooner than 30 days before the end of the warranty period.
   b. Not later than 10 days before the end of the warranty period.
   c. Consider the final verification mandrel test a warranty service, and include the costs related to final verification mandrel test in the Contract Price.
3. Utilize a 9 rod mandrel with minimum length equal to NPS and diameter as follows:

Nominal Pipe Size (NPS)	Mandrel Diameter, inches
6	5.50
8	7.37
10	9.21
12	10.96
15	13.56

4. Test procedure: Pull the mandrel through the line under test by 1 person, by hand, with reasonable effort, without the aid of mechanical equipment.
5. Failing test: Where the mandrel test is not successful, remove and replace the section of piping with the obstruction; test the piping again, including visible leaks test, pressure test with maximum leakage allowance, mandrel tests, and other specified tests:
   a. Correction of excessive deflection or obstructions by methods other than removal of the affected piping and replacement of the removed piping with new piping will not be accepted.

END OF SECTION

SECTION 15270

STEEL PIPE-GALVANIZED AND BLACK, ASTM A 53

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Steel pipe-galvanized and black, ASTM A 53.

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 09960 - High-Performance Coatings.
   b. Section 15052 - Common Work Results for General Piping.
   c. Section 15274 - Plastic Tape Wrap for Pipe.

1.02 REFERENCES

A. American Society of Mechanical Engineers (ASME):
1. B16.3 - Malleable-Iron Threaded Fittings: Classes 150 and 300.
2. B16.5 - Pipe Flanges and Flanged Fittings.
3. B16.9 - Factory-Made Wrought Buttwelding Fittings.
4. B16.11 – Forged Fittings, Socket-Welding and Threaded.

B. American Water Works Association (AWWA):
1. C200 – Steel Water Pipe- 6 Inches and Larger.
2. C203 - Coal-Tar Protective Coatings and Linings for Steel Water Pipelines-Enamel and Tape-Hot Applied.
3. C205 - Standard for Cement-Mortar Protective Lining and Coating for Steel Water Pipe-4 Inches and Larger-Shop Applied.
4. C206 - Field Welding of Steel Water Pipe.
5. C207 - Standard for Steel Pipe Flanges for Waterworks Service-Sizes 4 inches Through 144 inches.
6. C602 - Standard for Cement-Mortar Lining of Water Pipelines in Place-4 inches and Larger.
7. C606 - Standard for Grooved and Shouldered Joints.

C. ASTM International (ASTM):
1. A 47 - Standard Specification for Ferritic Malleable Iron Casting.
2. A 53 - Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless.
3. A 105 - Standard Specification for Carbon Steel Forgings for Piping Applications.

4. A 153 - Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
5. A 183 - Standard Specification for Carbon Steel Track Bolts and Nuts.
6. A 536 - Standard Specification for Ductile Iron Castings.
7. C 150 - Standard Specification for Portland Cement.
8. D 429 - Standard Test Methods for Rubber Property-Adhesion to Rigid Substrates.
9. D 2000 - Standard Classification System for Rubber Products in Automotive Applications.

1.03 SUBMITTALS

A. Shop drawings: Details of fittings and specials showing thickness and dimensions of plates, detail of welds, and materials; listing of proposed services and locations for use of grooved joint type piping; tabulated layout schedules for cement-mortar lined and coated steel pipe.

B. Pipe layout drawings.

C. Product data: Details of fittings and specials showing thickness and dimensions of plates, detail of welds, and materials; grooved joint piping fittings, gaskets, couplings, grooving of pipe and fittings, and pipe lining and coating.

D. Mill certificates.

E. Test reports:
   1. Gaskets.

PART 2 PRODUCTS

2.01 MATERIALS

A. Portland cement: In accordance with ASTM C 150, Type II, low alkali.

2.02 MANUFACTURED UNITS

A. Steel pipe:
   1. General:
      a. In accordance with ASTM A 53.
         1) Type: Type E - electric-resistance welded or Type S - seamless
         2) Grade: Grade A or B.
      b. Schedule:
         1) As indicated on the Drawings or as specified in Section 15052 pipe schedule.
         2) Minimum Schedule unless otherwise indicated on the Drawings or as specified in Section 15052 pipe schedule.
            a) Pipe 6 inches and smaller: Schedule 40.
            b) Pipe greater than 6 inch to 10 inch: Schedule 40ST.
            c) Pipe 12-inch and above: 0.25 inches.

B. Pipe fittings:
   1. Flanged and welding fittings:
      a. Butt -welding fittings in accordance with ASME B16.9. Schedule of fittings: same class or thickness as the pipe to which it connects.
   2. Screwed fittings:
      a. Malleable iron:
         1) Class 150 or Class 300in accordance with ASME B16.3, as specified in Section 15052 pipe schedule.
         2) Galvanized in accordance with ASTM A 153 where used with galvanized pipe.
      b. Forged Fittings, Socket-Welding and Threaded.
         1) Class: 150 or 300 in accordance with ASME B16.11.
   3. Grooved joint fittings:
      a. Fittings for grooved joint steel piping: Rigid-grooved type:
      b. Fittings for grooved joint piping:
         1) Manufacturers: One of the following or equal:
            a) Victaulic Company of America.
            b) Grinnell.
            c) Anvil.
         2) Ductile iron fittings:
            a) Larger than 4 inches in diameter: conforming to ASTM A536, Grade 65-45-12, long radius, per AWWA C110.
            b) Less than 4 inches in diameter: Malleable iron conforming to ASTM A47, Grade 32510
         3) Where cast fittings are not made, forged steel in accordance with ASME B 16.9, ASTM A 105, Grade B with 0.375 inch minimum wall thickness.
            a) Bends: Long radius,
         4) Fittings for grooved joint piping shall be furnished by the manufacturer of the grooved joint coupling.
         5) Fittings for grooved joint piping shall be for rigid-grooved type joints. Connection to flanged units shall be by means of a spool with one end flanged and the other grooved, long enough to prevent interference with adjacent valves, pumps, or other items, minimum length, 4 inches.

C. Pipe joints:
   1. General:
      a. Use type of pipe joints as indicated on the Drawings or as specified in Section 15052 pipe schedule.
      b. In addition to the type of pipe joints indicated on the Drawing or as specified in Section 15052 pipe schedule, use flexible couplings, unions or flanged joints to allow ready assembly and disassembly of the piping.
   2. Flanged joints:
      a. In accordance with ASME B16.5, steel, 150 or 300 pounds, slip-on or weld neck, galvanized in accordance with ASTM A 153 where used with galvanized pipe.
      b. Companion flanges
         1) In accordance with ASME B16.5, steel.
         2) Class 150 or 300 pounds, slip-on or welding neck.
      c. Weld flanges to pipe or fittings before applying lining.

d. Machine flanges or provide tapered filler for changes in grade or to slope lines for drainage.
e. Match pipe flanges to the valve flanges.
f. Flange bolts: As specified in Section 15052.
g. Gaskets: As specified in Section 15052.

3. Grooved joints:
   a. Grooves: Cut grooves. Rolled grooves are not acceptable.
   b. Couplings housing: Cast in 2 or more segments of ductile iron in accordance with ASTM A 536, Grade 65-45-12 or malleable iron in accordance with ASTM A 47, Grade 32510.
   c. Bolts and nuts: In accordance with ASTM A 183, Grade 2.
   d. Gaskets: Composition water sealing designed so that the internal piping pressure serves to increase the seal's watertightness.
      1) Gaskets for water service and oil-free air systems at temperatures less than 230 degrees Fahrenheit shall be made of ethylene propylene diene monomers (EPDM) in accordance with ASTM D 2000 Line Call Out 2CA615A25B24.
      2) Gaskets for use with cement-mortar lined steel piping shall be captured between the ends of the pipe to protect exposed metal from corrosion, and shall be made of nitrile in accordance with ASTM D 2000, Line Call Out 5BG615A14B24.
   e. Perform grooving of the pipe wall only on standard or heavier schedule weight pipe.
      1) For pipe with wall thickness less than standard weight, weld a shouldered end on the pipe in accordance with AWWA C606.
      2) Shoulder: Type B or D in accordance with AWWA C606.
   f. Couplings and grooving: Manufacturers: One of the following or equal:
      1) Victaulic Company of America.
      2) Grinnell.
      3) Anvil.
   g. Grooved joint piping shall not be used in the following installations:
      1) In underground and underwater installations.
      2) In piping subject to test pressures of 150 pounds per square inch gauge, or more.
      3) In steam and gas piping.
      4) In sludge and scum piping designed to be steam cleaned.
4. Welded joints: Butt welds-2 pass, full depth with beueled ends and no backing rings.

D. Pipe lining and coating:
   1. General:
      a. Lining and coating shall be as indicated on the Drawings or as specified in Section 15052 pipe schedule.
   2. Pipe coating:
      a. Extend pipe coating for underground piping 6 inches above finish grade or finish floor, and neatly terminate.
      b. Field paint aboveground steel pipe as specified in Execution of this Section.
      c. Coat exposed piping as specified in Section 09960.
      d. Coat submerged piping as specified in Section 15052 pipe schedule and Section 09960.

e. Cement-mortar coating:
   1) Cement-mortar coating: In accordance with AWWA C205, modified as follows:
      a) Sand: In accordance with AWWA C205 except that the total percentage of deleterious material shall not exceed 3 percent.
f. Plastic tape wrap: As specified in Section 15274.
   1) For buried pipe, wrap fittings, valves, and other odd shaped components in the pipeline with first and finish wrapping over the prime coat, total thickness of tape 80 mils.

3. Pipe lining:
   a. Cement-mortar lining:
      1) Shop apply cement-mortar lining in accordance with AWWA C205. At the option of CONTRACTOR, field apply with a pipe lining machine.
   b. Coal-tar enamel lining:
      1) Coal-tar enamel lining for interior of steel pipe: In accordance with AWWA C203.
   c. Coal-tar epoxy lining:
      1) Coal-tar epoxy lining: Epoxy bituminous coating as specified for submerged metal in Section 09960.
   d. Fusion epoxy:
      1) Fusion bonded epoxy as specified for submerged metal or exposed metal.
   e. High solids epoxy:
      1) High solids epoxy as specified for submerged metal or exposed metal in Section 09960.
   f. Polyurethane lining:
      1) Polyurethane as specified for submerged metal in Section 09960.

2.03 FABRICATION

A. Shop coat of primer:
   1. Flanges and portions of pipe not covered with cement-mortar shall be given a shop coating of primer.
   2. Primer compatible with finish coating system.

PART 3 EXECUTION

3.01 INSTALLATION

A. Pipe joints:
   1. General:
      a. Steel pipe joints shall be screwed, welded, flanged, grooved, or made with flexible joints. The type of joint for piping is as specified in Section 15052 pipe schedule or as indicated on the Drawings.
      b. In addition to the joints indicated on the Drawings, provide unions, flexible couplings, flanged joints, and other types of joints or means necessary to allow ready assembly and disassembly of the piping.
      c. Unless otherwise indicated on the Drawings or as specified in Section 15052 pipe schedule, pipe joints shall be as follows:
         1) Pipe smaller than 2 inches in nominal diameter shall have screwed joints, welded joints, unions, or flexible couplings.

2) Pipe 2 inches to 4 inches in nominal diameter shall have screwed joints, flanged joints, welded joints, or joints made with flexible couplings.
3) Pipe larger than 4 inches in nominal diameter shall have flanged joints, welded joints, or joints made with flexible couplings.

2. Flanged joints:
   a. Flanges shall come together at the proper orientation with no air gaps between the flanges after the gaskets are in place.
   b. Secure welding neck flanges with full penetration butt welds without backing rings.
   c. Secure slip-on flanges with both internal and external welds.
   d. After welding in place, the faces of flanges shall be perpendicular to the axis of the pipe, or, in the case of fittings, at the proper angle to each other, and bolt holes shall be in proper alignment.
3. Grooved joints:
   a. Assemble in accordance with manufacturer's published instructions.
   b. Support grooved joint pipe in accordance with manufacturer's recommendations. In addition, provide at least 1 support between consecutive couplings.
4. Screwed joints:
   a. Perform threading with clean, sharp dies.
      1) Wavy, rough, or otherwise defective pipe threads are not acceptable.
   b. Make screwed joints tight and clean with an application of Teflon tape or paste compound applied to the male threads only, except as follows:
      1) Make up liquid and liquefied petroleum gas lines, with litharge and glycerin.
   c. Provide railroad type unions with bronze-to-iron seat. Galvanized where used with galvanized pipe.
      1) Flanged joints may be used instead of unions.
5. Welded joints:
   a. Field welded joints: Electric arc welded in accordance with AWWA C206.
   b. Welder’s qualification: Qualified in accordance with AWWA C206.
      1) Welders' testing shall be at the CONTRACTOR's expense, including cost of test nipples, welding rods, and equipment.
   c. Do not weld galvanized pipe.

B. Pipe lining and coating:
   1. Pipe lining:
      a. Field applied cement-mortar lining shall be of the same density, smoothness, and thickness as shop applied lining, and in accordance with AWWA C602.
   2. Pipe Coating:
      a. Plastic tape wrap application:
         1) Wrap fittings, valves, and other odd shaped components in the pipeline with first and finish wrapping over the prime coat.
         2) Wrap joints, fittings, valves, and other irregular shapes of piping with extruded coatings with tape as specified in this subparagraph.
      b. Field coat aboveground steel pipe as specified in Section 09960.

3.02 FIELD QUALITY CONTROL

A. Field test fabricated steel manifolds with the pipe to which they connect.

END OF SECTION

SECTION 15274

PLASTIC TAPE WRAP FOR PIPE

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Plastic tape wrap for pipe.

1.02 REFERENCES

A. American Water Works Association (AWWA):
   1. C209 - Standard for Cold-Applied Tape Coating for the Exterior of Special Sections, Connections, and Fittings for Steel Water Pipelines.
   2. C214 - Standard for Tape-Coating Systems for the Exterior of Steel Water Pipelines.

B. National International (NACE):
   1. RP0274-74 - Standard Recommended Practice.

1.03 SUBMITTALS

A. Mill certificates.

B. Technical literature and data for holiday detection equipment.

PART 2 PRODUCTS

2.01 MANUFACTURED UNITS

A. Plastic tape wrap for exterior of steel pipe, fittings and specials.
   1. In accordance with AWWA C209 and AWWA C214.
   2. Tape coating system:
      a. Consist of the following:
         1) Primer.
         2) First layer of spirally applied 20 mil inner wrap.
         3) Middle layer of spirally applied 30 mil outer wrap.
         4) Finish layer of spirally applied 30 mil outer wrap.
      b. Minimum total coating thickness of 80 mils.
      c. All materials shall be of products of the same manufacturer.
   3. Primer: Manufacturers: One of the following or equal:
      a. Polyken Pipeline Coatings, Number 1019 or 1027 Primer.
      b. The Tapecoat Company, TC Omniprime Primer.
   4. Pipe wrap:
      a. First wrap: Manufacturers: One of the following or equal:
         1) Polyken Pipeline Coatings, Number 980-20 (932-50 for fittings).
         2) The Tapecoat Company, TC Omniprime Primer.

b. Middle wrap: Manufacturers: One of the following or equal:
   1) Polyken Pipeline Coatings, Number 955-30.
   2) The Tapecoat Company.
c. Finish wrap: Manufacturers: One of the following or equal:
   1) Polyken Pipeline Coatings, Number 955-30 White.
   2) The Tapecoat Company.

5. Filler tape: Manufacturers: One of the following or equal:
   a. Polyken, Number 939.
   b. The Tapecoat Company.
6. Joint wrap: Manufacturers: One of the following or equal:
   a. Polyken, Number 932-50, white Hi-Tack Joint Wrap tape.
   b. The Tapecoat Company, TC Omniprime Primer.

PART 3 EXECUTION

3.01 INSTALLATION

A. Plastic tape wrap application procedures shall be in accordance with manufacturer's published instructions.
   1. Apply plastic tape wrap in accordance with AWWA C209.
   2. Apply primer with brush, without runs and drips.
   3. Lap wrapping not less than 1/2 inch. A single wrap lapped 50 percent or more will not be acceptable.
   4. Application on welded joints:
      a. Remove sharp edges of weld spatter and slag with a file or ball peen hammer before wrapping welded joints.
      b. Clean and prime all surfaces.
         1) Then apply a wrap of 0.125-inch thick by 2-inch wide filler tape centered on the weld.
         2) Push and knead the tape into all voids.
         3) Start first wrapping 4 inches back on the pipe wrap, spiral wrap tape over the welded joint holding the proper tension and overlap, and finish 4 inches back on the pipe wrap on the other side of the joint.
      c. Apply 2 wraps of 30 mil joint tape, or the tape may be half lapped to obtain the double thickness.
      d. Apply finish wrapping in same manner.
   5. Wrap fittings, valves, and other odd shaped components in the pipeline with first and finish wrapping over the prime coat for a total thickness of 80 mils.
   6. Wrap joints, fittings, valves, and other irregular shapes of piping with extruded coatings with tape.

3.02 FIELD QUALITY CONTROL

A. Holiday detection testing:
   1. Perform a complete high voltage electrical inspection (holiday detection testing) of all steel piping systems and fittings coated with plastic tape wrap prior to burying.
      a. Perform high voltage electrical inspection in accordance with NACE RP0274-74.

b. Test voltage used for the electrical inspection of the piping and fittings shall be in accordance with the recommendations given by the tape coating manufacturer in their published literature.
c. Repair all holidays and defects found in the coating system by high voltage electrical inspection in accordance with the tape coating manufacturer's recommendations.
d. Retest repaired areas in the coating prior to burial of the piping.

2. Before conducting holiday detection testing on any piping systems, submit technical literature and data describing the testing instrumentation, equipment, electrodes, and other accessories that will be used.
   a. The literature and data shall include complete information covering the operation and use of the testing equipment, including operational voltage ranges.
3. All holiday detection testing and coating repair work shall be witnessed and inspected by the ENGINEER.

END OF SECTION

SECTION 15281

COPPER WATER TUBE-SEAMLESS, ASTM B 88

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Copper water tube-seamless, ASTM B 88.

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 15061 - Pipe Supports.
      b. Section 15062 - Preformed Channel Pipe Support System.

1.02 REFERENCES

A. ASTM International (ASTM):
   1. B 32 - Standard Specification for Solder Metal.
   2. B 88 - Standard Specification for Seamless Copper Water Tube.
   3. B 813 - Standard Specification for Liquid and Paste Fluxes for Soldering of Copper and Copper Alloy Tube.
   4. B 828 - Standard Practice for Making Capillary Joints by Soldering of Copper and Copper Alloy Tube and Fitting.

B. International Association of Plumbing and Mechanical Officials (IAPMO):
   1. IS 3 - Installation Standard for Copper Plumbing Tube, Pipe and Fittings.

PART 2 PRODUCTS

2.01 MATERIALS

A. Seamless copper water tube:
   1. Type: ASTM B 88:
      a. Exposed copper piping or tubing: Type L hard-drawn, rigid.
      b. Copper tubing buried in the ground or in plastic conduit: Type K soft-annealed.
   2. Fittings: Manufacturers: Solder type forged, or wrought copper. One of the following or equal:
      a. Hoke, Gyrolok.
      b. Crawford Fitting Company, Swagelok.
      c. Parker.

3. Solder: ASTM B 32, Alloy Grade Sb5.
4. Flux: ASTM B 813.
5. Dielectric insulating unions or fittings: Manufacturers: One of the following or equal:
   a. Mueller Company.
   b. Watts Series 3001A.
6. Special thread to tube adapters: Manufacturers: One of the following or equal:
   a. Crawford Fitting Company, Swagelok.
   b. Hoke, Gyrolok.
   c. Parker.

PART 3 EXECUTION

3.01 INSTALLATION

A. General:
   1. Support copper piping and tubing as specified in Sections 15061 and 15062.
   2. Clean copper lines with high-pressure air after first disconnecting piping at instruments, filters, pressure reducers, valve operators, and other special devices.
   3. Install copper pipe in accordance with IAPMO IS 3.

B. Installation of copper piping:
   1. Connect copper pipe connected to ferrous pipe or valves, or other non-copper items, by means of dielectric insulating unions or fittings.
   2. Where connections are made to meters or other devices having iron pipe size threaded fittings, provide special thread to tube adapters.

C. Installation of copper tubing:
   1. Install copper tubing in accordance with ASTM B 828 and IAPMO IS 3.
   2. Install copper tubing in straight runs, supported at intervals close enough to avoid sagging.
   3. Make cuts square with a tubing cutter or with a 32-tooth hacksaw.
      a. Provide a sizing tool to correct distortions.
   4. Ream the inside of the tubing and remove burrs from the outside, holding the end of the tubing downward and preventing chips and fillings from entering the tubing.
   5. Perform flaring with a flare block and yoke type screw feed flaring tool:
      a. After removing the tubing from the flare block, inspect both surfaces of the flare for splits, cracks, or other imperfections.
      b. Where there are imperfections, cut off the imperfect flare, and prepare a new flare.

3.02 FIELD QUALITY CONTROL

A. Testing: Test copper lines in the same manner as the piping system to which they connect.

END OF SECTION

SECTION 15286

STAINLESS STEEL PIPE AND TUBING

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Stainless steel piping and tubing.

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 15052 - Common Work Results for General Piping.
      b. Section 15121 - Pipe Couplings and External Joint Restraints.

1.02 REFERENCES

A. American Society of Mechanical Engineers (ASME):
   1. B16.1 - Gray Iron Pipe Flanges and Flanged Fittings: Classes 25, 125, and 250.
   2. B16.5 - Pipe Flanges and Flanged Fittings: NPS 1/2 through 24.
   3. B16.11 - Forged Fittings, Socket-Welded and Threaded.
   4. B31.3 - Process Piping.
   5. B36.19 - Stainless Steel Pipe.

B. American Welding Society (AWS):
   1. D1.6 - Structural Welding Code - Stainless Steel.

C. ASTM International (ASTM):
   1. A 182 - Standard Specification for Forged or Rolled Alloy and Stainless Steel Pipe Flanges, Forged Fittings, and Valves and Parts for High-Temperature Service.
   2. A 193 - Standard Specification for Alloy-Steel and Stainless Steel Bolting for High Temperature or High Pressure Service and Other Special Purpose Applications.
   3. A 194 - Standard Specification for Carbon and Alloy Steel Nuts and Bolts for High Pressure or High Temperature Service, or Both.
   4. A 240 - Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications.
   5. A 269 - Standard Specification for Seamless and Welded Austenitic Stainless Steel Tubing for General Service.
   6. A 276 - Standard Specification for Stainless Steel Bars and Shapes.

7. A 312 - Standard Specification for Seamless, Welded, and Heavily Cold Worked Austenitic Stainless Steel Pipes.
8. A 351 - Standard Specification for Castings, Austenitic, for Pressure-Containing Parts.
9. A 380 - Standard Practice for Cleaning, Descaling, and Passivation of Stainless Steel Parts, Equipment, and Systems.
10. A 358 Electric-Fusion-Welded Austentic Chromium-Nickel Alloy Steel Pipe for High-Temperature Service.
11. A 403 - Standard Specification for Wrought Austenitic Stainless Steel Piping Fittings.
12. A 743 - Standard Specification for Castings, Iron-Chromium, Iron-Chromium-Nickel, Corrosion Resistant, for General Application.
13. A 744 - Standard Specification for Castings, Iron-Chromium-Nickel, Corrosion Resistant, for Severe Service.
14. A 774 - Standard Specification for As-Welded Wrought Austenitic Stainless Steel Fittings for General Corrosive Services at Low and Moderate Temperatures.
15. A 778 - Standard Specification for Welded, Unannealed Austenitic Stainless Steel Tubular Products.
16. A 789 - Standard Specification for Seamless and Welded Ferritic/Austenitic Stainless Steel Tubing for General Service.
17. A 790 - Standard Specification for Seamless and Welded Ferritic/Austenitic Stainless Steel Pipe.
18. A 928 - Standard Specification for Ferritic/Austenitic (Duplex) Stainless Steel Pipe Electric Fusion Welded with Addition of Filler Metal.
19. A 967 - Standard Specification for Chemical Passivation Treatments for Stainless Steel Parts.
20. B 622 - Standard Specification for Seamless Nickel and Nickel-Cobalt Alloy Pipe and Tube.
21. B 912 - Standard Specification for Passivation of Stainless Steels Using Electropolishing.
22. F 593 - Standard Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs.

D. NSF International (NSF):
   1. Standard 61 - Drinking Water System Components - Health Effects.

1.03 DESIGN REQUIREMENTS

A. Piping layout: Lay out and fabricate piping systems with piping sections as long as possible, while still allowing shipment, so that joints are minimized.
   1. Piping design indicated on the Drawings illustrates piping layout and configuration and does not indicate the location of every joint and flexible coupling that may be needed to connect piping sections fabricated in the shop.
   2. Add joints and flexible couplings in a manner that achieves intent of maximizing size of individual piping sections.

B. Shop fabrication: Fabricate piping sections in the shop and pickle and passivate at point of manufacture.

C. Field assembly:
   1. Field welding is prohibited.
   2. Assemble shop-fabricated piping in the field using the joints designed into the piping layout or by using flexible couplings.

1.04 SUBMITTALS

A. Layout drawings: Detailed layout drawings showing dimensions and alignment of pipes; location of valves, fittings, and appurtenances; location of field joints; location of pipe hangars and supports; connections to equipment or structures; location and details of shop welds; and thickness and dimensions of fittings and gaskets.
   1. Prepare layout drawings.

B. Product data:
   1. Photographs, drawings, and descriptions of pipe, fittings, welding procedures, and pickling and passivating procedures.
   2. Material specifications for pipe, gaskets, fittings, and couplings.
   3. Data on joint types and components used in the system including stub ends, backing flanges, flanged joints, grooved joint couplings and screwed joints.

C. Manufacturing certifications.

D. Welder and weld operator qualification certificates and welding procedures.

E. Source quality control test reports.

PART 2 PRODUCTS

2.01 STAINLESS STEEL PIPE

A. General:
   1. Pipe sizes specified in the Specifications and indicated on the Drawings are nominal.

B. Wall thickness:
   1. As specified in Section 15052.

C. Piping material and manufacturing:
   1. Comply with the requirements outlined in the following table:

Service	Stainless Steel Grade	Pipe Manufacturing Process
For low chloride water service with chloride concentrates below 200 parts per million and/or free chlorine less than 2 parts per million at ambient temperatures.		
Piping 3 inches in nominal diameter and larger	Type 304L stainless steel in accordance with ASTM A 240	In accordance with ASTM A 778
Piping less than 3 inches in nominal diameter	Type 304L stainless steel in accordance with ASTM A 240	In accordance with ASTM A 312

Service	Stainless Steel Grade	Pipe Manufacturing Process
Engine Exhaust	Type 321/347	ASTM A 358, Class 1, Type 321/347
PREN: Pitting Resistance Equivalency Number PREN = Cr% + (3.3 x Mo%) + (16 x N%)		

UNS #	ALLOY	Cr%	Mo%	N%	Other	PREN
N10276	C-276	14.5-16	15-17	-	W 3-4.5	64
S32750	Alloy 2507	24-26	6-8	0.24-0.32	-	48
S32654	654SMO	24-25	7-8	-	-	47
N06625	Alloy 625	20-23	8-10	-	Cb 3.25-4.15	46
N08366	AL6XN	20-22	6-7	-	-	40
N06985	Alloy G	21-23.5	5.5-7.5	-	-	39
S32760	Zeron 100	24-26	3-4	0.2-0.3	W 0.5-1.0	37
S32205	Alloy 2205	22-23	3-3.5	0.14-0.20	-	34
N08904	904L	19-23	4-5	-	-	32
S31726	317LNM	17-20	4-5	0.1-0.2	-	32
N08825	Alloy 825	19-23.5	2.5-3.5	-	-	27
S32101	LDX-2101	21.5	0.3	0.22	-	26
S31603	316L	16-18	2-3	-	-	23
S30403	304L	18-20	-	-	-	18

2. Chemical analysis certificates.

D. Fittings for piping 3 inches in nominal diameter and greater:
   1. Material: In accordance with ASTM A 240 stainless steel, grade to match the pipe.
   2. Manufacturing standard: In accordance with ASTM A 774.
   3. Wall thickness of fitting: In accordance with ASME B36.19 for the schedule of pipe specified.
   4. End configuration: As needed to comply with specified type of joint.
   5. Dimensional standards:
      a. Fittings with weld ends: In accordance with ASME B16.11.
      b. Fittings with flanged ends: In accordance with ASME B16.5, Class 150.

E. Fittings for piping less than 3 inches in diameter:
   1. Material: In accordance with ASTM A 240 stainless steel, grade to match the pipe.
   2. Manufacturing standard: In accordance with ASTM A 403, Class WP.
   3. Wall thickness and dimensions of fitting: In accordance with ASME B16.11 and as required for the schedule of pipe specified.

4. End configuration: As needed to comply with specified type of joint.
5. Forgings in accordance with ASTM A 182, or barstock in accordance with ASTM A 276. Match forging or barstock material to the piping materials.

F. Piping joints:
1. Joint types, piping greater than 2 inches in diameter, general:
   a. Where type of joint is specifically indicated on the Drawings or specified, design and shop-fabricate piping sections utilizing type of joint illustrated or scheduled.
   b. Where type of joint is not specifically indicated on the Drawings or as specified in Section 15052 Piping Schedule, design and shop-fabricate piping sections utilizing any of the following joint types:
      1) Piping stub ends with backing flanges.
      2) Welded joints.
      3) Flanged joints.
      4) Grooved joints.
   c. Joints at valves and pipe appurtenances:
      1) Provide flanged valves and flanged pipe appurtenances in stainless steel piping systems with flanged ends.
      2) Design and fabricate piping sections to make connections with flanged valves and pipe appurtenances using piping stub ends with backing flanges, flanged coupling adapters or flanged joints.
      3) Flexible couplings and flanged coupling adapters: Provide stainless steel construction with materials matching the piping system, and conforming to requirements as specified in Section 15121.
      4) Buried piping: Welded or mechanically restrained.
2. Joints in piping 2 inches in diameter and smaller: Flanged, grooved, welded or screwed with Teflon tape thread lubricant, as specified in Section 15052.
3. Welded joints:
   a. Pipe 12 inches and larger in diameter: Automatically weld joints using gas tungsten-arc procedures.
   b. Piping 4 inches through 12 inches in diameter: Double butt welded joints.
   c. Piping less than 4 inches in diameter: Single butt-welded joints.
   d. Mark each weld with a symbol that identifies the welder.
4. Flanged joints: Conforming to the requirements in accordance with ASME B16.5, Class 150 or 300 as scheduled.
5. Piping stub ends and backing flanges for pipe 3 inches and larger:
   a. Piping stub ends: Cast stainless steel to match the pipe material with machined gasket and wetted surfaces of stub ends free of crevices, pits, cracks and protrusions.
      1) Manufacturers: The following or equal:
         a) Alaskan Copper Works, Figure SK-38.
   b. Backing flanges: Forged or plate stainless steel (type to match pipe material) with drilled bolt patterns in accordance with ASME B16.1, Class 125 or ASME B16.5, Class 150 [, 300 or 600, as scheduled].
      1) Manufacturers: The following or equal:
         a) Alaskan Copper Works, Figure SK-39 (tube) or SK-39P (pipe).
   c. Stub ends and backing flanges are not allowed for use with wafer style or lugged style valves.

6. Flanges for Schedule 40S and Schedule 80S pipe:
    a. Provide forged stainless steel (type matching piping system) welding neck flanges or slip-on flanges in accordance with ASME B16.5 Class 150 or 300 as scheduled.
    b. Material: In accordance with ASTM A 182.
7. Grooved joints:
    a. Pressure less than 500 pounds per square inch:
        1) Cut grooves from Schedule 40 or higher.
    b. Heavier schedule pipe sections used for cut groove ends:
        1) Tapered inside diameter to transition from the inside diameter of the lighter schedule pipe.
    c. Butt welds connecting pipes of different schedules that leave an abrupt change in inside diameter are not allowed.
    d. Couplings:
        1) Rigid type, stainless steel, Victaulic Style 008 or equal.

G. Gaskets:
1. Ozone and oxygen service: TFE sheet.
2. Aeration air service: As specified in Section 15052.
3. All other service applications: EPDM, nitrile, or other materials compatible with the process fluid.
    a. Drinking water applications: NSF Standard 61 compliant materials only.

H. Bolts for flanges and stub end/backing flanges:
1. Bolts and nuts: Type 316 stainless steel in accordance with ASTM A 193 heavy hex head.
    a. Bolt length such that after installation, end of bolt projects 1/8-inch to 3/8-inch beyond outer face of nut.
    b. Nuts: In accordance with ASTM A 194 heavy hex pattern.

I. Fabrication of pipe sections:
1. Welding: Weld in accordance with ASME B31.3.
2. Weld seams:
    a. Full penetration welds, free of oxidation, crevices, pits and cracks, and without undercuts.
    b. Provide weld crowns of 1/16 inch with tolerance of plus 1/16 inch and minus 1/32 inch.
    c. Where internal weld seams are not accessible, use gas tungsten-arc procedures with internal gas purge.
    d. Where internal weld seams are accessible, weld seams inside and outside using manual shielded metal-arc procedures.

J. Cleaning (pickling) and passivation:
1. Following shop fabrication of pipe sections, straight spools, fittings, and other piping components, clean (pickle) and passivate fabricated pieces.
2. Clean (pickle) and passivate in accordance with ASTM A 380 or A 967.
    a. If degreasing is required before cleaning to remove scale or iron oxide, cleaning (pickling) treatments with citric acid are permissible.
        1) However, these treatments must be followed by inorganic cleaners such as nitric acid/hydrofluoric acid.
    b. Passivation treatments with citric acid are not allowed.

3. Finish requirements: Remove free iron, heat tint oxides, weld scale, and other impurities, and obtain a passive finished surface.
4. For piping less than 2-inches in diameter:
   a. Following shop fabrication of piping sections, descale, clean and seal piping section in accordance with CGA Standard G-4.1.

2.02 STAINLESS STEEL TUBING

A. Stainless steel tubing:
   1. Seamless tubing made of Type 316L stainless steel and in accordance with ASTM A 269, wall thickness not less than 0.035 inch.

B. Fittings: Swage ferrule design:
   1. Components made of:
      a. Type 316 stainless steel.
   2. Double acting ferrule design, providing both a primary seal and a secondary bearing force.
   3. Flare type fittings are not acceptable.
   4. Manufacturers: One of the following or equal:
      a. Crawford Fitting Company, Swagelok.
      b. Hoke, Gyrolok.
      c. Parker, CPI.

C. Valves for use with stainless steel tubing:
   1. Ball type valves with swage ends to match tubing diameter.
   2. Constructed from:
      a. Type 316 stainless steel with TFE seats.
   3. Manufacturers: The following or equal:
      a. Crawford Fitting Company, Swagelok.

2.03 SOURCE QUALITY CONTROL

A. Visually inspect pipe for welding defects such as crevices, pits, cracks, protrusions, and oxidation deposits.

B. Provide written certification that the pipe as supplied are in accordance with ASTM A 778. Supplemental testing is not required.

C. Provide written certification that the fittings as supplied are in accordance with ASTM A 774.
   1. Supplementary testing is not required.

D. Thoroughly clean any equipment before use in cleaning or fabrication of stainless steel.

E. Storage: Segregate location of stainless steel piping from fabrication of any other piping materials.

F. Shipment to site:
   1. Protect all flanges and pipe ends by encapsulating in dense foam.
   2. Securely strap all elements to pallets with nylon straps. Use of metallic straps is prohibited.

3. Cap ends of tube, piping, pipe spools, fittings, and valves with non-metallic plugs.
4. Load pallets so no tube, piping, pipe spools, fittings, or valves bear the weight of pallets above.
5. Notify ENGINEER when deliveries arrive so ENGINEER may inspect the shipping conditions.
6. ENGINEER may reject material due to improper shipping methods or damage during shipment.

PART 3 EXECUTION

3.01 FIELD ASSEMBLY OF SHOP-FABRICATED PIPING SECTIONS

A. Join shop-fabricated piping sections together using backing flanges, flexible couplings, flanged coupling adapters, grooved couplings, or flanges.

B. Slope horizontal lines so that they can be drained completely.

C. Provide valve drains at low points in piping systems.

D. Install eccentric reducers where necessary to facilitate draining of piping system.

E. Provide access for inspection and flushing of piping systems to remove sediment, deposits, and debris.

3.02 FIELD QUALITY CONTROL

A. Test piping to pressure and by method as specified in Section 15052.
   1. If pressure testing is accomplished with water:
      a. Use only potable quality water.
      b. Piping: Thoroughly drained and dried or place immediately into service.

B. Visually inspect pipe for welding defects such as crevices, pits, cracks, protrusions, and oxidation deposits.

3.03 PROTECTION

A. Preserve appearance and finish of stainless steel piping by providing suitable protection during handling and installation and until final acceptance of the Work.
   1. Use handling methods and equipment to prevent damage to the coating, include the use of wide canvas slings and wide padded skids.
   2. Do not use bare cables, chains, hooks, metal bars, or narrow skids.
   3. Store stainless steel piping and fittings away from any other piping or metals. Storage in contact with ground or outside without projection from bad weather is prohibited.
   4. Protect stainless steel piping and fittings from carbon steel projections (when grinding carbon steel assemblies in proximity) and carbon steel contamination (do not contact stainless steel with carbon steel wire brush or other carbon steel tool).

END OF SECTION

SECTION 15293

DOUBLE CONTAINMENT PIPING

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Double contained piping systems and accessories.

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 15230 - Plastic Piping and Tubing.
      b. Section 15270 - Steel Pipe – Galvanized and Black, ASTM A 53.
      c. Section 15956 - Piping Systems Testing.

1.02 REFERENCES

A. ASTM International (ASTM):
   1. D 2564 - Specification for Solvent Cements for Poly (Vinyl Chloride) (PVC) Plastic Piping Systems.
   2. D 2855 - Practice for Making Solvent - Cemented Joints with Poly (Vinyl Chloride) (PVC) Pipe and Fittings.
   3. D 2996 - Standard Specification for Filament-Wound Fiberglass (glass-fiber-reinforced thermosetting-resin) Pipe.

1.03 SUBMITTALS

A. Product data.

B. Manufacturer's published installation instructions.

C. Submit information on expansion joints.

PART 2 PRODUCTS

2.01 DOUBLE CONTAINMENT PLASTIC PIPING SYSTEM

A. Materials:
   1. Compatible for continuous exposure to chemical service as indicated in the pipe schedule at ambient temperatures and maximum pressure equal to the test pressure.

2. Prefabricated fittings:
    a. Prefabricated fittings consisting of an inner (carrier) pipe elbow totally enclosed and spaced in an outer (containment) pipe elbow.
    b. Split fittings requiring field cutting, welding or joining shall not be used.
3. Inner (carrier) pipe: Shall consist of Schedule 80 PVC pipe, joined to fittings and each other solvent welding. Provide pipe as specified in Section 15230.
4. Outer (containment) pipe: Shall consist of Schedule 40 PVC pipe. Provide pipe as specified in Section 15230.
5. Spacers:
    a. Provide nonmetallic spacers on inner pipe to control sagging within containment pipe.
    b. Design and place spacers to withstand loads of the filled pipe and loads due to thermal expansion. Spacers shall be free of sharp edges and be bonded to the carrier pipe.

B. Design requirements:
1. Expansion loops: Provide expansion loops as required to compensate for expected thermal expansion for an ambient temperature range of 45 to 90 degrees Fahrenheit.
2. Access ports:
    a. Provide access ports for ease of installation, start-up, and maintenance of piping. Access ports shall consist of a tee fitting in the secondary containment piping, a 6-inch diameter riser pipe, and a bolted blind flange cover.
    b. Locate access ports at each low point.
3. Leak detection: Provide leak detection tee at each low point as indicated on the Drawings.

C. Manufacturers: One of the following or equal:
1. Guardian Systems, a product of IPEX Inc.
2. Harrington Industrial Plastics.
3. Permalert.

2.02 DOUBLE CONTAINMENT STEEL PIPING SYSTEM

A. Materials:
1. Material compatible with fuel oil.
2. Inner carrier pipe: Schedule 40 black steel pipe. Provide pipe as specified in Section 15270.
3. Outer (containment) pipe and fittings: Fiberglass epoxy or vinyl ester. Pipe shall meet ASTM specification D 2996 and be UL listed.
4. Containment systems shall be jointed in the field using 2 or 4 piece clamshell type fittings or the Quick-Lock joint for adjacent pipe lengths.
5. Spacers: Provide nonmetallic spacers on inner pipe to control sagging within containment pipe.
6. Provide low point sump in piping with provision for installation of a leak detector.
7. Provide special leak proof fittings to enclose all inner pipe fittings and yet allow any leaks to flow to the low point.

B. Manufacturers: One of the following or equal:
1. Ameron, Dualoy.
2. Fibercast, Dualcast.

PART 3 EXECUTION

3.01 INSTALLATION

A. Plastic piping systems:
   1. Secondary containment joints solvent cemented using heavy body-slow set PVC cement ASTM D 2564 made in accordance with ASTM D 2855.
   2. Install piping in accordance with manufacturers published instructions.
   3. Pipe shall be continuously sloped to drain to a low point. Provide tee with minimum 3-inch riser pipe to grade for inspection and access at all low points for buried double containment pipe. Provide threaded cap at top of riser pipe installed in a valve box.
   4. Provide tee with minimum 2-inch drainpipe with ball valve at all piping low points for exposed double containment piping.
   5. Ends of outer containment pipe shall be closed.

B. Steel piping systems:
   1. Install piping in accordance with manufacturer's published instructions.

3.02 FIELD QUALITY CONTROL

A. Plastic piping systems:
   1. Test Schedule 80 PVC (inner containment) pipe per testing methods specified in Section 15956.
   2. Test Schedule 40 PVC (outer containment) pipe as follows:
      a. Pneumatically test the pipe at a minimum of 5 pounds per square inch and a maximum of 10 pounds per square inch air pressure for 2-1/2 hours.
      b. Soap all external joints and visually inspect for leaks. All leaks shall be repaired in accordance with manufacturer's recommendations.
      c. Purge containment pipe annular space with nitrogen to remove moisture containing air following leak test.

B. Steel piping:
   1. Test Schedule 40 black steel (inner containment) pipe as specified in Section 15956.
   2. Test fiberglass epoxy or vinyl ester (outer containment) pipe as follows:
      a. Pneumatically test the pipe at a minimum of 5 pounds per square inch and a maximum of 10 pounds per square inch air pressure for 2-1/2 hours.
      b. Soap all external joints and visually inspect for leaks. All leaks shall be repaired in accordance with manufacturer's recommendations.
      c. Purge containment pipe annular space with nitrogen to remove moisture containing air following leak test.

END OF SECTION

SECTION 15400

PLUMBING FIXTURES AND EQUIPMENT

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Materials and installation of plumbing system.

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 01410 - Regulatory Requirements.
      b. Section 01740 - Warranties and Bonds.
      c. Section 15052 - Common Work Results for General Piping.

1.02 REFERENCES

A. American Society of Mechanical Engineers (ASME).

B. ASTM International (ASTM).

C. National Electrical Manufacturers Association (NEMA):
   1. 250- Enclosures for Electrical Equipment (1000 V Maximum).

D. Plumbing and Drainage Institute (PDI):
   1. PDI-WH 201 - Water Hammer Arresters Standard.

E. Title 24 of the California Code of Regulations.

1.03 DEFINITIONS

A. NEMA Type 3 enclosure in accordance with NEMA 250.

1.04 SYSTEM DESCRIPTION

A. System requirements:
   1. Include in plumbing system fixtures; soil, drain, vent, and water piping; connections; cleanouts, fittings, accessories, and testing for complete and functional system.
   2. Except in details, piping is indicated on the Drawings in diagrammatic form. Sizes and locations are indicated on the Drawings; however, not every offset

and fitting, nor every structural difficulty that will be encountered in the Work has been indicated.

3. As part of the Work, modify piping alignment indicated on the Drawings as necessary to avoid structural or mechanical obstructions and to clear the work of other trades.
4. Furnish such parts and pieces necessary to provide a complete and operational system.

1.05 SUBMITTALS

A. Manufacturer's published recommendations for sizing and locating the unit.

B. Design and construction details of the unit.

1.06 QUALITY ASSURANCE

A. Regulatory requirements: Perform work under this Section in accordance with the plumbing code specified in Section 01410, and in accordance with applicable laws and regulations, including requirements for accessibility, energy, water conservation, and health including related requirements for water fountains and coolers.
   1. Where provisions specified in these Specifications or the design indicated on the Drawings are in conflict with the plumbing code specified in Section 01410 or laws or regulations, the Code and the laws or regulations take precedence over the specified provisions and design.

B. All devices and fixtures supplied for projects in the State of California shall comply with Title 24 of the California Code of Regulations.

1.07 WARRANTY

A. Provide manufacturer's warranties for electric water heaters, booster electric water heaters, gas water heaters, and water softeners in accordance with Section 01740.

PART 2 PRODUCTS

2.01 MATERIALS

A. General:
   1. Manufactured units: Fixture fittings and piping which are exposed shall be heavy-duty chrome.
   2. Accessories:
      a. Stops:
         1) Fixtures, except showers, shall have stops at the fixtures' service.
         2) Stops for laboratory equipment, and for other equipment or fixtures for which stops have not been otherwise specified in this Section, shall be chrome-plated straight pattern compression stops or chrome-plated angle pattern compression stops.
      b. Supply faucets, traps, and waste piping for laboratory equipment with the equipment unless otherwise specified.

B. Drain, waste, and vent piping:
   1. Piping:
      a. Piping for drain, waste and vent: As specified in Section 15052.
   2. Joints:
      a. Threaded joints: American standard taper screw threads, clean cut, and made up with graphite and oil or other suitable pipe compounds.
      b. Slip joints permitted only in trap seals or on the inlet side of the traps.
         1) Do not use long screws or bushings.
      c. Other types of joints: As specified in the piping sections.
   3. Fittings:
      a. Fittings for screwed waste and vent piping: Cast iron drainage pattern fittings.
      b. Additional provisions for fittings specified within piping section.
   4. Flashing:
      a. Roof vent, roof drain, and pipe flashing: Minimum 4-pound lead sheet.

C. Plumbing piping accessories:
   1. Cleanouts:
      a. Wall-mounted cleanouts (WCO) for concealed piping: Provide complete including cast-iron tapped tee, round smooth stainless steel access cover, and securing screw.
         1) Manufacturers: One of the following or equal:
            a) Josam Company, 58910-19 (Tee & Plug) and 58600 (Access Cover).
            b) Zurn Industries, Z1446-BP
      b. Floor cleanouts (FCO) in finished floor areas: Provide complete including cast-iron ferrule, countersunk plug, gastight and watertight seal, adjustable cleanout head extension, scoriated nickel-bronze top, and securing screw.
         1) Manufacturers: One of the following or equal:
            a) Josam Company, 56070.
            b) Zurn Industries, Inc., ZN-1400.
      c. Floor cleanouts (FCO) in unfinished floor areas: Same as floor cleanouts specified for finished floor areas, except heavy-duty scoriated nickel-bronze top suitable for heavy traffic conditions.
         1) Manufacturers: One of the following or equal:
            a) Josam Company, 55000.
            b) Zurn Industries, Inc., Z-1400-HD.
      d. Yard cleanouts (YCO) in asphalt or ground areas: Floor cleanouts in unfinished floor areas specified before, for encasement in a concrete pad as indicated on the Drawings and flush with grade.
   2. Traps:
      a. Furnish traps with the fixtures.
         1) Do not provide double trapped fixtures.
      b. Traps installed on bell-and-spigot pipe: Cast iron.
      c. Traps installed on threaded pipe: Recessed drainage pattern or as specified with the fixture.
   3. Floor drainage:
      a. Floor drainage piping: Cast iron soil pipe and fittings.
      b. Equipment and floor drains.
         1) Provide with adjustable strainer head, floor level grate, 4-inch diameter funnel extension and provided with no-hub outlet and nickel bronze top.

2) Manufacturers: One of the following or equal:
   a) Floor drain:
      (1) Josam Company, 30000-A, combination drip drain, less clamping collar.
      (2) Zurn Industries, Inc., ZN-415 strainer.
   b) Funnel extension:
      (1) Josam Company, E-2.
      (2) Zurn Industries, Inc., ZN-328.
   c) Other floor drains with no-hub outlet and nickel bronze Type B strainer:
      (1) Josam Company, 30000-A universal floor drain with adjustable strainer, less clamping collar.
      (2) Zurn Industries, Inc., ZN-415.
3) Strainer sizing:
   a) 3-inch drain strainers: 6-inch diameter
   b) 4-inch drain strainers: 8-inch diameter.

c. Heavy-duty floor drains with sedimentation bucket:
   1) Heavy-duty floor drains: 12 inches square with coated cast-iron body, grate, and slotted sediment bucket.
      a) Manufacturers: One of the following or equal:
         (1) Josam Company, 37810.
         (2) Zurn Industries, Inc., Z-610.

d. Floor sinks for indirect wastes:
   1) Floor sinks:
      a) Full, half, or quarter grate, 16 inches square by 6 to 7 inches deep, acid resisting enamel interior and exterior, no-hub outlet, pipe size as indicated on the Drawings.
      b) Manufacturers: One of the following or equal:
         (1) Josam Company, 49400.
         (2) Zurn Industries, Inc., Z-1920.

e. Trench drains:
   1) Modular, 6 inches wide, 12 inches long extensions, bottom outlet, with secondary dome strainer, length as indicated on the Drawings.
   2) Manufacturers: One of the following or equal:
      a) Josam Company, 76000.
      b) Zurn Industries, Inc., Z-664.

4. Roof drains:
   a. Main roof drains:
      1) Main roof drains:
         a) Provide complete, including coated cast-iron body, combined flashing collar and gravel stop, polypropylene dome strainer, underdeck clamp where required, and pipe of size indicated on the Drawings.
         b) Manufacturers: One of the following or equal:
            (1) Josam 21500-3-10-20.
            (2) Zurn Z-100 ERC.

   b. Overflow roof drains: Provide same as main roof drains but with a 2-inch water dam.
      1) Manufacturers: One of the following or equal:
         a) Josam Company, 26010-23.
         b) Zurn Industries, Inc., ZRB-100-89.

c. Scupper roof drains: Provide complete, including coated cast-iron body, coated cast-iron or bronze angle strainer, 90-degree or 45-degree threaded outlet where required, and pipe of size indicated on the Drawings.
   1) Manufacturers: One of the following or equal:
      a) Josam Company, 24700.
      b) Zurn Industries, Inc., Z-187.
d. Downspout nozzles: Provide complete, including nickel-bronze body and wall flange.
   1) Pipe size: As indicated on the Drawings.
   2) Manufacturers: One of the following or equal:
      a) Josam Company, 25010-50-SF.
      b) Zurn Industries, Inc., ZANB-199.

5. Air gaps:
   a. Provide fixed air gaps with threaded outlets:
   b. Manufacturers: One of the following or equal:
      1) Josam Company, 1800.
      2) Zurn Industries, Inc. Z-1025.
6. Narrow wall hydrants:
   a. Provide complete, including bronze body and interior parts, replaceable seat washer, screwdriver-operated stop valve on the supply, key-operated control valve, 3/4-inch female inlet, and 3/4-inch male standard hose connection.
   b. Provide narrow wall hydrant with an encased stainless steel box with hinged cover operating key lock, and the word "WATER" stamped on the cover, 3-5/8-inch face to back dimension, suitable for moderate climate conditions.
   c. Manufacturers: One of the following or equal:
      1) Zurn Industries, Inc., Z-1350.

D. Wash sinks:
   1. Wall-mounted service sink:
      a. Provide wall-mounted service sink: 22 inches by 18 inches cast-iron with acid-resisting porcelain enamel interior, 9-inch high drilled back, concealed hanger, stainless steel rim guard, rough chromium plated utility sink faucet with rigid hose end spout with pail hook, backflow preventer, indexed lever handles, 1/2-inch female union inlets with adjustable flanges, integral stops, cast-iron adjustable "P" trap standard with metal strainer, gaskets, and cleanout plug.
      b. Provide faucets that deliver not more than 15 gallons per minute at 60 pounds per square inch gauge inlet pressure.
      c. Manufacturers: One of the following or equal:
         1) Wall-mounted service sink:
            a) American Standard, Inc.
            b) Crane Company.
            c) Eljer Industries.
            d) Kohler Company.
         2) Carrier:
            a) Josam Company.
            b) Jay R. Smith Manufacturing Company.
            c) Zurn Industries, Inc.

2. Floor-mounted service sink:
    a. Provide floor-mounted service sink: 28 inches by 28 inches cast iron with acid-resisting porcelain enameled corner floor sink, removable vinyl coated rim guard, rough chromium-plated utility sink faucet with rigid hose end spout, 5-foot hose with wall hook, backflow preventer, indexed 4 arm handles, 1/2-inch female union inlets with adjustable flanges, integral stops, and service sink strainer.
    b. Provide faucets that deliver not more than 15 gallons per minute at 60 pounds per square inch gauge inlet pressure.
    c. Manufacturers: One of the following or equal:
        1) American Standard, Inc.
        2) Crane Company.
        3) Eljer Industries.
        4) Kohler Company.
3. Kitchen sinks:
    a. Single compartment stainless steel sinks: Provide furnish complete with 18-gauge stainless steel single bowl, self rimming, soft satin finish with mirror polished bowl edges, flush fittings deck, sound dampening, 6-1/2 inches deep, 33-inch by 21-inch bowl size; 1 hole punching size, stainless steel crumb strainer cup, 1-1/2 inch by 4 inch 20-gauge stainless steel tail piece; adjustable cast brass "P" trap with tubing drain to wall, 1-1/2-inch inlet, 1-1/- inch outlet, ground swivel joint, cleanout plug, slip inlet; faucet supply assembly with 3/8-inch angle valve, wheel handle flexible tube riser, chrome finish.
    b. Kitchen faucet: Center mount post type, single lever faucet with 9-1/2-inch tubular swing spout with aerator and 0.2 gallons per minute maximum flow, brass construction, finished in chrome plate.

E. Toilets, urinals, lavatories, and showers:
1. Flush valve type water closets:
    a. Wall mounted water closets:
        1) Provide complete with wall mounted vitreous china elongated bowl, water-saver type, siphon jet action, 1-1/2-inch top spud, chrome-plated flush valve with vacuum breaker, non-hold-open type handle with flush volume adjustability at 1.28 gallons per flush, 1-inch screwdriver angle stop and flush connection, white solid plastic seat with open front, stainless steel hinge and check, concealed carrier, and mounting height as required.
        2) Provide water closets indicated on the Drawings meeting ADA accessibility standards in accordance with related requirements of Laws and Regulations.
        3) Manufacturers: One of the following or equal:
            a) Flush valve type water closets:
                (1) American Standard, Inc.
                (2) Crane Company.
                (3) Eljer Industries.
                (4) Kohler Company.
            b) Flush valves:
                (1) Delany.
                (2) Sloan Valve Company.
            c) Carrier:
                (1) Josam Company.

(2) Jay R. Smith Manufacturing Company.
(3) Zurn Industries, Inc.

2. Tank type water closets:
   a. Floor-mounted water closets:
      1) Provide vitreous china, elongated bowl, siphon jet action, close coupled 1.7-gallon tank, freestanding, white solid plastic seat with open front, seat cover, tank fittings including flush valve, float valve, and trip lever, copper water supply tube, and shutoff valve. Provide flush valve with maximum delivery of 1.28 gallons per flush.
      2) Provide water closets indicated on the Drawings meeting ADA accessibility standards in accordance with related requirements of Laws and Regulations.
      3) Manufacturers: One of the following or equal:
         a) American Standard, Inc.
         b) Crane Company; or equal.
3. Flush type urinals:
   a. Provide flush type urinals complete with wall-mounted vitreous china washout bowl, 3/4-inch top spud, outlet connection threaded 2 inches inside, privacy shields, concealed wall hangers for wall mounted units, flush chrome-plated brass valve with vacuum breaker for maximum delivery of 0.5 gallons per flush, 3/4-inch screwdriver stop and flush connection, and concealed carrier.
   b. Provide urinals indicated on the Drawings meeting ADA accessibility standards in accordance with related requirements of Laws and Regulations.
   c. Manufacturers: One of the following or equal:
      1) Flush type urinals:
         a) American Standard, Inc.
         b) Crane Company.
         c) Eljer Industries.
         d) Kohler Company.
      2) Flush valve:
         a) Delany.
         b) Sloan Valve Company.
         c) Watrous.
      3) Carrier:
         a) Josam Company.
         b) Jay R. Smith Manufacturing Company.
         c) Zurn Industries, Inc.
4. Lavatories:
   a. Provide lavatories complete with wall mounted 20-inch by 18-inch vitreous china bowl with backsplash and front overflow; concealed arms and concealed wall hanger; with soap depression and 1-inch diameter drilling for soap dispenser; with 4-inch center inlets, faucet, 4-inch centers, single lever handle, 1/2-inch male IP connectors, chrome finish, 3/8-inch supply assemblies, 3/8-inch angle valve, loose key handles, escutcheon, automatic flow control, drain with integral perforated grid, 1-1/4-inch diameter by 4-inch tail piece, adjustable cast brass "P" trap with 1-1/4-inch inlet, 1-1/4-inch outlet, escutcheon and chrome finish.
   b. Provide lavatories indicated on the Drawings meeting ADA accessibility standards in accordance with related requirements of Laws and Regulations.
   c. Provide self-closing faucets that deliver not more than 0.4 gallons per minute at 60 pounds per square inch gauge inlet pressure.

d. Manufacturers: One of the following or equal:
    1) Lavatory:
        a) American Standard, Inc.
        b) Crane Company.
        c) Eljer Industries.
        d) Kohler Company.
    2) Carrier:
        a) Josam Company.
        b) Jay R. Smith Manufacturing Company.
        c) Zurn Industries, Inc.

5. Shower fixtures:
    a. Provide shower fixtures complete with adjustable spray showerhead, showerhead arm, adjustable escutcheon flange, bypass valve with renewable seats, crown handles, 8-inch centers, screwdriver stops, chrome finish, 1/2-inch female IPS union supplies and 2.0 gallons per minute flow restrictor at 80 pounds per square inch gauge inlet pressure.
    b. Manufacturers: One of the following or equal:
        1) American Standard, Inc.
        2) Crane Company.
        3) Eljer Industries.
        4) Kohler Company.

F. Water heaters:
1. Electric water heaters:
    a. Electric water heaters: Provide complete with 15-gallon glass lined storage tank, 2 inches minimum fiberglass insulation, exterior steel casing with factory standard enamel finish, 1.5-kwatt high efficiency immersion type heating elements, automatic temperature control and externally adjustable setting, recovery rate of 10 gallons per hour at 60 degrees Fahrenheit temperature rise; ASME rated temperature and pressure relief valve, magnesium anode, tank cleanout, 3-year warranty that shall commence in accordance with Section 01740, Underwriter's Laboratory listed; suitable for 120-volt, 3-phase, 60 hertz electrical power supply.
    b. Water heater shall meet the requirements of Title 24 of the California Code of Regulations.
    c. Manufacturers: One of the following or equal:
        1) A. O. Smith Corporation. Model as indicated on the Drawings.
        2) State Industries, Inc., Equivalent model.
2. Tankless gas water heaters:
    a. Provide tankless water heater with the following characteristics:
        1) Electronic ignition.
        2) Forced direction vent.
        3) No requirement for minimum water flow rate.
        4) Input heating capacity: Min 17,000 btu/hr; Maximum 180,000 btu/hr.
        5) Heating coils: Stainless steel.
        6) Electrical requirements:
            a) Voltage: 120 volts.
            b) Power: 200 watts.
            c) Amperage: Maximum 2 amps.
    b. Manufacturers: One of the following or equal:
        1) Navient, model as indicated on the Drawings.

G. Surge arresters:
   1. Water hammer arresters:
      a. Provide water hammer arresters with stainless steel shell, hydro-pneumatic cushion of argon gas, elastomer bellows, stainless steel adapter, and female threaded plug.
      b. Size arresters for each fixture supply branch: Determined in accordance with the PDI Standard PD1-WH201.
      c. Manufacturers: One of the following or equal:
         1) Jay R. Smith Manufacturing Company, Series 5000.
         2) Josam Company 75000.
         3) Zurn Industries, Inc., Series Z-1700.

PART 3 EXECUTION

3.01 PREPARATION

A. Rough-in fixtures and accessories in accordance with the dimensions supplied by the manufacturers of the fixtures.

3.02 INSTALLATION

A. General:
   1. Mount fixtures and accessories without cutting of finish surface.
   2. Make cross connections between piping for domestic water supply and piping for contaminated sources only by means of appropriate connection devices that prevent backflow from the contaminated sources to the domestic water supply.
      a. Provide connection devices approved by the Public Health authorities having jurisdiction over the Work.
   3. Conceal plumbing piping unless otherwise indicated on the Drawings or specified in the specifications.
   4. Furnish and install vents required in drainage piping as part of the plumbing system, in accordance with Laws and Regulations.
   5. Insulate hot water piping.

B. Drain, waste, and vent piping:
   1. Where not specified otherwise, install horizontal piping with a grade of 1/4 inch per foot.
   2. Provide vents, roof drains, and pipes flashed and made watertight at the roof with lead sheet flashings.
   3. Extend flashing not less than 6 inches up the pipes, and counterflash with standard cast iron or malleable iron recessed roof couplings.
   4. Extend flashing for vents up to the top of the vent and turn down into the pipe.
   5. Extend flashing shields not less than 8 inches from vent and pipe in all directions.

C. Plumbing piping accessories:
   1. Provide cleanouts of the same size as the size of the waste and drain piping on which cleanouts are installed, up to 4 inches in diameter. Provide cleanouts 4 inches in diameter on waste and drain piping larger than 4 inches diameter.
   2. Provide traps at all fixture and equipment connections to the sanitary drainage system. Install traps as near to the fixtures as possible.

3. Sizes of equipment drains and of floor drains shall be as indicated on the Drawings.
4. When indicated on the Drawings, cut holes in heavy-duty floor drain grate for a drainpipe from equipment or other source.

D. Water softeners:
1. Install water-softening equipment in accordance with manufacturer's instructions. Provide piping for drain and overflow connections to the equipment drains.

3.03 FIELD QUALITY CONTROL

A. Testing:
1. Test soil, waste, drain, and vent lines as specified and in accordance with plumbing code as specified in Section 01410.
2. Test water piping with water under a pressure of 100 pounds per square inch.
3. Repair and correct defective work disclosed by testing. Repeat testing until defective work is corrected.

3.04 CLEANING

A. Flush piping and leave clean, as required by public health authorities having jurisdiction over the Work.

END OF SECTION

SECTION 15430

EMERGENCY EYE/FACE WASH AND SHOWER EQUIPMENT

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Emergency shower and eyewash.

B. Related section:
   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 15050 - Common Work Results for Mechanical Equipment.
      b. Section 16050 - Common Work Results for Electrical.

1.02 REFERENCES

A. American National Standards Institute (ANSI):
   1. Z358.1 - Emergency Eyewash and Shower Equipment.
   2. Z535.1 - Safety Color.

B. American Society of Mechanical Engineers (ASME).

C. National Electrical Manufacturers Association (NEMA).

D. National Fire Protection Association (NFPA).

E. California Department of Occupational Safety and Health Administration (Cal-OSHA).

F. Underwriters Laboratories, Inc. (UL).

1.03 SUBMITTALS

A. Shop drawings.

B. Product Data:
   1. Submit manufacturer's product literature information for products specified.
   2. Manufacturer's Installation Instructions.

C. Operation and Maintenance Data.

D. Warranty.
   1. Refer to Section 15050.

1.04 QUALITY ASSURANCE

A. Manufacturer qualifications: Show evidence that the firm has been engaged in producing such materials and products for at least 5 years and that the product submitted has a satisfactory performance record of at least 5 years.

B. Installer qualifications: Installer shall have 3 years experience in installing these materials for similar projects and shall be approved by the manufacturer prior to bidding of the project.

C. Regulatory requirements:
   1. As applicable, equipment of this Section shall comply with requirements of public agencies of the state where the project is located including ASME, Cal-OSHA, NFPA, OSHA, and UL.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Packing and shipping: Deliver to the job site in manufacturer's original containers.

B. Delivery: After wet operations in building are completed.

C. Storage and protection:
   1. Store materials in original, unopened containers in compliance with manufacturer's printed instructions.
   2. Keep materials dry until ready for use.
   3. Keep packages of material off the ground, under cover, and away from sweating walls and other damp surfaces.
   4. Protect finished surfaces from soiling and damage during handling and installation. Keep covered with a protective covering.

PART 2 PRODUCTS

2.01 EMERGENCY SHOWERS AND EYE/FACE WASHES

A. General design requirements:
   1. Combination unit emergency shower with eye/face wash:
      a. Floor mounted fixture consisting of pipe standard, showerhead assembly, and eyewash assembly.
      b. Provide stanchion and floor flange, with interconnecting piping.
      c. Provide shower/eyewash unit with integral controls to alarm the system is in use.
         1) Flow switch:
            a) Construction:
               (1) NEMA Type 7 in hazardous Areas.
               (2) NEMA Type 4X in all other areas.
               (3) Type 316 Stainless Steel.
            b) Type: Paddle switch or similar displacement technology.
            c) Alarm Contacts: Double pole, double throw contacts rated at 2.0 Amps at 120VAC configurable for either Normally Open or Normally Closed.
   2. Showerhead flow: 20.0 gallons per minute flow, minimum.
   3. Eye/face wash flow: 3.0 gallons per minute flow, minimum.

4. Meet or exceed all requirements of ANSI Z358.1.
5. Provide ANSI compliant identification sign and markings.

B. PVC combination unit emergency shower and eye/face wash:
1. Manufacturers: One of the following or equal:
   a. HAWS, Model No. 8336.
   b. Guardian Equipment, Model No. G1990.
   c. Bradley, Model No. S19-310PVC.
2. Pipe standard: 2 inch Schedule 80 PVC pipe and fittings, with stainless steel rod providing additional support overhead; 2-1/2-inch diameter floor flange.
3. Shower head:
   a. Material and size: ABS plastic, 10-inch diameter.
   b. Valve and actuator: Type 316 stainless steel stay open steel ball valve actuated by rigid stainless steel pull rod.
4. Eye/face wash:
   a. Valve and actuator: Stay open Type 316 stainless steel ball valve with stainless steel ball operated by stainless steel push handle.
   b. Head(s): ABS plastic or polypropylene soft-flow eye/face wash type heads, with integral flip top protective dust covers releasing with water pressure.
   c. Receptor bowl: ABS plastic.

C. Stainless steel combination unit emergency shower and eye/face wash:
1. Manufacturers: One of the following or equal:
   a. HAWS, Model No. 8330.
   b. Guardian Equipment, Model No. G1996.
   c. Bradley, Model No. S19-310SSJP.
2. Pipe standard: 1-1/4 inch stainless steel pipe and fittings, with stainless steel rod providing additional support overhead; 5 inch diameter floor flange.
3. Shower head:
   a. Material and size: Stainless steel, 10-inch diameter.
   b. Valve and actuator: Stay open Type 316 stainless steel ball valve actuated by rigid stainless steel pull rod.
4. Eye/face wash:
   a. Valve and actuator: Stay open Type 316 stainless steel ball valve with stainless steel ball operated by stainless steel push handle and foot treadle.
   b. Heads: Twin ABS plastic, polypropylene or stainless steel soft-flow eye/face wash type heads, with integral protective dust covers.
5. Receptor bowl: Stainless steel.

D. Safety shower tester:
1. Manufacturers: One of the following or equal:
   a. Haws, Model No. 9010 with No. 9009.
   b. Guardian Equipment, Model No. AP250-005.
   c. Bradley, Model No. S19-330ST.
2. Kit includes:
   a. Minimum 5 gallon plastic bucket
   b. 7 foot long watertight 12-gallon translucent vinyl plastic bag for attaching over drench showerhead.
      1) Bag shall have drawstring at top and be hemmed at bottom.
   c. Testing record card.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install products in accordance with manufacturers' recommendations.

B. Install fixed equipment in accordance with manufacturer's instructions.

C. Plumbing and mechanical work as specified in Section 15050.

D. Electrical connections and distribution as specified in Section 16050.

3.02 PROTECTION

A. Repair or replace defective equipment with new.

3.03 EQUIPMENT APPLICATION SCHEDULE

A. Furnish and install emergency showers and eye/face wash units in accordance with the following schedule.

Equipment Type and Style	Application
PVC combination unit emergency shower and eye/face wash	Inside or around Chemical Facility
Stainless steel combination unit emergency shower and eye/face wash	All other applications
Safety shower tester	Provide two

END OF SECTION

SECTION 15732

AIR CONDITIONING UNITS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Packaged electric cool air conditioning units

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 01410 - Regulatory Requirements.
      b. Section 01610 - Project Design Criteria.
      c. Section 01612 - Seismic Design Criteria.
      d. Section 01614 - Wind Design Criteria.
      e. Section 01740 - Warranties and Bonds.
      f. Section 15050 - Common Work Results for Mechanical Equipment.
      g. Section 15082 - Piping Insulation.
      h. Section 15820 - Ductwork Accessories.
      i. Section 15936 - Heating, Ventilating, and Air Conditioning Controls.
      j. Section 15954 - HVAC Systems Testing, Adjusting, and Balancing.
      k. Section 16050 - General Requirements for Electrical Work.
      l. Section 16060 - Grounding and Bonding.
      m. Section 16075 - Electrical Identification.
      n. Section 16123 - 600 Volt or Less Wires and Cables.
      o. Section 16130 - Conduits.
      p. Section 16134 - Boxes.
      q. Section 16140 - Wiring Devices.
      r. Section 16222 - Low Voltage Motors up to 500 Horsepower.

1.02 REFERENCES

A. Air-Conditioning, Heating, and Refrigeration Institute (AHRI):
   1. 210-240 - Performance Rating of Unitary Air-Conditioning and Air-Source Heat Pump Equipment.
   2. 270 - Sound Rating of Outdoor Unitary Equipment.
   3. 340/360 - Performance Rating of Commercial and Industrial Unitary Air-Conditioning and Heat Pump Equipment.

B. American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE):
   1. Standard 15 - Safety Standard for Refrigeration System.
   2. Standard 52.2 - Methods of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size.
   3. Standard 62.1 - Ventilation for Acceptable Indoor Air Quality.

C. American National Standards Institute (ANSI):
   1. Z21.47 - Gas Fired Central Furnaces (except Direct Vent Central Furnaces) with Addenda.

D. Air Movement and Control Association International, Inc. (AMCA):
   1. 210 - Laboratory Methods for Testing Fans for Certified Aerodynamic Performance Rating.

E. Federal Specification (FS):
   1. Standard 141 - Paint, Varnish, Lacquer and Related Materials: Methods of Inspection, Sampling and Testing.

F. National Electric Code (NEC).

G. National Electrical Manufacturers Association (NEMA):
   1. 250 - Enclosures for Electrical Equipment (1000 V Maximum).

H. National Fire Protection Association (NFPA):
   1. 54 - National Fuel Gas Code.
   2. 90A - Standard for the Installation of Air Conditioning and Ventilating Systems.

I. National Roofing Contractors Association (NRCA).

J. Underwriters' Laboratories, Inc. (UL).

K. Title 24 of the California Code of Regulations (Title 24).

1.03 DEFINITIONS

A. NEMA Type 3R enclosure in accordance with NEMA 250.

1.04 SYSTEM DESCRIPTION

A. Design requirements:
   1. Seismic supports: Design support to meet criteria as specified in Section 01612.
   2. Wind supports: For exterior units, design support that meet the criteria as specified in Section 01614.
   3. Electrical components: UL listed and met the design and installation requirements of the NEC.
   4. Gas, water piping, drains, and venting: In accordance with building code, mechanical code, and plumbing code a specified in Section 01410 and in accordance with NFPA 90A.
   5. Motors: As specified in Section 16222.
   6. Fans: Rated in accordance with AMCA 210.

7. Unit air conditioners: Rated in accordance with AHRI Standards 210-240 or 340/360 and AHRI 270. Conform to the latest version of ASHRAE 15.
8. Unit air conditioners with heating options: Certified in accordance with ANSI Z21.47.
9. Refrigerant: HFC R-410A.
10. For projects located in California, comply with energy efficiency requirements of Title 24.

B. Performance requirements:
1. As specified and as listed on the Air Conditioning Unit Schedule at the end of this Section.
2. Outdoor noise levels: Outdoor noise levels in the 8 octave band range as measured in accordance with AHRI Standard 270 for unit air conditioners and split system condensers shall not exceed the following:

Unit Nominal Capacity (tons)	**Octave Bands (Hertz)**							
	63	**125**	**250**	**500**	**1,000**	**2,000**	**4,000**	**8,000**
3 to 5	64	70	71	74	74	71	67	61
6	79	85	78	74	71	73	66	59
7-1/2 to 10	64	70	73	79	82	78	74	67
12-1/2 and larger	84	88	84	83	84	78	72	68

3. Units shall be capable of starting and running at 125 degrees Fahrenheit ambient outdoor air temperature and exceeding the maximum load criteria of AHRI Standard 210-240 or 340/360.
4. Cooling capacities and energy efficiency ratios: Provide units with the following cooling capacities and energy efficiency ratios (EER) as rated in accordance with AHRI 210-240 or 340/360 and 270, unless scheduled OTHERWISE.

Nominal Capacity (tons)	**Air Fan (scfm)**	**Net Cooling Cap (Btu/h)**	**EER(1)**
3	1,200	37,000	10.3
4	1,600	48,500	10.3
5	2,000	63,000	10.3
6	2,100	72,000	10.3
7-1/2	2,750	94,000	10.3
8-1/2	3,000	102,000	10.3
10	4,000	122,000	10.3
12-1/2	4,500	142,000	9.7

Notes:
(1) Deduct 0.2 from the required EERs for units with a heating section other than electric resistance heat.

5. Units with heating capabilities: Meet or exceed the following efficiencies:
   a. Annual fuel utilization efficiency: 80 percent.

b. Steady state efficiency: 80 percent.
c. For projects located in California, California seasonal efficiency: 76.9 percent.

6. Unit air flows for cooling: A minimum of 300 cubic feet per minute per ton but not exceeding 500 cubic feet per minute per ton of cooling unless scheduled otherwise.
7. Air filters: 25 to 30 percent efficiency when rated in accordance with ASHRAE Standard 52.2.

C. Electrical and controls:
1. Design and supply necessary electrical power and control systems, components, and wiring to make a complete functioning system. Design to perform the system ventilating functions with the control systems as specified in Section 15936 or as indicated on the Drawings and as specified in the following Sections:
a. Section 16050.
b. Section 16060.
c. Section 16075.
d. Section 16123.
e. Section 16130.
f. Section 16134.
g. Section 16140.
h. Section 16222.

1.05 SUBMITTALS

A. Shop drawings:
1. System layout, mechanical, electrical power, and control diagrams.
2. Materials.
3. Supports and seismic bracing calculations and details.
4. Cut sheets on all primary and ancillary equipment.
5. Proposed cutting and patching.
6. Maximum recommended equipment vibration levels and field-testing method.
7. Noise levels in 8 octave bands showing compliance with specified levels.
8. Copy of all factory test results.

B. Operation and Maintenance Data.

C. Warranties.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Deliver units in 1 piece, factory assembled, piped, internally wired, charged with refrigerant and compressor oil, and tested.

B. Protect equipment from dust and atmospheric exposure:
1. Provide temporary closures for equipment openings designed for airflow.

C. Protect equipment from dust and atmospheric exposure as recommended by the unit manufacturer.
1. Provide temporary closures for equipment openings designed for airflow.

1.07 SITE CONDITIONS

A. As specified in Section 01610.

B. Units shall be capable of starting and operating in ambient temperatures as specified in this Section.

1.08 WARRANTY

A. Special warranties: From the date specified in Section 01740.
   1. 5-year warranty: All components.
   2. 5 years: For refrigerant compressors and closed or sealed refrigerant systems.
   3. 5 years: For gas fired heat exchangers.
   4. 5 years: For evaporator and condensing coils.

1.09 MAINTENANCE

A. Extra materials:
   1. Provide 2 extra sets of filters per unit installed.
   2. Provide 1 extra set of drive belts for each size belt system provided.

PART 2 PRODUCTS

2.01 PACKAGED ELECTRIC-COOL AIR CONDITIONING UNITS

A. Manufacturers: One of the following or equal:
   1. Trane, Series TSC for units 3 to 10 tons; TSH for units 12 to 25 tons.
   2. Carrier:
      a. Constant air volume: Series 50PG for units 2 to 25 tons; 50PM for units 15 to 25 tons.

B. Compressors:
   1. Fully hermetically sealed, high efficiency, reciprocating or scroll type, with internal and external vibration isolation.
   2. Equipped with high-pressure relief.

C. Fans:
   1. Evaporator (supply) fan:
      a. Direct or belt driven, forward curved, double inlet, centrifugal type, steel with corrosion resistant finish, statically and dynamically balanced.
      b. Permanently sealed ball bearings and permanently lubricated.
   2. Condenser fan:
      a. Propeller type, direct drive, aluminum blades, dynamically balanced, and vertical discharge.
      b. Permanently sealed ball bearings and permanently lubricated.
   3. Induced draft blower:
      a. Direct or belt drive, single inlet, forward curved centrifugal type, statically and dynamically balanced.
      b. Made from steel with corrosion resistant finish.

D. Coils:
   1. Evaporator and condenser coils, seamless copper tubes with mechanically bonded aluminum plate fins.
   2. Evaporator and condenser coils, internal piping, and appurtenances: Factory applied phenol-formaldehyde thermosetting resinous coating (Heresite) or complete coat.

E. Refrigerant components: Refrigerant circuit including:
   1. Accumulator.
   2. Filter drier.
   3. Expansion device.
   4. Gauge ports.
   5. Flow control valves.
   6. Circuit feed system.
   7. Service gauge connections on suction, discharge, and liquid lines to charge, evacuate and contain refrigerant.

F. Controls and equipment safety features:
   1. Provide system controls for a complete and properly functioning system that operates as specified in Section 15936. Provide, as a minimum, the following:
      a. Condenser fan controls.
      b. Evaporator fan controls.
      c. Motor contactors.
      d. 24-volt control circuit and transformer if 24-volt control is specified in the Air Conditioning Unit Schedule.
      e. Manually resettable circuit breakers.
      f. Electronic thermostat.
      g. 5-minute compressor cycle delay.
      h. Differential enthalpy economizer control.
      i. Check filter switch suitable for field connection remote alarm.
      j. 2-stage cooling.
   2. Equipment safety features, include:
      a. High-pressure switches.
      b. Compressor overtemperature and overcurrent.
      c. Loss of charge/low pressure switch.
      d. Freeze stat on evaporator.
      e. Lock out protection.

G. Electrical:
   1. Unit power and control wiring entering unit cabinet at 1 location.

H. Unit casing:
   1. Manufactured of minimum 22-gauge galvanized steel, bonderized, corrosion protected, and exterior coated with a baked enamel finish interior primer coated. Coating shall withstand Federal Test Method Standard 141 (Method 6061) 500-hour salt spray test.
   2. Weatherproof design, reinforced, and braced for maximum rigidity.
   3. Indoor air section compartment: Insulated with minimum 1/2-inch thick, permanent, fireproof, odorless glass fiber material, and coated on the air side.
   4. Provide gasketed removable panels or access doors to service equipment components and connections.

5. Provide with:
    a. Filter rack for 2-inch filters accessible through hinged access door.
    b. Non-corrosive drain pan in accordance with ASHRAE Standard 62.1.
    c. Minimum 3/4-inch horizontal drain connection.
    d. Knockouts for utility and control connections.
    e. Minimum 14 gauge steel roll formed base rail with lifting holes.

I. Filter section:
1. Low velocity 2-inch thick pleated filters of commercially available sizes.
2. Filter face velocity: Not to exceed 350 feet per minute nominal flow.
3. All filters for any 1 unit shall be the same size.
4. Manufacturers: The following or equal:
    a. American Air Filter.
    b. Airguard.

J. Motors:
1. As specified in Section 16222, except as modified in this Section:
    a. Compressor motors: Cooled by refrigerant gas passing through windings and with line break thermal and current overload protection.
    b. Evaporator fan motor, condenser fan motor, and induced draft blower motor: Permanently lubricated ball bearings and inherent automatic reset thermal overload protection.

K. Accessories:
1. Roof curb:
    a. Factory fabricated of 16-gauge galvanized steel with wood nailer strip and gaskets.
    b. Capable of supporting entire unit weight.
    c. Suitable for installing and connecting ductwork to curb.
    d. In accordance with NRCA Standards.
    e. Shall extend a minimum of 8 inches above top of built up roofing, but shall be no less than 14 inches high. Flashing in accordance with NRCA Standards.
2. Economizer:
    a. Integrated type capable of compressor operation while modulating to utilize up to 100 percent outdoor air for cooling when outdoor air and humidity are at set acceptable levels.
    b. Including:
        1) Differential bulb enthalpy control.
        2) Damper drive motor.
        3) Gravity relief damper.
        4) Low leakage dampers, not to exceed 3 percent leakage at 1-inch static pressure.
3. Thermostat and subbase: When control system is not specified in Section 15936, provide:
    a. 1-stage heating and 2-stage cooling.
    b. Automatic changeover with heat-cool-auto-off settings.
    c. Fan control on-off-auto settings.
    d. Digital temperature and setpoint indication.
    e. Indicator light for unit failure.
    f. Programmable electronic night setback for cooling and heating with 7-day programming capability.
    g. Wall mounted.

h. Necessary contacts for unit operation as specified in Section 15936.
i. Adjustable heating and cooling setpoints.

4. Compressor cycle delay to prevent compressor from a minimum of 5 minutes after shutdown.
5. Differential enthalpy sensor for economizer control.
6. Hail guard to protect against damage from hail and other flying debris.
7. Check filter switch with contacts for field installed remote light or alarm.
8. Coil guard grill to protect condenser coil from penetration by large objects.
9. 15-amp convenience outlet, ground fault interrupter receptacle, factory installed transformer, and independent fuse protection.
10. Provide flexible duct connectors where duct connects to the unit.

2.02 SOURCE QUALITY CONTROL

A. Completely factory test each unit in cooling and heating (if unit is supplied with heating option) modes including economizer operation. Coils and cooling system shall then be evacuated for 30 minutes prior to final charging of unit before shipment.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine and verify that Work is in condition to receive installation specified in this Section.
   1. Take measurements and verify dimensions to ascertain fit of installation.
   2. Ascertain structural sufficiency to support installation.
   3. Ascertain that supports and openings are correctly located; otherwise cut new openings where required.
      a. Submit details of proposed cutting and patching.
   4. Confirm specified thermostat or other controls are compatible with specified equipment.

B. Examine and verify structural details and sections indicated on the Drawings, ascertain adequacy, and determine conflicts in dimensions and clearances.

3.02 PREPARATION

A. Before installation, remove dust and debris from equipment and ducts.

B. During installation and until equipment is operated, protect equipment and ducts from dust and debris by covering openings with tape or plastic.

3.03 INSTALLATION

A. Observe applicable installation requirements as specified in Section 15050.

B. Anchoring and support:
   1. Provide anchoring and support designed in accordance with current engineering practice for equipment and appurtenances by attaching or connecting to supporting members or by providing other supports.

C. Adjust alignment of ducts where necessary to resolve conflicts with architectural features or to resolve conflicts with the work of other trades.

D. Install and wire unit air conditioners, controls, and thermostats in accordance with manufacturer's recommendations.

E. Provide flexible duct and flexible piping connections at connections to unit air conditioners.

F. Install roof curb and unit as recommended by unit manufacturer.

G. Install NRCA approved flashing and counterflashing.

H. Provide venting in accordance with building code, mechanical code, and plumbing code as specified in Section 01410 and in accordance with NFPA 54.

I. Upon completion of installation, clean duct, and debris from ductwork, and equipment.

3.04 FIELD QUALITY CONTROL

A. Test equipment and installation to verify tightness, operation, unit air conditioner vibration within manufacturer's submitted maximum, and that outdoor sound power at levels measured in accordance with manufacturer's submittal recommended procedure does not exceed the specified performance requirements for outdoor noise levels.

B. Test equipment performance and balance equipment as specified in Section 15954.

3.05 SCHEDULES

A. Air Conditioning Unit Schedule: Refer to the Administration and Maintenance Building drawings for additional equipment and requirements.

Air Conditioning Unit Schedule											
		Evaporator					Condenser	Heating	Unit Power		Other Requirements
Equip. No. and Type	Location	Total/ Sensible (MBH)	Air Fan CFM	Fan ESP, "WC	Inlet DB/WB (degrees F)	Outlet DB/WB (degrees F)	Inlet Air DB (degrees F)	Gas Btu/hr	Volts/ Phases/ MCA	OSA (cfm)	See Notes at end of Schedule for Requirements
51-ACU-470	Sludge Dewatering Building - Electrical Room	115	4,500	0.8	82/67	59/54	90	-	460/3/40	40	2, 5, 6, 13, 15, 18, 20, 21, 23
70-ACU-440	Electrical Building-Electrical room	70	2,860	0.8	82/67	59/54	90	-	460/3/30	30	2, 5, 6, 13, 15, 18, 20, 21, 23

Notes:
1. Roof-Mounted Single Unit Package.
2. Base-/Floor-Mounted Single Unit Package.
14. Provide Indoor Air Handling Unit with Direct Drive Fan.
15. Provide Indoor Air Handling Unit with Belt Drive Fan and

Air Conditioning Unit Schedule											
		Evaporator					Condenser	Heating	Unit Power		Other Requirements
Equip. No. and Type	Location	Total/ Sensible (MBH)	Air Fan CFM	Fan ESP, "WC	Inlet DB/WB (degrees F)	Outlet DB/WB (degrees F)	Inlet Air DB (degrees F)	Gas Btu/hr	Volts/ Phases/ MCA	OSA (cfm)	See Notes at end of Schedule for Requirements

3. Roof-Mounted Condenser Split System.
4. Base-/Floor-Mounted Condenser Split System.
5. Side Supply Discharge Connection.
6. Side Return Connection.
7. Bottom Supply Discharge Connection.
8. Bottom Return Connection.
9. Provide Electric Heating.
10. Provide Natural Gas Heating.
11. Provide LPG Gas Heating.
12. 120-Volt Control Voltage.
13. 24-Volt Control Voltage.

Adjustable Sheaves.

16. Provide duct-mounted Fan Coil Unit in accordance with Section 15841 sized for scheduled conditions.
17. Provide Outside Air Manual Damper.
18. Provide Economizer.
19. Thermostat Provided by CONTRACTOR.
20. Thermostat Provided by AC Unit Manufacturer.
21. Control system specified in Section 15936.
22. Wall-mounted unit with self-contained controls.
23. Include service option with return-air smoke detector sensor to be wired in field to shut down unit upon detection of smoke.
24. Split System Unit.

END OF SECTION

SECTION 15762

HEATING UNITS

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Electric Unit Heaters (EUH).
   2. Thermostats for unit heater.

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 01612 - Seismic Design Criteria.
      b. Section 01614 - Wind Design Criteria.
      c. Section 15050 - Basic Mechanical Materials and Methods.
      d. Section 15936 - HVAC Controls.
      e. Section 15954 - HVAC Testing, Adjusting, and Balancing.
      f. Section 16222 - Motors.

1.02 REFERENCES

A. International Conference of Building Officials (ICBO):
   1. Uniform Building Code (UBC).
   2. Uniform Mechanical Code (UMC).

B. International Association of Plumbing and Mechanical Officials (IAPMO):
   1. Uniform Plumbing Code (UPC).

C. National Electric Code (NEC).

D. National Fire Protection Association (NFPA).

E. Underwriters Laboratories (UL).

F. Title 24 of California Code of Regulations (Title 24).

1.03 SYSTEM DESCRIPTION

A. Design Requirements:
   1. Provide seismic and wind supports meeting the seismic design criteria as specified in Section 01612 and wind design criteria for exterior units as specified in Section 01614.

2. Electrical components: UL listed and meeting the design and installation requirements of the NEC.
3. Hot water piping, gas piping, drains, venting, and other appurtenances of unit heaters: Comply with installation requirements of the Uniform Mechanical Code, the Uniform Plumbing Code, and the National Fire Protection Association.
4. Noise levels for unit heaters installed in offices, hallways, or entry areas: Not to exceed 10 Sones as measured in accordance with AMCA Publication 302.
5. Motors supplied with heating units: As specified in Section 16222.
6. Heaters: For projects located in California, comply with efficiency requirements of Title 24, as set forth by the California Energy Commission.

B. Performance requirements are included in the Heating Unit Schedules at the end of this Section.

C. Design and supply necessary electrical power and control systems, components, and wiring to make a complete functioning system. Comply with referenced electrical Specification Sections and design to perform system-heating functions as a complete functioning system.

1.04 SUBMITTALS

A. Shop Drawings:
1. System layout, mechanical, electrical power, and control diagrams.
2. Materials.
3. Supports and seismic bracing calculations and details.
4. Cut sheets on primary and ancillary equipment.
5. Sound ratings of fans in Sones per AMCA Publication 302.
6. For projects located in California, certification of compliance with Title 24 efficiency standards and approval by the California Energy Commission.

B. Samples: Manufacturer's standard color chips for cabinets finish.

C. Certificates: Successful testing of burners used in gas unit heaters.

D. Operation and maintenance data.

E. Warranties.

1.05 QUALITY ASSURANCE

A. Provide heating units and controls that are listed by Underwriters' Laboratories.

B. Regulatory Requirements:
1. For projects located in California, comply with and install in accordance with Title 24 energy efficiency regulations.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Protect equipment from dust and atmospheric exposure as recommended by the unit manufacturer.

1.07 SITE CONDITIONS

A. As specified in Section 15050.

1.08 WARRANTY

A. As specified in Section 15050, except heating elements and coils.

B. Heating Elements and Coils: 10-year warranty.

PART 2 PRODUCTS

2.01 ELECTRIC UNIT HEATERS (EUH)

A. Manufacturers: One of the following or equal.
   1. Trane, Type UHEC.
   2. Markel, Series 5100.
   3. Chromalox, Type LUH or VUH.

B. Fan Type: Aluminum axial flow.
   1. Provide fan guards.
   2. Dynamically balance.
   3. Fan designed for quiet operation.
   4. Permanently lubricated ball bearings.
   5. Automatic reset thermal overload protection.

C. Heating Element Characteristics:
   1. Rated capacity at entering air temperature of 65 degrees F.
   2. Fin type, steel plated heater elements, with elements brazed to common fins, designed for maximum strength and maximum heat transfer.
   3. 3-phase designed for balanced phases.
   4. Over temperature cut-out with automatic reset.

D. Features:
   1. Built-in magnetic contactors.
   2. Control transformer for 24- or 120-volt control as indicated in the Heating Unit Schedules.
   3. Required mounting brackets.
   4. Individually adjustable outlet louvers.
   5. Cabinet formed of minimum thickness 18-gauge steel with steel stiffeners.
   6. Controls:
      a. Provide Integral thermostat.
      b. Provide control transformer suitable for 24-volt or 120-volt control as indicated in the Heating Unit Schedules.

E. Finishes:
   1. Casing finish backed enamel in manufacturer's standard color.

2.02 THERMOSTATS FOR UNIT HEATERS

A. Type: Integral, heat only with fan AUTO-ON selector switch when fan part of unit and separate system ON-OFF selector switch.

B. Dial or lever temperature setpoint adjustment with 45 to 90 degrees F setpoint range.

C. Setpoint and temperature indication.

D. Control voltage as indicated in the attached Heating Unit Schedules.

E. Bi-metallic or mercury contacts suitable for 1- or 2-stage unit heater control as specified for the heater size or as scheduled.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine and verify that Work is in condition to receive installation specified in this Section.
   1. Take measurements and verify dimensions to ascertain fit of installation.
   2. Ascertain structural sufficiency to support installation.
   3. Ascertain that chassis, shafts, and openings are correctly located. Otherwise cut new openings where required.
   4. Confirm specified thermostat and other controls are compatible with specified equipment.

B. Examine and verify structural details and sections indicated on the Drawings, ascertain adequacy, and determine possible conflicts in dimensions and clearances.

3.02 PREPARATION

A. Before installation, remove dust and debris from equipment and ducts.

B. During installation and until equipment is operated, protect equipment and ducts from dust and debris by covering openings.

3.03 INSTALLATION

A. Anchoring and Support: Install anchoring for seismic and wind forces to meet the design criteria specified in Sections 01612 and 01614.

B. Alignment: Adjust ductwork alignment when necessary to resolve conflicts with architectural and structural features or to resolve conflicts with work of other trades.

C. Install and wire unit heaters and thermostats in accordance with manufacturer's recommendations.
   1. Provide disconnect switches at the unit heaters wherever indicated on the Drawings, specified in this Section, scheduled and wherever required by code.

D. Adjust heater units with louvers for optimum air circulation.

3.04 FIELD QUALITY CONTROL

A. Test equipment and installation to verify operation is within manufacturer's standards and that noise levels do not exceed levels specified.

B. Test equipment performance and balance equipment in accordance with Section 15954.

3.05 HEATING UNIT SCHEDULES

A. Electric Heating Unit Schedule. Refer to the Administration and Maintenance Building drawings for additional equipment and requirements.

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ELECTRIC HEATING UNIT SCHEDULE

Equip. No.	Location	Capacity		Fan		Additional Requirements (see Schedule Notes)
		Input kW/V/Ph.	Output MBH	cfm	hp	
70-HTR-722	Solids Handling Building Unit Heater No. 1	5/480/3	17.1	400	1/125	3, 5, 7, 8, 11, 13, 15

Notes:
(1) Steam service.
(2) Hot water service.
(3) Electric service.
(4) Thermostat provided by CONTRACTOR.
(5) Thermostat provided by heater manufacturer.
(6) Horizontal mounting.
(7) Vertical mounting.
(8) Wall mounting.
(9) Floor mounting.
(10) Recessed mounting.
(11) 24-volt control voltage.
(12) 120-volt control voltage.
(13) Fan direct drive.
(14) Fan belt drive.
(15) Unit located inside building (indoors).
(16) Unit located on roof or building exterior.
(17) Natural gas fired.
(18) Liquefied petroleum gas fired.
(19) Unit flange mounted.
(20) Unit slip-in mounted.
(21) Provide stainless steel UH exchanger.
(22) Provide stainless steel UH gas burner.
(23) Side air intake to fan.
(24) Side air discharge.
(25) Down air discharge from unit.
(26) Down air inlet.
(27) Provide unit suitable for NEC Group D, Class 1, Division 1 hazardous location.

END OF SECTION

SECTION 15812

METAL DUCTWORK

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes: Aluminum ductwork.

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 01612 - Seismic Design Criteria.
   b. Section 15052 - Basic Piping Materials and Methods.
   c. Section 15053 - Seismic Restraints for Piping.
   d. Section 15061 - Pipe Supports.
   e. Section 15084 - Ductwork Insulation.
   f. Section 15954 - HVAC Systems Testing, Adjusting, and Balancing.

1.02 REFERENCES

A. American Society for Testing and Materials (ASTM):
1. B 209 - Specification for Aluminum and Aluminum-Alloy Sheet and Plate.

B. Sheet Metal and Air Conditioning Contractors' National Association (SMACNA):
1. Heating Ventilation Air Condition Duct Construction Standards - Metal & Flexible.
2. Seismic Restraint Guidelines for Mechanical Systems.

1.03 SYSTEM DESCRIPTION

A. Design Requirements:
1. Custom design and fabricate metal ductwork for the applications indicated on the Drawings and for the conditions specified.
2. Conform to SMACNA Manual for gauge of sheet metal, joint types, reinforcement, bracing, hangers and supports, fabrication, and installation.
   a. Sheet Metal Thicknesses: The greater of that thickness required to conform to SMACNA for the design pressure specified and the following minimum thicknesses:

Diameter or Largest Dimension of Rectangular Duct (Inches)	Minimum Sheet Thickness, Inches (B&S Gauge)
Up to 12	0.025 (22)

Diameter or Largest Dimension of Rectangular Duct (Inches)	Minimum Sheet Thickness, Inches (B&S Gauge)
13 to 30	0.032 (20)
Larger than 31	0.040 (18)

b. Spacing of Hangers and Supports: Provide design of supports as required accordance with Sections 15053, and 15061. When supports are not shown, provide supports as required to conform to SMACNA but no greater than the spacing indicated on the Drawings or the following requirements; whichever is less:
   1) Ducts 18 Inches and Smaller in Largest Dimension: 8 feet on center.
   2) Ducts Larger Than 18 Inches and Smaller than 40 Inches in Largest Dimension: 8 feet on center.
   3) Ducts Over 40 Inches in Largest Dimension: 4 feet on center.

c. Support Connections: Provide design of support connections. Connections shall be accordance with SMACNA. As a minimum, all support connections to metal or wood roofs shall be located at roof framing members only. No penetrations through roof deck, roof membrane, or connections to roof membrane are acceptable.

3. Design Pressure: 2 inches water column unless otherwise indicated on the Drawings or specified.
4. Seismic Design Criteria: As specified in Sections 15053 and 15061 and SMACNA Seismic Restraint Guidelines for Mechanical Systems.
5. Hanger Reinforcement:
   a. Ducts 18 Inches and Smaller in Largest Dimension: None.
   b. Ducts over 18 Inches and Under 30 Inches in Largest Dimension: 1-1/2-inch by 1-1/2-inch by 1/8-inch angles, 8 feet on center.
   c. Ducts 30 Inches and Larger in Largest Dimension: 1-1/2-inch by 1-1/2-inch by 1/8-inch angles, 4 feet on center.
6. When ducts are specified with insulation on interior walls, size duct to provide clear inside dimensions indicated on the Drawings.
7. Materials for hangers and supports:
   a. Unless otherwise specified, restraints, including braces, pipe and structural attachments, shall match the pipe support material as specified in Section 15061.
   b. Nuts, bolts, and washers shall match materials specified for the nuts, bolts, and washers in Section 15061.

B. Miscellaneous Design Details:
1. Changes in Duct Size: Use uniformly tapering sections. Taper not more than 1 inch in 5 inches of run unless otherwise indicated on the Drawings.
2. Bends: With the exception of miter bends, design bends with inside radii equal to duct width or diameter.
   a. Install turning vanes at miter bends.
3. Duct Sleeves: Install duct sleeve when ducts pass through concrete or masonry walls, slabs, or ceilings.
4. Access Openings: Install in locations that allow access to dampers, fusible links, controllers, and similar devices.
5. Flexible Connections: Install at connections to air handling equipment and at locations indicated on the Drawings.

1.04 SUBMITTALS

A. Shop Drawings:
   1. Duct material and details of construction.
   2. System layout including floor and wall penetrations.
   3. Supports and anchoring details.
   4. Other materials and components for duct systems.

B. Product Data: Products and components used in the duct system including turning vanes, dampers, flexible connections, and access doors.

C. Design Data - Seismic Design Calculations:
   1. Design calculations for duct construction as specified in Section 15061 and SMACNA.

D. Warranties: As specified in Section 15050.

PART 2 PRODUCTS

2.01 MATERIALS

A. Ducts: Aluminum alloy 3003-H14 in accordance with ASTM B 209.

B. Flexible Connectors: 1/4-inch thick neoprene coated sheeting.

C. Turning Vanes: Match duct material.

D. Reinforcing: Formed or extruded aluminum angles.

E. Ductwork Insulation: As specified in Section 15084.

2.02 COMPONENTS

A. Duct Sleeves:
   1. Sleeve Flanges: 4 inches wide.
   2. Size: 2 inches larger than the duct or duct with external insulation.

B. Access Openings:
   1. Size: 2 inches less than duct size.
   2. Doors: Gauge not less than duct sheet. Provide continuous hinge and latch on outside.
   3. Gasket: Along door periphery.
   4. Visual Panel: 1/8-inch thick, clear plexiglass.

C. Turning Vanes:
   1. Material: Same as ductwork.
   2. Type:
      a. Single-blade vanes for duct widths less than 36 inches.
      b. Airfoil type vanes for duct widths of 36 inches and greater. No trailing edge.
   3. Mounted in side rails.
   4. Provide turning vanes for square-turn elbows and splitters.
   5. Size: 2-inch blades for ducts up to 18 inches, 4-1/2 inch blades for larger ducts.

D. Splitter Dampers: Provide at branch take-offs where necessary for balancing system.

E. Extractors:
   1. Components:
      a. Synchronized steel curved blades.
      b. Heavy side rails.
      c. Screw operator.
   2. Provide extractors at take-off from main supply duct adjacent to diffusers, registers, or grilles where splitter is not used.

2.03 FABRICATION

A. Fabricate ductwork to the configuration and dimensions indicated on the Drawings.

B. Dimensions indicate net free area. Increase duct dimensions by thickness of insulation when internal insulation is specified.

C. Do not utilize S-clips, duct tape, or externally applied mastic on medium pressure duct systems.

D. Do not use snap lock seams.

E. Provide flexible duct connectors at all connections to fans and other air movement equipment.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine and verify that Work is in condition to receive metallic ductwork as specified in this Section.
   1. Take measurements and verify dimensions on shop drawings to ascertain fit of installation.
   2. Ascertain that supports and openings are correctly located.

B. Examine and verify structural details and determine conflicts in dimensions and clearances.

3.02 INSTALLATION

A. Before installation, remove dust and debris from ducts.

B. Adjust duct alignment where necessary to resolve conflicts with architectural features or to resolve conflicts with the work of other trades.

C. Install ductwork to provide a system free of buckling, warping, or vibration.

D. Hangers: Install hangers as indicated on the Drawings. When hangers are not detailed, conform to SMACNA System Duct Design and Seismic Restraint Manual standards and the following requirements:
   1. Rectangular Ducts Concealed in Ceiling Spaces:
      a. Use metal strap hangers.

b. Fasten to sides of duct with two screws.
c. Fasten to bottom of duct with one screw.

2. Rectangular Ducts in Exposed Areas:
   a. Install shelf angle trapeze hangers or Unistrut type hangers.
   b. Install sway bracing as required by seismic calculations, minimum one brace at right angle to each duct run.
3. Round Ducts in Exposed Areas:
   a. Install two half-round bands with rods bolted to panels.
   b. Install sway bracing as required by seismic calculations, minimum one brace at right angle to each duct run.

E. Flexible Connections:
   1. Install with collar and metal band to form airtight joints.
   2. Install with minimum 4 inches of slack in fabric.
   3. Exterior Locations: Install sheet metal weather cover over fabric.

F. Provide closed-cell neoprene gaskets at flanged joints.

3.03 FIELD QUALITY CONTROL

A. Inspect ductwork under operating conditions. Correct audible leaks and leaks that can be felt with the hand.

B. Test and balance ducting systems as specified in Section 15954.

END OF SECTION

SECTION 15814

FIBERGLASS REINFORCED PLASTIC DUCTWORK

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes: Fiberglass reinforced plastic ductwork.

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 01600 - Product Requirements.
   b. Section 01740 - Warranties and Bonds.
   c. Section 06608 - Fiberglass Reinforced Plastic.
   d. Section 09960 - High-Performance Coatings.
   e. Section 15052 - Basic Piping Materials and Methods.
   f. Section 15053 - Seismic Restraints for Piping.
   g. Section 15061 - Pipe Supports.
   h. Section 15820 - Ductwork Accessories.

C. Inclusion of a specific manufacturer's name in the Specifications does not mean that the specific manufacturer's standard product will be acceptable. Specified manufacturer's or other manufacturer's standard product shall be modified as required to meet the Specifications.

1.02 DESIGN CRITERIA

A. Ducting Under Pressure Conditions: 12 inches water column.

B. Ducting Under Vacuum Conditions: 6 inches water column.

C. Support Spacing: As designed per Section 15061 and as needed to comply with wall thicknesses calculations but not greater than the following:
1. Contact-molded Ductwork: Maximum 5-foot centers.
2. Filament-wound Ducts: Maximum 12-foot centers.
3. Design support system with one support on either side of flexible connections.
4. Materials for hangers and supports:
   a. Unless otherwise specified, restraints, including braces, pipe, and structural attachments, shall match the pipe support material as specified in Section 15061.
   b. Nuts, bolts, and washers shall match materials specified for the nuts, bolts, and washers in Section 15061.

D. Minimum Flooding: Design ductwork for water accumulation as follows:
   1. Rectangular Ductwork: 1 inch deep across bottom of duct.
   2. Round Ductwork: 2 inches deep across bottom of duct.

E. Design Tensile Stress: Calculations for design of wall thickness assume a laminate ultimate tensile stress of 9,000 psi. maximum. Decrease ultimate tensile stress as appropriate to the laminate design.
   1. Round Ducting: The maximum allowable design tensile stress shall be the ultimate tensile stress divided by 5.
   2. Rectangular Ducting: The maximum allowable design tensile stress shall be the ultimate tensile stress divided by 10.

F. CONTRACTOR is specifically warned to review the requirements in Article 1.04. No deviation from the Specifications will be considered.

1.03 SUBMITTALS

A. Product Data: Composition of materials, configuration of external stiffeners, flexible connections, and technical data sheets for resins.

B. Shop Drawings:
   1. Drawings showing ductwork layout, dimensions, joint types, and support locations.
   2. Locations of external stiffeners and expansion joints.
   3. Fabrication details.
   4. Support locations, types, and details.

C. Calculations:
   1. Wall thickness calculations based upon design criteria.
   2. Stresses and reaction loads at supports.
   3. Comply with Section 06608.
   4. Manufacturer's Installation Instructions.
   5. Support calculations per Section 15061.

D. Warranties: As specified in Sections 01740 and 15050 and as complemented herein.
   1. Warrant product free of defects in material and workmanship, for 20 years from the date specified in Section 01740. Cover parts and labor.
   2. Issue warranty in the OWNER's name.

1.04 QUALITY ASSURANCE

A. Qualification of Ducting Manufacturer: Manufacturer with experienced personnel, physical facilities, and management capacity sufficient to produce custom-made, corrosion resistant fiberglass reinforced plastic products of quality and size specified with a minimum of 10 years satisfactory performance record.

B. Submit test results in accordance with Section 06608 verifying that ductwork meets standards specified. Also, comply with Section 06608 as to the requirements of FRP manufacturing and standard testing. If there is a conflict between this Section and Section 06608, the more stringent requirements shall govern.

C. Ductwork system supplier shall be the manufacturer of the ductwork. “Packagers” of the ductwork system that are not the manufacturer shall not be accepted.

PART 2 PRODUCTS

2.01 SCOPE OF SUPPLIES

A. Supply materials and labor to provide fiberglass reinforced plastic ducting, fasteners, field joints, expansion joints, and supports required for complete installation of a duct system as indicated on the Drawings.

2.02 MANUFACTURERS

A. Fiberglass Reinforced Plastic Ductwork: One of the following or equal:
   1. Daniel Mechanical, Upland, CA.
   2. Fiber-tech Engineering, Inc., Escondido, CA.
   3. Paramount Plastics, Rancho Cucamonga, CA.

B. Inclusion of a specific manufacturer’s name in the Specifications does not mean that the specific manufacturer’s standard product and the standard testing will be acceptable. Specified manufacturer’s standard product and standard testing shall be modified as required to meet the Specifications.

2.03 DUCTWORK MATERIALS

A. Comply with applicable portions of Section 06608.

B. Minimum Corrosion Liner:
   1. 1 "C" or Nexus veil as specified for the service environment.
   2. Remainder 1 1/2 ounce per square foot mat to total minimum thickness of 0.096 inch on surface exposed to the service environment.

C. Ultra Violet Stabilizer: Add to the exterior surface resin coat of fabrications intended for outside service, in the type and amount recommended by the resin manufacturer.

D. Resin: Fire-retardant premium vinyl ester as follows, unless otherwise recommended by the resin manufacturer for the service environment.
   1. Manufacturers: One of the following or equal:
      a. Dow, Derakane 530.
      b. Ashland, Hetron 992FR.
      c. Interplastic, VE 8440.
      d. Reichhold Dion, VER 9300FR.

E. Resin for Structural Layers: Resin with sufficient antimony trioxide or pentoxide for Class I fire rating.

F. Color:
   1. Add pigment to the exterior surface resin coat such that the color of the duct will be similar to the paint used for all equipment, except ducting for air conditioning systems concealed above suspended ceilings.
   2. Ducting for air conditioning systems concealed above suspended ceilings do not need to be pigmented.

2.04 DUCTWORK FABRICATION

A. Filament wound construction for round ducting and contact molded for rectangular ducting and in accordance with Section 06608.
   1. Wall thickness shall be sufficient to comply with design criteria but shall not be less than the minimum thicknesses requirements shown in the following table:

Duct Size	Round Ducting (wall thickness, inches)	Rectangular Ducting (wall thickness, inches)
For 18-inch and smaller	0.2	0.25
20- to 36-inch ducts	0.3	0.375
42- to 54-inch ducts	0.4	0.500
60- to 72- inch ducts	0.5	0.625

B. Fittings:
   1. Type: Contact molded.
   2. Wall Thickness: At least equal to the thickness of the thickest adjacent ducting.

C. Joints:
   1. Flanged or butt and strap joints.
   2. Gaskets for Flanged Joints: 1/8-inch neoprene over full flange face.
   3. Thickness of Butt and Strap Joint Overlays: At least equal to the thickness of the thickest adjacent duct.

D. Fasteners: Type 316 stainless steel.

E. Buried Foul Air Duct:
   1. FRP duct used for buried foul air exhaust shall be filament wound and shall be manufactured in accordance with ASTM D2996.
   2. Calculations determining wall thickness shall be submitted for review by the ENGINEER.
      a. Calculations shall bear the stamped seal of a Professional Engineer licensed in the State of California.
      b. The minimum wall thickness shall be in accordance with Article 2.04, Paragraph A or approved calculations, whichever is greater.
   3. The underground FRP duct shall be back filled and installed per manufacturer instructions.
   4. The underground FRP duct shall be designed to withstand H-20 live loads when buried using backfill compacted to a minimum of 95 percent.
   5. A 6-inch bed of sand shall be used to separate the FRP buried duct from the backfill.

6. Buried FRP duct shall be installed per ASTM D3839.
7. CONTRACTOR shall determine the thickness of the duct based on the requirements listed herein and on the soil bearing and dead load bearing pressures and soil covers.

2.05 FLEXIBLE CONNECTIONS

A. Manufacturers: One of following or equal:
   1. Belmont.
   2. Garlock.
   3. Ethylene Corporation.

B. Materials: Minimum 14-ounce neoprene encased canvas, flameproof, suitable for use in service environment.

C. Design:
   1. Number of volutes needed to satisfy axial and lateral movement requirements.
   2. Airtight at pressures encountered.

D. Elastomeric sleeves or boots may be used for direct expansion joints on low-pressure and low-vacuum systems.

2.06 DUCT SUPPORTS

A. Provide duct supports as indicated on the Drawings.

B. When duct supports are not indicated on the Drawings provide support and seismic bracing in accordance with the SMACNA Design Manual and in accordance with Sections 15052, 15053, and 15061.

2.07 DUCT AND PIPE COATING

A. Coat duct and pipe per Section 09960. Color to be selected by OWNER during construction.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install products in accordance with shop drawings and manufacturer's instructions.

B. Drawings indicated general routing only and shall be modified as necessary.

3.02 FLEXIBLE CONNECTIONS

A. Unless otherwise indicated on the plans, install flexible connections between ducting and rotating equipment and on maximum spacing of 30-foot centers. Flexible connections shall be of materials compatible with the intended service.

B. Restrain flexible connections by control rods.

END OF SECTION

SECTION 15815

FLEXIBLE DUCTWORK

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Flexible ductwork.

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 01612 - Seismic Design Criteria.
   b. Section 15954 - HVAC Systems Testing, Adjusting, and Balancing.

1.02 REFERENCES

A. National Fire Protection Association (NFPA):
1. 90A - Standard for the Installation of Air-Conditioning and Ventilating Systems.

B. Sheet Metal and Air Conditioning Contractors' National Association (SMACNA):
1. HVAC Duct Construction Standards - Metal and Flexible.
2. Seismic Restraint Manual: Guidelines for Mechanical Systems.

C. Underwriters Laboratories. Inc. (UL).
1. 181 - Factory-Made Air Ducts and Air Connectors.

1.03 SYSTEM DESCRIPTION

A. Design requirements:
1. Spacing of hangers and supports: As required in accordance with SMACNA and as required to maintain UL listing for the ducting but no greater than the spacing indicated on the Drawings or recommended by the manufacturer.
2. Changes in duct size: Use uniformly tapering aluminum connector sections; taper not more than 1 inch in 5 inches of run unless otherwise indicated on the Drawings.
3. Connections to registers: Support registers independently from ducting; collars to be 2 inches minimum length; attach duct to collar with stainless steel draw band.
4. Duct dimensions on the Drawings indicate net inside diameter; increase duct dimensions as required to obtain indicated diameter.
5. Meet UL 181 and be listed as Class 1 air duct in accordance with NFPA 90A.

1.04 SUBMITTALS

A. Shop drawings:
   1. Duct material and details of construction.
   2. System layout.
   3. Supports and anchoring details.
   4. Other materials and components for duct systems.

B. Product data: Products and components used in the duct system including turning vanes, dampers, flexible connections, and access doors.

C. Design data - seismic design calculations:
   1. Design calculations for duct support construction as specified in Section 01612 and in accordance with SMACNA.

PART 2 PRODUCTS

2.01 NON-METALLIC FLEXIBLE DUCTING

A. Manufacturers: The following or equal:
   1. C. A. Schroeder, Inc. Casco Silent Flex II.

B. Characteristics:
   1. Liner: Spunbonded non-woven nylon porous surface for sound absorption.
   2. Wire reinforcement: High carbon spring steel helix with zinc coating.
   3. Insulation: Fiberglass with thermal resistance R rating of 8.
   4. Outer jacket: Gray polyethylene jacket rated as UL Class 1 with 0.05 perm rating.
   5. End treatment: Adjustable male/female aluminum collars with stainless steel clamps to hold duct to collar.
   6. Design pressure: Positive 1.5 inches and negative 0.5 inches water column unless otherwise indicated on the Drawings or specified.
   7. Air velocity: Rated for up to 4,000 feet per minute continuous operation.
   8. Friction loss: Not more than 0.15 inches water column per 100 feet at 500 cubic feet per minute for 12 inch diameter duct.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine and verify that Work is in condition to receive ductwork as specified in this Section.
   1. Take measurements and verify dimensions on shop drawings to ascertain fit of installation.
   2. Ascertain that supports and openings are correctly located.

B. Examine and verify structural details and determine conflicts in dimensions and clearances.

3.02 INSTALLATION

A. Before installation, remove dust and debris from ducts.

B. Adjust duct alignment where necessary to resolve conflicts with architectural features or to resolve conflicts with the work of other trades.

C. Length of flexible duct between the rigid ductwork and air distribution terminal shall not exceed 65 feet unless otherwise indicated on the Drawings.

D. Hangers: Install hangers as indicated on the Drawings. When hangers are not detailed, in accordance with SMACNA Duct Design, and Seismic Restraint Manual standards and the following requirements:
   1. Ducts concealed in ceiling spaces:
      a. Use galvanized steel strap hangers.

E. Bends: Minimum bend radius to duct centerline, 1 duct diameter.

F. Provide non-metallic flexible ducting as indicated on the Drawings:
   1. Flexible duct shall be no longer than 7 feet to the terminal.

3.03 FIELD QUALITY CONTROL

A. Inspect ductwork under operating conditions. Correct audible leaks and leaks that can be felt with the hand.

B. Test and balance ducting systems as specified in Section 15954.

END OF SECTION

SECTION 15816

DUCT FOR CORROSIVE FUME EXHAUST

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Duct for corrosive fume exhaust.

1.02 REFERENCES

A. American Society of Heating, Refrigeration, and Air Conditioning Engineers (ASHRAE):
   1. ASHRAE Handbook.

B. Sheet Metal and Air Conditioning Contractor's National Association (SMACNA):
   1. HVAC Duct Construction Standards: Metal & Flexible.
   2. Round Industrial Duct Construction Standards.

C. National Fire Protection Association (NFPA):
   1. 90A - Standard for the Installation of Air-Conditioning and Ventilating Systems.
   2. 90B - Standard for the Installation of Warm Air Heating and Air-Conditioning Systems.
   3. 91 - Standard for Exhaust Systems for Air Conveying of Vapors, Gases, Mists, and Noncombustible Particulate Solids.

1.03 QUALITY ASSURANCE

A. Manufacturer's qualifications:
   1. Firms regularly engaged in the manufacture of coated stainless steel duct products of types, materials, and sizes required for a period of not less than 8 years.
   2. Manufacturer shall have metal and coating capabilities with in their own manufacturing facility.
   3. Manufacturer must have available for supply video training for contractors.

B. The OWNER and/or his representatives shall have the right to tour the manufacturer's plant any time that fabrication is being performed on duct intended for this project.

C. Codes and standards:
   1. Duct shall have a certified flame spread of 0 and a smoke generation rate under than 25.
   2. SMACNA standards: Comply with SMACNA's HVAC Duct Construction Standards, Metal and Flexible for fabrication and installation of metal duct and SMACNA's Round Industrial Duct Construction Standards intended for use by designers of industrial ventilation systems.

D. Installer qualifications: Installation contractors shall have at least 3 years of successful experience on duct projects, specifically industrial exhaust systems.
   1. Codes and standards:
      a. ASHRAE Standards: Comply with ASHRAE Handbook, Equipment Volume, Chapter 1 Duct Construction, for fabrication and installation of metal duct.
      b. NFPA Compliance: Comply with NFPA 90A, NFPA 90B, and NFPA 91
      c. Field Reference Manual: Have available for reference at project field office, copy of SMACNA Round Industrial Duct Construction Standards.

1.04 SUBMITTALS

A. Submit manufacturer's technical product data and installation instructions for coated stainless steel duct.

B. Shop drawings:
   1. Submit scaled layout drawings of coated duct and fittings including, but not limited to, duct sizes, locations, elevations, and slopes of horizontal runs, walls and floor penetrations, and connections.
   2. Show interface and spatial relationships between coated duct and adjacent equipment.
   3. Show modifications of indicated requirements and how those modifications ensure that free area, materials, and rigidity are not reduced.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Protect coated duct from damage due to normal handling during shipment and storage.
   1. Cover duct openings with tape or plastic to prevent dirt and moisture from entering ducts and fittings.

B. Consignee must inspect shipment upon delivery and note any and all damages and discrepancies on bill of lading and notify manufacturer within 24 hours.

C. Coated duct should not be stored in an area where it will have a chance to be damaged from traffic and debris.

D. All coated duct should be stored on cardboard, styrofoam, or similar materials.

E. Where possible, store inside and protect from dirt and debris.

F. Where necessary to store outside, store above grade, and enclose with waterproof wrapping to protect from dirt and debris.

G. If coating is scratched during shipping or handling, it must be inspected using the methods described in this Section.
   1. Contact the manufacturer for approved repair procedures.

PART 2 PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. Coated stainless steel exhaust duct and fittings:
   1. PSP® & PSP-EZ™ (PermaShield Pipe) as manufactured by: Fab-Tech, Incorporated, 480 Hercules Drive, Colchester, VT, 05446.

B. Coating:
   1. PermaShield fluoropolymer barrier coating: Fab-Tech, Incorporated, 480 Hercules Drive, Colchester, VT 05446.

C. Duct joint sealant, joint tape and die-cut sheet gasket:
   1. Gore-Tex® (Fully Expanded 100 percent PTFE) as manufactured by: W.L. Gore and Associates, Inc., Elkton, MD.

Part Number	Description (inch)
0000C-FAB	3/16 by 1/8 Joint Sealant
0000D-FAB	1/4 by 1/8 Joint Sealant
KK-FAB	1/4 by 3/16 Joint Sealant
0100100.75	.010 Gasket Tape

2.02 DUCT CONSTRUCTION MATERIALS

A. Coated stainless steel duct shall be constructed in full accordance with the specifications below:
   1. Base metal shall be AISI 300 series stainless steel, constructed to a duct gauge and reinforcing system in accordance with SMACNA Round Industrial Duct Construction Standards with a Class 1, 6-inch WG schedule.
      a. Longitudinal seams shall be fusion welded.
      b. Transverse seams shall be butt welded, no dissimilar filler materials allowed.
   2. The coating shall be PermaShield fluoropolymer barrier thermoplastic resin. The average coating thickness shall not exceed 12 mils (0.012 inch). Complete and uniform coating coverage is required.
   3. The manufacturer shall perform dielectric testing of the coating on all pieces of duct.
      a. All coated surfaces will be subjected to 2,500 volts DC with no failures (sparks or audible alarms) indicated.
   4. Duct joints:
      a. Cast stainless steel ring is the preferred method for connecting coated duct smaller than 16-inch diameter.
      b. Companion (Van Stone) flange is the preferred method for connecting coated duct 16-inch diameter and larger.
      c. PSP-EZ™ clamp (V-ring insert band clamps) is the alternate method for connecting duct smaller than 16-inch diameter.
         1) Gasket: Form-in-place fully expanded 100-percent PTFE.

2.03 MISCELLANEOUS DUCT CONSTRUCTION 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 duct system requirements including proper connection of duct and equipment. Support materials in contact with the duct shall be fabricated of compatible materials unless otherwise specified.

1. Duct fittings:
   a. Factory fabricated duct fittings to match adjoining ducts and to comply with the contracted duct requirements.
      1) Unless otherwise specified, fabricate elbows with centerline radius equal to 1 and 1-1/2 times the duct diameter.
      2) Unless otherwise specified, use 45-degree laterals and 45-degree elbows for branch take-off connections.
      3) Limit angular tapers to 30 degrees for contracting tapers and 20 degrees for expanding tapers.
   b. Predetermine location of duct drains prior to manufacturer's fabrication. Drains are to be located at the lowest vertical point of all main and branch ducts that are P-trapped and/or as indicated on the Drawings to allow removal of condensate.
   c. Factory fabricate duct and fittings with predetermined location of test holes for monitors.
2. Duct joints:
   a. General: Duct joints may be either cast stainless steel (companion bolted cast rings), Van Stone (companion angle ring bolted flanges), or PSP-EZ™ (V-ring insert band clamps).
      1) Cast stainless steel 4-inch to 14-inch diameter or Van Stone flange 16-inch to 120-inch diameter:
         a) Construction shall be generally cast metal or roll formed.
            (1) Materials shall be either Mild Steel Alloy or AISI 300 series stainless steel.
         b) Boltholes shall be elongated.
         c) Hardware shall be SAE Grade 5 Plated steel alloy. Grade 5 hardware shall be tightened to the following values:

Bolt Diameter	Torque (pound-foot)
5/16 inch	22
3/8 inch	36

         d) Gasket shall be Gore-Tex® joint sealant:
            (1) 4-inch diameter to 11-inch diameter = 3/16 inch by 1/8 inch.
            (2) 12-inch diameter to 24-inch diameter = 1/4 inch by 1/8 inch.
            (3) 25-inch diameter and up = 1/4 inch by 3/16 inch.
      2) PSP-EZ™ joints:
         a) Construction shall be generally roll-and-press formed stainless steel sheet goods.
         b) Duct flanges will be backed with a half-round shaped loose metallic ring shaped to work with formed profile of clamp band.
            (1) One circumferential bolt with 1 locknut is used to tighten the clamp to the duct.

c) Gasket shall be a self adhesive Gore-Tex® tape 0.010 by 0.75 inches on each end of duct (4-inch diameter to 14-inch diameter) or a singular die-cut Gore-Tex® gasket (2-inch diameter to 3-inch diameter) as specified by the manufacturer.

(1) Clamp bolt shall be tightened to the following values:

Clamp Bolt Diameter (inches)	Torque (pound-inch)
1/4 (Ø2, 3, 4,6,8)	75
5/16 (Ø10, 12, 14)	120

PART 3 EXECUTION

3.01 PREPARATION

A. Before installation, remove dust and debris from ducts.

B. During installation and until equipment is operated, protect ducts from dust and debris by covering openings with tape or plastic.

3.02 INSTALLATION

A. Examine areas and conditions under which coated duct are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to installer.

B. Assemble and install coated stainless steel duct while using extreme care not to scratch surface of coating (if scratched, immediately contact manufacturer for repair instructions) and in accordance with recognized industry practices, which will achieve airtight, under 1-percent leakage. Install each run with a minimum number of joints. Align duct accurately at connections, with internal surfaces smooth. Support ducts rigidly with suitable ties, braces, hangers and anchors of type, which will hold in accordance with SMACNA Industrial Duct Construction Standards.

1. Coating must not be penetrated during installation. No fastening devices such as Tek-style screws, rivets, etc. are to be used on any part of a coated duct application. Test holes and slots for monitoring must be predetermined before fabrication and coating unless using approved Fab-Tech Field Modification Kits. Install coated stainless steel duct as indicated on the Drawings and described herein, following applicable state and city codes, and per SMACNA HVAC Duct Construction Standards.
2. Routing: Locate coated stainless steel duct runs, except as otherwise indicated, vertically and horizontally and avoid diagonal runs wherever possible. Locate runs as indicated by diagrams, details, and notations or, if not otherwise indicated, run duct in the shortest route that does not obstruct usable space or block access for servicing building and its equipment. Hold ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building. Wherever possible in finished and occupied spaces, conceal duct from view by locating in mechanical shafts, hollow wall construction, or above suspended ceilings. Do not encase horizontal runs in solid partitions, except as specifically shown. Coordinate layout with suspended ceiling and lighting layouts and similar finish work.

3. Electric equipment spaces: Do not route duct through transformer vaults and their electrical equipment spaces and enclosures.
4. Penetrations: Where ducts pass through interior partitions and exterior walls, and are exposed to view, conceal space between construction openings and duct with sheet metal flanges of same gauge as duct. Overlap opening on 4 sides by at least 1-1/2 inches.

END OF SECTION

SECTION 15820

DUCTWORK ACCESSORIES

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Dampers and Damper Operators.
   2. Diffusers, Grilles and Registers.
   3. Screens.
   4. Flexible duct connectors.
   5. Other Ductwork Accessories.

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 01600 - Product Requirements.
      b. Section 01740 - Warranties and Bonds.
      c. Section 15050 - Common Work Results from Mechanical Equipment.
      d. Section 15954 - HVAC Systems Testing, Adjusting, and Balancing.

1.02 DEFINITIONS

A. Dampers, diffusers, grilles, and registers specified are indicated on the Drawings by the abbreviations listed below. Each abbreviation is followed by a hyphen and a number to designate the required style of unit:
   1. BD: Balancing Damper.
   2. BDD: Backdraft Damper.
   3. FL: Flexible Duct Connector.
   4. RR: Return Register or Grille.
   5. SR: Supply Register, Grille or Diffuser.

B. Return Registers:
   1. RR designation includes wall, ceiling and duct-mounted air exhaust, or return devices including diffusers and grilles with or without control dampers.

C. Supply Registers:
   1. SR designation includes wall, ceiling and duct mounted air supply devices including diffusers and grilles with or without control dampers.

1.03 SUBMITTALS

A. Shop Drawings: Indicate location of duct accessories.

B. Product Data: Manufacturer, model, materials, sizes, pressure drop charts, capacities and included accessories.

C. Warranties: As specified in Sections 01740 and 15050 and as supplemented herein.
   1. Warrant product free of defects and workmanship for 10 years from the date specified in Section 01740.
   2. Issue warranty in the OWNER's name.

PART 2 PRODUCTS

2.01 DAMPERS

A. Manufacturers:
   1. Provide dampers manufactured by the same manufacturer.
   2. Dampers: One of the following or equal. One manufacturer's model is listed with each style, similar models from other listed vendors are acceptable:
      a. Ruskin Manufacturing.
      b. American Warming and Ventilating.
      c. Swartwout.

B. Materials:
   1. Metallic Ductwork: Aluminum for aluminum duct work; Aluminum or galvanized steel for galvanized steel ductwork unless specified otherwise with styles.
   2. Fiberglass Reinforced Plastic Ductwork: Fiberglass reinforced plastic where not otherwise specified.

C. Components: Include specified damper type with frame actuators, clips, connectors and other accessories necessary for mounting; provide locking quadrant manual actuator or electric actuator as indicated on the Drawings.

D. Volume Control and Balancing Dampers:
   1. BD-1, Style 1 Balancing Damper, Commercial Rectangular Control Damper:
      a. Service: Office or laboratory air distribution systems.
      b. Size and Installation: Size as indicated on the Drawings suitable for mounting in rectangular ducting.
      c. Frame: 0.125-inch thick 6063T5 aluminum with mounting flanges on both sides.
      d. Blades: Opposed airfoil shape 6063T5 aluminum.
      e. Blade Axles: Hexagonal plated steel with molded synthetic bearings.
      f. Seals: Extruded vinyl blade edge; flexible metal compressible type for jamb as required.
      g. Finish: Mill.
      h. Manufacturers: One of the following or equal:
         1) Ruskin, Model CD50.

   2. BD-7, Style 7 Balancing Damper, Fiberglass Heavy Duty Industrial Round Damper:
      a. AMCA listed and rated for Zero leakage.

b. Service: Air systems up to 12 inches water column and up to 72 inches diameter.
c. Size and installation: Size as indicated on the Drawings suitable for flange mounting in round ducting.
d. Frame: Vinyl ester resin fiberglass construction conforming to ASME RTP1 with 30-mil resin rich interior corrosion layer; flanges integral to the web layup.
e. Blade: Vinyl ester resin fiberglass, stiffened as required; provide 30-mil resin rich corrosion layer on both sides; provide Viton® elastomer edge seal.
f. Blade axle: Vinyl ester resin fiberglass rod with PTFE bearings and axle shaft seal.
g. Manufacturers: The following or equal:
1) Swartwout, Model 912.
2) Daniel Company, Zero leakage DanElast.

E. Backdraft Dampers (BDD):
1. BDD-1, Style 1 Backdraft Damper, Heavy Duty Counterbalanced Backdraft Damper:
a. Service: Low-pressure opening at 0.02-inch water column in rectangular ducts or wall mounting for spot air velocities up to 3,500 feet per minute; weather resistant for exhaust applications.
b. Size and Installation: Size as indicated on the Drawings and suitable for mounting as indicated.
c. Frame: 2.25-inch deep, 0.125-inch minimum thickness 6063T5 aluminum with insect screen and water stop.
d. Blades: 0.070-inch minimum thickness 6063T5 aluminum with Zytel bearings, elastomer edge seals and aluminum tie-bar; blades require no more than 4.25 inches clearance beyond frame when fully open.
e. Counterbalance: Zinc-plated bar on blades; adjustable down to 0.02-inch water column opening.
f. Finish: Kynar in manufacturer’s standard colors to be selected by the ENGINEER.
g. Manufacturers: One of the following or equal:
1) Ruskin, Model CDB6.
2. BDD-4, Style 4 Backdraft Damper, Fiberglass Heavy Duty Counterbalanced Backdraft Damper:
a. Service: Low pressure opening at 0.02 inches water column in rectangular ducts with external adjustable counterbalance assembly
b. Size and Installation: Size as indicated on the Drawings and suitable for mounting as indicated.
c. Frame: 8.0-inch deep, vinyl ester resin fiberglass; flange mount
d. Blades: 0.125-inch minimum thickness Series 625 vinyl ester resin on 0.75-inch diameter fiberglass axles with PTFE bearings; blades require no more than 2 inches clearance beyond frame when fully open.
e. Counterbalance: Type 316 stainless steel counterbalance weight and arm; adjustable down to 0.02-inch water column opening.
f. Finish: Selected by the ENGINEER from manufacturer's standard colors.

g. Manufacturers: One of the following or equal:
   1) Daniel Mechanical, Model 901.
   2) Swartwout, Model 426.
h. Certification: BDD-4 dampers shall be AMCA certified, licensed, and tested using AMCA 500 D test method and shall bear the AMCA seal.

2.02 DIFFUSERS, GRILLES, AND REGISTERS

A. Manufacturers:
   1. Provide diffusers, grilles, and registers manufactured by the same manufacturer.
   2. Diffusers, grilles, and registers: One of the following or equal. One manufacturer's model is listed with each style, similar models from other listed vendors are acceptable:
      a. Titus Manufacturing Corp.
      b. Tuttle and Bailey.
      c. Kees, Inc.
      d. Metal Industries, Inc. (MetalAire).
      e. Krueger.

B. Materials:
   1. For Metallic Ductwork: Aluminum for aluminum ductwork; Aluminum or galvanized steel for galvanized steel ductwork unless specified otherwise with styles.
   2. For Fiberglass Reinforced Plastic Ductwork: Fiberglass reinforced plastic where not otherwise specified.

C. Components: Include specified style with frame, clips, connectors and other accessories necessary for mounting.

D. Appearance: Similar for units in same room or space.

E. Finishes:
   1. In chlorine, hypochlorite, or sodium bisulfite storage or pumping rooms and building exhaust systems for these areas: Coat with two 1-1/2 mils thick coats of synthetic vinyl plastic coating suitable for use in gas contaminated exhaust system including chlorine, sulfur dioxide, ozone, or a combination thereof of such gases.
      a. Manufacturers: One of the following or equal:
         1) Bisonite M, Amercoat Number 23 and 55.
         2) Plasite, 2441.
   2. In other locations, specified factory standard with the style requirements of a color selected by ENGINEER from standard manufacturer's colors.

F. Supply Diffuser, Grille, and Register Styles:
   1. SR-1, Supply Register Style 1:
      a. Size and installation: Square 4-way grille size as indicated on the Drawings framed for surface mounting on gypsum, T-bar ceiling, or directly mounted on exposed ducting; provide 4 inch flanged drop frame when duct mounted.
      b. Faceplate: Removable grille with 4-way field adjustable deflection blades; provide gasket at frame for sealing.

c. Core: Adjustable vanes with rectangular or round neck to match ducting; adjust vanes to flow pattern indicated on the Drawings.
d. Damper: Provide opposed blade volume control damper suitable for use with ducting type as indicated on the Drawings; damper to be adjustable through the face of the unit.
e. Materials: Steel frame, core, damper, and faceplate with baked acrylic finish.
f. Manufacturers: The following or equal:
1) Titus, Model MCD.

2. SR-2, Supply Register Style 2:
a. Size and installation: 24-inch-by-24-inch panel and frame suitable for suspended T-bar lay in ceiling.
b. Faceplate: Removable, perforated with 3/16-inch holes on 1/4-inch centers.
c. Core: Adjustable, anti-smudge flow pattern with deflection patterns as indicated on the Drawings and rectangular or round neck to ducting.
d. Damper: Provide opposed blade volume control damper suitable for use with ducting type as indicated on the Drawings; damper to be adjustable through the face of the unit.
e. Materials: Aluminum frame, core, damper, and faceplate.
f. Manufacturers: The following or equal:
1) Krueger, Model 6200/6500 Series.

G. Return Diffuser, Grille, and Register Styles:
1. RR-1, Return Register Style 1:
a. Size and Installation: Rectangular grille with size as indicated on the Drawings framed for surface mounting on gypsum or directly mounted on exposed ducting; provide 4-inch flanged drop frame when duct mounted.
b. Faceplate: Removable grille with fixed double deflection blades spaced at 3/4 inch; front blades parallel to long dimension with 35-degree deflection; provide gasket at frame for sealing.
c. Core: When connected to ducting, provide suitable rectangular or round neck to match ducting; when filter indicated on the Drawings, provide 1-inch deep filter frame and hinged face with 1/4 turn fasteners.
d. Damper: When connected to ducting, provide opposed blade volume control damper suitable for use with ducting type as indicated on the Drawings; damper to be adjustable through the face of the unit.
e. Materials: Aluminum frame, core, damper and face plate.
f. Manufacturers: One of the following or equal:
1) Titus, Model 350FL or Model 350FF1.

2. RR-2, Return Register Style 2:
a. Size and installation: 24-inch-by-24-inch panel and frame suitable for suspended T-bar lay in ceiling.
b. Faceplate: Removable, perforated with 3/16 inch holes on 1/4 inch centers matching SR-1 in appearance.
c. Core: When connected to ducting, provide suitable rectangular or round neck connection to ducting type indicated on the Drawings.
d. Damper: When connected to ducting, provide opposed blade volume control damper suitable for use with ducting type as indicated on the Drawings; damper to be adjustable through the face of the unit.

e. Materials: Aluminum frame, core, damper, and faceplate.
f. Manufacturers: The following or equal:
1) Titus, Model PAR-AA.

2.03 SCREENS

A. Characteristics and Features:
1. Bird Screen: 1/2-inch mesh by 14-gauge.
2. Insect Screens: 18 by 14 mesh.
3. Screens and frames, same material as ductwork, hood, louver, fan, or equipment connected to screen.
4. Screens secured in frames.

2.04 FLEXIBLE CONNECTIONS

A. Provide flexible duct connectors at all connections to fans and other air movement equipment as indicated on the Drawings.

B. FL-1, Duct to Duct Flexible Connection:
1. Fabric shall be fire resistant, waterproof, mildew-resistant, and airtight. At least 4 inches of fabric shall be exposed. Flexible connections shall be in accordance with the requirements of UL and NFPA.
2. Interior locations:
a. Fabric for flexible connections installed inside office areas shall be Neoprene coated glass fabric suitable for a temperature range of -20 degrees F to 180 degrees F and shall have a weight of at least 27 ounces per square yard and a thickness of 0.024 inches.
b. Manufacturers: The following or equal:
1) Ventfabrics “Ventglas”.
3. Exterior locations:
a. Fabric for flexible connections exposed to sunlight or the weather shall be glass fabric coated with chlorosulfurated polyethylene suitable for a temperature range of -10 degrees F to 250 degrees F and shall have a weight of at least 24 ounces per square yard and a thickness of 0.019 inches.
b. Manufacturers: The following or equal:
1) Ventfabrics “Ventlon”.

C. FL-3, Duct to Equipment Heavy Duty Flexible Connection:
1. Materials: EPDM rubber vulcanized with minimum of 1 ply of reinforcing fabric; 3/16 inch thick.
2. Unit shall have minimum movement of:
a. Axial compression: 2.25 inches.
b. Axial extension: 1.25 inches.
c. Lateral offset: 1.25 inches.
3. Provide 3/8 inch thick by 2-inch wide pre-drilled retaining rings/back-up bars to clamp the expansion joints into the ducting system.
4. The expansion joint shall be of fully molded construction. Splices will not be allowed in the body of the expansion joint.
5. Manufacturers: One of the following or equal:
a. Proco Series 500, Style 530 Fabric Fan Connector.
b. Holz Rubber Style 952 Arch Design Expansion Joint

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine and verify that Work is in condition to receive installation specified in this Section. Take measurements and verify dimensions to ascertain fit of installation.

3.02 PREPARATION

A. Before installation, remove dust and debris from ducts and accessories.

3.03 INSTALLATION

A. Install items in accordance with manufacturers' instructions.

B. FL-3, Flexible Connections: Install at connections between duct and air handling equipment and at locations indicated on the Drawings.

C. FL-1 and FL-2, Flexible Connections:
   1. Install at building expansion joints and as indicated on the Drawings.
   2. Install with collar and metal band to form airtight joints.
   3. Install with minimum 4 inches of slack in fabric.
   4. Exterior locations: Install sheet metal weather cover over fabric.
   5. Duct alignment shall be a maximum of 1/2-inch offset.
   6. The minimum/maximum gap shall be 2-inches and 6-inches.
   7. Lap longitudinal joints and glue per manufacturer’s recommendations

3.04 FIELD QUALITY CONTROL

A. Set grilles, dampers and diffusers to achieve flows and flow patterns indicated on the Drawings and test finished system as specified in Section 15954.

B. Mark final balance positions on all manual damper actuators with paint pen in a distinctive color.

END OF SECTION

SECTION 15830

FANS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Fans, including:
   1. Type 4 - Sidewall propeller fans.
   2. Type 12 - Fiberglass reinforced plastic centrifugal fans.

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 01612 - Seismic Design Criteria.
      b. Section 01614 - Wind Design Criteria.
      c. Section 09960 - High-Performance Coatings.
      d. Section 15050 - Common Work Results for Mechanical Equipment.
      e. Section 15852 - Louvers.
      f. Section 15936 - Heating, Ventilating, and Air Conditioning Controls.
      g. Section 15954 - HVAC Systems Testing, Adjusting, and Balancing.
      h. Section 16050 - Common Work Results for Electrical.
      i. Section 16060 - Grounding and Bonding.
      j. Section 16075 - Electrical Identification.
      k. Section 16123 - 600 Volt or Less Wires and Cables.
      l. Section 16130 - Conduits.
      m. Section 16134 - Boxes.
      n. Section 16140 - Wiring Devices.
      o. Section 16222 - Low Voltage Motors up to 500 Hp.
      p. Section 16411 - Disconnect Switches.

1.02 REFERENCES

A. American Bearing Manufacturers Association (ABMA):
   1. 9, Load Ratings and Fatigue Life for Ball Bearings.
   2. 11, Load Ratings and Fatigue Life for Roller Bearings.

B. Air Movement and Control Association International, Inc. (AMCA):
   1. 210, Laboratory Methods of Testing Fans for Certified Aerodynamic Performance Rating.
   2. 211, Certified Rating Program- Product Rating Manual for Fan Air Performance.

3. 300, Reverberant Room Method for Sound Testing of Fan.
4. 301, Methods for Calculating Fan Sound Ratings from Laboratory Test Data.

C. American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE):
1. 52.1 - Gravimetric and Dust Spot Procedures for Testing Air-Cleaning Devices Used in General Ventilation for Removing Particle Matter.
2. 68 - Laboratory Methods of Testing to Determine Sound Power in a Duct.

D. ASTM International (ASTM):
1. A 108 - Standard Specification for Steel Bar, Carbon and Alloy, Cold-Finished.
2. D 4167 - Standard Specification for Fiber Reinforced Plastic Fans and Blowers.
3. E 84 - Standard Test Method for Surface Burning Characteristics of Building Materials.

E. National Electrical Code (NEC).

F. National Electrical Manufacturers Association (NEMA):
1. 250 – Enclosures for Electrical Equipment (1000 V Maximum).

G. National Fire Protection Association (NFPA):
1. 90A - Standard for Installation of Air Conditioning and Ventilating Systems.
2. 820 - Standard for Fire Protection in Wastewater Treatment and Collection Facilities.

H. National Roofing Contractors Association (NRCA).

I. Occupational Safety and Health Administration (OSHA).

J. Underwriters' Laboratories, Inc. (UL).

1.03 DEFINITIONS

A. As used in this Section and on the drawings, abbreviations and Fan Schedule headings have the following meaning:
1. SF or SPF: Supply Fan.
2. EF or EXF: Exhaust Fan.
3. Type: Fan type as specified in this Section.
4. SP or ESP: Fan External Static Pressure in inches water column.
5. Size: Nominal fan blade or wheel diameter in inches.
6. Hp: Fan motor hp.
7. V/Ph: Fan motor voltage and power phases.

B. NEMA:
1. Type 1 enclosure in accordance with NEMA 250.
2. Type 3R enclosure in accordance with NEMA 250.

1.04 SYSTEM DESCRIPTION

A. Design requirements:
1. Provide fans that have sharply rising pressure characteristics that extend throughout the operating range and continue to rise beyond efficiency peak.

2. Provide fans that peak as close as possible to the maximum efficiency and whose operating range is within the normal fan selection range.
3. When scheduled, provide guided vibration isolator for fans, so that not more than 10 percent of the vibration amplitude of the fan and motor is transmitted to the supporting structure.
4. Design fan inner scroll and air stream surfaces to maintain smoothness for entire fan service life.
5. Seismic supports: Seismic design criteria as specified in Section 01612.
6. Wind supports for exterior units: Wind design criteria as specified in Section 01614.
7. Electrical components: UL listed and meeting the design and installation requirements of the NEC.
8. Applicable portions as specified in Section 15050.
9. Motors supplied with fans: Manufacturer's standard when type not scheduled; provide motor voltage phases and speed as scheduled; motor not to be overloaded at any point on the fan curve including belt losses.
10. Roof curbs: Designed in accordance with NRCA standards.
11. Insulation and adhesives: Meet NFPA 90A requirements for flame spread and smoke generation.
12. Belt drive systems: Adjustable for minimum within 5-percent speed change, rated for 1.5 times maximum hp motor available for the scheduled fan size or model.
13. Screens: Provide bird or insect screen as specified with the fan type or as listed on the Fan Schedule:
    a. Bird screen: Stainless steel; 0.5-inch mesh 18 gauge.
    b. Insect screen: Stainless steel mesh and frame.
14. Finishes: When not specified with fan type, coat ferrous metals as specified in Section 09960.
15. Accessories: Provide accessories specified and those scheduled.
16. Provide fans with fire/smoke control system as specified under paragraph Fire/Smoke Control System Design Requirements.

B. Performance requirements:
1. Performance requirements are included in the Fan Schedule located at the end of this Section.
2. Fan performance: Rated and licensed to bear the AMCA label in accordance with AMCA 210 and AMCA 211.
3. Total sound power levels in the 8-octave band range as measured in accordance with ASHRAE 68, AMCA 301, or AMCA 300 as appropriate for each fan: Not to exceed the lesser of the following or the Sones levels on the Fan Schedule.

Sound Power Level, decibel levels referenced to 10-12 watts								
Frequency, Hz	**63**	**125**	**250**	**500**	**1,000**	**2,000**	**4,000**	**8,000**
General	100	98	94	88	84	84	78	75

4. Air filters supplied with fans: 25 to 30 percent dust spot efficiency when rated per ASHRAE Testing Standard 52.1.
5. Bearings: Rated per ABMA 9 or 11 for a L10 life rating of not less than 50,000 hours; provide greater life when specified with each fan type.

C. Electrical and control system design:
   1. Design and supply necessary electrical power and control systems, components, and wiring to make a complete functioning system. Design to perform the system ventilating functions with the control systems as specified in Section 15936 or as indicated on the Drawings.

D. Fire control system design requirements:
   1. Provide all supply, exhaust, and odor control fans greater than or equal to 2,000 cubic feet per minute with smoke control system including the following minimum components.
      a. Duct or fan mounted smoke detector as specified in Section 15936.
      b. Fan interlock to shut down fan upon smoke detection.
      c. Signals for fans and smoke detectors to and from local fire alarm control panel if a fire alarm control panel is part of project design.
      d. Provide all wire, conduit, end of line resistors, and other electrical equipment for complete functioning smoke control system. Provide in conformance with the electrical, mechanical, and instrumentation Drawings. When no electrical design for smoke control system is indicated, CONTRACTOR shall provide design and installation of the smoke control system.

1.05 SUBMITTALS

A. Product data:
   1. Materials.
   2. Primary and ancillary equipment.
   3. Sound Power Level in each of 8 octave bands and overall Sones.

B. Shop drawings:
   1. Fan system layout, mechanical, electrical power, and control diagrams.
   2. Supports, vibration isolators, and seismic bracing calculations and details.
   3. Calculated fan vibration levels and field-testing method.
   4. Bearing life.
   5. Fan performance curves showing specified operating condition.

C. Operation and maintenance data.

1.06 QUALITY ASSURANCE

A. Provide fans:
   1. Listed by UL.
   2. Rated in accordance with AMCA.

1.07 DELIVERY, STORAGE, AND HANDLING

A. Deliver units in 1 piece, factory assembled, internally wired, and lubricated.

B. Protect equipment from dust and atmospheric exposure as recommended by the unit manufacturer.
   1. As a minimum, provide temporary closures for equipment openings designed for airflow.

1.08 EXTRA MATERIALS

A. Provide 2 extra sets (3 sets total) of filters per installed fan for fans specified with filters.

B. Provide 1 extra set of belts per installed fan for fans specified with belt drives.

PART 2 PRODUCTS

2.01 TYPE 4, SIDEWALL PROPELLER FANS

A. Manufacturers: One of the following or equal:
   1. Greenheck, Model SC, or SBC.
   2. Loren Cook Company, Model AWD or AWB.
   3. Penn Ventilator, similar model.

B. Characteristics:

C. Type: Wall-mounted, low noise propeller type, packaged unit.
   1. Fan: Statically and dynamically balanced propeller with aluminum blades, unless noted otherwise.
   2. Motor: Permanently lubricated; selected to avoid running in the service factor.

D. Accessories:
   1. Motor and fan side OSHA guards.
   2. Wall mount collar.
   3. Bird screen.
   4. Finish: Coat fan, housing, and accessories with polyester finish.
   5. Diffusers and louvers when scheduled.
   6. Mounting hardware.

2.02 TYPE 12, FRP BASE MOUNT CENTRIFUGAL FANS

A. Manufacturers: One of the following or equal:
   1. New York Blower Company.
   2. Hartzell Fan.

B. Characteristics:
   1. Fan design/construction: In accordance with ASTM D 4167.
   2. Fan housing: Solid fiberglass reinforced plastic (FRP).
   3. Fan wheel: Backward curved or backward inclined airfoil blades, or pressure blower type where applicable, non-overloading throughout entire curve at rated speed; solid FRP, totally encapsulated aluminum core insert for secure attachment to shaft.
   4. Shaft: Ground and polished ASTM A 108 grade 1040/1045 steel with Hastelloy sleeve in air stream or Type 316 stainless steel. Shaft to have maximum 1 mil run-out.
   5. Bearings: Minimum ABMA L-10 life rating of 100,000 hours, grease lubricated with lube tubes extended to outside of housing.
   6. Shaft seal: Provide Teflon® elements in FRP casing, Type 316 stainless steel double lip rings and springs. Extend shaft seal 1/2 inch beyond seal.
   7. Duct connections: Provide flanged connections.

8. Drain: Provide 1-inch diameter FRP pipe bonded to a low point in the housing; provide PVC ball valve and threaded plug.
9. Fan inspection port: Provide 8-inch diameter fan housing port to allow examination of interior.
10. Motor and belt cover/guard: Provide FRP, aluminum, or Type 316 stainless steel cover over motor and belt drive with louvered side panels to allow motor ventilation sufficient to prevent overheating at 100 percent of full load.
11. Electrical grounding: Coat air stream surfaces with graphite-impregnated resin with grounding straps to motor frames or fan base to control static electricity.
12. Abrasive moisture coating: Coat fan wheel with 50- to 60-mil abrasive/erosive resistant coating.
13. Base and bearing support structures: Rigid Structural FRP, aluminum, or Type 316 stainless steel.
14. Duct connection orientation: As indicated on the Drawings.
15. Drive: Belt or direct as scheduled.
16. FRP requirements:
    a. Suitable for continuous operation when exposed to vapors and gases expected to include methane, hydrogen sulfide, chlorine gas, sulfur dioxide, gasoline vapors, ammonia, and water saturated air. Air stream may contain droplets of dilute sulfuric acid, greases, and particulate matter and may vary from 30 degrees F to 130 degrees F.
    b. Housing resin:
        1) Type: Premium polyester resin
        2) Resin shall achieve Class I flame spread rating below 25 when tested in accordance with ASTM E 84 without the use of additives.
        3) Manufacturer: One of the following or equal:
            a) Ashland Chemical Company.
            b) Derakane.
            c) Hetron 92FR; Dow Chemical Company.
    c. Wheel resin:
        1) Type: Premium Vinyl ester resin.
        2) Resin shall achieve Class II flame spread rating below 30 when tested in accordance with ASTM E 84.
        3) Manufacturer: One of the following or equal:
            a) Dow Chemical Company.
            b) Derakane 510A40 or 570A40; Ashland Chemical Company.
            c) Hetron.
    d. Protect fiberglass surfaces with minimum 10-mil thickness of ultraviolet resistant resin after initial visual inspections of housing exterior is complete.
    e. Provide Veil-Nexus corrosion resistant surfacing veil and additional coat of fiberglass reinforced plastic resin on surfaces exposed to the air stream for corrosion resistance and chopped strand fiberglass for structural core strength.
17. Balancing: Dynamically balance fan assembly after fabrication and assembly to a maximum of 0.15 inches per second of unbalance at the operating speed.
18. Other accessories:
    a. Vibration isolators: Provide rubber-in-shear type or spring type.
    b. Cover access doors: FRP, neoprene gasket, non-hinged, stainless steel bolts.
    c. Fasteners: Type 316 stainless steel and shall be encapsulated in FRP when exposed to air stream.

2.03 SOURCE QUALITY CONTROL

A. Factory test fans listed on the Fan Schedule for proper operation, performance, and electrical controls.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine and verify that Work is in condition to receive installation specified in this Section.

B. Take measurements and verify dimensions to ascertain fit of installation.

C. Ascertain support and openings are correctly located.

3.02 PREPARATION

A. Before installation, remove dust and debris from equipment and ducts.

B. During installation and until equipment is operated, protect equipment and ducts from dust and debris by covering openings with tape or plastic.

3.03 INSTALLATION

A. Observe applicable installation requirements as specified in Section 15050.

B. Anchoring and support:
   1. Provide anchoring and support for fans and appurtenances.
   2. Provide anchoring to sustain seismic and wind forces as specified in Sections 01612 and 01614.

C. Adjust alignment of ducts where necessary to resolve conflicts with architectural features or to resolve conflicts with the work of other trades.

D. Install and wire unit fans and controls in accordance with manufacturer's recommendations.

E. Install flexible connections to fans.

F. Install roof curb and fan as recommended by fan manufacturer.

G. For fan housings with threaded water trap drain, provide drain piped from fan housing to the nearest drain channel, floor drain, or sump.

3.04 FIELD QUALITY CONTROL

A. Test equipment and installation to verify tightness, operation, and unit vibration is within manufacturer's submitted maximum.

B. Test equipment performance and balance equipment as specified in Section 15954.

3.05 SCHEDULES

A. Fan Schedule: Refer to the Administration and Maintenance Building drawings for additional equipment and requirements.

Equip. No.	Location	Fan							Motor			Additional Requirements *(See listed Notes)*
		Type	Drive	Min. CFM	Min. ESP"	Max. rpm	Fan Diam.	Noise Sones or dba	hp	V/Ph.	Max. rpm	
11-FAN-071	Odor control System	12	Belt	600	10	2,256	18	Q4, 82 dba at 5 ft	3	460/3	1,800	1, 5, 8, 12
11-FAN-072	Odor control System	12	Belt	600	10	2,256	18	Q4, 82 dba at 5 ft	3	460/3	1,800	1, 5, 8, 12
51-SF-477	Dewatering Building	12	Belt-2 speed	13,000/6,500	1	1,005	30	Q4, 80 dba at 5 ft	7.5	460/3	1,800/900	1, 7, 22
51-EF-471	Dewatering Building	4	Direct	1,000	0.3	860	18	10	1/3	115/1	860	1, 7, 19
51-EF-472	Dewatering Building	4	Direct	1,000	0.3	860	18	10	1/3	115/1	860	1, 7, 19
51-EF-473	Dewatering Building	4	Direct	2,750	0.3	1,160	20	28	0.5	460/3	1,160	1, 7, 12, 19, 22
51-EF-474	Dewatering Building	4	Direct	2,750	0.3	1,160	20	28	0.5	460/3	1,160	1, 7, 12, 19, 22
51-EF-475	Dewatering Building	4	Direct	2,750	0.3	1,160	20	28	0.5	460/3	1,160	1, 7, 12, 19, 22
51-EF-476	Dewatering Building	4	Direct	2,750	0.3	1,160	20	28	0.5	460/3	1,160	1, 7, 12, 19, 22
70-EF-801	Electrical Building-Generator room	4	Direct	1,500	0.25	1,160	16	8	1/4	115/1	1,160	1, 7, 19
70-EF-802	Electrical Building-Generator room	4	Direct	1,500	0.25	1,160	16	8	1/4	115/1	1,160	1, 7, 19
70-EF-721	Electrical Building-Fire Pump room	4	Direct	800	0.125	1,160	12	8	1/6	115/1	1,160	1, 7, 15, 19

Notes:

1. Provide bird screen.
2. Provide insect screen.
3. Provide backdraft damper, counterbalanced for minimum pressure loss.
4, Provide exterior weather hood.
5. Provide adjustable belt sheaves.
6. Provide vibration isolators.
7. Provide manufacturer std. motor enclosure.
8. Provide TEFC motor enclosure and wiring suitable for Class 1, Div. 2 locations.
9. Provide explosion proof motor and wiring suitable for Class 1, Div. 1 locations.
10. Provide variable frequency drive speed controller as specified in this Section.
11. Provide SCR speed controller as specified in this Section.
12. Provide exterior disconnect switch at fan, NEMA Type 4X.
13. Provide NEMA Type 1 disconnect switch at fan inside housing.
14. Provide 120-volt, line voltage thermostat Type 2 as specified in Section 15936.
15. Provide 24 volt, low-voltage thermostat type T-5 as specified in Section 15936.
16. Interlock fan with motorized louver dampers, other fans, or equipment as indicated on the Drawings.
17. Provide replaceable filters.
18. Provide motorized backdraft damper.
19. Provide exterior weather louver, Type L-1 as specified in Section 15852 and indicated on the Drawings.
20. Provide fiberglass canopy hood, size as indicated on the Drawings.
21. Fan selection based on existing opening; field verify opening size and select maximum sized, slowest rpm fan to fit opening and meet performance conditions.
22. Provide fire/smoke control system for all fans greater than 2,000 cfm.

END OF SECTION

SECTION 15852

LOUVERS

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Louvers.

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 15954 - HVAC Testing, Adjusting, and Balancing.

1.02 REFERENCES

A. Air Movement and Control Association (AMCA):
   1. 500 - Test Methods for Louvers, Dampers, and Shutters.

1.03 PERFORMANCE REQUIREMENTS

A. Performance: Meet requirements when tested in accordance with AMCA 500.

B. Designed for 20 pounds per square foot wind load.

1.04 SUBMITTALS

A. Shop Drawings: Include dimensions, anchorage details, and relationships to adjacent materials.

B. Product data.

1.05 QUALITY ASSURANCE

A. Provide louvers with the following, unless otherwise specified:
   1. AMCA certification and rating in accordance with AMCA 500 for air performance and water penetration.

PART 2 PRODUCTS

2.01 GENERAL

A. Louver Types: Louvers are marked on the Drawings with a letter L followed by a number referring to a louver type in this section. Individual louver size and airflow rates are as indicated on the Drawings.

B. Accessories:
   1. Provide installation clips and flanged or jamb-mounting styles suitable for the mounting locations as indicated on the Drawings.
   2. Provide extended sills for louvers indicated as installed recessed from the exterior wall surface.
   3. Provide stainless steel fasteners unless noted otherwise.

C. Protective Coatings for Aluminum in Contact with Concrete or Masonry:
   1. Manufacturers: One of the following or equal:
      a. Koppers Company, Inc.
      b. Tarmastic 100.
      c. Porter Coatings.

2.02 STATIONARY WEATHER LOUVERS, TYPE L-1

A. Manufacturers: One of the following or equal:
   1. Ruskin Air and Sound Control, Model ELF 6375DXH.
   2. Airolite Company, LLC, equivalent product.
   3. American Warming and Ventilating, Inc., equivalent product.

B. Requirements:
   1. Type: Stationary louver with drainable blades.
   2. Frame: 6-inch deep, minimum 0.125-inch thick, Type 6063-T5 aluminum with downspouts and caulking channel provided.
   3. Blades: Minimum 0.125-inch thick, Type 6063-T5 aluminum drainable blades, stationary mounted at 37.5 degrees.
   4. Screens: Removable aluminum frame with aluminum wire; insect screens on intakes and bird screens on exhausts.
   5. Pressure Drop (without screen): Maximum 0.15 inches water column for exhaust service and 0.12 inches water column for intake service at 1,000 feet per minute free area velocity.
   6. Water Penetration: Maximum 0.01 ounce water per square foot at 1,014 feet per minute free area velocity.
   7. Mullions: Hidden.
   8. Finish: Kynar finish; color as selected.

2.03 ACOUSTICAL LOUVERS, TYPE L-2

A. Manufacturers: One of the following or equal:
   1. Ruskin Co., Model ACL 845.
   2. Airolite Co., equivalent model.
   3. Industrial Acoustics Co., equivalent model.

B. Requirements:
1. Type: Stationary acoustical louver with louver depth as indicated on the Drawings.
2. Material: Minimum 0.081-inch thick extruded or formed aluminum for frame and blades.
3. Frame: 8-inch deep formed aluminum frame with 0.100-inch nominal wall thickness.
4. Blades: 0.040-inch perforated aluminum interior surface; blades positioned at 45-degree angle and spaced approximately 6 inches center to center.
5. Screens: 1/2-inch mesh by 19-gage aluminum or stainless steel bird screen with removable frame.
6. Pressure Drop: Maximum 0.13-inch water column pressure drop at 1,000 feet per minute free area velocity for intake louvers.
7. Free Area: Minimum 25 percent.
8. Finish: Kynar finish; color as selected.
9. Acoustical Performance: Attenuation at least as follows for the depth of louver indicated:

	Attenuation (dB)			
Frequency (hertz)	**4-inch Depth**	**6-inch Depth**	**8-inch Depth**	**12-inch Depth**
63	9	8	7	10
125	11	8	8	8
250	9	10	12	15
500	11	12	15	17
1,000	15	19	20	23
2,000	17	24	24	25
4,000	16	24	24	21
8,000	16	24	23	20

2.04 SIGHTPROOF STATIONARY LOUVERS, TYPE L-3

A. Manufacturers: One of the following or equal:
1. Ruskin, Model ELF 40V.
2. American Warming and Ventilating, Inc., equivalent product.
3. Airolite Company, equivalent product.

B. Requirements:
1. Type: Stationary sightproof louver with drainable blade.
2. Frame: 4 inches deep, minimum 0.081 inch thick, Type 6063-T5 aluminum with downspouts and caulking channel provided.
3. Blades: Minimum 0.081 inch thick, Type 6063-T5 aluminum chevron blades, spaced at 4-inch centers, stationary mounted at 60 degrees.
4. Screens: Removable 0.75-inch deep aluminum frame with aluminum wire; insect screens on intakes and bird screens on exhausts.
5. Mullions: Hidden.
6. Finish: Kynar; color as selected.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install louvers in accordance with manufacturer's instructions; caulk all frames to make weather tight.

B. Install louvers for machinery, engines, and similar equipment to allow easy louver removal for machinery or engine removal through the louver opening space without louver projections on floors or walls.

C. Anchor louvers to concrete or masonry with concrete anchors through jambs.

D. Corrosion Protection:
   1. Aluminum in Contact with Concrete or Masonry: Apply two coats bitumastic black solution.
   2. Aluminum in Contact with Dissimilar Metal, Except Stainless Steel: Isolate from dissimilar metal with neoprene gaskets, sleeves, or washers. Use stainless steel fasteners.
   3. Field Testing: As specified in Section 15954.

END OF SECTION

SECTION 15936

HEATING, VENTILATING, AND AIR CONDITIONING CONTROLS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Controls for Heating, Ventilating, and Air Conditioning (HVAC) Systems:
   1. Thermostats.
   2. Duct mounted smoke detectors.
   3. HVAC control descriptions.

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 01740 - Warranties and Bonds.
      b. Section 15050 - Common Work Results for Mechanical Equipment.
      c. Section 15954 - HVAC Systems Testing, Adjusting, and Balancing.

1.02 REFERENCES

A. CSA International (CSA).

B. National Electric Code (NEC).

C. National Electrical Manufacturers Association (NEMA):
   1. 250 - Enclosures for Electrical Equipment (1,000 Volts Maximum).

D. National Fire Protection Association (NFPA):
   1. 90A - Standard for the Installation of Air-Conditioning and Ventilating Systems.

E. Underwriters' Laboratories, Inc. (UL):
   1. 1479 - Fire Tests of Through-Penetration Firestops.

1.03 DEFINITIONS

A. NEMA:
   1. Type 4X enclosure in accordance with NEMA 250.

1.04 SYSTEM DESCRIPTION

A. General requirements:
   1. All electrical components shall be UL listed and meet the design and installation requirements of the NEC.
   2. Complete, functional system: Provide all necessary electrical power and control systems, components, and wiring to make a complete functioning system.
   3. Comply with electrical Sections for electrical power and control systems.
   4. System control functions to perform as described in Products.
   5. Materials: New, free from defects, and of the quality specified.
   6. Common manufacturer: Provide components, component accessories, and devices, as much as possible, by the same manufacturer throughout the work.
   7. Mounting: Mount control components and devices in accessible locations for maintenance and as recommended by the manufacturer; provide necessary manufacturer approved mounting and configuration hardware for mounting and operation of control components and devices.

B. Fire detection system design requirements:
   1. Provide all supply and exhaust fans greater than 2,000 cubic feet per minute with a smoke control system including the following minimum components.
      a. Fan and air handling unit interlocks interlock to shut down upon smoke detection signal from fire alarm control panel.
      b. Field wiring terminal blocks for connection of shut down signals from local fire alarm control panel.

1.05 SUBMITTALS

A. Shop drawings:
   1. Manufacturer's information including:
      a. Catalog information clearly marked to show specific products, models, and sizes being furnished.
      b. Component cut sheets.
   2. Control diagrams showing the interconnection of control components including wiring terminal strip diagrams.
   3. Detail drawings showing control panel layout and dimensions including control panel terminal strips for wiring to outside control devices and panels.

B. Operations and Maintenance Data.

1.06 QUALITY ASSURANCE

A. The control system shall be designed to conform to UL and CSA standards.

1.07 DELIVERY, STORAGE, AND HANDLING

A. The system control products shall be stored and handled per manufacturer's recommendations.

1.08 SITE CONDITIONS

A. Elevation and ambient conditions as specified in Section 15050.

1.09 WARRANTY

A. Special warranties: Warranty period shall commence in accordance with Section 01740.
   1. 2 year: Parts and on-site labor for components, systems, and programming.

PART 2 PRODUCTS

2.01 THERMOSTATS

A. General:
   1. Thermostat types: Thermostat types are called out on the drawings by the letter T followed by a number; this designation refers to the specified thermostat types given in this Section; where no type is called out, provide 1 of the specified types that will match the controlled equipment requirements and provide a functioning system.
   2. Manufacturers: One of the following or equal:
      a. Johnson Controls, model as specified with each type.
      b. Honeywell, Tradeline, equivalent models.

B. T-1, Type 1 Thermostat, Heating Only, Line Voltage:
   1. Johnson Controls Model:
      a. Dry locations (no hose bibs or open water processes in room): Model A19BAC-1 in NEMA 1 enclosure.
      b. Wet Locations (hose bibs or open water processes in room): Model A19PRC-1 in NEMA 4X enclosure.
   2. Switch action: Single pole double throw, open on rising temperature.
   3. Sensing element: Coiled bulb and capillary.
   4. Setpoint: 30 to 110 degrees Fahrenheit with knob adjuster and visible scale.
   5. Electrical ratings: 16 amps alternating current at 120 volts, 9.2 amps alternating current at 208 volts.

C. T-2, Type 2 Thermostat, Cooling Only, Line Voltage:
   1. Johnson Controls Model:
      a. Dry locations (no hose bibs or open water processes in room): Model A19BBC-2 in NEMA 1 enclosure.
      b. Wet locations (hose bibs or open water processes in room): Model A19KNC-1 in rain and dust-tight enclosure.
   2. Switch action: Single pole double throw, close on rising temperature.
   3. Sensing element: Coiled bulb and capillary.
   4. Setpoint: 30 to 110 degrees Fahrenheit with knob adjuster and visible scale.
   5. Electrical ratings: 16 amps alternating current at 120 volts, 9.2 amps alternating current at 208 volts.
   6. Differential range: For dry locations, 3 to 12 degrees Fahrenheit adjustable; for wet locations, 5 degrees Fahrenheit fixed.

D. T-3, Type 3 Thermostat, Heating and Cooling, Line Voltage, Single Stage for MCC Room or Office Environments:
   1. Johnson Controls Model:
      a. Dry locations (no hose bibs or open water processes in room): Model T22TFB-1 in high impact plastic enclosure.

2. Switch action: Single pole double throw, open on rising temperature in heat mode, close on rising temperature in cooling mode.
3. Sensing element: Liquid charged sensing with diaphragm and lever.
4. Setpoint: 40 to 90 degrees Fahrenheit with knob adjuster and visible scale; provide local ambient temperature indicator in degrees Fahrenheit.
5. Selector switch: Heat-Off-Cool.
6. Electrical ratings: 16 amps alternating current at 120 volts, 9.2 amps alternating current at 208 volts.

E. T-4, Type 4 Thermostat, Electronic, Heating and Cooling, Low Voltage, Proportional:
1. Johnson Controls Model:
   a. Model TC-6500 with T-4000 - 2142 plastic enclosure.
2. Sensing element: Resistance temperature element.
3. Setpoint: 55 to 85 degrees Fahrenheit with adjuster and visible scale; provide local ambient temperature indicator in degrees Fahrenheit.
4. Electrical ratings:
   a. Input: 21 volts direct current.
   b. Output: 1 to 18 volt direct current, proportional to temperature change from setpoint; direct acting above setpoint and reverse acting below set point; 1 to 2 degree Fahrenheit deadband.
5. Cover: Provide plastic cover with thermometer and setpoint window.

F. T-5, Type 5 Thermostat, Electronic, Heating and Cooling, Low Voltage, programmable:
1. Honeywell Model: Model TB8220U1003.
2. Setpoint: 40 to 90 or 99 degrees Fahrenheit with adjuster and visible scale; provide local ambient temperature indicator in degrees Fahrenheit.
3. Electrical ratings:
   a. Input: 24 volts direct current.

2.02 DUCT-MOUNTED SMOKE DETECTORS

A. Manufacturers: The following or equal:
1. System Sensor Series D4120.

B. General:
1. Provide duct mounted smoke detectors downstream of fans and ahead of branch connections in air supply ducting with flows greater than 2,000 cubic feet per minute whether or not smoke detectors are indicated on the Drawings.
2. Smoke detectors shall be UL listed for use in air distribution systems and shall comply with NFPA 90A.
3. Connect the smoke detector to:
   a. Building fire alarm system.
   b. Fan control circuit to shut down supply fan upon detection of smoke.
   c. Damper control circuits to close supply air dampers to prevent spread of smoke.

C. Characteristics:
1. Photoelectric type.
2. Operating temperature range of 32 degrees Fahrenheit to 150 degrees Fahrenheit.

3. Operate at airflow velocities of 100 to 4,000 feet per minute.
4. Power supply voltage:
   a. 120 volts alternating current, 60 hertz.
5. Capable of mounting to rectangular or round ducts.
6. Integral filter to reduce dust.

D. Accessories:
1. Provide metal sampling tube and end cap to match duct width. Sampling tube shall be able to be installed without use of tools.
2. Provide mounting base and hardware.
3. Provide duct access door as specified in Section 15812. Provide similar for nonmetalic ducting.
4. Provide a 120 volt 10 amp DPDT auxiliary contact and a 30 VDC 10 amp DPDT auxiliary contact.
5. Provide remote annunciator with alarm and power LEDs.
6. Provide remote test station.

2.03 HVAC CONTROL DESCRIPTIONS

A. General: Provide control systems that will maintain room or area comfort under changing ambient conditions and varying use; descriptions in this Section are general in nature and do not cover every mode of operation.

B. Dewatering Building HVAC system sequence of operation:
1. Supply fan (51-SF-420).
   a. The supply fan provides outside air to the Dewatering Building. The fan is provided with HAND/OFF hand switch at the respective MCC. The fan operates manually and when turned ON, it operates continuously until it is manually turned OFF.
   b. Running status indication is provided at the SCADA system for the fan.
   c. The fan will shut down in case of smoke detection by the duct smoke detector.
2. Exhaust fan (51-EF-421, 51-EF-422, 51-EF-423, 51-EF-424, 51-EF-425, 51-EF-426):
   a. The fans exhaust air from the building to the outside. Each exhaust fan is provided with HAND/OFF hand switch at the respective MCC. The fan operates manually and when turned ON, it operates continuously until it is manually turned OFF.
   b. Running status indication is provided at the SCADA system for each fan.
   c. The fans will shut down in case of smoke detection by the smoke detectors at fans.
3. Electrical room AC unit (51-ACU-440):
   a. The AC unit is a packaged electric cool air conditioning unit and supplies cooling and ventilation air to the electrical room and PLC room. The unit is controlled to maintain a room setpoint thermostat.
   b. Running status and alarm fault or smoke fail indications of the AC unit are provided at the SCADA system.
   c. The AC unit is provided with a duct-mounted smoke detector. In case of smoke detection in ACU fan ducting, the unit will shut down.

C. Electrical Building HVAC system sequence of operation:
   1. Exhaust fan (70-EF-801, 70-EF-802):
      a. The fans exhaust air from the Generator room to the outside. Each exhaust fan is provided with HAND/OFF/AUTO hand switch at the Local Control Panel.
      b. In HAND, the fan operates continuously.
      c. In AUTO, the fan operates on thermostat control.
      d. Running status indication is provided at the Local Control Panel and SCADA system for each fan.
   2. Exhaust fan (70-EF-721, 70-EF-722):
      a. The fans exhaust air from the Generator room to the outside. Each exhaust fan is provided with HAND/OFF/AUTO hand switch at the Local Control Panel.
      b. In HAND, the fan operates continuously.
      c. In AUTO, the fan operates on thermostat control.
      d. Running status indication is provided at the Local Control Panel and SCADA system for each fan.
   3. Electrical room AC unit (70-ACU-800):
      a. The AC unit is a packaged electric cool air conditioning unit and supplies cooling and ventilation air to the electrical room. The unit is controlled to maintain a room setpoint thermostat.
      b. Running status and alarm fault or smoke fail indications of the AC unit are provided at the SCADA system.
      c. The AC unit is provided with a duct-mounted smoke detector. In case of smoke detection in ACU fan ducting, the unit will shut down.

D. Administration Building HVAC system sequence of operation:
   1. Exhaust fan (EF-1):
      a. The fan exhausts air from the toilet rooms to the outside. Exhaust fan to be interlocked so when F-2 is energized fan is energized. Fan remains on until F-2 furnace is off.
   2. Exhaust fan (EF-2):
      a. The fans exhaust air from the lab room to the outside. Fan to run concurrent with F-1.
   3. Exhaust fan (EF-3):
      a. The fan exhausts air from fume hood FH-1 in the lab room to the outside. Fan to be controlled with a switch on the wall next to the hood. Switch to be labeled “EF-3; HOOD”. When EF-3 is energized, EF-2 is to go off. When EF-3 is shut off, EF-2 is re-energized.
   4. Exhaust fan (EF-6):
      a. The fan exhausts air from the lab room main fume hood, FH-2, to the outside. Fan to run concurrent with F-1. The fan is controlled by a switch on the hood.
   5. HVAC systems (F-1 & 2 and DS-1):
      a. The HVAC systems are two gas-fired furnaces in the attic. Each FAU has a cooling coil supplying heating, cooling and ventilation air for the building. The units are controlled by a programmable thermostat (T-5) to maintain a room setpoint of 74F for cooling and 72F for heating. Program with a 2F degree deadband.
      b. The HVAC system is a ductless cooling only unit serving the server room. It is controlled by its own programmable thermostat to maintain a room setpoint of 74F for cooling. Program with a 2F degree deadband.

E. Maintenance Building HVAC system sequence of operation:
   1. Exhaust fan (EF-4):
      a. The fan exhausts air from the toilet room to the outside. Exhaust fan to be interlocked with the light switch.
   2. Exhaust fan (EF-5):
      a. The fans exhaust air from the building to the outside. Fan to be controlled with a switch on the wall, labeled “EXHAUST FAN”.
   3. HVAC systems: (DS-2):
      a. The HVAC system is a ductless heat pump serving the office only. It is controlled by its own programmable thermostat to maintain a room setpoint of 74F for cooling and 72F for heating. Program with a 2F degree deadband.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine and verify that Work is in condition to receive installation specified in this Section.

B. Take measurements and verify dimensions to ascertain fit of installation.

C. Ascertain structural sufficiency to support installation.

D. Ascertain that supports and openings are correctly located; cut new openings where required.
   1. Submit details of proposed cutting and patching.

3.02 PREPARATION

A. Before installation remove dust and debris from equipment and accessories.

B. During installation, and until equipment is operated, protect equipment and accessories from dust and debris.

3.03 INSTALLATION

A. Install as indicated on the Drawings, in accordance with NFPA 90A, and per the manufacturer’s written instructions.

B. Coordinate installation of HVAC control systems with other trades.
   1. Prior to installation, coordinate wiring and conduit requirements with electrical subcontractor.

C. Mount remote annunciator and test station on wall near smoke detector.
   1. Devices shall be easily accessible from floor level.
   2. Label annunciator and test station.

D. Provide all electrical work to support smoke detector.
   1. Coordinate with electrical subcontractor.

E. Sensor and control station mounting:
   1. Where not otherwise indicated, mount 5 feet above floor or walking level.
   2. Provide insulating back plates when mounting is on an exterior wall or a wall adjoining an unconditioned space.
   3. Shield outside thermostats or sensors from the sun; provide thermostats with remote bulb and compensated capillary.
   4. Install locking covers where indicated on the Drawings.

3.04 FIELD QUALITY CONTROL

A. Test each control system and provide written, signed, and dated test report.
   1. Test individual control components and accessories to comply with the Specifications.
   2. Test functions of each control system as a complete system to comply with the Specifications.

B. Test each control component and system as part of HVAC system testing, adjusting, and balancing as specified in Section 15954.

END OF SECTION

SECTION 15954

HVAC SYSTEMS TESTING, ADJUSTING, AND BALANCING

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Heating, ventilation, and air conditioning systems testing, adjusting, and balancing.

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 01660 - Testing, Training, and Commissioning.

1.02 REFERENCES

A. Associated Air Balance Council (AABC):
   1. National Standards for Field Measurements and Instrumentation, Total System Balance, Air Distribution-Hydronic Systems.

B. National Environmental Balancing Bureau (NEBB):
   1. Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems.

C. Sheet Metal and Air Conditioning Contractors' National Association, Incorporated (SMACNA):
   1. Heating, Ventilating, and Air Conditioning Systems - Testing, Adjusting, and Balancing.

1.03 TESTING, ADJUSTING, AND BALANCING WORK REQUIREMENTS

A. Procure the services of an independent air balance and testing agency belonging to and in good standing with the Associated Air Balance Council or the National Environmental Balancing Bureau to perform air and hydronic balancing, testing, and adjustment of building and process air conditioning, heating, and ventilating air systems.

B. The Work Includes: Balancing new air systems installed as part of this contract and air systems affected by the installation of new equipment.

C. Perform testing of heating, ventilating, and air conditioning equipment, balancing of distribution systems, and adjusting of air terminal units and ductwork accessories to ensure compliance with Specifications and Drawings. Perform Tests for Following:
   1. Air handling units.
   2. Heating units.
   3. Fans.
   4. Odor scrubber fans.
   5. Air terminal units.
   6. Ductwork accessories.
   7. Ducting.
   8. HVAC controls.
   9. Other specified HVAC equipment.

D. Test each mode of operation of thermostats, electronic controllers, and pneumatic, electric or electronic heating, ventilating, and air conditioning instruments to ensure operation as specified.

E. Test and adjust room distribution patterns at air outlets.

F. Provide instruments required for testing, adjusting, and balancing operations; retain possession of instruments; remove instruments from site at completion of services.

G. Make instruments available to the ENGINEER to facilitate spot checks during testing.

H. Provide test holes for pressure and pitot flow measurements; provide plugs for all test holes after testing.

1.04 QUALITY ASSURANCE

A. Test, balance, and adjust environmental systems in accordance with either:
   1. AABC: National Standards for Field Measurements and Instrumentation, Total Systems Balance, Air Distribution-Hydronics System.
   2. NEBB: Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems.

B. Perform services under direction of AABC or NEBB certified supervisor.

C. Calibrate and maintain instruments in accordance with requirements of standards. Make calibration histories of instruments available for examination.

D. Make measurements in accordance with accuracy requirements of standards.

E. Testing, Adjusting, and Balancing Performance Requirements:
   1. Comply with procedural standards of certifying association.
   2. Execute each step of prescribed testing, balancing, and adjusting procedures without omission.
   3. Accurately record required data.
   4. Make measurements in accordance with recognized procedures and practices of certifying association.
   5. Measure air volume discharged at each outlet and adjust air outlets to design air volumes within 5 percent over.

1.05 SUBMITTALS

A. Resumes of proposed supervisor and personnel showing training and qualifications.

B. Interim Reports: At least 30 days prior to starting field work, submit the following:
   1. Set of report forms filled out as to design flow values and installed equipment pressure drops, and required cubic feet per minute for air terminals.
   2. Develop heating, ventilating, and air conditioning system schematic similar to Figure 6-1 in SMACNA Testing, Adjusting, and Balancing.
   3. Complete list of instruments proposed to be used, organized in appropriate categories, with data sheets for each showing:
      a. Manufacturer and model number.
      b. Description and use when needed to further identify instrument.
      c. Size or capacity range.
      d. Latest calibration date.

C. Final Report: At least 15 days prior to CONTRACTOR's request for final inspection, submit three copies of final reports, on applicable reporting forms. Include:
   1. Identify instruments that were used and last date of calibration of each.
   2. Procedures followed to perform testing, adjusting, and balancing.
   3. Identification and succinct description of systems included in report.
   4. Initial balance test results made with all dampers and air control devices in full open positions.
   5. Description of final locations and sizes, including opening area and dimensioned configuration of orifices and other restrictions used to achieve final balanced flows.
   6. Description of final location and opening positions of dampers, registers, louvers, and valves.
   7. Schematics of systems included in report; use schematics as part of testing, adjusting, and balancing report to summarize design and final balanced flows.
   8. Testing, adjusting, and balancing report forms.
   9. Final field results established for system balancing including air flow, fan speeds, and fan static pressures at the fan inlet and outlet.
   10. Appendices.
   11. Include Appendices For:
      a. Raw field data taken during testing.
      b. Sample calculation sheet for each type of calculation made to convert raw field data to final results.
      c. Initial air balance results with dampers and registers in full open position; include air flow at all inlets and outlet, initial fan speed and fan suction and discharge pressures.

D. Proposed schedule for testing and balancing.

E. Certificate of proper installation. Comply with Section 01660.

1.06 SITE CONDITIONS

A. Prior to start of testing, adjusting, and balancing, verify that:
   1. Systems installation is complete and in full operation.
   2. Outside conditions are within reasonable range relative to design conditions.
   3. Lighting fixtures are energized.

4. Special equipment such as computers, laboratory equipment, and electronic equipment are in full operation.
5. Requirements for preparation for testing and balancing have been met for elements of each system that requires testing.

PART 2 PRODUCTS

Not Used.

PART 3 EXECUTION

3.01 FIELD QUALITY CONTROL

A. Testing, Adjusting, and Balancing Acceptance Criteria: Consider testing, adjusting, and balancing procedures successful and complete when heating, ventilating and air conditioning systems and components are functioning properly and system air and water flows are within specified tolerances of design flows.

3.02 TESTING, ADJUSTING, AND BALANCING

A. Test, adjust, and balance separate complete heating, ventilating, and air conditioning systems.

B. Include in testing, adjusting, and balancing related existing heating, ventilating, and air conditioning components.

C. Perform testing, adjusting, and balancing cycles until air flows meet acceptance criteria.
   1. Ascertain air flow balance between overall requirements and flow in individual supply and exhaust grills.

D. Initial Testing, Adjusting, and Balancing: Perform first test on each system with dampers, grills, orifices, and other variable air flow devices in their full open position; measure and report initial air flows, fan speed, and fan static pressures at fan inlet and outlet.
   1. Adjust total system flow downward or upward by adjusting fan speed until one inlet or outlet is at indicated flow and all other flows exceed indicated flows.
   2. Adjust fan speed by changing fan drives or sheaves as necessary.

E. Subsequent Testing, Adjusting, and Balancing: Perform adjustments in subsequent testing, adjusting, and balancing by adjusting dampers, louvers, or size of orifices or plates.
   1. Measure and record air volume discharged at each inlet and outlet and adjust air inlets and outlets to design air volumes within 0 to 5 percent over design rates.
   2. Adjust fan speeds and motor drives within drive limitations, for required air volume.
   3. Measure cfm and static pressures and adjust air supply and exhaust fan units to deliver at least 100 to 105 percent of the design air volume.

4. Measure and record static air pressure conditions on fans, including filter and coil pressure drops, and total pressure across the fan.
5. Evaluate building and room pressure conditions to determine adequate supply and return air conditions.
6. Evaluate space and zone temperature of conditions to determine adequate performance of the systems to maintain temperatures without draft.
7. Permanently mark final balance positions of balancing dampers.

F. Develop heating, ventilating, and air conditioning system schematics similar to Figure 6-1 in SMACNA Testing, Adjusting, and Balancing.

G. Accurately record the required data on Associated Air Balance Council or National Environmental Balancing Bureau test and balance report forms.

H. Measure amperage draw of fan and pump motors for final balance.

I. Test primary source equipment in accordance with AABC or NEBB procedures.
1. Primary source equipment includes items listed in Part 1 not previously tested as part of this testing, adjusting, and balancing work.
2. Complete appropriate AABC or NEBB equipment test forms for each piece of equipment.
3. Calculate cooling and heating capacities to show conformance with specified capacities.
4. Adjust equipment as needed to deliver specified cooling and heating loads.
5. Record final equipment performing characteristics and adjustment settings in the final design report.

END OF SECTION

SECTION 15956

PIPING SYSTEMS TESTING

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Test requirements for piping systems.

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 01410 - Regulatory Requirements.
   c. Section 01500 - Temporary Facilities and Controls.
   d. Section 15052 - Common Work Results for General Piping.

1.02 REFERENCES

A. National Fuel Gas Code (NFGC).

B. American Society of Mechanical Engineers (ASME):
1. B31.1 - Power Piping.
2. B31.3 - Process Piping.
3. B31.8 - Gas Transmission and Distribution Piping Systems.

C. Underwriters Laboratories Inc. (UL).

1.03 TESTING REQUIREMENTS

A. General requirements:
1. Testing requirements are stipulated in Laws and Regulations; are included in the Piping Schedule in Section 15052; are specified in the specifications covering the various types of piping; and are specified in this Section.
2. Requirements in Laws and Regulations supersede other requirements of Contract Documents, except where requirements of Contract Documents are more stringent, including higher test pressures, longer test times, and lower leakage allowances.
3. Test plumbing piping in accordance with Laws and Regulations, the plumbing code, as specified in Section 01410, and UL requirements.

4. Test natural gas piping:
    a. For less than 125 pounds per square inch gauge working pressure, test in accordance with mechanical code, as specified in Section 01410, or the National Fuel Gas Code, whichever is more stringent.
    b. For 125 pounds per square inch gauge or greater working pressure, test per ASME B31.3 or ASME B31.8, whichever is more stringent.
5. When testing with water, the specified test pressure is considered to be the pressure at the lowest point of the piping section under test.
    a. Lower test pressure as necessary (based on elevation) if testing is performed at higher point of the pipe section.

B. Furnish necessary personnel, materials, and equipment, including bulkheads, restraints, anchors, temporary connections, pumps, water, pressure gauges, and other means and facilities required to perform tests.

C. Water for testing, cleaning, and disinfecting:
    1. Water for testing, cleaning, and disinfecting will be provided as specified in Section 01500.

D. Pipes to be tested: Test only those portions of pipes that have been installed as part of this Contract. Test new pipe sections prior to making final connections to existing piping. Furnish and install test plugs, bulkheads, and restraints required to isolate new pipe sections. Do not use existing valves as test plug or bulkhead.

E. Unsuccessful tests:
    1. Where tests are not successful, correct defects or remove defective piping and appurtenances and install piping and appurtenances that comply with the specified requirements.
    2. Repeat testing until tests are successful.

F. Test completion: Drain and leave piping clean after successful testing.

G. Test water disposal: Dispose of testing water into the treatment process at the headworks or the Influent Splitter Box. Discharging test water downstream of the Influent Splitter Box is prohibited.

1.04 SUBMITTALS

A. Submit as specified in Section 01330.

B. Schedule and notification of tests:
    1. Submit a list of scheduled piping tests by noon of the working day preceding the date of the scheduled tests.
    2. Notification of readiness to test: Immediately before testing, notify ENGINEER in writing of readiness, not just intention, to test piping.
    3. Have personnel, materials, and equipment specified in place before submitting notification of readiness.

1.05 SEQUENCE

A. Clean piping before pressure or leak tests.

B. Test gravity piping underground, including sanitary sewers, for visible leaks before backfilling and compacting.

C. Underground pressure piping may be tested before or after backfilling when not indicated or specified otherwise.

D. Backfill and compact trench, or provide blocking that prevents pipe movement before testing underground piping with a maximum leakage allowance.

E. Test underground piping before encasing piping in concrete or covering piping with slab, structure, or permanent improvement.

PART 2 PRODUCTS

Not Used.

PART 3 EXECUTION

3.01 TESTING ALIGNMENT, GRADE, AND DEFLECTION

A. Alignment and grade:
   1. Visually inspect the interior of gravity piping with artificial light, reflected light, or laser beam.
   2. Consider inspection complete when no broken or collapsed piping, no open or poorly made joints, no grade changes that affect the piping capacity, or no other defects are observed.

B. Deflection test:
   1. Pull a mandrel through the clean piping section under test.
   2. Perform the test not sooner than 30 days after installation and not later than 60 days after installation.
   3. Use a 9-rod mandrel with a contact length of not less than the nominal diameter of the pipe within 1 percent plus or minus.
   4. Consider test complete when the mandrel can be pulled through the piping with reasonable effort by 1 person, without the aid of mechanical equipment.

3.02 AIR TESTING METHOD FOR PRESSURE PIPING

A. Air test piping, indicated with "AM" in the Piping Schedule, with air or another nonflammable or inert gas.

B. Test gas, air, liquefied petroleum gas, liquid chlorine, and chlorine gas piping by the air test method:
   1. Test chlorine piping with dry air or nitrogen having a dew point of minus 40 degrees Fahrenheit or less. Supply temporary air dryers as necessary.

C. Test at pressure as specified in Piping Schedule in Section 15052:
   1. Provide temporary pressure relief valve for piping under test:
      a. Set at the lesser of 110 percent of the test pressure or 50 pounds per square inch gauge over the test pressure.

2. Air method test pressures shall not exceed 110 percent of the piping maximum allowable working pressure calculated in accordance with the most stringent of ASME B31.1, ASME B31.3, ASE B31.8, or the pipe manufacturer's stated maximum working pressure.
3. Gradually increase test pressure to an initial test pressure equal to the lesser of 1/2 the test pressure or 25 pounds per square inch gauge.
4. Perform initial check of joints and fittings for leakage.
5. Gradually increase test pressure in steps no larger than the initial pressure. Check for leakage at each step increase until test pressure reached.
6. At each step in the pressure, examine and test piping being air tested for leaks with soap solution.
7. Consider examination complete when piping section under test holds the test pressure for 15 minutes without losses.

3.03 TESTING GRAVITY FLOW PIPING

A. Test gravity flow piping indicated with "GR" in the Piping Schedule, as follows:
   1. Unless specified otherwise, subject gravity flow piping to the following tests:
      a. Alignment and grade.
      b. For plastic piping test for deflection.
      c. Visible leaks and pressure with maximum leakage allowance, except for storm drains and culverts.
   2. Inspect piping for visible leaks before backfilling.
   3. Provide temporary restraints when needed to prevent movement of piping.
   4. Pressure test piping with maximum leakage allowance after backfilling.
   5. With the lower end plugged, fill piping slowly with water while allowing air to escape from high points. Keep piping full under a slight head for the water at least 24 hours:
      a. Examine piping for visible leaks. Consider examination complete when no visible leaks are observed.
      b. Maintain piping with water, or allow a new water absorption period of 24 hours for the performance of the pressure test with maximum leakage allowance.
      c. After successful completion of the test for visible leaks and after the piping has been restrained and backfilled, subject piping to the test pressure for minimum of 4 hours while accurately measuring the volume of water added to maintain the test pressure:
         1) Consider the test complete when leakage is equal to or less than the following maximum leakage allowances:
            a) For concrete piping with rubber gasket joints: 80 gallons per day per inch of diameter per mile of piping under test:
               (1) Advise manufacturer of concrete piping with rubber gasket joints of more stringent than normal maximum leakage allowance.
            b) For vitrified claypiping: 500 gallons per day per inch of diameter per mile of piping under test.
            c) For other piping: 80 gallons per day per inch diameter per mile of piping under test.

3.04 TESTING HIGH-HEAD PRESSURE PIPING

A. Test piping for which the specified test pressure in the Piping Schedule is 20 pounds per square inch gauge or greater, by the high head pressure test method, indicated "HH" in the Piping Schedule.

B. General:
   1. Test connections, hydrants, valves, blowoffs, and closure pieces with the piping.
   2. Do not use installed valves for shutoff when the specified test pressure exceeds the valve's maximum allowable seat differential pressure. Provide blinds or other means to isolate test sections.
   3. Do not include valves, equipment, or piping specialties in test sections if test pressure exceeds the valve, equipment, or piping specialty safe test pressure allowed by the item's manufacturer.
   4. During the performance of the tests, test pressure shall not vary more than plus or minus 5 pounds per square inch gauge with respect to the specified test pressure.
   5. Select the limits of testing to sections of piping. Select sections that have the same piping material and test pressure.
   6. When test results indicate failure of selected sections, limit tests to piping:
      a. Between valves.
      b. Between a valve and the end of the piping.
      c. Less than 500 feet long.
   7. Test piping for minimum 2 hours for visible leaks test and minimum 2 hours for the pressure test with maximum leakage allowance.

C. Testing procedures:
   1. Fill piping section under test slowly with water while venting air:
      a. Use potable water for all potable waterlines and where noted on the Piping Schedule.
   2. Before pressurizing for the tests, retain water in piping under slight pressure for a water absorption period of minimum 24 hours.
   3. Raise pressure to the specified test pressure and inspect piping visually for leaks:
      a. Consider visible leakage testing complete when no visible leaks are observed.

D. Pressure test with maximum leakage allowance:
   1. Leakage allowance is zero for piping systems using flanged, National Pipe Thread threaded and welded joints.
   2. Pressure test piping after completion of visible leaks test.
   3. For piping systems using joint designs other than flanged, threaded, or welded joints, accurately measure the makeup water necessary to maintain the pressure in the piping section under test during the pressure test period:
      a. Consider the pressure test to be complete when makeup water added is less than the allowable leakage and no damage to piping and appurtenances has occurred.
      b. Successful completion of the pressure test with maximum leakage allowance shall have been achieved when the observed leakage during the test period is equal or less than the allowable leakage and no damage to piping and appurtenances has occurred.

c. When leakage is allowed, calculate the allowable leakage by the following formula:

$L = S \times D \times P^{1/2} \times 133{,}200^{-1}$

wherein the terms shall mean:

L = Allowable leakage in gallons per hour.

S = Length of the test section in feet.

D = Nominal diameter of the piping in inches.

P = Average observed test pressure in pounds per square inches gauge, at the lowest point of the test section, corrected for elevation of the pressure gauge.

x = The multiplication symbol.

3.05 TESTING LOW-HEAD PRESSURE PIPING

A. Test piping for which the specified test pressure is less than 20 pounds per square inch gauge, by the low head pressure test method, indicated "LH" in the Piping Schedule.

B. General:
   1. Test pressures shall be as scheduled in Section 15052.
   2. During the performance of the tests, test pressure shall not vary more than plus or minus 2 pounds per square inch gauge with respect to the specified test pressure.
   3. Test connections, blowoffs, vents, closure pieces, and joints into structures, including existing bell rings and other appurtenances, with the piping.
   4. Test piping for minimum 2 hours for visible leaks test and minimum 2 hours for the pressure test with maximum leakage allowance.

C. Visible leaks test:
   1. Subject piping under test to the specified pressure measured at the lowest end.
   2. Fill piping section under test slowly with water while venting air:
      a. Use potable water for all potable waterlines and where noted on the Piping Schedule.
   3. Before pressurizing for the tests, retain water in piping under slight pressure for the water absorption period of minimum 24 hours.
   4. Raise pressure to the specified test pressure and inspect piping visually for leaks. Consider testing complete when no visible leaks are observed.

D. Pressure test with maximum leakage allowance:
   1. Pressure test piping after completion of visible leaks test.
   2. Accurately measure the makeup water necessary to maintain the pressure in the piping section under test during the pressure test period:
      a. Consider the pressure test to be complete when makeup water added is less than the allowable leakage of 80 gallons per inch of nominal

diameter, per mile of piping section under test after 24 hours, and no damage to piping and appurtenances has occurred.

b. Successful completion of the leakage test shall have been achieved when the observed leakage is equal or less than the allowable leakage and no damage to piping and appurtenances has occurred.

E. Optional joint test:

1. When joint testing is allowed by note in the Piping Schedule, the procedure shall be as follows:
   a. Joint testing will be allowed only for low head pressure piping.
   b. Joint testing does not replace and is not in lieu of any testing of the piping system or trust restraints.
2. Joint testing may be performed with water or air.
3. Joint test piping after completion of backfill and compaction to the top of the trench.
4. Joint testing with water:
   a. Measure test pressure at the invert of the pipe. Apply pressure of 4 feet plus the inside diameter of the pipe in water column within 0.20 feet in water column.
   b. Maintain test pressure for 1 minute.
   c. Base the allowable leakage per joint on 80 gallons per inch nominal diameter, per mile of piping, per 24 hours equally distributed to the actual number of joints per mile for the type of piping.
   d. Consider the pressure test to be complete when makeup water added is less than the allowable leakage.
   e. Successful completion of the joint test with water shall have been achieved when the observed leakage is equal or less than the allowable leakage.
5. Joint testing with air:
   a. Apply test pressure of 3 pounds per square inch gauge with a maximum variation of plus 0.20 and minus 0.00 pounds per square inch.
   b. Maintain test pressure for 2 minutes.
   c. Consider the pressure test to be complete when the test pressure does not drop below 2.7 pounds per square inch for the duration of the test.

END OF SECTION

SECTION 15958

MECHANICAL EQUIPMENT TESTING

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Testing of mechanical equipment and systems.

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 01660 - Testing, Training, and Commissioning.
      b. Section 02318 - Trenching.
      c. Section 15956 - Piping Systems Testing.
      d. Section 16222 - Low Voltage Motors up to 500 Horsepower.
      e. Section 16950 - Field Electrical Acceptance Tests.
      f. Section 17950 - Testing, Calibration, and Commissioning.

1.02 REFERENCES

A. American National Standards Institute (ANSI):
   1. S1.4 Specification for Sound Level Meters.

B. Hydraulic Institute (HI).

1.03 SUBMITTALS

A. Schedule of factory tests and field tests as specified in Section 01660 and this Section.

B. Test instrumentation calibration data.

C. Start-up plan as specified in Section 01660.

D. Test plan specified in this Section.

E. Test result reports.

PART 2 PRODUCTS

Not Used.

PART 3 EXECUTION

3.01 QUALITY CONTROL TESTING AND REPORTING

A. Scheduling and notification:
   1. Witnessed source quality control tests: Schedule test date and notify ENGINEER at least 30 days prior to start of test.
   2. Field quality control tests: Schedule test date and notify ENGINEER at least 7 days prior to start of test.

B. Testing levels:
   1. Test equipment based on test levels specified in the equipment section of this Project.
   2. Requirements for Test Levels 1 to 4 are defined below.
   3. Test levels apply for both Source (Factory) Quality Control Tests and Field Quality Control Tests as specified in the equipment sections of this Project.
   4. If testing is not specified in the equipment section, provide Level 1 testing.
   5. Requirements of Section 01660 apply to Test Levels.

C. Witnessing: Source Quality Control Tests not witnessed unless specified otherwise in the equipment section or Section 01660; Field Quality Control Tests shall be witnessed.

D. Instrumentation: Provide necessary test instrumentation which has been calibrated within 1 year from date of test to recognized test standards traceable to the National Institute of Standards and Technology, Washington, D.C. or approved source. Properly calibrated field instrumentation permanently installed as a part of the Work may be utilized for Field Quality Control Tests.

E. Temporary facilities and labor: Provide necessary fluids, utilities, temporary piping, temporary supports, temporary access platforms or access means and other temporary facilities and labor necessary to safely operate the equipment and accomplish the specified testing. With OWNER's permission, some utilities may be provided by fully tested permanently installed utilities that are part of the Work.

F. Test fluids:
   1. Factory tests: Use water or air as appropriate at ambient conditions unless specified otherwise in the equipment section.
   2. Field tests: Use specified process fluid at available conditions.

G. Pressure testing: Hydrostatically pressure test pressure containing parts in the factory at the appropriate standard or code required level above the equipment component specified design pressure or operating pressure, whichever is higher. Submit pressure test reports before shipping.

H. Test measurement and result accuracy:
   1. Use test instruments with accuracies as recommended in the appropriate referenced standards. When no accuracy is recommended in the referenced standard, use 1 percent or better accuracy test instruments. Improved (lower error tolerance) accuracies specified elsewhere prevail over this general requirement.
   2. Do not adjust results of tests for instrumentation accuracy. Measured values and values directly calculated from measured values shall be the basis for comparing actual equipment performance to specified requirements.

I. Field testing:
   1. Submit test plan as specified in Section 01660 and this Section. Indicate test start time and duration, equipment to be tested, other equipment involved or required; temporary facilities required, number and skill or trade of personnel involved; safety issues and planned safety contingencies; anticipated effect on OWNER's existing equipment and other information relevant to the test. Provide locations of all instruments to be used for testing. Provide calibration records for all instrumentation.
   2. Perform general start-up and testing procedures as specified in Section 01660.
   3. Prior to testing, verify equipment protective devices and safety devices have been installed, calibrated, and tested.

J. Reports: Submit reports for source and field-testing. Submit Source Quality Control Test result reports before shipping equipment to the field. Report features:
   1. Report results in a bound document in generally accepted engineering format with title page, written summary of results compared to specified requirements, and appropriate curves or plots of significant variables in English units.
   2. Include appendix with a copy of raw, unmodified test data sheets indicating test value, date and time of reading, and initials of person taking the data.
   3. Include appendix with sample calculations for adjustments to raw test data and for calculated results.
   4. Include appendix with the make, model, and last calibration date of instrumentation used for test measurements.
   5. Include in body of report a drawing or sketch of the test system layout showing location and orientation of the test instruments relative to the tested equipment features.

3.02 EQUIPMENT TESTING, GENERAL

A. Tests for pumps, all levels of testing:
   1. Test in accordance with applicable HI Standards in addition to the requirements in this and other Sections.
   2. Test tolerances: In accordance with appropriate HI Standards, except the following modified tolerances apply:
      a. From 0 to plus 5 percent of head at the specified flows.
      b. From 0 to plus 5 percent of flow at the rated design point head.
      c. No negative tolerance for the efficiency at the specified flows.
      d. No positive tolerance for vibration limits. Vibration limits and test methods in HI Standards do not apply, use limits and methods specified in this or other Sections of the Specifications.

B. Tests for drivers: Test motors as specified in Section 16222. Test other drivers as specified in the driver equipment section.

3.03 REQUIREMENTS FOR VIBRATION TESTING

A. Definitions:
   1. Peak-to-peak displacement: The root mean squared average of the peak-to-peak displacement multiplied by the square root of 2.
   2. Peak velocity: The root mean squared average of the peak velocity multiplied by the square root of 2.
   3. Peak acceleration: The root mean squared average of the peak acceleration multiplied by the square root of 2.

4. High frequency enveloping: A process to extract very low amplitude time domain signals associated with impact or impulse events such as bearing or gear tooth defects and display them in a frequency spectrum of acceleration versus frequency.
    a. Manufacturers: One of the following or equal:
        1) Rockwell Automation, Entek Group, "Spike Energy" analysis.
        2) CSI, "PeakVue."
5. Low-speed equipment: Equipment or components of equipment rotating at less than 600 revolutions per minute.
6. High-speed equipment: Equipment and equipment components operating at or above 600 revolutions per minute.

B. Vibration instrumentation requirements:
1. Analyzers: Use digital type analyzers or data collectors with anti-aliasing filter, 12 bit A/D converter, fast fourier transform circuitry, phase measurement capability, time wave form data storage, high frequency enveloping capabilities, 35 frequency ranges from 21 to 1,500,000 cycles per minute, adjustable fast fourier transform resolution from 400 to 6,400 lines, storage for up to one hundred 3,200 line frequency spectra, RS232C data output port, circuitry for integration of acceleration data to velocity or double integration to displacement.
    a. Manufacturers: One of the following or equal:
        1) Entek-IRD, Division of Rockwell Automation, Enpac 1200 with applicable data analysis software or Entek Model 838 analyzer with built in printer.
        2) Computational Systems Inc., (CSI) Division of Emerson Electric, Model 2120A, Data Collector/analyzer with applicable analysis software.
2. Analyzer settings:
    a. Units: English, inches/second, mils, and gravitational forces.
    b. Fast fourier transform lines: Most equipment 1,600 minimum; for motors, enough lines as required to distinguish motor current frequencies from rotational frequencies, use 3,200 lines for motors with a nominal speed of 3,600 revolutions per minute; 3,200 lines minimum for High Frequency Enveloping; 1,600 lines minimum for low speed equipment.
    c. Sample averages: 4 minimum
    d. Maximum frequency (Fmax): 40 times rotational frequency for rolling element bearings, 10 times rotational frequency for sleeve bearings.
    e. Amplitude range: Auto select but full scale not more than twice the acceptance criteria or the highest peak, whichever is lower.
    f. Fast fourier transform windowing: Hanning Window.
    g. High pass filter: Minus 3 dB at 120 cycles per minute for high speed equipment. Minus 3 dB at 21 cycles per minute for low speed equipment.
3. Accelerometers:
    a. For low-speed equipment: Low frequency, shear mode accelerometer, 500 millivolts per gravitational force sensitivity, 10 gravitational force range, plus/minus 5 percent frequency response from 0.5 hertz to 850 hertz, magnetic mount.
        1) Manufacturers: One of the following or equal:
            a) Wilcoxon Research, Model 797L.
            b) PCB, Model 393C.

b. For high speed equipment: General purpose accelerometer, 100 millivolts per gravitational force sensitivity, 50 gravitational force range, plus/minus 3dB frequency response range from 2 hertz to 12,000 hertz when stud mounted, with magnetic mount holder.
   1) Manufacturers: One of the following or equal:
      a) Wilcoxon Research, Model 793.
      b) Entek-IRD Model 943.

C. Accelerometer mounting:
   1. Use magnetic mounting or stud mounting.
   2. Mount on bearing housing in location with best available direct path to bearing and shaft vibration.
   3. Remove paint and mount transducer on flat metal surface or epoxy mount for High Frequency Enveloping measurements.

D. Vibration testing results presentation:
   1. Provide equipment drawing with location and orientation of measurement points indicated.
   2. For each vibration measurement take and include appropriate data on equipment operating conditions at the time vibration data is taken; for pumps, compressors, and blowers record suction pressure, discharge pressure, and flow.
   3. When Vibration Spectra Data required:
      a. Plot peak vibration velocity versus frequency in cycles per minute.
      b. Label plots showing actual shaft or part rotation frequency, bearing inner and outer race ball pass frequencies, gear mesh frequencies and relevant equipment excitation frequencies on the plot; label probable cause of vibration peaks whether in excess of specification limits or not.
      c. Label plots with equipment identification and operating conditions such as tag number, capacity, pressure, driver horsepower, and point of vibration measurement.
      d. Plot motor spectra on a log amplitude scale versus frequency.
   4. For low speed equipment, plot peak vibration displacement versus frequency as well as velocity versus frequency.
   5. Provide name of manufacturer and model number of the vibration instrumentation used, including analyzer and accelerometer used together with mounting type.

3.04 TESTING LEVELS

A. Level 1 Quality Control Tests:
   1. Level 1 General Equipment Performance Test:
      a. For equipment, operate, rotate, or otherwise functionally test for 15 minutes minimum after components reach normal operating temperatures.
      b. Operate at rated design load conditions.
      c. Confirm that equipment is properly assembled, equipment moves or rotates in the proper direction, shafting, drive elements and bearings are installed and lubricated in accordance with proper tolerances, and that no unusual power consumption, lubrication temperatures, bearing temperatures, or other conditions are observed.

2. Level 1 Pump Performance Test:
    a. Measure flow and head while operating at or near the rated condition; for factory testing, testing may be at reduced speeds with flow and head corresponding to the rated condition when adjusted for speed using the appropriate affinity laws.
    b. Use of a test driver is permitted for factory tests when actual driver is given a separate test at its point of manufacture as specified in Section 16222 or the applicable equipment section. Use actual driver for field tests.
    c. Record measured flow, suction pressure, discharge pressure, and make observations on bearing temperatures and noise levels.
3. Level 1 Vibration Test:
    a. Test requirement:
        1) Measure filtered vibration spectra versus frequency in 3 perpendicular planes at each normally accessible bearing housing on the driven equipment, any gears and on the driver; 1 plane of measurement to be parallel to the axis of rotation of the component.
        2) Vibration spectra versus frequency shall be in accordance with Vibration Acceptance Criteria.
    b. Equipment operating condition: Test at specified maximum speed.
4. Level 1 Noise Test:
    a. Measure unfiltered overall A-weighted sound pressure level in dBA at 3 feet horizontally from the surface of the equipment and at a mid-point of the equipment height.

B. Level 2 Quality Control Tests:
1. Level 2 General Performance Test:
    a. For equipment, operate, rotate, or otherwise functionally test for at least 2 hours after components reach normal operating temperatures.
    b. Operate at rated design load conditions.
    c. Confirm that equipment is properly assembled, equipment moves or rotates in the proper direction, shafting, drive elements and bearings are installed and lubricated in accordance with proper tolerances, and that no unusual power consumption, lubrication temperatures, bearing temperatures, or other conditions are observed.
2. Level 2 Pump Performance Test:
    a. Test 2 hours minimum for flow and head at the rated condition; for factory testing, testing may be at reduced speeds with flow and head corresponding to the rated condition when adjusted for speed using the appropriate affinity laws.
    b. Use of a test driver is permitted for factory tests when actual driver is given a separate test at its point of manufacture as specified in Section 16222. Use actual driver for field tests.
    c. Test for flow and head at 2 additional conditions; 1 at 25 percent below the rated flow and 1 at 10 percent above the rated flow.
    d. Record measured flow, suction pressure, discharge pressure, and observations on bearing temperatures and noise levels at each condition.
3. Level 2 Vibration Test:
    a. Test requirement:
        1) Measure filtered vibration spectra versus frequency and measure vibration phase in 3 perpendicular planes at each normally accessible bearing housing on the driven equipment, any gears and

on the driver; 1 plane of measurement to be parallel to the axis of rotation of the component; measure actual rotational speeds for each vibration spectra measured using photometric or other tachometer input connected directly to the vibration data collector.

2) Vibration spectra versus frequency shall be in accordance with Vibration Acceptance Criteria.

b. Equipment operating condition: Repeat test requirements at design specified maximum speed and at minimum speed for variable speed equipment.

c. Natural frequency test of field installed equipment:

1) Excite the installed equipment and support system in 3 perpendicular planes, use same planes as operating vibration measurement planes, and determine the as-installed natural resonant frequency of the driven equipment, the driver, gears and supports.

2) Perform test at each bearing housing, at each support pedestal, and for pumps on the suction and discharge piping.

3) Perform with equipment and attached piping full of intended service or process fluid.

4. Level 2 Noise Test:

a. Measure filtered A-weighted overall sound pressure level in dBA for each of 8 octave band mid-points beginning at 63 hertz measured at 3 feet horizontally from the surface of the equipment at mid-point height of the noise source.

C. Level 3 Quality Control Tests:

1. Level 3 General Equipment Performance Tests:

a. For equipment, operate, rotate, or otherwise functionally test for at least 4 hours after components reach normal operating temperatures.

b. Operate at rated design load conditions for 1/2 the specified time; operate at each of any other specified conditions for a proportionate share of the remaining test time.

c. Confirm that equipment is properly assembled, equipment rotates in the proper direction, shafting and bearings are installed and lubricated in accordance with proper tolerances, and that no unusual noise, vibration or temperatures are observed.

d. Take appropriate capacity, power or fuel consumption, torque, revolutions per minute, pressure and temperature readings using appropriate test instrumentation to confirm equipment meets specified performance requirements at the design rated condition.

e. Bearing temperatures: During maximum speed or capacity performance testing, measure and record the exterior surface temperature of each bearing versus time.

2. Level 3 Pump Performance Test:

a. Test 4 hours minimum for flow and head at or near the rated condition; for factory testing, testing may be at a reduced speeds with flow and head corresponding to the rated condition when adjusted for speed using the appropriate affinity laws.

b. Use of a test driver is permitted for factory tests when actual driver is given a separate test at its point of manufacture as specified in Section 16222. Use actual driver for field tests.

c. Test each specified flow and head condition at the rated speed and test at minimum as well as maximum specified speeds; operate at each test

condition for a minimum of 15 minutes; for factory testing, test at other speeds may be omitted if test driver at reduced speeds is used for rated condition testing.

d. Record measured shaft revolutions per minute, flow, suction pressure, discharge pressure; record measured bearing temperatures (bearing housing exterior surface temperatures may be recorded when bearing temperature devices are not required by the equipment section) and record observations on noise levels.

3. Level 3 Vibration Test:
   a. Requirements: Same as Level 2 vibration test except data taken at each operating condition tested and with additional requirements below.
   b. Perform High Frequency Enveloping Analysis for gears and bearings.
      1) Measure bearing element vibration directly on each bearing cap in a location close as possible to the bearing load zone that provides a smooth surface and direct path to the bearing to detect bearing defects.
      2) Report results in units of acceleration versus frequency in cycles per minute.
   c. Perform Time Wave Form analysis for gears, low speed equipment and reciprocating equipment; plot true peak amplitude velocity and displacement versus time and label the period between peaks with the likely cause of the periodic peaks (relate the period to a cause).
   d. Plot vibration spectra on 3 different plots; peak displacement versus frequency, peak acceleration versus frequency and peak velocity versus frequency.
4. Level 3 Noise Test: Measure filtered, un-weighted overall sound pressure level in dB at 3 feet horizontally from the surface of the equipment at mid-point height and at 4 locations approximately 90 degrees apart in plan view; report results for each of 8 octave band mid-points beginning at 63 hertz.

D. Level 4 Quality Control Tests:
1. Level 4 General Equipment Performance Test:
   a. For equipment, operate, rotate, or otherwise functionally test for at least 8 hours after components reach normal operating temperatures.
   b. Operate at rated design load conditions for1/2 the specified time; operate at each of any other specified conditions for a proportionate share of the remaining test time.
   c. Confirm that equipment is properly assembled, equipment rotates in the proper direction, shafting and bearings are installed and lubricated in accordance with proper tolerances, and that no unusual noise, vibration or temperatures are observed.
   d. Take appropriate capacity, power or fuel consumption, torque, revolutions per minute, pressure and temperature readings using appropriate test instrumentation to confirm equipment meets specified performance requirements at the design rated condition.
   e. Bearing temperatures: During maximum speed or capacity testing, measure and record the exterior surface temperature of each bearing versus time.
2. Level 4 Pump Performance Test:
   a. Test 8 hours minimum for flow and head; begin tests at or near the rated condition; for factory and field-testing, test with furnished motor at full speed.

b. Test each specified flow and head condition at the rated speed and test at minimum as well as maximum specified speeds; operate at each test condition for a minimum of 20 minutes or longer as necessary to measure required performance, vibration and noise data at each test condition.
c. Record measured shaft revolutions per minute, flow, suction pressure, discharge pressure; record measured bearing temperatures (bearing housing exterior surface temperatures may be recorded when bearing temperature devices not required by the equipment section) and record observations on noise levels.
d. Bearing temperatures: During maximum speed or capacity testing, measure and record the exterior surface temperature of each bearing versus time.
e. Perform efficiency and/or Net Positive Suction Head Required (NPSHr) and/or priming time tests when specified in the equipment section in accordance with the appropriate HI standard and as follows:
1) Perform NPSHr testing at maximum rated design speed, head and flow with test fluids at ambient conditions; at maximum rated speed, test at 15 percent above rated design flow, and 25 percent below rated design flow.
2) Perform efficiency testing with test fluids at maximum rated speed.
3) Perform priming time testing with test fluids at maximum rated speed.

3. Level 4 Vibration Test: Same as Level 3 vibration test.
4. Level 4 Noise Test: Same as Level 3 Noise Test except with data taken at each operating condition tested.

3.05 SOURCE QUALITY CONTROL

A. Test equipment as specified for each type of test at the test levels specified in equipment sections. Prepare and submit test reports as specified.

B. Inspection and balancing:
1. Statically and dynamically balance each of the individual rotating parts as required to achieve the required field vibration limits. Statically and dynamically balance the completed equipment rotating assembly and drive shaft components.
2. Furnish copies of material and component inspection reports including balancing reports for equipment system components and for the completed rotating assembly.

C. Critical speed of rotating equipment: Satisfy the following:
1. The first lateral and torsional critical speed of all constant, variable, and 2-speed driven equipment that is considered rigid such as horizontal pumps, all non-clog pumps, blowers, air compressors, and engines shall be at least 25 percent above the equipment's maximum operating speed.
2. The first lateral and torsional critical speed of all constant, variable, and 2-speed driven equipment that is considered flexible or flexibly mounted such as vertical pumps (vertical in-line and vertical non-clog pumps excluded) and fans shall at least 25 percent below the equipment's lowest operating speed.
3. The second lateral and torsional critical speed of all constant, variable, and 2-speed equipment that is considered flexible or flexibly mounted shall be at least 25 percent above the maximum operating speed.

3.06 FIELD QUALITY CONTROL

A. Test equipment as specified for each type of test at the test levels specified in equipment sections. Prepare and submit test reports as specified. Comply with latest version of applicable standards.

B. For variable speed equipment, conduct test to establish performance over the entire speed range and at the average operating condition. Establish performance curves for:
   1. The speed corresponding to the rated maximum capacity.
   2. The speed corresponding to the minimum capacity.
   3. The speed corresponding to the average operating conditions.

3.07 VIBRATION ACCEPTANCE CRITERIA

A. Testing of rotating mechanical equipment: Tests are to be performed by an experienced, factory trained, and independent authorized vibration analysis expert.

B. Vibration displacement limits: Unless otherwise specified, equipment operating at speeds 600 revolutions per minute or less is not to exhibit unfiltered readings in excess of following:

Operating Speed (revolutions per minute)	**Unfiltered (Overall) Peak-to-Peak Amplitude (mils)**
	All Rotating Equipment
0 - 300	6.5
301 - 600	4.5
Note: For all equipment, axial shaft displacements not to exceed 50 percent of the maximum radial shaft displacements shown in the table relative to the casing.	

C. Vibration velocity limits: Unless otherwise specified, equipment operating at speeds greater than 600 revolutions per minute is not to exceed the following peak velocity limits:

Item	**Unfiltered Overall Limit (inches per second)**	**Any Filtered Peak Limit (inches per second)**
Non-Clog Solids Handling Centrifugal Pumps	0.35	0.25
Horizontal and Vertical In-Line Centrifugal Pumps (other than Non-Clog type)	0.18 (Input BHP 25 or less)	0.14 (Input BHP 25 or less)
	0.22 (Input BHP more than 25 but less than 100)	0.18 (Input BHP more than 25 but less than 100)
	0.25 (Input BHP 100 or more)	0.20 (Input BHP 100 or more)
Vertical Turbine, Mixed Flow, and Propeller Pumps	0.31 (Input BHP 100 or less)	0.22

Item	Unfiltered Overall Limit (inches per second)	Any Filtered Peak Limit (inches per second)
	0.35 (Input BHP 125 or more)	0.25
Vertical Turbine, Mixed Flow, and Propeller Short Set Pumps	0.28 (Input BHP 100 or less)	0.21
	0.33 (Input BHP 125 or more)	0.24
Motors	See Applicable Motor Specification	
Gear Reducers, Radial	Not to exceed AGMA 6000-A88 limits	
Other Reducers, Axial	0.10	0.10
Centrifugal Fans and Blowers	0.15	0.10
Other Equipment, Radial	0.16	0.10
Other Equipment, Axial	0.10	0.10

D. Equipment operation: Measurements are to be obtained with equipment installed and operating within capacity ranges specified and without duplicate equipment running.

E. Additional criteria:
   1. No narrow band spectral vibration amplitude components, whether sub-rotational, higher harmonic, or synchronous multiple of running speed, are to exceed 40 percent of synchronous vibration amplitude component without manufacturer's detailed verification of origin and ultimate effect of such excitation.
   2. The presence of discernable vibration amplitude peaks in Test Level 2 or 3 vibration spectra at bearing inner or outer race frequencies shall be cause for rejection of the equipment.
   3. For motors, the following shall be cause for rejection:
      a. Stator eccentricity evidenced by a spectral peak at 2 times electrical line frequency that are more than 40 percent of the peak at rotational frequency.
      b. Rotor eccentricity evidenced by a spectral peak at 2 times electrical line frequency with spectra side bands at the pole pass frequency around the 2 times line frequency peak.
      c. Other rotor problems evidenced by pole pass frequency side bands around operating speed harmonic peaks or 2 times line frequency side bands around rotor bar pass frequency or around 2 times the rotor bar pass frequency.
      d. Phasing problems evidenced by 1/3 line frequency side band spectral peaks around the 2 times electrical line frequency peak.
   4. The presence of peaks in a High Frequency Enveloping spectra plot corresponding to bearing, gear or motor rotor bar frequencies or harmonics of these frequencies shall be cause for rejection of the equipment; since inadequate lubrication of some equipment may be a cause of these peaks,

lubrication shall be checked, corrected as necessary and the high frequency envelope analysis repeated.

3.08 NOISE REQUIREMENTS AND CONTROL

A. Make measurements in relation to reference pressure of 0.0002 microbar.

B. Make measurements of emitted noise levels on sound level meter meeting or exceeding ANSI S1.4, Type II.

C. Set sound level meter to slow response.

D. Unless otherwise specified, maximum free field noise level not to exceed 85 dBA measured as sound pressure level at 3 feet from the equipment.

3.09 FUNCTIONAL AND OPERATIONAL TESTING OF EQUIPMENT

A. Functional testing as specified in Section 01660 and this Section.

B. General checkout: Prior to operating equipment, inspect, test, and check supporting systems, including but not limited to power systems, control systems, piping systems, lubrication systems, and safety systems.
   1. Test and calibrate instrumentation and electrical devices as specified in Sections 16950 and 17950.
   2. Test and prepare piping as specified in Sections 02318 and 15956.
   3. As a minimum for control systems associated with the equipment, perform the following:
      a. Individual Loop Tests: Test from field device to intermediate terminations to controller and back to controlled element.
      b. End-to-end test: Simulate input at field device and observe control system response at the final field control element.
   4. Prior to testing, provide signed and dated certificates of calibration for test instrumentation and equipment.

C. Operation of related existing equipment: OWNER will operate related existing equipment or facilities necessary to accomplish the testing.

D. Acceptable tests: Demonstrate the equipment performance meets the requirements of this Section and the equipment section; when the equipment fails to meet the specified requirements, perform additional more detailed testing to determine the cause, correct, repair, or replace the causative components and repeat the testing that revealed the deficiency.

E. Operational testing: As specified in Section 01660.

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. 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 00700 - General Conditions.
      b. Section 01140 - Work Restrictions.
      c. Section 01292 - Schedule of Values.
      d. Section 01312 - Project Meetings.
      e. Section 01330 - Submittal Procedures.
      f. Section 01410 - Regulatory Requirements.
      g. Section 01450 - Quality Control.
      h. Section 01610 - Project Design Criteria.
      i. Section 01612 - Seismic Design Criteria.
      j. Section 01614 - Wind Design Criteria.
      k. Section 01660 - Testing, Training, and Commissioning.
      l. Section 01740 - Warranties and Bonds.
      m. Section 01770 - Closeout Procedures.
      n. Section 01782 - Operation and Maintenance Data
      o. Section 16052 - Hazardous Classified Area Construction.
      p. Section 16210 - Utility Coordination.
      q. Section 16222 - Low Voltage Motors up to 500 Horsepower.
      r. Section 16075 - Electrical Identification.
      s. Section 16130 - Conduits.
      t. Section 16305 - Electrical System Studies.
      u. Section 16950 - Field Electrical Acceptance Tests.

C. Interfaces to equipment, instruments, and other components:
   1. The 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 Section 00700.
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.

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. Contract Documents:
1. General:
    a. The 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 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 indicated on the Drawings are approximate. Use the shop drawings to determine the proper layout, foundation, and pad requirements, 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. It is the Contractor's responsibility to ensure that the equipment being furnished fits within the defined space.

c. Installation details:
   1) The Contract Drawings include typical installation details the Contractor is to use to complete the Electrical Work. For cases where a typical detail does not apply, develop installation details that may be necessary for completing the Work, and submit these details for review by the Engineer.

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.

F. Alternates/Alternatives:
   1. Coordinate with Section 00700 for substitute item provisions.

G. Changes and change orders:
   1. As specified in Section 00700.

1.02 REFERENCES

A. Code compliance:
   1. As specified in Section 01410.
   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. ASTM International (ASTM).
      c. Illuminating Engineering Society (IES).Institute of Electrical and Electronics Engineers (IEEE).
      d. Insulated Cable Engineers Association (ICEA).
      e. InterNational Electrical Testing Association (NETA).
      f. International Society of Automation (ISA).

g. National Electrical Manufacturers Association (NEMA):
   1) 250 - Enclosures for Electrical Equipment (1000 V Maximum).
h. National Fire Protection Association (NFPA):
   1) 70 - National Electric Code (NEC).
i. National Institute of Standards and Technology (NIST).
j. Underwriters' Laboratories, Inc. (UL).

B. Compliance with laws and regulations:
   1. As specified in Section 00700.

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. FAT: Factory acceptance test.
   2. ICSC: Instrumentation and controls subcontractor.
   3. LCP:Local control panel: Operator interface panel that may contain an HMI, pilot type control devices, operator interface devices, control relays, etc. and does not contain a PLC or RIO.
   4. PCM: Process control module: An enclosure containing any of the following devices: PLC, RTU, or RIO.
   5. PCIS: Process control and instrumentation system.
   6. RTU: Remote telemetry unit: A controller typically consisting of a PLC, and a means for remote communications. The remote communications devices typically are radios, modems, etc.
   7. Space: That portion of the switchgear, motor control center, panelboard, switchboard or control panel that does not physically contain a device but is capable of accepting a device with no modifications to the equipment, i.e., provide all standoffs, bus, and hardware, as part of the space.
   8. 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.
   9. System supplier: Refer to Quality Assurance in this Section.
   10. VCP: Vendor control panel: Control panels that are furnished with particular equipment by a vendor other than the ICSC. These panels may contain PLCs, RIO, OIT, HMI, etc.
   11. 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 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.

1.05 SUBMITTALS

A. Furnish submittals as specified in Section 01330 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 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.

C. Submittal organization:
   1. First page:
      a. Specification section reference.
      b. Name and telephone number of individual who reviewed submittal before delivery to Engineer.
      c. Name and telephone number of individual 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 exactly the same order as the items are referenced, listed, and/or organized in the specification section. 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.

D. Operation and maintenance manuals:
   1. As specified in Section 01782.
   2. Furnish the Engineer with a complete set of written operation and maintenance manuals 8 weeks before energization start-up and/or commissioning.

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

F. Schedule of values:
   1. In addition to completing all items referred to in the schedule of values, Section 01292, submit per unit material and labor costs used in developing the final bid for the electrical system, for the express purpose of pricing and cost justification for any proposed change orders. In addition to the items shown on the schedule of values, provide per unit material and labor costs for conduit and wire installation for specific types, sizes, and locations as indicated on the Drawings and Conduit Schedule. It is the responsibility of the electrical subcontractor to prove to the Engineer's satisfaction that said per unit costs were used in the development of the final Bid amount.

G. Roof penetrations:
   1. 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.

H. Record Documents:
   1. Furnish as specified in Section 01770.
   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.
   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 on 11-inch by 17-inch using Bond paper.
         2) Provide electronic copies of these documents on CD-ROM disks in MicroStation by Bentley Version 8. 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 2000 and printed on 8.5-inch by 11-inch plain bond paper:
         1) Provide electronic copies of these documents on CD-ROM disks.
   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.

I. Test reports:
   1. As specified in Section 01330.
   2. Additional requirements for acceptance test reports are specified in Section 16950.

J. Calculations:
   1. Where required by specific Electrical Specifications:
      a. Because 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.

K. Factory acceptance test:
   1. As specified in Section 01330.

1.06 QUALITY ASSURANCE

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

1.07 DELIVERY, STORAGE, AND 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:
   1. 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:
   1. 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 classification:
      a. Provide all electrical equipment and construction techniques suitable for the seismic requirements for the Site, as specified in Section 01612.
   3. Wind:
      a. Provide all electrical equipment and construction techniques suitable for the Site wind loading criteria, as specified in Section 01614.
   4. Altitude, temperature and humidity:
      a. As specified in Section 01610.
      b. Provide all electrical components and equipment fully rated for continuous operation at this altitude, with no additional derating 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 Fahrenheit above the minimum operating temperature and 10 degrees Fahrenheit 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. 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 Standard 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 316L 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.

C. Plant area Electrical Work requirements:

1. Provide all Electrical Work in accordance with the following table, unless otherwise specifically indicated on the Drawings:

PLANT AREA	**NEMA ENCLOSURE TYPE**	**EXPOSED CONDUIT TYPE**	**ENVIRONMENT W = WET D = DAMP C = CLEAN/DRY X = CORROSIVE H = HAZARDOUS**	**SUPPORT MATERIALS**
Area 3				
REW Pond Structures	4X	PCS	W X	Stainless steel
Main Entrance Gate	4X	PCS	W X	Stainless steel
Service Entrance Gate	4X	PCS	W X	Stainless steel

PLANT AREA	NEMA ENCLOSURE TYPE	EXPOSED CONDUIT TYPE	ENVIRONMENT W = WET D = DAMP C = CLEAN/DRY X = CORROSIVE H = HAZARDOUS	SUPPORT MATERIALS
Area 4				
Plant Drain Pump Station	4X and 7[1]	PCS	W X H: Class 1, Division 1, Group D, within tank. Class 1, Division 2, Group D, 18-inch envelope above tank openings, extending 3 feet horizontally beyond tank openings.	Stainless steel
Storm Water Pump Station	4X and 7[1]	PCS	W X H: Class 1, Division 1, Group D, in wetwell. Class 1, Division 2, Group D, 18-inch envelope above tank openings, extending 3 feet horizontally beyond tank openings.	Stainless steel
Storm Water Retention Pond	4X	PCS	W X	Stainless steel
Area 5				
Administration Building Interior	1 or 12	EMT (Including concealed locations)	C	Galvanized steel
Administration Building Exterior	4X	PCS	W X	Stainless steel
Area 6				
Maintenance Building	1 or 12	GRC	C	Galvanized steel
Maintenance Building Exterior	4X	PCS	W X	Stainless steel

PLANT AREA	NEMA ENCLOSURE TYPE	EXPOSED CONDUIT TYPE	ENVIRONMENT W = WET D = DAMP C = CLEAN/DRY X = CORROSIVE H = HAZARDOUS	SUPPORT MATERIALS
Area 10				
Influent Meter Vault	4X and 7(1), unless noted otherwise	PCS, unless note otherwise.	W: Unless noted otherwise. X: Unless noted otherwise. H: Class 1, Division 2, Group D, interior up to top of wall.	Stainless steel, unless noted otherwise.
Headwork / Septage Receiving	4X and 7(1), unless noted otherwise	PCS, unless note otherwise.	H: Class 1, Division 2, Group D, 18-inch envelope above channels, extending 3 feet horizontally beyond channels.	Stainless steel, unless noted otherwise.
Headworks Channel Interior	4X and 7(1), unless noted otherwise	PCS, unless note otherwise.	H: Class 1, Division 1, Group D.	Stainless steel, unless noted otherwise.
Screens, Screenings Compactors, , and Motorized Gates	4X and 7(1), unless noted otherwise	PCS, unless note otherwise.	H: Class 1, Division 1, Group D, for Equipment. Class 1, Division 2, Group D, within a 10-foot envelope around equipment.	Stainless steel, unless noted otherwise.
Screenings Bin Storage	4X and 7(1), unless noted otherwise	PCS, unless note otherwise.	H: Class 1, Division 2, Group D. Within a 10-foot envelope around bin storage.	Stainless steel, unless noted otherwise.

PLANT AREA	NEMA ENCLOSURE TYPE	EXPOSED CONDUIT TYPE	ENVIRONMENT W = WET D = DAMP C = CLEAN/DRY X = CORROSIVE H = HAZARDOUS	SUPPORT MATERIALS
Area 11				
Odor Control Facility	4X and 7[1]	PCS	W X H: Class 1, Division 2, Group D. Within 3 feet of fans, dampers, flexible connections, flanges, pressurized unwelded ductwork, and biofilters.	Stainless steel
Area 20				
Oxidation Ditch Tanks	4X and 7[1], unless noted otherwise	PCS, unless noted otherwise.	W: Unless noted otherwise. X: Unless noted otherwise. H: Class 1, Division 2, Group D, for interior of the tank from the minimum operating water surface to the top of the lower tank wall; 18 inches above the top of the lower tank wall and extending 18 inches beyond the lower exterior wall; 18-inch envelope above grade extending 10 feet horizontally from the lower exterior tank walls.	Stainless steel, unless noted otherwise.
Influent Splitter Box Interior	-	-	H: Class 1, Division 1, Group D.	-

PLANT AREA	NEMA ENCLOSURE TYPE	EXPOSED CONDUIT TYPE	ENVIRONMENT W = WET D = DAMP C = CLEAN/DRY X = CORROSIVE H = HAZARDOUS	SUPPORT MATERIALS
Influent Splitter Box Exterior	4X and 7[(1)], unless noted otherwise	PCS, unless noted otherwise	H: Class 1, Division 2, Group D, 18-inch envelope above channel openings, extending 3 feet horizontally beyond channel openings.	Stainless steel, unless noted otherwise.
Mixed Liquor Splitter Box	4X and 7[(1)], unless noted otherwise	PCS, unless noted otherwise	H: Class 1, Division 2, Group D, for interior of the tank from the minimum operating water surface to the top of the lower tank wall; 18 inches above the top of the lower tank wall and extending 18 inches beyond the lower exterior wall; 18-inch envelope above grade extending 10 feet horizontally from the lower exterior tank walls.	Stainless steel, unless noted otherwise.

PLANT AREA	NEMA ENCLOSURE TYPE	EXPOSED CONDUIT TYPE	ENVIRONMENT W = WET D = DAMP C = CLEAN/DRY X = CORROSIVE H = HAZARDOUS	SUPPORT MATERIALS
Area 21				
Secondary Clarifiers	4X and 7[1]	PCS	W X H: Class 1, Division 2, Group D, for interior of the tank from the minimum operating water surface to the top of the tank wall; 18 inches above the top of the tank and extending 18 inches beyond the exterior wall; 18-inch envelope above grade extending 10 feet horizontally from the exterior tank walls.	Stainless steel
Area 23				
Scum Pump Station	4X and 7[1]	PCS	W: Unless noted otherwise. X: Unless noted otherwise. H: Class 1, Division 1, Group D, within tank. Class 1, Division 2, Group D, 18-inch envelope above tank openings, extending 3 feet horizontally beyond tank openings.	Stainless steel
Area 28				
Filter Influent Pump Station	4X	PCS	W X	Stainless steel
Area 30				
Tertiary Filters	4X	PCS	W X	Stainless steel

PLANT AREA	NEMA ENCLOSURE TYPE	EXPOSED CONDUIT TYPE	ENVIRONMENT W = WET D = DAMP C = CLEAN/DRY X = CORROSIVE H = HAZARDOUS	SUPPORT MATERIALS
Area 31				
UV Facility	4X	PCS	W X	Stainless steel
Area 32				
Chemical Facility	4X	PCS	W X	Stainless steel
Area 40				
Effluent Pump Station	4X	PCS	W X	Stainless steel
Area 50				
Sludge Storage Tank Area	4X and 7(1), unless noted otherwise.	PCS, unless noted otherwise.	W: Unless noted otherwise. X: Unless noted otherwise. H: Class 1, Division 2, Group D, 18-inch envelope above high water level and 10 feet horizontally from wetted walls.	Stainless steel, unless noted otherwise.
Sludge Storage Dry Pit (Contains blowers and sludge pumps)	7(1), unless noted otherwise.	PCS, unless noted otherwise.	H: Class 1, Division 2, Group D, interior area, to top of pit wall.	Stainless steel, unless noted otherwise.
Area 51				
Dewatering Building Electrical Room	1, gasketed	GRC	C	Galvanized steel
Dewatering Building Signal Room	1, gasketed	GRC	C	Galvanized steel
Dewatering Building Dewatering Room	4X	PCS	W X	Stainless steel.

PLANT AREA	NEMA ENCLOSURE TYPE	EXPOSED CONDUIT TYPE	ENVIRONMENT W = WET D = DAMP C = CLEAN/DRY X = CORROSIVE H = HAZARDOUS	SUPPORT MATERIALS
Dewatering Building Exterior including Truck Loading Pad	4X	PCS	W X	Stainless steel
Area 60				
Water Storage Tank, Equipment Area, and Groundwater Wells	4X	PCS	W X	Stainless steel
Area 70				
Electrical Building Electrical Room	1, gasketed	GRC	C	Galvanized steel
Electrical Building Signal Room	1, gasketed	GRC	C	Galvanized steel
Electrical Building Generator Room	1 or 12	GRC	C	Galvanized steel
Electrical Building Fire Pump Room	4X	PCS	W X	Stainless steel
Electrical Building Mechanical Room	1 or 12	GRC	C	Galvanized steel
Electrical Building Exterior	4X	PCS	W X	Stainless steel

Abbreviations for Exposed Conduit Types:

EMT: Electric Metallic Tubing

GRC: Galvanized Rigid Steel

PCS: PVC Coated Steel

Notes:

(1) Enclosures containing arching or sparking devices shall be provided with a rating of both NEMA 4X and 7.

2. Modify exposed conduit runs as specified in Section 16130.

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING

A. General:
   1. As specified in Section 01312.
   2. Testing requirements are specified in Section 16950 and other sections.
   3. General scheduling requirements are specified in Section 01324A.
   4. Work restrictions and other scheduling requirements are specified in Section 01140.

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. Switchgear.
      b. Engine generators.

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 procedures 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 as specified in Sections 00700 and 01740:
   1. Provide additional warranty as specified in the individual Electrical Specifications.

1.12 SYSTEM TESTING AND START-UP

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.

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 COMMISSIONING (NOT USED)

1.15 MAINTENANCE

A. Before completion of the Testing Phase (specified in Section 01660), perform all maintenance activities required by any sections of the Specifications including any calibrations, final adjustments, component replacements or other routine service required before placing equipment or systems in service.

B. Furnish all spare parts as required by other sections of the Specifications.

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 EXISTING PRODUCTS (NOT USED)

2.03 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 as specified in Section 00700.

C. Stainless steel:
   1. Where stainless steel is indicated or used for any portion of the Electrical Work, provide a non-magnetic, corrosion-resistant alloy, ANSI Type 316, satin finish.
   2. Provide exposed screws of the same alloys.
   3. Provide finished material free of any burrs or sharp edges.
   4. Use only stainless steel hardware, when chemically compatible, in all areas that are or could be in contact with corrosive chemicals.
   5. Use stainless steel hardware, when chemically compatible, in all chemical areas or areas requiring NEMA Type 4X construction.
   6. Do not use stainless steel in any area containing chlorine, gas or solution, chlorine products or ferric chloride.

2.04 MANUFACTURED UNITS (NOT USED)

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS (NOT USED)

2.07 ACCESSORIES (NOT USED)

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 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. 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.

B. Provide a complete electrical system:
   1. Install all extra conduits, cables, and interfaces as may be necessary to provide a complete and operating electrical, PCIS, and HVAC system.

3.02 PREPARATION (NOT USED)

3.03 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 indicated on the Drawings:
      a. 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.

B. Install all material and equipment in accordance with the manufacturer's installation instructions, including anchoring methods and leveling criteria:
   1. Where Contractor asks to deviate from the manufacturer's recommendations, such changes must be reviewed and accepted by the Engineer and manufacturer before installation.

C. 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 below grade walls with a waterproof, non-shrink, non-metallic grout, unless otherwise indicated on the typical installation details:
      a. Use the installation details indicated on the Drawings as a guide for acceptable sealing methods.

D. 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 is likely to require examination or has serviceable parts.
   2. Where the Drawings do not show dimensions for locating equipment, install equipment in the approximate locations indicated on the Drawings.
      a. 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 the Drawings do not indicate the exact mounting and/or supporting method to be used, use materials and methods similar to the mounting details indicated on the Drawings.

E. Earthwork and concrete:
   1. Install all trenching, shoring, concrete, backfilling, grading and resurfacing associated with the Electrical Work:
      a. Requirements as specified in the Contract Documents.

F. Roof penetrations:
   1. Seal conduit penetrations in accordance with roofing manufacturer's instructions.

G. Terminations:
   1. 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 indicated on the Drawings and the other equipment, notify the Engineer as specified in Section 00700.
   2. Location of manholes and pull boxes indicated on the Drawings are approximate. Coordinate exact location of manholes and pull boxes with Mechanical and Civil Work.
   3. Provide additional manholes or pull boxes to those shown where they are required to make a workable installation.
      a. In manholes, install all cables operating at less than 50 VDC in PVC coated flexible metallic conduit, with corrosion resistant fittings.

I. Labeling:
   1. Provide all nameplates and labels as specified in Sections 16075 and Section 16305.

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.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 FIELD QUALITY CONTROL

A. Inspection:
   1. Allow for inspection of electrical system installation as specified in Section 01450.
   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 the 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 structural engineer to inspect 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.

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.
3. Record results of the required tests along with the date of test:
a. 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.

3.08 ADJUSTING (NOT USED)

3.09 CLEANING

A. As specified in Section 01770.

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 and re-lamp all new and existing luminaires that were used in the areas affected by the construction, and return all used lamps to the Owner.

E. As specified in other sections of the Contract Documents.

3.10 DEMONSTRATION AND TRAINING

A. Furnish all personnel and equipment necessary to conduct the demonstration and training requirements as specified in the individual sections and Section 01660.

3.11 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.

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 16052

HAZARDOUS CLASSIFIED AREA CONSTRUCTION

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Executing and completing Work in hazardous and/or classified areas as defined by the National Electrical Code (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.
   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 16130 - Conduits.
      d. Section 16134 - Boxes.
      e. Section 16140 - Wiring Devices.
      f. Section 16150 - Low Voltage Wire Connections.

1.02 REFERENCES

A. As specified in Section 16050.

1.03 DEFINITIONS

A. As specified in Section 16050.

B. Specific definitions:
   1. For the purposes of these Specifications, the terms "Hazardous" and "Classified" will be considered synonymous.

1.04 SYSTEM DESCRIPTION (NOT USED)

1.05 SUBMITTALS

A. Furnish submittals as specified in Sections 01330 and 16050.

1.06 QUALITY ASSURANCE

A. As specified in Section 16050.

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.
   2. Except as modified in Articles 500 through 516, all other applicable rules contained in the NEC shall apply to electric equipment and wiring installed in hazardous and/or classified locations.
   3. 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.

1.07 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 16050.

1.08 PROJECT OR SITE CONDITIONS

A. A list of hazardous areas is specified in Section 16050.

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY (NOT USED)

1.12 SYSTEM STARTUP (NOT USED)

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 COMMISSIONING (NOT USED)

1.15 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS (NOT USED)

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS (NOT USED)

2.04 MANUFACTURED UNITS (NOT USED)

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS

A. Conduit and sealing fittings:
   1. As specified in Section 16130.

B. Conduit boxes and bodies:
   1. As specified in Section 16134.

C. Wiring devices:
   1. As specified in Section 16140.

2.07 ACCESSORIES (NOT USED)

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 16050.

B. Conduit installation:
   1. As specified in Section 16130.
   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 are 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:
         1) Liquid-tight metal conduit with approved fittings.
      c. Maximum length as specified in Section 16130.

C. Sealing fittings:
   1. Provide an approved seal, no more than 12 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 similar to “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 12 inches of the enclosure.
3. Install a conduit seal within 12 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.

D. Boxes and fittings:
1. Class I Division 1 areas:
    a. Utilize threaded connections for all metallic boxes, fittings, and joints to the conduit system.
2. Class I Division 2 areas:
    a. 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.
2. Class I Division 2 areas:
    a. Boxes not containing arcing parts:
        1) Material and NEMA ratings as specified in Section 16050.
        2) Pressed metal boxes are not allowed.
    b. Provide heavy duty cast construction type conduit fittings and joints:
        1) 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.
   3. Bond the non-current-carrying metal parts of equipment, raceways, and other enclosures as required by the NEC to ensure electrical continuity.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 FIELD QUALITY CONTROL

A. As specified in Section 16050.

B. Obtain inspection and approval from the ENGINEER before and after each seal is poured.

3.08 ADJUSTING (NOT USED)

3.09 CLEANING (NOT USED)

3.10 DEMONSTRATION AND TRAINING (NOT USED)

3.11 PROTECTION (NOT USED)

3.12 SCHEDULES (NOT USED)

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. Main bonding jumper.
   5. Ground connections.
   6. 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.
   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. As specified in Section 16050.

B. ASTM International (ASTM):
   1. B 3 - Standard Specification for Soft or Annealed Copper Wire.
   2. B 8 - Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft.

C. Institute of Electrical and Electronics Engineers (IEEE):
   1. 81 - IEEE Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Grounding System.

D. Underwriters Laboratories, Inc. (UL):
   1. 467 - Ground and Bonding Equipment.

1.03 DEFINITIONS

A. As specified in Section 16050.

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. Grounding 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, shall be:
   1. 5 ohms or less for industrial systems.
   2. 1 ohm or less for Electrical Building and Dewatering Building.

1.05 SUBMITTALS

A. Furnish submittals as specified in Sections 01330 and 16050.

B. Product data:
   1. Catalog cut sheets.

1.06 QUALITY ASSURANCE

A. As specified in Section 16050.

B. All grounding components and materials shall be UL listed and labeled.

1.07 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 16050.

1.08 PROJECT/SITE CONDITIONS (NOT USED)

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

A. As specified in Section 16050.

1.12 SYSTEM START-UP

A. As specified in Section 16050.

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 COMMISSIONING

A. To be performed per Section 16950. Measure grounding electrode system resistance to ground in accordance with IEEE 81 fall of potential test.

1.15 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Compression connectors: One of the following or equal:
   1. FCI Burndy.
   2. Thomas & Betts.

B. Ground rods: One of the following or equal:
   1. Erico.
   2. Harger.
   3. Conex.

C. Ground cable: One of the following or equal:
   1. Nehring.
   2. Harger.
   3. Southwire.

D. Precast ground well boxes: One of the following or equal:
   1. Brooks Products, 3-RT Valve Box.
   2. Christy Concrete Products, G12 Valve Box.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS

A. Ground rod:
   1. Minimum: 3/4-inch diameter, 10 feet long.
   2. Uniform 10 mil covering of electrolytic copper metallically bonded to a rigid steel core:
      a. 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 B 8.
      c. Bare copper in accordance with ASTM B 3.
   2. Size is as indicated on the Drawings, but not less than required by the NEC.

C. Compression connectors:
   1. Manufactured of high copper alloy specifically for the particular grounding application.

2. Suitable for direct burial in earth and concrete.
3. Identifying compression die number inscription to be impressed on compression fitting.

D. Equipment grounding conductors:
1. Conductors shall be the same type and insulation as the load circuit conductors:
a. Use 600-volt insulation for the equipment grounding conductors for medium voltage systems.
2. Minimum size in accordance with the NEC.

E. Grounding electrode conductors:
1. Minimum size in accordance with the NEC.

F. Main bonding jumpers and bonding jumpers:
1. Minimum size in accordance with the NEC.

2.04 MANUFACTURED UNITS (NOT USED)

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS (NOT USED)

2.07 ACCESSORIES

A. Precast ground well boxes:
1. Minimum 10 inch interior diameter.
2. Traffic-rated cast iron cover.
3. Permanent “GROUND” marking on cover.

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 16050.

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 lugs for connection of grounding conductor at both ends of metallic conduit runs. Bond ground bushings to the grounding system.

F. 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.

G. Interconnect the secondary switchgear, switchboard, or panelboard neutral bus to the ground bus in the secondary switchgear, switchboard, or panelboard compartment, only at service entrance point or after a transformer.

H. Duct bank ground system:
   1. Provide a bare copper grounding conductor the entire length of each duct bank, embedded in the concrete of the duct bank as indicated on the Drawings and specified in the Specifications.
   2. Bond duct bank ground conductors together where duct banks join, merge, intersect, or split.

I. Grounding at service (600 V or Less):
   1. Connect the neutral to ground only at one point within the enclosure of the first disconnecting means on the load side of the service transformer.

J. 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 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.

K. Grounding electrode system:
   1. Ground ring:
      a. Provide all trenching and materials necessary to install the ground ring as indicated on the Drawings.
      b. Ground ring conductor shall be in direct contact with the earth, or where embedded, concrete, of the size as indicated on the Drawings.
      c. Minimum burial depth 36 inches or as indicated on the Drawings.
      d. Re-compact disturbed soils to original density in 6-inch lifts.
   2. Ground rods:
      a. Locations as indicated on the Drawings.
      b. Length of rods forming an individual ground array shall be equal in length.
      c. Drive ground rods and install grounding conductors before construction of concrete slabs and duct banks.
      d. Pre-crimp all ground rods, as recommended by the manufacturer, before crimping connector to ground rod**.**
   3. Metal underground water pipe:
      a. Bond metal underground domestic water pipe to grounding electrode system.
   4. Metal frame of building or structure:
      a. Bond metal frame of building or structure to grounding electrode system.
   5. Extend grounding conductors through concrete to accessible points for grounding equipment and electrical enclosures.
   6. Install grounding system at each structure where switchgear, motor control centers, switchboards, panelboards, panels, or other electrical equipment are installed.

L. 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. Use manufacturer’s terminal block jumpers to interconnect ground terminals.
   4. Connection to the panel main ground bus shall be via a green No. 12 conductor to the main ground bus for the panel.

M. Telephone panel ground:
   1. Install individual ground rod or ground system at telephone panels:
      a. Install a dedicated grounding electrode conductor from the telephone panel to the grounding electrode system.
      b. Do not connect any other grounds to the telephone panel grounding electrode conductor.
   2. Install ground rod or ground system in accordance with telephone company requirements.

N. Antenna ground:
   1. Install individual ground rod or ground system for communication system antenna:
      a. Install a dedicated grounding electrode conductor from the antenna ground to the grounding electrode system.
      b. Do not connect any other grounds to the antenna grounding electrode conductor.
   2. Install ground rod or ground system in accordance with the radio manufacturer's requirements.

O. Where indicated on the Drawings, install ground rods in precast ground wells.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 FIELD QUALITY CONTROL

A. As specified in Section 16050.

B. Measure grounding electrode system resistance to ground in accordance with IEEE 81.

3.08 ADJUSTING

A. Under the direction of the ENGINEER, add additional parallel connected ground rods and/or deeper driven rods until the ground resistance measurement meets the specified resistance requirements:
   1. Use of salts, water, or compounds to attain the specified ground resistance is not acceptable.

3.09 CLEANING (NOT USED)

3.10 DEMONSTRATION AND TRAINING (NOT USED)

3.11 PROTECTION

A. As specified in Section 16050.

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 16070

HANGERS AND SUPPORTS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. 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.
   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 01410 - Regulatory Requirements.
      c. Section 05120 - Structural Steel.
      d. Section 09960 - High-Performance Coatings.
      e. Section 16050 - Common Work Results for Electrical.

1.02 REFERENCES

A. As specified in Section 16050.

B. ASTM International (ASTM):
   1. A 123 - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
   2. A 153 - Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
   3. A 240 – 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.

1.04 SYSTEM DESCRIPTION

A. Design requirements:
   1. Conform to the requirements of the Building Code as specified in Section 01410.

2. Demonstrate the following using generally accepted engineering methods:
    a. That the anchors to the structure are adequate to resist 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:
        1) 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.
    c. Wind loading requirements:
        1) All exterior freestanding equipment shall be anchored in place by methods that will satisfy the requirements for wind design specified in Section 16050.
    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.

B. Performance requirements:
1. 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 Sections 01330 and 16050.

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.

1.07 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 16050.

1.08 PROJECT OR SITE CONDITIONS

A. As specified in Section 16050.

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

A. As specified in Section 16050.

1.12 SYSTEM STARTUP

A. As specified in Section 16050.

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 COMMISSIONING (NOT USED)

1.15 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. One of the following or equal:
   1. Thomas & Betts.
   2. Power-Strut.
   3. Unistrut.
   4. Cooper B-Line.
   5. Robroy.
   6. Aickinstrut.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS

A. Use materials appropriate for the area as specified in Section 16050.

B. Hot dip galvanized steel:
   1. Supports:
      a. In accordance with ASTM A 123 or A 153.
      b. Minimum zinc coating thickness of 2.6 mils.
   2. Hardware:
      a. Electro-galvanized.
      b. In accordance with ASTM A 153.

C. Stainless steel:
   1. Supports:
      a. In accordance with ASTM A 240.
      b. ANSI Type 316 material.
   2. Hardware:
      a. ANSI Type 316 material.

D. PVC coated galvanized steel:
   1. Supports:
      a. Hot dip galvanized steel as specified in this Section.
      b. PVC coating thickness of 10 to 20 mils.
   2. Hardware:
      a. ANSI Type 316 material.

E. Fiberglass:
   1. Supports:
      a. Vinyl ester.
   2. Hardware:
      a. Polypropylene.
      b. Thermal plastic elastomer.
      c. Fiberglass reinforced plastic.

2.04 MANUFACTURED UNITS (NOT USED)

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS (NOT USED)

2.07 ACCESSORIES

A. Anchors:
   1. As specified in Section 05120.

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES

A. Paint and finish all supporting structures as specified in Section 09960.

2.11 SOURCE QUALITY CONTROL (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 16050.

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.
      a. Mount channel vertically along the length of the device so that water or moisture may run freely behind the device.

E. Corrosion protection:
   1. Isolate dissimilar metals, except where required for electrical continuity.
      a. 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.

G. Anchoring methods:
   1. Solid concrete: Anchor bolts, anchor rods, or post-installed anchors as specified in Section 05120.

2. Metal surfaces: Machine screws or bolts.
3. Hollow masonry units: Post-installed anchors as specified in Section 05120.

H. When supporting devices on metal or wood stud construction, bridge studs with preformed channel, and mount the devices to the channel.

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.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 FIELD QUALITY CONTROL

A. As specified in Section 16050.

3.08 ADJUSTING (NOT USED)

3.09 CLEANING (NOT USED)

3.10 DEMONSTRATION AND TRAINING (NOT USED)

3.11 PROTECTION

A. As specified in Section 16050.

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 16075

ELECTRICAL IDENTIFICATION

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Identifying electrical, instrumentation, and process equipment and components.
   2. Material, manufacturing, and installation requirements for identification devices.

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 16130 - Conduits.

1.02 REFERENCES

A. As specified in Section 16050.

B. Occupational Safety and Health Administration (OSHA).

1.03 DEFINITIONS

A. As specified in Section 16050.

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. Device nameplates information:
   a. Designations as indicated on the Drawings and identified on the Process and Instrumentation Drawings.
   b. Device tag and loop number ID (#) (e.g., EDV-#).
   c. Circuit ID (e.g., LPA-11).
   d. Area served (e.g., Lighting Chemical Building).

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. Wire numbers shall correspond to the wire numbers on the control drawings or the panel and circuit numbers for receptacles and lighting.
      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. Multi-conductor cables shall be assigned a cable number that shall be attached to the cable at intermediate pull boxes and stub-up locations beneath freestanding equipment. All multi-conductor and instrumentation cables shall be identified at pull points as described above:
         1) Label armored multi-conductor cable using the conduit number as indicated on the Drawings, following the requirements for conduit markers in Section 16130.
   2. Provide the following wiring numbering schemes throughout the project for field wires between process control module, (PCM), vendor control panels, (VCP), motor control centers, (MCC), field starters, field instruments, etc.

(ORIGIN LOC.)–(ORIGIN TERM.)/(DEST. LOC.)–(DEST. TERM.)

OR

(ORIGIN LOC.)–(ORIGIN TERM.)
(DEST. LOC.)–(DEST. TERM.)

Where:

ORIGIN LOC.	=	Designation for originating panel or device
ORIGIN TERM.	=	Terminal designation at originating panel or device
DEST. LOC.	=	Designation for destination panel or device
DEST. TERM.	=	Terminal designation at destination panel, device, or PLC I/O address at destination panel

   a. Identify equipment and field instruments as the origin.
   b. PCMs are always identified as the destination.
   c. Location is the panel designation for VCP, LCP, or PCM. For connections to MCCs, location is the specific starter tag and loop number. Location is the tag and loop number for motor starters, field instruments, and equipment. Any hyphen in the panel designation or tag and loop number shall be omitted.

d. Terminal designation is the actual number on the terminal block where the conductor terminates at field devices and vendor control panels. For multi-conductor cables, all terminal numbers shall be shown, separated by commas.

e. Terminal designations at motor leads shall be the motor manufacturer's standard terminal designation (e.g., T1, T2, T3, etc.).

f. Terminal designations at PCMs where the field conductor connects to field terminal blocks for a PLC input or output shall be the PLC address (Note: the following PLC I/O numbering scheme is typical for Allen-Bradley, the numbering scheme should be modified to match that of the actual PLC manufacturer used for the project):

   1) Discrete Point: W:X:Y/Z
      Analog Point: W:X:Y.Z
      Where:
      W = I for input, O for output
      X = PLC number (1, 2, 3…)
      Y = Slot number (01, 02, 03…)
      Z = Terminal number (00, 01, 02…) for a discrete point or a word number for an analog point (1, 2, 3…)

g. Terminal designations at PCMs where the conductor does not connect to a PLC I/O point shall be the terminal number with a "C" prefix (e.g., C0010). For common power after a fuse or neutrals after a switch, the subsequent points shall have and capital letter suffix starting with "A" (e.g., C0010A).

3. **Case 1**: Vendor control panel (VCP) to process control module (PCM):
   Field wire number/label: A-B/C-D
   A = Vendor control panel number without hyphen (VCP#)
   B = Terminal number within VCP (manufacturer's or vendor's standard terminal number)
   C = Process control module number without hyphen (PCM#)
   D = Either the PLC address if the field terminal is connected directly to a PLC input or output point or the terminal number with a "C" prefix if not connected directly to a PLC I/O point (C0010)

   Examples: VCP#-10/PCM#-I:1:01/01
   VCP#-10/PCM#-O:1:10/07
   VCP#-10/PCM#-C0100

4. **Case 2**: Field instrument to process control module (PCM):
   Field wire number/label: E-F/C-D
   C = Process control module number without hyphen (PCM#)
   D = Either the PLC address if the field terminal is connected directly to a PLC input or output point or the terminal number with a "C" prefix if not connected directly to a PLC I/O point (C0010)
   E = Field mounted instrument tag and loop numbers without hyphen (EDV#)
   F = Manufacturer's standard terminal number within instrument. Use both terminal numbers for analog points separated by a comma

   Examples: TIT#-2,3/PCM#-I:1:01.1
   TSH#-1/PCM#-I:2:01/00

5. **Case 3**: Motor control center (MCC) to process control module (PCM):
   Field wire number/label: G-B/C-D
   B = Terminal number within Motor Control Center (manufacturer's or vendor's standard terminal number)
   C = Process control module without hyphen (PCM#)
   D = Either the PLC address if the field terminal is connected directly to a PLC input or output point or the terminal number with a "C" prefix if not connected directly to a PLC I/O point (C0010)
   G = Actual starter designation in the motor control center without hyphen (MMS#)

   Examples: MMS#-10/PCM#-I:1:01/01
   MMS#-10/PCM#-O:1:10/07
   MMS#-10/PCM#-C0100

6. **Case 4**: Motor control center (MCC) to vendor control panel (VCP):
   Field wire number/label: G-B/A-B
   A = Vendor control panel number without hyphen (VCP#)
   B = Terminal number within motor control center or vendor control panel (manufacturer's or vendors standard terminal number)
   G = Actual starter designation in the motor control center without hyphen (MMS#)

   Example: MMS#-X2/VCP#-10

7. **Case 5**: Motor leads to a motor control center (MCC):
   Field wire number/label: H-I/G-B
   B = Terminal number within motor control center (manufacturer's standard terminal number)
   G = Actual starter designation in the motor control center without hyphen (MMS#)
   H = Equipment tag and loop number without hyphen (PMP#)
   I = Motor manufacturer's standard motor lead identification (e.g., T1, T2, T3, etc.)

   Example: PMP-#-T3/MMS#-T3

8. **Case 6**: Remote or separately mounted starter or variable frequency drive (VFD) to process control module (PCM):
   Field wire number/label: J-B/C-D
   B = Terminal number within starter or variable frequency drive (manufacturer's standard terminal number)
   C = Process control module number without hyphen (VCP#)
   D = Either the PLC address if the field terminal is connected directly to a PLC input or output point or the terminal number with a "C" prefix if not connected directly to a PLC I/O point (C0010)
   J = Starter or variable frequency drive tag and loop number without hyphen (MMS#)

   Examples: MMS#-10/PCM#-I:1:01/01
   MMS#-10/PCM#-O:2:10/07
   MMS#-10/PCM#-C0010

9. **Case 7**: Field bus trunk segment:
   Field cable number/label: C/K-L/M; C/K-L/H; C/K-L/J
   C = Process control module without hyphen (PCM#)
   K = Field bus cable type
   L = Field bus segment number
   M = Field Bus field network component without hyphen (PTB1) or
   H = Equipment tag and loop number without hyphen (EMV#) or
   J = Starter or variable frequency drive tag and loop number without hyphen (VFD60.0112)

   Examples: PCM#/PA-1A/PTB1
   PTB1/PA-1B/PTB2
   PCM#/DN-1A/VFD#
   PCM#/DP-2A/ EMV#

10. **Case 8**: Field bus spur (drop):
    Field cable number/label: E/K-L/M
    E = Field mounted instrument tag and loop numbers without hyphen (FIT#)
    K = Field bus cable type.
    L = Field bus segment number
    M = Field bus field network component without hyphen (PTB1), identify ports on the device

    Examples: FIT#/PA-1C/PTB1-1
    FIT#/PA-1D/PTB1-2

11. Identify all spare conductors as required for other field wires with an “S” prefix:

    Example: S MMS#-10/PCM#-C011

1.05 SUBMITTALS

A. Furnish submittals as specified in Sections 01330 and 16050.

B. Product data:
   1. Nameplates:
      a. Color.
      b. Size:
         1) Outside dimensions.
         2) Lettering.
      c. Material.
      d. Mounting means.
   2. Nameplate schedule:
      a. Show exact wording for each nameplate.
      b. Include nameplate and letter sizes.
   3. Wire numbers:
      a. Manufacturer’s catalog data for wire labels and label printer.

C. Record documents:
   1. Update the conduit schedule to reflect the exact quantity of wire numbers including spares and destination points for all wires.

1.06 QUALITY ASSURANCE (NOT USED)

1.07 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 16050.

1.08 PROJECT SITE CONDITIONS (NOT USED)

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

A. As specified in Section 16050.

1.12 SYSTEM START-UP

A. As specified in Section 16050.

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 COMMISSIONING (NOT USED)

1.15 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Nameplates and signs:
   1. One of the following or equal:
      a. Brady.
      b. Seton.

B. Conductor and cable markers:
   1. Heat-shrinkable tubing:
      a. One of the following or equal:
         1) Raychem for conductors #10 and smaller.
         2) Brady locking tab cable markers for conductors #8 and larger.
         3) Thomas & Betts.
         4) Kroy.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS

A. Nameplates:
   1. Fabricated from white-center and red face or black-center, white face laminated plastic engraving stock:
      a. 3/32-inch thick material.
      b. Two-ply.

c. With chamfered edges.
d. Block style engraved characters of adequate size to be read easily from a distance of 6 feet:
1) No characters smaller than 1/8-inch in height.

B. Signs:
1. Automatic equipment and high voltage signs:
a. Suitable for exterior use.
b. In accordance with OSHA regulations.

C. Conductor and cable markers:
1. Machine printed black characters on white tubing.
2. Ten point type or larger.

D. Conduit and raceway markers:
1. Solid brass tags.
a. Minimum thickness: 0.036 inch.
b. Letter characters stamped.
c. Minimum letter height: 3/16-inch.

2.04 MANUFACTURED UNITS (NOT USED)

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS (NOT USED)

2.07 ACCESSORIES (NOT USED)

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL

A. Nameplates:
1. Provide all nameplates for control panel operator devices (e.g., pushbuttons, selector switches, pilot lights, etc.):
a. Same material and same color and appearance as the device nameplates, in order to achieve an aesthetically consistent and coordinated system.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 16050.

B. Nameplates:
   1. Attach nameplates to equipment with rivets, bolts, or sheet metal screws, approved waterproof epoxy-based cement or install in metal holders welded to the equipment.
   2. On NEMA Type 4, NEMA Type 4X, or NEMA Type 7 enclosures, use epoxy-based cement to attach nameplates.
   3. 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. Heat-shrinkable tubing:
      a. Tubing shall be shrunk using a heat gun that produces low temperature heated air.
      b. Tubing shall be tight on the wire after it has been heated.
      c. Characters shall face the open panel and shall read from left to right or top to bottom.
      d. Marker shall start within 1/32 inch of the end of the stripped insulation point.

D. Conduit markers:
   1. Furnish and install conduit markers for every conduit in the electrical system that is identified in the conduit schedule or part of the process system:
      a. Conduit markings shall match the conduit schedule.
   2. Mark conduits at the following locations:
      a. Each end of conduits that are greater than 10 feet in length.
      b. Where the conduit penetrates a wall or structure.
      c. Where the conduit emerges from the ground, slab, etc.
      d. The middle of conduits that are 10 feet or less in length.
   3. Mark conduits after the conduits have been fully painted.
   4. Position conduit markers so that they are easily read from the floor.
   5. Attach brass tag conduit markers with Type 316 stainless steel wires.
   6. Mark conduits before construction review by Engineer for punch list purposes.
   7. Label intrinsically safe conduits in accordance with the requirements of the NEC.

E. Signs and labeling:
   1. Furnish and install permanent warning signs at mechanical equipment that may be started automatically or from remote locations:
      a. Fasten warning signs with round head stainless steel screws or bolts.
      b. Locate and mount in a manner to be clearly legible to operations personnel.
   2. Furnish and install permanent and conspicuous warning signs on equipment (front and back), doorways to equipment rooms, pull boxes, manholes, etc where the voltage exceeds 600 volts.

3. Furnish and install warning signs on equipment that has more than one source of power.
   a. Warning signs to identify every panel and circuit number of the disconnecting means of all external power sources.
4. Place warning signs on equipment that has 120 VAC control voltage source used for interlocking.
   a. Identify panel and circuit number or conductor tag for control voltage source disconnecting means.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 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.

3.08 ADJUSTING (NOT USED)

3.09 CLEANING (NOT USED)

3.10 DEMONSTRATION AND TRAINING (NOT USED)

3.11 PROTECTION (NOT USED)

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 16123

600 VOLT OR LESS WIRES AND CABLES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. 600 volt class wire and cable.
   2. Instrumentation class wire and cable.
   3. Network cable.
   4. Fire alarm wire and cable.
   5. Telephone wire and 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.
   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 16060 - Grounding and Bonding.
      d. Section 16075 - Electrical Identification.

1.02 REFERENCES

A. As specified in Section 16050.

B. ASTM International (ASTM):
   1. B 3 - Standard Specification for Soft or Annealed Copper Wire.
   2. B 8 - Standard Specification for Concentric-Lay–Stranded Copper Conductors, Hard, Medium-Hard, or Soft.

C. CSA International (CSA).

D. Insulated Cable Engineers Association (ICEA):
   1. NEMA WC 70/ICEA S-95-658-1999 - Standard for Nonshielded Power Cables Rated 2000 Volts or Less for the Distribution of Electrical Energy.
   2. NEMA WC 57/ICEA S-73-532 - Standard for Control, Thermocouple Extension, and Instrumentation Cables.

E. National Electrical Manufacturers Association (NEMA):
   1. 250 - Enclosures for Electrical Equipment (1000 V Maximum).

F. National Fire Protection Association (NFPA):
   1. 70 - National Electrical Code (NEC).
   2. 72 - National Fire Alarm and Signaling Code.
   3. 101 - Life Safety Code.

G. Telecommunications Industry Association/Electronics Industry Association (TIA/EIA):
   1. 568-C.2 - Balanced Twisted-Pair Telecommunication Cabling and Components Standard.

H. Underwriter's Laboratories Inc., (UL):
   1. 44 - Thermoset-Insulated Wires and Cables.
   2. 1424 - Standard for Cables for Power-Limited Fire-Alarm Circuits.
   3. 1569 - Standard for Metal-Clad Cables.
   4. 2196 - Standard for Tests for Fire Resistive Cables.
   5. 2225 - Standard for Cables and Cable-Fittings For Use in Hazardous (Classified) Locations.

1.03 DEFINITIONS

A. As specified in Section 16050.

B. Definitions of terms and other electrical considerations as set forth in the:
   1. ASTM.
   2. ICEA.

C. NEMA:
   1. Type 4 enclosure in accordance with NEMA 250.
   2. Type 4X enclosure in accordance with NEMA 250.

1.04 SYSTEM DESCRIPTION

A. Furnish and install the complete wire and cable system.

1.05 SUBMITTALS

A. Furnish submittals as specified in Sections 01330 and 16050.

B. Product data:
   1. Manufacturer of wire and cable.
   2. Insulation:
      a. Type.
      b. Voltage class.
   3. American wire gauge (AWG) size.
   4. Conductor material.
   5. Pulling compounds.

C. Shop drawings:
   1. Show splice locations.

D. Test reports:
   1. Submit test reports for meg-ohm tests.

E. Calculations:
   1. Submit cable pulling calculations to the ENGINEER for review and comment for all cables that will be installed using mechanical pulling equipment. Show that the maximum cable tension and sidewall pressure will not exceed manufacturer recommended values:
      a. Provide a table showing the manufacturer's recommended maximum cable tension and sidewall pressure for each cable type and size included in the calculations.
      b. Submit the calculations to the ENGINEER a minimum of 2 weeks before conduit installation.

1.06 QUALITY ASSURANCE

A. As specified in Section 16050.

B. All wires and cables shall be UL listed and labeled.

1.07 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 16050.

1.08 PROJECT OR SITE CONDITIONS (NOT USED)

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

A. As specified in Section 16050.

1.12 SYSTEM START-UP

A. As specified in Section 16050.

1.13 OWNER`S INSTRUCTIONS (NOT USED)

1.14 COMMISSIONING (NOT USED)

1.15 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. One of the following or equal:
   1. 600 volt class wire and cable:
      a. General Cable.
      b. Okonite Company.
      c. Southwire Company.

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.
3. Network cables:
    a. Belden CDT.
    b. General Cable.
    c. CommScope.
4. Fire alarm wire and cable:
    a. West Penn Wire.
    b. Olympic Wire and Cable.
    c. Rockbestos Surprenant Cable Corporation.
    d. Draka Lifeline.
5. Telephone wire and cable:
    a. American Telephone and Telegraph.
    b. West Penn Wire.
    c. Olympic Wire and Cable.
    d. Superior Essex Inc.
    e. Draka Comteq.
    f. General Cable.
    g. Okonite.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS

A. Conductors:
    1. Copper in accordance with ASTM B 3.

2.04 MANUFACTURED UNITS

A. General:
    1. Provide new wires and cables manufactured within 1 year of the date of delivery to the Site.
    2. Permanently mark each wire and cable with the following at 24-inch intervals:
        a. AWG size.
        b. Voltage rating.
        c. Insulation type.
        d. UL symbol.
        e. Month and year of manufacture.
        f. Manufacturer's name.
    3. Identify and mark wire and cable as specified in Section 16075:
        a. Use integral color insulation for Number 2 AWG and smaller wire.
        b. Wrap colored tape around cable larger than Number 2 AWG.

B. 600 volt class wire and cable:
   1. Provide AWG or kcmil sizes as indicated on the Drawings or in the Conduit Schedules:
      a. When not indicated on the Drawings, size wire as follows:
         1) In accordance with the NEC:
            a) Use 75 degree Celsius ampacity ratings.
            b) Ampacity rating after all derating factors, equal to or greater than rating of the overcurrent device.
         2) Provide Number 12 AWG minimum for power conductors.
         3) Provide Number 14 AWG minimum for control conductors.
   2. Provide Class B stranding in accordance with ASTM B 8:
      a. Provide Class C stranding where extra flexibility is required.
   3. Insulation:
      a. XHHW-2.
      b. 90 degrees Celsius rating.
   4. Multiconductor cables:
      a. Number and size of conductors as indicated on the Drawings or in the Conduit Schedules.
      b. Individual conductors with XHHW-2 insulation.
      c. Overall PVC jacket.
      d. Tray cable rated.
      e. Color-coding for control wire in accordance with ICEA Method 1, E-2 in accordance with NEMA WC 57/ICEA S-73-532.
      f. Ground conductor: Bare:
         1) Sized in accordance with NEC.

C. Instrumentation class cable:
   1. Type TC.
   2. Suitable for use in wet locations.
   3. Voltage rating: 600 volts.
   4. Temperature rating:
      a. 90 degrees Celsius rating in dry locations.
      b. 75 degrees Celsius rating in wet locations.
   5. Conductors:
      a. Insulation:
         1) Flame-retardant PVC, 15 mils nominal thickness, with nylon jacket 4 mils nominal thickness.
      b. Number 16 AWG stranded and tinned.
      c. Color code:
         1) Pair: Black and white.
         2) Triad: Black, white and red.
         3) Multiple pairs or triads:
            a) Color-coded and numbered.
   6. Drain wire:
      a. 18 AWG.
      b. Stranded, tinned.
   7. Jacket:
      a. Flame retardant, moisture and sunlight resistant PVC.
      b. Ripcord laid longitudinally under jacket to facilitate removal.

8. Shielding:
    a. Individual pair/triad:
        1) Minimum 1.35-mil double-faced aluminum foil/polyester tape overlapped to provide 100 percent coverage.
    b. Multiple pair or triad shielding:
        1) Group shield: Minimum 1.35-mil double-faced aluminum foil/polyester tape overlapped to provide 100 percent coverage.
        2) Completely isolate group shields from each other.
        3) Cable shield: 2.35 mils double-faced aluminum and synthetic polymer backed tape overlapped to provide 100 percent coverage.
    c. All shielding to be in contact with the drain wire.

D. Network cables:
1. Category 6A:
    a. General:
        1) Provide all Cat 6A cables meeting the standards set by TIA/EIA-568-C.2.
    b. Conductors:
        1) 24 AWG solid bare copper conductors.
    c. Insulation:
        1) Polyolefin.
        2) 4 non-bonded twisted pair cables formed into a cable core.
    d. 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.
    e. Outer jacket:
        1) PVC with ripcord.
    f. Electrical characteristics:
        1) Frequency range: 0.772-100 MHz.
        2) Attenuation: 32.1 dB/100 m.
        3) Near-end crosstalk (NEXT): 39.3 dB.
        4) Power sum NEXT: 37.3 dB.
        5) Attenuation to crosstalk ratio (ACR): 7.2 dB.
        6) Power sum attenuation to crosstalk ratio (PSACR): 5.3 dB/100 m.
        7) Equal level far-end crosstalk (ELFEXT): 22.8 dB.
        8) Power sum ELFEXT: 19.8 dB/100 m.
        9) Return loss: 17.3 dB.
        10) Propagation delay**:** 537 ns/100 m.
        11) Delay skew: 45 ns/100 m.
        12) Propagation delay (skew), max: 2.5 ns/100 m.
2. RS-485 cable:
    a. Two-wire:
        1) Shielded twisted pair.
        2) Tinned, copper conductors minimum with 7 by 30 stranding.
        3) AWG #22.
        4) Insulation:
            a) FHDPE: Foam high-density polyethylene.
            b) 300-volt insulation level.

5) Outer shield:
    a) 100 percent coverage.
    b) Tape/braid.
    c) Aluminum foil-polyester tape.
    d) Tinned copper braid.
6) Outer shield drain wire:
    a) Tinned, copper conductor minimum with 7 by 30 stranding.
    b) AWG #22.
7) Outer jacket PVC:
    a) Sunlight resistant.
8) UL/CSA flame tested.
9) Minimum bending radius 2.5 inches.
10) Nominal OD 0.284 inch.

b. Four-wire:
1) Shielded twisted 2 pair.
2) Tinned, copper conductors minimum with 7 by 30 stranding.
3) AWG #22.
4) Insulation:
    a) FHDPE: Foam high-density polyethylene.
    b) 300-volt insulation level.
5) Outer shield:
    a) 100 percent coverage.
    b) Tape/braid.
    c) Aluminum foil-polyester tape.
    d) Tinned copper braid.
6) Outer shield drain wire:
    a) Tinned, copper conductor minimum with 7 by 30 stranding.
    b) AWG #22.
7) Outer jacket PVC: Polyvinyl Chloride.
    a) Sunlight resistant.
8) UL/CSA flame tested.
9) Minimum bending radius 3.6 inches.
10) Nominal OD 0.356 inch.

E. Fire alarm cable:
1. Number of pairs: As indicated on the Drawings or as necessary for the application.
2. Voltage rating: 300 V minimum.
3. Two-hour fire rating in accordance with UL 2196.
4. Provide fire alarm cable in accordance with the requirements of UL 1424.
5. Provide Type FPLP (power-limited plenum rated) for all cabling within ducts, plenums, and all spaces used for air handling:
    a. Cable must meet NEC standards, and must have adequate fire-resistant and low smoke-producing characteristics.
6. Provide Type FPLR (power-limited riser rated) for all vertical runs that pass from floor to floor:
    a. FPLR cable must meet NEC standards, and must have fire-resistant characteristics capable of preventing the carrying of fire from floor to floor.

7. FPL (power-limited general purpose) is only suitable for general-purpose fire alarm use and shall not be used for risers, ducts, plenums, and in air-handling spaces:
    a. FPL cable must meet NEC standards, and must be listed as resistant to the spread of fire.
8. Cable substitutions are not permitted unless approved by ENGINEER.
9. Meets code requirements of NFPA 72 and NFPA 101.
10. Conductor insulation:
    a. Low smoke PVC.
    b. Minimum 105 degrees Celsius rating.
11. Conductor jacket:
    a. Low smoke PVC.
    b. Ripcord and surface-printed with year of manufacture and cable description at maximum 24-inch intervals.
    c. Minimum 105 degrees Celsius rating.

F. Telephone cable:
1. Number of twisted pairs: As indicated on the Drawings.
2. Voltage rating: 300 volts.
3. Insulation: Thermoplastic, color coded in accordance with telephone industry standards.
4. Insulation:
    a. Non-plenum: High molecular weight polyethylene.
    b. Plenum-rated: FEP.
5. Jacket:
    a. Non-plenum: PVC.
    b. Plenum-rated: Low smoke PVC.
    c. Surface-printed with year of manufacture and cable description at maximum 24-inch intervals.
6. Shield: 8 mil aluminum or copper, overlapped to provide 100 percent coverage, covered totally on both sides with copolymer or equal coating able to provide an effective moisture barrier.
7. Conductors: ASTM B3, solid, soft, bare copper.
8. Use minimum Number 24 AWG conductors, unless otherwise indicated on the Drawings.
9. Twist insulated conductors into pairs with varying lengths of lay.
10. Apply non-hygroscopic core tape over cable core as a dielectric and heat barrier.
11. Provide plenum-rated cable for wiring within ducts, plenums, and all spaces used for air handling.

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS (NOT USED)

2.07 ACCESSORIES

A. Wire ties:
   1. One of the following or equal:
      a. T&B "Ty-Rap" cable ties.
      b. Panduit cable ties.

B. Wire markers:
   1. As specified in Section 16075.

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL

A. Assembly and testing of cable shall comply with the applicable requirements of ICEA S-95-658-1999.

B. Test Type XHHW-2 in accordance with the requirements of UL 44.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 16050.

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 120 VAC control wiring:
    a. Power - Red.
    b. Neutral - White.
5. The following color code shall be followed for all general purpose DC control circuits:
    a. Grounded conductors - White with blue stripe.
    b. Ungrounded conductors - Blue.
6. Switch legs shall be violet. Three-way switch runners shall be pink.
7. Wires in intrinsically safe circuits shall be light blue.
8. Wire colors shall be implemented in the following methods:
    a. Wires manufactured of the desired color.
    b. Continuously spiral wrap the first 6 inches of the wire from the termination point with colored tape:
        1) Colored tape shall be wrapped to overlap 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:
1. For all Number 4 AWG and larger, use an approved wire-pulling lubricant while cable is being installed in conduit:
    a. Ideal Products.
    b. Polywater Products.
    c. 3M Products.
    d. Greenlee Products.
    e. Or equal as recommended by cable manufacturer.
    f. Do not use oil, grease, or similar substances.

E. Cable pulling:
1. Prevent mechanical damage to conductors during installation.
2. For cables Number 1 AWG and smaller, install cables by hand.
3. For cables larger than Number 1 AWG, power pulling winches may be used if they have cable tension monitoring equipment.
4. Provide documentation that maximum cable pulling tension was no more than 75 percent of the maximum recommended level as published by the cable manufacturer. If exceeded, the ENGINEER may, at his discretion, require replacement of the cable.
5. Ensure cable pulling crews have all calculations and cable pulling limitations while pulling cable.
6. Make splices or add a junction box or pull box 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.

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:
   1. Wrap the conductor clockwise so that the wire loop is closed as the loop is tightened.
   2. Do not use crimp lugs on solid wire.

J. Terminate stranded conductors on equipment box lugs such that all conductor strands are confined within the lug:
   1. 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:
      a. Obtain ENGINEER’s approval prior to making any splices.
   2. Lighting and receptacle circuit conductors may be spliced without prior approval from the ENGINEER.
   3. Where splices are necessary because of extremely long wire or cable lengths that exceed standard manufactured lengths:
      a. Splice box NEMA rating requirements as specified in Section 16050.
      b. Make splices in labeled junction boxes for power conductors.
      c. Make splices for control and instrument conductors in terminal boxes:
         1) Provide terminal boards with setscrew pressure connectors, with spade or ring lug connectors.
   4. Power and control conductors routed in common raceways may be spliced in common junction boxes.
   5. Clearly label junction and terminal boxes containing splices with the word "SPLICE."
   6. Leave sufficient slack at junction boxes and termination boxes to make proper splices and connections. Do not pull splices into conduits.
   7. Install splices with compression type butt splices and insulate using a heat-shrink sleeve:
      a. In NEMA Type 4 or NEMA Type 4X areas, provide heat-shrink sleeves that are listed for submersible applications.
   8. Splices in below grade pull boxes, in any box subject to flooding, and in wet areas shall be made waterproof using:
      a) A heat shrink insulating system listed for submersible applications.
      b) Or an epoxy resin splicing kit.

L. Apply wire markers to all wires at each end after being installed in the conduit and before meg-ohm testing and termination.

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. Shield grounding requirements as specified in Section 16060.

N. Multi-conductor cable:
   1. Where cable is not routed in conduit with a separate ground conductor, use one conductor in the cable as a ground conductor:
      a) Use an internal ground conductor, if it is no smaller than as indicated on the Drawings and in accordance with NEC requirements for equipment ground conductor size.
      b) Where 2 parallel cables are used, and the internal ground conductor in each cable does not meet NEC requirements for the combined circuit, use 4-conductor cable, with one of the full-sized conductors serving as ground.

O. Telephone cable:
   1. Install telephone cables in dedicated metallic raceways, including raceways in ductbanks, manholes, and pull boxes.

P. Fire alarm cable:
   1. Install fire alarm cable in dedicated metallic raceways as indicated on the Drawings.

Q. Signal cable:
   1. Separate and isolate electrical signal cables from sources of electrical noise and power cables by minimum 12 inches.

R. Submersible cable in wet wells:
   1. Provide Kellem's grip or stainless steel wire mesh to support cable weight and avoid stress on insulation.

S. 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 indicated on the Drawings.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 FIELD QUALITY CONTROL

A. As specified in Section 16050.

B. Grounding:
   1. As specified in Section 16060.

3.08 ADJUSTING (NOT USED)

3.09 CLEANING (NOT USED)

3.10 DEMONSTRATION AND TRAINING (NOT USED)

3.11 PROTECTION

A. As specified in Section 16050.

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 16125

FIBER OPTIC CABLE AND APPURTENANCES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Fiber optic cable:
      a. Fiber splices and terminations.
      b. Related accessories.

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 01782 - Operation and Maintenance Data
      c. Section 16050 - Common Work Results for Electrical.
      d. Section 16075 - Electrical Identification.
      e. Section 16130 - Conduits.
      f. Section 16950 - Field Electrical Acceptance Tests.
      g. Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
      h. Section 17733 - Control System - Network Materials and Equipment.

C. Furnish a complete fiber optic network as indicated on the Drawings.

1.02 REFERENCES

A. As specified in Section 16050.

B. Bellcore Standards:
   1. GR-20, "Generic Requirements for Optical Fiber and Optical Fiber Cables."
   2. GR-409, "Generic Requirements for Intrabuilding Fiber."

C. Electronic Industry Association (EIA) 455B "Standard Test Procedure for Fiber Optic Fibers, Cables, Transducers, Sensors, Connecting and Terminating Devices, and Other Fiber Optic Components":
   1. FOTP - 1 Cable Flexing for Fiber Optic Interconnecting Devices.
   2. FOTP - 2 Impact Test Measurements for Fiber Optic Devices.
   3. FOTP - 3 Procedure to Measure Temperature Cycling Effects on Optical Fibers, Optical Cable, and Other Passive Fiber Optic Components.
   4. FOTP - 4 Fiber Optic Connector/Component Temperature Life.

5. FOTP - 5 Humidity Test Procedure for Fiber Optic Connecting Devices.
6. FOTP - 11 Vibration Test Procedure for Fiber Optic Connecting Devices and Cables.
7. FOTP - 17 Maintenance Aging of Fiber Optic Connectors and Terminated Cable Assemblies.
8. FOTP - 18 Acceleration Testing of Fiber Optic Components and Assemblies.
9. FOTP - 21 Mating Durability for Fiber Optic Interconnecting Devices.
10. FOTP - 25 Repeated Impact testing of Fiber Optic Cables and Cable Assemblies.
11. FOTP - 26 Crush Resistance of Fiber Optic Interconnecting Devices.
12. FOTP - 28 Method for Measuring Dynamic Tensile Strength of Optical Fibers.
13. FOTP - 31 Fiber Tensile Proof Test Method.
14. FOTP - 32 Fiber Optic Circuit Discontinuities.
15. FOTP - 33 Fiber Optic Cable Tensile Loading and Bending Test.
16. FOTP - 34 Interconnecting Device Insertion Loss Test.
17. FOTP - 35 Fiber Optic Component Dust (Fine Sand) Test.
18. FOTP - 36 Twist Test for Fiber Optic Connecting Devices.
19. FOTP - 37 Low or High Temperature Bend Test for Fiber Optic Cable.
20. FOTP - 41 Compressive Loading Resistance of Fiber Optic Cables.
21. FOTP - 59 Measurements of Fiber Point Defects Using an OTDR.
22. FOTP - 61 Measurement of Fiber or Cable Attenuation Using an OTDR.
23. FOTP - 78 Spectral Attenuation Cutback Measurement for Single mode Optical Fibers.
24. FOTP - 80 Cutoff Wavelength of Un-cabled Single mode Fiber by Transmitted Power.
25. FOTP - 81 Compound Flow (Drip) Test for Filled Fiber Optic Cable.
26. FOTP - 82 Fluid Penetration Test for Fluid-Blocked Fiber Optic Cable.
27. FOTP - 85 Fiber Optic Cable Twist Test.
28. FOTP - 86 Fiber Optic Cable Jacket Shrinkage.
29. FOTP - 88 Fiber Optic Cable Bend Test.
30. FOTP - 89 Fiber Optic Cable Jacket Elongation and Tensile Strength.
31. FOTP - 91 Fiber Optic Cable Twist-Bend Test.
32. FOTP - 98 Fiber Optic Cable External Freezing Test.
33. FOTP - 169 Chromatic Dispersion Measurement of Single mode Optical Fibers by the Phase-Shift Method.
34. FOTP - 170 Cable Cutoff Wavelength of Single mode Fiber by Transmitted Power.
35. FOTP - 178 Measurements of Strip Force Required for Mechanically Removing Coatings from Optical Fibers.

D. ICEA Standards:
1. S-83-596, “Optic Fiber Premises Distribution Cables.”
2. S-87-640, “Optic Fiber Outside Plant Communications Cable.”
3. S-104-696, “Fiber Optic Premises Distribution Cables.”

E. TIA/EIA Standards:
1. 568-B (Series), “Commercial Building Telecommunications Standards.”
2. 569 (Series), “Commercial Building Standard for Telecommunications Pathways and Spaces.”
3. 598, “Color Coding of Fiber Optic Cables.”

F. U.S. Department of Agriculture, Rural Electrification Agency REA-PE-90, "Totally Filled Fiber Optic Cable."

G. NEC OFN-LS/UL 1666 - "Test for Flame Propagation Height of Electrical and Optical-Fiber Cables Installed Vertically in Shafts."

H. UL 1685 - "Standard for Vertical-Tray Fire-Propagation and Smoke-Release Test for Electrical and Optical-Fiber Cables."

1.03 DEFINITIONS

A. As specified in Sections 16050 and 17050.

B. Specific definition:
   1. N/Cm: Newtons per centimeter.

1.04 SYSTEM DESCRIPTION (NOT USED)

1.05 SUBMITTALS

A. Furnish submittals as specified in Sections 01330 and 16050.

B. Product data:
   1. Complete manufacturer's brochures that identify materials and options.
   2. Completed data sheets, including catalog number and source for determining catalog number.
   3. Manufacturer's installation instructions.
   4. Include the following:
      a. Manufacturer's data on testing equipment used on this project.
      b. Manufacturer's specifications and data sheets for all fiber types.
      c. Manufacturer's specifications and data sheets for all connectors, bulkheads, splicing kits, breakout devices, and appurtenances used connecting and terminating the fiber spans.
   5. Catalog data on all testing devices proposed for use plus certifications of accuracy, calibration, and traceability to standards of the National Institute for Standards and Testing.
   6. Manufacturer's test procedures and quality assurance procedures:
      a. After review, the Engineer may require that additional tests be performed before installation.

C. Shop drawings:
   1. Interconnection cabling diagrams for the complete system including every fiber in each cable.
   2. Drawings indicating the locations of all pull boxes including pull box identifiers and lengths.
   3. Submit optical power budget calculations for all fiber segments. Include the following:
      a. Minimum transmit power of active devices.
      b. Minimum receive sensitivity.
      c. Available power, in dBm.

d. Loss for each segment in dBm, including cable attenuation and connector losses. Use manufacturer's data for cable attenuation, at the wavelength to be used. Assume 0.5 dB per connector.
e. Demonstrate that remaining power budget at each receiver is equal to or greater than 3.0 dBm.

D. Installation instructions:
1. Submit a cable pulling and splicing work plan a minimum of 45 days before the planned initiation of cable pulling. The cable pulling and splicing work plan must be approved a minimum of 15 days before pulling cable. Include the following:
a. Pull tension calculations.
b. Detailed description of pull operation methods for all conduit runs.
c. Tools and equipment to be used for cable installation and testing.
d. Physical location of equipment setup and type.
e. Exact locations of splice points.
f. Safety and manual assist cable-pulling operations.
g. Detailed schedule for pulling and testing cables.
h. The name and qualifications of the supervisory personnel directly responsible for the installation of the conduit system.
i. Sample fiber optic cable test sheets.
j. All signed test sheet results.

E. Operation and maintenance manuals:
1. Compile completed test reports, instruction manuals, and manufacturer's information into the operating manuals and submitted in accordance with Section 01782.

F. Test reports:
1. Submit the results of all specified tests to the Engineer.
2. Submit 3 copies of all test reports showing the results of all tests specified herein or in Section 16950:
a. Test forms shall include the following information at a minimum:
1) Test type.
2) Test location.
3) Test date.
4) Wavelength.
5) Index of refraction.
6) Cable identification.
7) Fiber type.
8) Fiber number.
9) Fiber color.
10) Result of the value of the tested parameter.
3. Furnish hard copy and electronic copy for all OTDR traces.
4. Submit certification that the fiber optic cable has passed each testing stage:
a. Submit separate documentation for each testing stage result.

G. Record documents:
1. Furnish updated electrical drawings, network diagrams, and fiber cable block diagrams at the end of construction and submit as Record Drawings.

H. Calculations:
   1. Cable pulling calculations for all conduit runs:
      a. Indicate on the submittal any additional pull boxes that are required, including pull box identifiers and a written description of the location.

1.06 QUALITY ASSURANCE

A. As specified in Section 16050.

B. Furnish all cable and appurtenances manufactured within 1 year of installation.

C. Proof test all optical fibers by the fiber manufacturer at a minimum load of 50 kpsi.

D. Provide 100 percent attenuation testing for all optical fibers:
   1. Include with each cable reel the attenuation of each fiber.

E. Provide information on at least 5 successful fiber optic cable installations of comparable size and complexity in the past 3 years with name, address, and telephone number of facility owner, name of project with completion date, and type of conduit system and length of cable pulled.

1.07 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 16050.

B. Package the cable for shipment on wooden reels:
   1. Seal both ends of the cable to prevent the ingress of moisture.
   2. Place fiber cable assemblies on reels such that both cable ends are available for testing.
   3. Weatherproof cable reel markings shall include the following:
      a. Manufacturer.
      b. Date of manufacture.
      c. Shipping date.
      d. Cable identification.
      e. Cable configuration/fiber count.
      f. Cable length.
      g. Gross weight.
      h. Cable test date.
      i. Handling instructions.
      j. Direction to unreel.

1.08 PROJECT OR SITE CONDITIONS

A. As specified in Section 16050.

1.09 SEQUENCING

A. Testing:
   1. Perform testing of each fiber in each cable as follows:
      a. At the factory before shipment.
      b. At the project site upon delivery.

c. After installation, before breakout and terminations.
d. After installation is complete.

2. Submit test reports following each set of tests as specified herein.

B. Notify the Engineer and Owner a minimum of 15 days before post-installation testing.

1.10 SCHEDULING

A. As specified in Section 16050.

1.11 WARRANTY

A. As specified in Section 16050.

1.12 SYSTEM START-UP (NOT USED)

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 COMMISSIONING (NOT USED)

1.15 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Acceptable manufacturers are indicated with each component type as listed in the remainder of this Specification.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS (NOT USED)

2.04 MANUFACTURED UNITS

A. General fiber cable requirements:
1. Suitable for the installed environment.
2. Color-coded fibers according to EIA/TIA-598.
3. Color-coded buffer tubes according to EIA/TIA-598.
4. Furnish buffer tubes of a single layer nylon construction or of a material with similar mechanical performance.
5. Fillers may be included in the cable core to lend symmetry to the cable cross-section where needed.
6. Utilize a glass reinforced plastic rod as the central anti-buckling member.
7. Apply binders with sufficient tension to secure the buffer tubes to the central member without crushing the buffer tubes:
   a. Provide binders that are:
      1) Non-hygroscopic.
      2) Non-wicking (or rendered so by the flooding compound).
      3) Dielectric with low shrinkage.
8. Provide a minimum of 1 ripcord under the cable sheath.

9. Provide the high tensile strength Aramid yarns, Kevlar, and/or fiberglass helically stranded evenly around the cable core:
    a. No metallic elements whatsoever are allowed in non-armored cable.
10. The jacket or sheath shall be free of holes, splits, and blisters.
11. Mark the jacket or sheath with:
    a. Manufacturer's name.
    b. The words "Optical Cable."
    c. Year of manufacture.
    d. Sequential meter marks.
    e. Repeat markings every 1 meter.
    f. The actual length of the cable to be within 1 percent of the length marking.
    g. The marking must be in a contrasting color to the cable jacket.
    h. The height of the marking:
        1) Approximately 2.5 millimeters.
12. The shipping, storage, and operating temperature range of the cable shall be -40 degrees Celsius to +70 degrees Celsius.
13. General performance characteristics:
    a. The rated tensile load of the cables:
        1) 2,670 N (600 lbf) for armored cables, 1,334 N (300 lbf) for non-armored cables.
        2) Maximum fiber strain within a cable no greater than 60 percent of the fiber proof test level.
    b. Non-armored fiber optic cables: compressive load withstand of 220 N/cm applied uniformly over the length of the cable.
    c. Armored fiber optic cables: compressive load withstand of 440 N/cm applied uniformly over the length of the cable.
    d. The average increase in attenuation for the fibers: $\leq$0.10 dB at 1,550 nanometers for a cable subjected to this load:
        1) With no measurable increase in attenuation after load removal.
    e. Test in accordance with FOTP-41, "Compressive Loading Resistance of Fiber Optic Cable," except that the load must be applied at the rate of 3 millimeters to 20 millimeters per minute and maintained for 10 minutes.
    f. Capable of withstanding 25 cycles of mechanical flexing at a rate of 30 ± 1 cycles/minute.
    g. The average increase in attenuation for the fibers: $\leq$ 0.10 dB at 1,550 nanometers at the completion of the test.
    h. For armored cables, any visible cracks causing separation of the armor and propagating more than 5 millimeters constitutes failure.
    i. Outer cable jacket cracking or splitting observed under 10X magnification, constitutes failure.

B. Indoor/outdoor cable:
    1. General:
        a. Application: Interior and exterior of buildings.
    2. Cable construction:
        a. General:
            1) Cable type: Indoor/Outdoor - Flame retardant, low smoke, zero halogen, UV resistant.
            2) Fiber count: As indicated on the Drawings.
            3) Fiber type: Single mode.
            4) Buffer tube: Loose tube.
            5) Armoring: None.

6) Waterproofing: Water blocking layer.
7) Strength member: Central nonmetallic strength member with a coefficient of thermal expansion similar to the fibers.
8) Approvals and listings: NEC OFN-LS/ UL 1666 and UL 1685.
9) Design and test criteria: S-104-696.

b. Testing:
1) All fibers in the cable:
a) Proof test of 100 kpsi.
b) Each optical fiber: Bellcore GR-409 strip force testing.
c) No gaps are allowed between the coating material and the buffer material visible under a 50-power microscope.

c. Outer jacket material:
1) Linear low-density polyethylene.
2) Color: black.
3) Meet all requirements of the NEC for use in all indoor/outdoor areas (excluding plenums) without being enclosed in conduit.
4) Flame retardant OFNR riser rated conforming to UL 1666.
5) Printed with all necessary UL marks and manufacturer identification.
6) Sequential printing of footage in 2-foot increments.
7) With a ripcord incorporated under the cable jacket.

d. Manufacturers: One of the following or equal:
1) Corning Cable Systems Freedm® LST (OFNR Loose-Tube).
2) KRONE LSZH, Indoor/Outdoor (OFNR) distribution cables.

C. Single mode fibers:
1. All fibers in the cable must be usable fibers and meet required specifications.
2. Each optical fiber shall consist of a doped silica core surrounded by a concentric silica cladding.
3. Single mode fiber characteristics:
a. Fiber type: Single mode:
b. Core diameter: 8.2 +/-2.5 µm.
c. Clad diameter: 125 +/- 0.7 µm.
d. Cladding non-circularity: < 0.7 percent.
e. Numerical aperture: 14 +/-0.015.
f. Maximum attenuation: 0.4 dB/km @ 1,310 nm, 0.3 dB/km @ 1,550 nm.
g. Gigabit Ethernet distance: 5,000 m @ 1,310 nm.
h. Coating diameter: 245 +/- 5 µm.
i. Cabled cutoff wavelength: < 1,260.
j. Mode-field diameter: 9.2 +/- 0.4 µm @ 1,310 nm, 10.4 +/- 0.5 µm @ 1,550 nm.
k. Zero dispersion wavelength: 1,313 nm.
l. Dispersion slope: 0.086 ps/(nm^2*km).
4. Manufacturers: One of the following or equal:
a. ADC/KRONE Group.
b. Berk-Tek.
c. Corning Cable Systems.

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS (NOT USED)

2.07 ACCESSORIES

A. Patch cords:
   1. General:
      a. Connector types to match supplied equipment and the patch panel terminations.
      b. Maximum length of patch cords: 25 feet.
      c. Provide 2 spare patch cords (or 1 duplex patch cord) of each type used at each PLC or network cabinet.
      d. Factory assembled and optically tested.
   2. Manufacturers: One of the following or equal:
      a. Krone.
      b. Corning Cable Systems.

B. Fiber connectors:
   1. As specified in Section 17733.

C. Fiber optic identification/warning tags:
   1. Black letters on orange or yellow background.
   2. UV resistant polyethylene or other suitable material.
      a. Manufactured by Almetek or equal.

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL

A. Factory test:
   1. Before shipment and while on the shipping reel, test 100 percent of all fibers for attenuation:
      a. Copies of the results shall be:
         1) Maintained on file.
         2) Attached to the cable reel in a waterproof pouch.
         3) Submitted before the delivery of the cable to the job site to Engineer for approval.
   2. Conduct the flex test in accordance with FOTP-104 test condition I and III with a maximum sheave diameter of 20X the cable OD.
   3. Verify that the cable withstands 25 impact cycles with:
      a. The average increase in attenuation for the fibers <0.20 dB at 1,550 nanometers.
      b. No evidence of cracking or splitting.
      c. Conduct the test in accordance with FOTP-25.
   4. Certify that the cable withstands a tensile load of 2,700 N (600 pounds):
      a. Without exhibiting an average increase in attenuation of greater than 0.10 dB.
      b. Test in accordance with FOTP-33 using a maximum mandrel and sheave diameter of 560 millimeters.
      c. Apply the load for 1 hour in Test Condition II.
   5. Certify that the cable withstands a simulated lightning strike:
      a. Peak value of the current pulse greater than 105kA.

b. Use a test current with a damped oscillatory maximum time-to-peak value of 15 µs (which corresponds to a minimum frequency of 16.7 kHz) and a maximum frequency of 30 kHz.
c. The time to half-value of the waveform envelope 40 to 70 µs.
d. Conduct the test in accordance with the FOTP-181.
e. In addition to the analysis criterion set forth in FOTP-181, the integrity of the buffer tubes (or analogous loose tube, i.e., core tube) and strength members must be intact after removal of the cable specimens from the test box.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify the condition of the conduit system before installation of the fiber optic cable or inner duct.

B. Pass a test mandrel through all fiber optic conduits prior to pulling fiber or installing inner duct.
   1. Run the mandrel in both directions.

C. Examine all materials and equipment before installation and verify they are free from physical damage and defects.

3.02 PREPARATION

A. Before fiber splicing terminating or testing activities, verify sufficient workspace is available to perform the activity without interferences from other trades.

B. Pre-installation test:
   1. Conduct pre-installation tests on all fiber optic cable.
   2. Upon arrival at the site:
      a. Inspect the cable and reel for damage.
      b. Test all fibers with an optical time domain reflectometer (OTDR) for fiber integrity.
      c. Verify that the fiber lengths are consistent with the cable manufacture.
      d. Verify that all traces yield no point discontinuities.
   3. Complete test sequence and obtain approval from the Engineer of submitted test results before cable installation:
      a. Replace any cable failing to meet the requirements of the required tests and test before installation.
   4. Submit copies of the test results to the Engineer within 5 days after the delivery to the site.

3.03 INSTALLATION

A. As specified in Section 16050.

B. Install fiber optic patch cords in open network trays or in dedicated conduits no longer than 25 feet in length.

C. Install all fiber optic system components in accordance with the recommendations of the manufacturer.

D. Install fiber optic cable in continuous lengths without intermediate splices, except where approved by the Engineer.

E. Installation:
   1. Utilize personnel certified by the manufacturer with specific knowledge of the cable manufacturer's recommended procedures:
      a. Schedule Engineer, 5 days before installation, to witness all cable installations.
   2. Properly attach the fiber optic cable's strength elements to a 600-pound breakaway swivel containing tension or shear pins using Kellums pulling grips that are a minimum of 18 inches long.
   3. Certify that cable tensile limits do not exceed cable pull tension and bend limits using tension monitoring devices.
   4. Leave an extra loop of fiber optic cable in each pull box.
   5. Conform with the cable manufacturer's specifications, practices, and the following requirements:
      a. When power equipment is used to install fiber optic cables, use low speeds and do not exceed a rate of 30 meters per minute.
      b. Do not exceed the tensile and bending limitation for fiber optic cables under any circumstances.
      c. Use large diameter wheels, pulling sheaves, and cable guides to maintain the specified bending radius.
      d. Use commercial dynamometers or load cells to monitor pulling tension.
      e. A nonfreezing type of swivel inserted between the pulling line and cable pulling grip to prevent twisting under strain.
      f. All cable to be installed using a breakaway swivel.
   6. Apply to all conduits a lubricant at each conduit ingress and egress location during the pull operation:
      a. Pour or pump lubricant into the end of the conduit at the feed location at a nominal application rate of 3 gallons per 1,000 feet of cable.
      b. If the conduit is open at intermediate locations, then apply the appropriate proportion of lubricant at each opening.
      c. Continuously lubricate the cable as it is being pulled by pouring or pumping the lubricant into the conduit at the feed location and at each intermediate location.
      d. Station workers at each intermediate location as required.
      e. Remove all excess lubricant that has collected.
      f. Remove and clean the surrounding area after cable installation.
   7. Install using a hydraulic capstan or winch equipped with a recording running line dynamometer graph which measures and records pulling tensions:
      a. Use pulling equipment with “slip-load” capability to allow the winch to maintain a constant pulling force without taking up the winch line.
      b. Use pulling equipment equipped with a hydraulic bypass set so that a maximum tension of 600 pounds is not exceeded.
      c. Use only equipment designed to prevent a preset pulling tension from being exceeded.
      d. Fiber optic cable manufacturer to provide the pulling tension setpoint.
      e. If during the pulling operation excessive tension is detected, cease all operations and notify the Engineer.

8. Position the cable reel at the feed point in alignment with the raceway and in such a position that the cable can be passed from the top of the reel in a long, smooth bend into the raceway system:
    a. The use of a cable feeder is required, unless the cable is hand-pulled.
9. Supply all bull wheels, blocks, split wheels, cable feeders, and necessary equipment required to provide a clean and safe operation:
    a. The cable shall not be allowed to travel over any wheel or block that has a radius less than the minimum radius allowed by the cable manufacturer.
10. Minimize the use of snatch blocks and rollers to guide the cable into the conduit at the feed point:
    a. Slack feed by hand the cable into the feed point and raceway without the use of rollers.
11. Tend the cable reel at all times and turn by hand to provide the required cable slack:
    a. Under no circumstances shall the cable tension be allowed to turn the cable reel.
12. Use a rim roller, with a wheel radius greater than the minimum cable bending radius placed at the manhole or vault opening to prevent the cable from dragging on the manhole rim or steps.
13. Perform a continuous thorough visual inspection for flaws, breaks, and abrasions in the cable sheath as the cable leaves the reel, and maintain a slow pulling speed to permit this inspection.
14. Damage to the sheath or finish of the cable is cause for rejecting the cable:
    a. Replace any cable damaged in any way during installation.
15. If the cable becomes damaged during installation, stop operations and notify the Engineer immediately:
    a. Engineer to determine whether to replace the entire reel of cable or to install a termination panel to eliminate the damaged section.
16. Document all pulls by a graph which is annotated with the following information:
    a. Reel number.
    b. Pull point ID.
    c. Date and time.
    d. Explanations for abnormalities in readings or interruptions.
    e. Sign-off by Contractor and Engineer.
17. Under no conditions shall the fiber optic cable be left exposed or unattended.

F. After the cables are installed and spliced:
    1. Rack the cables.
        a. Loosely secure in racked position with wire ties.
        b. Attach imprinted plastic coated cloth identification/warning tags to each cable in at least 2 locations in each handhole/manhole.

G. Splices:
    1. Submit all splice locations to the Engineer for approval before installation of the fiber cables.
    2. Provide field splices in a splice tray located in a waterproof splice enclosure:
        a. Splice enclosure manufactured by Tyco/Raychem FOSC style splice enclosure, or equal.
    3. Loop the individual fibers a minimum of 1 full turn within the splice tray to avoid macro/micro bending.
    4. After completion of cable terminations, neatly dress all cables.

5. Protect all splices with a thermal shrink sleeve.
6. Provide fusion type fiber optic cable splicing meeting the following requirements:
   a. Joins multimode or single mode fibers.
   b. Establishes a permanent fusion splice.
   c. Waterproof.
   d. Re-enterable, rearrangable, and reusable.
   e. Splice loss < 0.10 dB.
   f. Protected by a splice enclosure.
7. Requirement for outdoor fiber splice enclosures:
   a. Seal.
   b. Bond.
   c. Anchor.
   d. Protect fiber optic cable splices.
   e. Stand-alone unit that does not require an outer enclosure.
   f. Provide for a maximum of 6 cable entries in a butt-end configuration.
   g. Used in aerial, underground, and direct buried applications.
8. Requirement for indoor fiber splice enclosures:
   a. Anchor.
   b. Protect fiber optic cable splices.
   c. Stand-alone unit that does not require an outer enclosure.
   d. Suitable for the minimum number of splices at that location plus additional capacity for reconfigurations.
9. Re-splice any splice that has a loss greater than 0.10 dB.
10. Fiber cables will have a service loop of no less than 40 feet prior to entering the interconnected enclosure or patch panels.

H. Terminations:
   1. Terminate all fiber inside a patch panel.
      a. Direct landing to a switch, router hub, or PLC will not be allowed.
   2. Terminate all cables using factory assembled terminations pig tail spliced to the cable ends.
   3. Labeling:
      a. Permanently label all cable terminations. Use labels produced by a wire printer using pressure sensitive polyester labels. Label patch panels as specified in Section 16075.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 FIELD QUALITY CONTROL

A. As specified in Section 16050.

B. General:
   1. All test results shall meet or exceed manufacturer specifications:
      a. Test each fiber of each cable for breaks, abnormalities, and overall attenuation characteristics.
      b. Replace any fiber that does not meet or exceed manufacturer specifications.

2. Conduct post-installation tests of the fiber optic system in accordance with Section 16950.
3. Pre-installation tests and post-installation tests to be witnessed and signed off by Engineer and Owner.
4. Perform attenuation tests with an optical loss test set capable and calibrated to show anomalies of 0.1 dB as a minimum:
    a. Test multimode fibers at 850 nanometers and 1,300 nanometers.
    b. Test single mode fibers at 1,310 and 1,550 nanometers.
5. Perform OTDR tests on fiber cables less than 100 meters with the aid of a launch cable:
    a. Adjust OTDR pulse width settings to a maximum setting of 1/1000th of the cable length or 10 nanoseconds.

3.08 ADJUSTING (NOT USED)

3.09 CLEANING

A. Clean all fiber optic connectors after termination and before testing. After cleaning, cover all un-terminated connectors with a protective boot.

B. At the completion of construction, touch up the finish on all fiber patch panels and enclosures.

3.10 DEMONSTRATION AND TRAINING (NOT USED)

3.11 PROTECTION

A. As specified in Section 16050.

B. Protect the fiber system from physical damage and the encroachment of dust, before, during, and after installation.

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 16130

CONDUITS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Metallic conduits:
      a. Rigid galvanized steel (GRC).
      b. Polyvinyl chloride coated steel (PCS).
      c. Electrical metallic tubing (EMT).
      d. Liquid-tight flexible metal (SLT).
      e. Explosionproof flexible (EFLX).
   2. Nonmetallic conduits:
      a. Rigid nonmetallic (PVC).
      b. Liquid-tight flexible nonmetallic (NFC).
      c. Inner duct.
   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.
   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 16052 - Hazardous Classified Area Construction.
      d. Section 16070 - Hangers and Supports.
      e. Section 16133 - Duct Banks.
      f. Section 16075 - Electrical Identification.

1.02 REFERENCES

A. As specified in Section 16050.

B. American National Standards Institute (ANSI):
   1. C80.1 - Electrical Rigid Steel Conduit.
   2. C80.3 - Steel Electrical Metallic Tubing.

C. National Electrical Manufacturer's Association (NEMA):
   1. RN-1 - Polyvinyl Chloride (PVC) Externally Coated Galvanized Rigid Steel Conduit and Intermediate Steel Conduit.

2. TC2 - Electrical Polyvinyl Chloride (PVC) Conduit.
3. TC3 - Polyvinyl Chloride (PVC) Fittings for Use with Rigid PVC Conduit and Tubing.
4. TC13 - Electrical Nonmetallic Tubing.
5. TC14 - Reinforced Thermosetting Resin Conduit (RTRC) and Fittings.

D. Underwriters Laboratories (UL):
1. 1 - Standard for Flexible Metal Conduit.
2. 6 - Standard for Electrical Rigid Metal Conduit - Steel.
3. 6A - Standard for Electrical Rigid Metal Conduit - Aluminum, Red Brass, and Stainless Steel.
4. 360 - Standard for Liquid-Tight Flexible Steel Conduit.
5. 651 - Standard for Schedule 40 and 80 Rigid PVC Conduit and Fittings.
6. 797 - Standard for Electrical Metallic Tubing - Steel.
7. 1660 - Standard for Liquid-Tight Flexible Nonmetallic Conduit.

1.03 DEFINITIONS

A. As specified in Section 16050.

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. IMC: Intermediate metallic conduit.
6. EMT: Electrical metallic tubing.
7. PVC: Polyvinyl chloride rigid nonmetallic conduit.
8. SLT: Sealtight – liquid-tight flexible conduit.
9. EFLX: Explosionproof flexible conduit.
10. FLX: Flexible metallic conduit.
11. NFC: Nonmetallic flexible conduit.
12. 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 Sections 01330 and 16050.

B. Product data:
1. Furnish complete manufacturer’s catalog sheets for every type and size of conduit, fitting, conduit body, and accessories to be used on the Project.

2. Furnish complete manufacturer's recommended special tools to be used for installation if required.
3. Certified test results for PVC-coated metallic conduit showing the adhesive bond is stronger than the tensile strength of the PVC.

C. Certifications:
1. 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 underground and concealed conduits from building lines.
3. Furnish hard copy drawings and electronic files in MicroStation V8.

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.

B. All conduits, conduit bodies, and fittings shall be UL listed and labeled.

C. Every installer of 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.

B. Do not expose type PVC and NFC 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.

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 SCHEDULING (NOT USED)

1.11 WARRANTY

A. As specified in Section 16050.

1.12 SYSTEM START-UP

A. As specified in Section 16050.

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 COMMISSIONING (NOT USED)

1.15 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Galvanized rigid steel conduit:
   1. One of the following or equal:
      a. Western Tube and Conduit.
      b. Allied Tube and Conduit.
      c. Wheatland Tube Co.

B. Polyvinyl chloride coated rigid steel conduit:
   1. One of the following or equal:
      a. Robroy Industries.
      b. Ocal, Inc.

C. Electrical metallic tubing:
   1. One of the following or equal:
      a. Allied Tube and Conduit.
      b. Western Tube and Conduit.

D. Flexible metallic conduit:
   1. One of the following or equal:
      a. AFC Cable Systems.
      b. Allied Tube and Conduit.
      c. ALFLEX.
      d. Electriflex.

E. Flexible nonmetallic conduit:
   1. One of the following or equal:
      a. Electriflex.
      b. Carlon.
      c. Anaconda.
      d. Liquatite.

F. Sealtight liquid-tight flexible conduit:
   1. One of the following or equal:
      a. Southwire.
      b. AFC Cable Systems.
      c. Electriflex.
      d. Anaconda.

G. Explosionproof flexible conduit:
   1. One of the following or equal:
      a. Appleton.
      b. Crouse Hinds.
      c. Hubbell Killark.

H. Rigid nonmetallic polyvinyl chloride conduit:
   1. One of the following or equal:
      a. Carlon.
      b. Cantex.
      c. Triangle Conduit and Cable.

I. Electrical nonmetallic tubing:
   1. One of the following or equal:
      a. Carlon Flex-Plus Blue.
      b. Specified Technologies, Inc.

J. Inner duct:
   1. One of the following or equal:
      a. Carlon.
      b. Endot Industries.

K. Conduit bodies:
   1. One of the following or equal:
      a. Crouse-Hinds.
      b. Appleton.
      c. O-Z / Gedney.
      d. Ocal.
      e. Robroy.
      f. Carlon.

L. Galvanized rigid steel conduit expansion fittings:
   1. One of the following or equal:
      a. Crouse-Hinds.
      b. Appleton.
      c. O-Z / Gedney.

M. Conduit sleeve:
   1. One of the following or equal:
      a. Crouse-Hinds.
      b. Appleton.
      c. O-Z / Gedney.

N. Conduit seals:
   1. One of the following or equal:
      a. Appleton.
      b. Crouse-Hinds.
      c. O-Z / Gedney.

O. Conduit hangers and supports:
   1. As specified in Section 16070.

P. Conduit through wall and floor seals:
   1. The following or equal:
      a. O-Z / Gedney:
         1) Type "WSK".
         2) Type “CSM”.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS (NOT USED)

2.04 MANUFACTURED UNITS (NOT USED)

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS

A. GRC:
   1. All threads: NPT standard conduit threads with a 3/4-inch taper per foot:
      a. Running conduit threads are not acceptable.
   2. Hot-dip galvanized inside and out:
      a. Ensures complete coverage and heats the zinc and steel to a temperature that ensures the zinc alloys with the steel over the entire surface.
      b. Electro-galvanizing is not acceptable.
   3. Manufactured in accordance with:
      a. UL-6.
      b. ANSI C80.1.

B. PCS:
   1. The steel conduit, before PVC coating, shall be new, unused, hot-dip galvanized material, conforming to the requirements for type GRC.
   2. Coated conduit conforms to NEMA Standard RN-1:
      a. 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 Fahrenheit (-1 degree Celsius).
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. EMT:
1. Hot-dip galvanized inside and out and finally exterior chromated and lacquered:
    a. Electro-galvanizing is not acceptable.
2. Organic corrosion resistant I.D. coating.

D. FLX:
1. Materials:
    a. Single strip steel hot-dip galvanized on all 4 sides before conduit fabrication.
    b. Full wall:
        1) Reduced wall thickness not allowed.
2. Interlocking design formed from continuous metal strip for integrity and flexibility**.**
3. UL conduits through penetration fire wall rating:
    a. 3-hour rated for steel.
    b. 2-hour rated for aluminum.
4. UL rated for cable tray and environmental air-handling space requirements**.**

E. NFC:
1. Provide liquid-tight and corrosion resistant flexible nonmetallic conduit and fittings.
2. Fabricated from a hard PVC spiral completely surrounded by flexible PVC:
    a. UL listed for sunlight resistance.
    b. Suitable for use at conduit temperatures of 80 degrees Celsius dry, 60 degrees Celsius wet, and 60 degrees Celsius oil resistant.
3. Temperature range -20 degrees Celsius to +80 degrees Celsius.

F. SLT:
   1. Temperature rated for use in the ambient temperature at the installed location but not less than the following:
      a. General purpose:
         1) Temperature range -20 degrees Celsius to +80 degrees Celsius.
      b. Oil resistant:
         1) Temperature range -20 degrees Celsius to +60 degrees Celsius.
   2. Sunlight resistant, weatherproof, and watertight.
   3. Manufactured from single strip steel, hot-dip galvanized on all 4 sides before conduit fabrication.
   4. Strip steel spiral wound resulting in an interior that is smooth and clean for easy wire pulling.
   5. Overall polyvinyl chloride jacket.
   6. With integral copper ground wire, built in the core, in conduit trade sizes 1/2 inch through 1-1/4 inch.

G. EFLX:
   1. Suitable for the hazardous Class and Group where installed:
      a. As specified in Section 16050.
   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.
   2. Rated for 90 degrees Celsius conductors or cable.
   3. Rated for use in direct sunlight.

I. Inner duct:
   1. High density polyethylene.
   2. Corrugated.
   3. Resin properties:
      a. Density, g/cm^3: 0.941 to 0.955.
      b. Melt index g/10 minute Condition E: 0.05 to 0.5.
      c. Flexural modulus, MPa (pounds per square inch): 80,000 minimum.
      d. Tensile strength at yield (pounds per square inch): 3,000 minimum.
      e. Environmental stress crack resistance condition B, F_{10}: 96 hours minimum.
      f. Brittleness temperature: -75 degrees Celsius.
   4. Size: 1.25-inch.
   5. Colors: orange, gray, white, blue, green, red, brown.

J. Conduit bodies:
   1. Material consistent with conduit type:
      a. Malleable iron bodies and covers when used with type GRC conduit.
      b. PVC bodies and covers when used with type PVC.
      c. PVC-coated malleable iron bodies and covers when used with type PCS.
      d. Malleable iron or aluminum bodies with pressed steel or aluminum covers when used with EMT conduit.

2. Conduit bodies to conform to Form 8, Mark 9, or Mogul design:
   a. 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. Gasketed covers attached to bodies with stainless steel screws secured to threaded holes in conduit body.

2.07 ACCESSORIES

A. Connectors and fittings:
   1. Manufactured with compatible materials to the corresponding conduit.

B. Insulated throat metallic bushings:
   1. Construction:
      a. Malleable iron or zinc plated steel 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 Celsius.
      e. Use fully insulated bushings on nonmetallic conduit system made of high impact 150 degrees Celsius rated non-combustible thermosetting phenolic.

C. Insulated grounding bushings:
   1. Construction:
      a. Malleable iron or steel, zinc plated, with a positive metallic end stop.
      b. Integrally molded non-combustible phenolic insulated surfaces rated 150 degrees Celsius.
      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, 3-piece construction.
      d. Rated for Class I Division 1 Group D in hazardous areas.

E. FLX fittings:
   1. Provide insulated die-cast connectors with ridges that thread into the inside of the conduit to achieve a force fit.
   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:
         1) 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.

G. Hubs for threaded attachment of steel conduit to sheet metal enclosures:
   1. Construction:
      a. Insulated throat.
      b. PVC coated when used in corrosive areas.
      c. Bonding locknut.
      d. Recessed neoprene O-ring to assure watertight and dust-tight connector.
      e. One half (1/2)-inch through 1-1/4-inch steel zinc electroplated.
      f. One and one half (1-1/2)-inch through 6-inch malleable iron zinc plated.
      g. Aluminum with aluminum conduit.
   2. Usage:
      a. All conduits in damp, wet, outdoor, and corrosive areas shall use threaded hubs for connections to sheet metal enclosures.

H. Sealing fittings:
   1. Construction:
      a. 40 percent wire fill capacity.
      b. PVC-coated when used in corrosive areas.
      c. Malleable ductile iron with steel conduit.
      d. Crouse-Hinds Type EYD where drains are required.
      e. Crouse-Hinds Type EYS where drains are not required.
      f. 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.
         1) Not affected by surrounding atmosphere or liquids.
      c. Melting point shall be 200 degrees Fahrenheit 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. 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.

K. Expansion/deflection couplings:
1. Use to compensate for movement in any directions between 2 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.

L. Expansion couplings:
1. Shall allow for expansion and contraction of conduit:
   a. Permitting 8-inch movement, 4 inches in either direction.
2. Constructed to maintain electrical continuity of the conduit system.
3. Materials:
   a. Head: Malleable or ductile iron.
   b. Sleeve: Steel.
   c. Insulating bushing: Phenolic.
   d. Finish: Hot-dip galvanized.

M. Inner duct couplings and fittings:
   1. Couplings:
      a. Self-threading.
      b. Nonmetallic.
   2. Fittings:
      a. Multi-access fitting:
         1) 4 hole.
         2) Sized for conduit containing inner duct.
      b. Duct plugs:
         1) Sized for inner duct diameter.
         2) Install in all both ends of all unused ducts.
      c. Split plugs:
         1) Sized for inner duct and cable diameters.
         2) Install at both ends of all utilized ducts.

N. EMT connectors and couplings:
   1. Construction:
      a. Compression connectors and couplings shall be concrete tight.
      b. All connectors shall have insulated throats.
      c. All connectors shall be compression type.

O. Conduit markers:
   1. As specified in Section 16075.

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL

A. As specified in Section 16050.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 16050.

B. General:
   1. Conduit routing:
      a. The Electrical Drawings are diagrammatic in nature:
         1) Install conduit runs as specified with schematic representation indicated on the Drawings and as specified.

2) Modify conduit runs to suit field conditions, as accepted by the Engineer:
   a) Make changes in conduit locations that are consistent with the design intent but are dimensionally different, or routing to bypass obstructions.
   b) Make changes in conduit routing due to the relocation of equipment.
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 is responsible for any deviations in general location, conduit size, routing, or changes to the conduit schedule without the express written approval or direction by the Engineer:
   1) The Engineer is the sole source in determining whether the change is constituted as a deviation:
   2) Perform any changes resulting in additional conduits, or extra work from such deviations.
   3) Incorporate any deviations on the Record Documents.

2. Use only tools recommended by the conduit manufacturer for assembling 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 Fahrenheit to 149 degrees Fahrenheit.
   b. Clearances of 12 inches from surfaces greater than 149 degrees Fahrenheit.
   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 with conduit bodies.
7. Install conduit with total conduit bends between pull locations less than or equal to 270 degrees.

8. Route all exposed conduit to preserve headroom, access space and work space 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.
9. Plug conduits brought into pull boxes, manholes, handholes, and other openings until used to prevent entrance of moisture.
10. Install conduit through wall and floor seals where indicated on the Drawings.
11. For 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.
12. 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.
13. Install complete conduit systems before conductors are installed.
14. 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.
15. Underground and embedded conduits:
    a. Install underground conduits, including conduit runs below slabs-on-grade in concrete-reinforced duct bank construction:
        1) As specified in Section 16133.
    b. Make underground conduit size transitions at pull boxes and manholes.
    c. Install spare conduits in underground duct banks towards top center of runs to allow for ease of installation of future cables as conduits enter underground manholes and pull boxes.

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.

D. Hazardous areas:
1. As specified in Section 16050 for hazardous areas and specific Class and Division.
2. As specified in Section 16052 for hazardous area conduit installation requirements.

E. Conduit usage:
1. Exposed conduits:
    a. Rigid conduit:
        1) Install the rigid conduit type for each location as specified in Section 16050.
        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 EFLX in Class I Division 1 locations.
   2) Minimum size: 3/4-inch:
      a) 1/2 when required for connection to instruments.
   3) Maximum length:

Conduit Trade Size	Flexible Conduit Length (in)
1/2	18
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

2. Concrete encased and 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) 2 inches in duct banks unless otherwise indicated on the Drawings.
      2) 1 inch for in slab conduits unless otherwise indicated on the Drawings.
3. Direct buried and sand bedded ductbank conduits:
   a. Type PCS.
   b. Minimum size: 1 inch.
4. PVC coated rigid metallic conduit:
   a. Use specifically manufactured or machined threading dies to manufacturer's specifications to accommodate the PVC jacket.
5. EMT:
   a. May be used when specified in Section 16050.
   b. Provide supports spaced at minimum 5 feet on center and within 2 feet of each outlet box, junction box, pull box, cabinet, or other enclosure.
6. GRC:
   a. Conduit shall be cut square and reamed before threading.

7. PVC:
    a. Conduit terminations shall be via threaded adapters into threaded hubs on the junction boxes or conduit bodies.
    b. Conduit terminations into boxes without threaded hubs shall utilize a threaded adapter and a flat neoprene washer on the outside of the box.
        1) Use a locknut on the inside of the box to tighten the adapter to the box.
    c. Route conduit to afford it the maximum physical protection.
        1) If necessary, cover conduit to afford additional protection when it cannot be shielded by the structure or machinery frames.
            a) Use Schedule 80 where exposed runs may be subject to physical damage.
8. Inner duct (applicable for fiber optic cable only):
    a. Install inner duct in PVC conduit as indicated on the Drawings.
    b. Each inner duct conduit shall be a separate color.

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. The following conduit systems shall use large radius sweep elbows:
        1) Underground conduits.
        2) Conduits containing medium voltage cables.
        3) Conduits containing shielded cables.
        4) Conduits containing fiber optic cables.
    e. Provide large radius factory-made bends for 1-1/4-inch trade size or larger.
    f. Make field bends with a radius of not less than the requirements found in the NEC:
        1) 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.
    g. 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:
      1) 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 enter 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, pull boxes, or low points of conduit.

H. Conduit supports:
   1. General:
      a. Provide appropriate hangers, supports, fasteners, and seismic restraints to suit applications:
         1) As specified in Section 16070.
         2) Provide support materials consistent with the type of conduit being installed as specified in Section 16050.
      b. Support conduit at the intervals required by the NEC.
      c. Perforated strap and plumbers tape are not acceptable for conduit supports.

2. Above suspended ceilings:
    a. Support conduit on or from the structure, do not support conduit from hanging wires or suspended ceiling grid.
3. Concealed conduit on wood:
    a. Use 2-hole galvanized steel straps screwed or nailed to the wood or hammer-driven stamped galvanized type supports having serrated or sawtooth edges on the driven portion and designed specifically for the size and type of conduit being supported. Drive these latter supports so that the conduit is tightly and rigidly supported. Replace any dented or damaged conduit.
4. In steel stud construction:
    a. Tie conduit at maximum 4-foot intervals with No. 16 gauge double annealed galvanized wire or conduit clips so that conduit cannot move from vibration or other causes.
5. Conduit on concrete or masonry:
    a. Use 1-hole malleable iron straps with metallic or plastic expansion anchors and screws or support from preset inserts.
    b. Use preset inserts in concrete when possible.
    c. Use pipe spacers (clamp backs) in wet locations.
    d. On plaster or stucco, use 1-hole malleable iron straps with toggle bolts.
6. Conduit on metal decking:
    a. Use 1-hole malleable iron straps with 1-inch long cadmium-plated Type A panhead sheet metal screws. Fully or partially hammer-driven screws are not acceptable.
7. Suspended conduit:
    a. Use malleable iron factory-made split-hinged pipe rings with threaded suspension rods sized for the weight to be carried (minimum 3/8-inch diameter), Kindorf, or equal.
    b. For grouped conduits, construct racks with threaded rods and tiered angle iron or preformed channel cross members. Clamp each conduit individually to a cross member. Where rods are more than 2 feet long, provide rigid sway bracing.
8. Supports at structural steel members:
    a. Use beam clamps.
    b. Drilling or welding may be used only as specified or with approval of the Engineer.
9. PCS systems:
    a. Provide right angle beam clamps and “U” bolts specially formed and sized to snugly fit the outside diameter of the coated conduit. Provide "U" bolts with PVC encapsulated nuts that cover the exposed portions of the threads.
    b. Securely fasten exposed conduits with Type 316 stainless steel clamps or straps or PVC-coated clamps or straps manufactured and supplied by the PCS conduit supplier.

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, GRC) 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 polyethylene rope rated 250 pounds tensile strength in each empty conduit more than 10 feet in length.
2. Seal ends of all conduit with approved, manufactured conduit seals, caps or plugs immediately after installation:
    a. Keep ends sealed until immediately before pulling conductors.

K. Miscellaneous:
1. Seal roof penetrations for raceways and other items that penetrate the roof in accordance with roofing manufacturer's instructions and as indicated on the Drawings.
2. Provide electrical unions at all points of union between ends of rigid conduit systems that cannot otherwise be coupled:
    a. Running threads and threadless couplings are not allowed.
3. Replace any conduit installed that the Engineer determines does not meet the requirements of this Specification.

3.04 ERECTION, INSTALLATION, APPLICATIONS, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 FIELD QUALITY CONTROL

A. As specified in Section 16050.

3.08 ADJUSTING (NOT USED)

3.09 CLEANING (NOT USED)

3.10 DEMONSTRATION AND TRAINING (NOT USED)

3.11 PROTECTION

A. As specified in Section 16050.

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 16133

DUCT BANKS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Electrical underground duct banks.
   2. Duct spacing and terminations.
   3. Steel reinforcing of concrete.
   4. Excavation and patching.
   5. Coordination with other underground utilities.
   6. Concrete.

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 02318 - Trenching.
      c. Section 03200 - Concrete Reinforcing.
      d. Section 03300 - Cast-In-Place Concrete.
      e. Section 16130 - Conduits.
      f. Section 16050 - Common Work Results for Electrical.

1.02 REFERENCES

A. As specified in Section 16050.

1.03 DEFINITIONS

A. As specified in Section 16050.

1.04 SYSTEM DESCRIPTION

A. Provide trenching, forming, rebar, spacers, conduit, concrete, backfill, and compaction necessary for the complete installation of the duct banks.

B. Provide reinforced concrete duct banks for all conduits installed below grade, on the site, below structures, or in contact with the earth, unless otherwise indicated on the Drawings.

1.05 SUBMITTALS

A. Furnish submittals as specified in Sections 01330 and 16050.

B. Product data:
   1. PVC conduit spacers.
   2. Detectable underground marking tape.
   3. Pull line.

C. Provide applicable submittal documents as specified in:
   1. Section 02318.
   2. Section 03200.
   3. Section 03300.

D. Shop drawings:
   1. Submit site plan drawings of duct banks including underground profiles indicating all underground utilities.

1.06 QUALITY ASSURANCE

A. As specified in Section 16050.

1.07 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 16050.

1.08 PROJECT OR SITE CONDITIONS

A. As specified in Section 16050.

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

A. As specified in Section 16050.

1.12 SYSTEM START-UP

A. As specified in Section 16050.

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 COMMISSIONING (NOT USED)

1.15 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Conduit spacers:
   1. One of the following or equal:
      a. Carlon Snap-Loc.
      b. Cantex.
      c. Osburn Associates, Inc.

B. Detectable underground marking tape:
   1. One of the following or equal:
      a. Blackburn Manufacturing Company.
      b. Pro-Line Safety Products.
      c. Panduit.

C. Pull line:
   1. One of the following or equal:
      a. Arnco.
      b. Greenlee.
      c. Osburn Associates, Inc.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS

A. Provide conduit as specified in Section 16130:
   1. Use duct suitable for use with 90-degree Celsius rated conductors.

B. Provide reinforcing steel as specified in Section 03200:
   1. Provide minimum Number 4 reinforcing steel.

2.04 MANUFACTURED UNITS

A. Conduit spacers:
   1. Provide conduit spacers recommended by the conduit manufacturer or specified above.
   2. Saddle type.
   3. Non-metallic, non-corrosive, non-conductive.
   4. Interlocking type:
      a. Vertical interlocking.
      b. Horizontal interlocking.
   5. Suitable for concrete encasement.
   6. Molded-in rebar holder.
   7. Accommodates 2-inch through 6-inch conduit sizes.
   8. Relieves the conduit from both horizontal and vertical stresses.

B. Pull line:
   1. Minimum 1/4-inch wide, flat design.
   2. Polyester.
   3. Minimum pulling strength 1,200 pounds.

C. Detectable marking tape:
   1. Provide a detectable tape, locatable by a cable or metal detector from above the undisturbed grade.
   2. Aluminum core laminated between polyethylene film.
   3. Six-inch wide red tape imprinted with black lettering "CAUTION - BURIED ELECTRIC UTILITIES."

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS (NOT USED)

2.07 ACCESSORIES (NOT USED)

2.08 MIXES

A. Concrete mix requirements as specified in Section 03300.

B. Provide a red-oxide conduit encasement coloring agent as specified in Section 03300.

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 16050.

B. Duct banks:
   1. Install duct banks encased in concrete at least 24 inches below finish grade, unless otherwise indicated on the Drawings.
   2. Damage minimization:
      a. Conduit should not be left exposed in an open trench longer than is necessary.
      b. Protect all underground duct banks against damage during pouring of concrete or backfilling.
   3. All plastic conduit fittings to be joined should be exposed to the same temperature conditions for a reasonable length of time before assembly.
   4. Provide No. 4/0 American Wire Gauge bare copper ground wire the entire length of duct bank and bond to the grounding system as indicated on the Drawings.
   5. Install underground ducts to be self-draining:
      a. Slope duct banks away from buildings to manholes or pull boxes.

b. Slope duct banks uniformly from manholes to manholes or both ways from high points between manholes.
c. Slope a minimum of 1/4 inch per 10 feet.

6. Where new duct banks join to existing manholes make the proper fittings and fabricate the concrete envelopes to ensure smooth durable transitions, as indicated on the Drawings.
7. Install pull line in spare conduits:
   a. Provide adequate pull line at both ends of conduits to facilitate conductor pulling.
   b. Cap above ground spare conduit risers at each end with screw-on conduit caps.

C. Trenching:
1. Perform trenching as specified in Section 02318.
2. Trench must be uniformly graded with the bottom, rock free and covered with select material.
3. Whenever possible, use the walls of the trench as forms for concrete encasement:
   a. Forms are required where the soil is not self-supporting.
4. Avoid damaging existing ducts, conduits, cables, and other utilities.

D. Duct spacing:
1. Separate conduits with manufactured plastic spacers using a minimum space between the outside surfaces of adjacent conduits of 2 inches.
2. Install spacers to maintain uniform spacing of duct assembly a minimum of 4 inches above the bottom of the trench during concrete pour. Install spacers on 8-foot maximum intervals:
   a. Due to some distortion of conduit from heat, and other means, it may be necessary to install extra spacers within the duct bank:
      1) Install the intermediate set of spacers within normal required spacing to maintain the proper horizontal clearance:
         a) Clearance is required to allow the proper amount of concrete to infiltrate vertically among the duct to ensure proper protection.
3. Spacers shall not be located at the center of a bend:
   a. Locate spacer in the tangent, free of the coupling on fabricated bends.
   b. Locate spacers midway between the tangent and the center bend on trench formed sweeps.

E. Terminating:
1. Use bell ends in duct at entrances into cable vaults.
2. Make conduit entrances into cable vaults tangential to walls of cable vault.
3. Form trapezoidal transitions between duct bank and cable vaults as needed in order to ensure adequate cable bending radius for the duct bank-to-vault transition.
4. New manhole or handhole applications, provide a single opening or “window” per duct bank, sized to accommodate the duct bank envelope.

F. Concrete:
1. Install concrete as specified in Section 03300.
2. Provide nonferrous tie wires to prevent displacement of the conduits during pouring of concrete:
   a. Tie wire shall not act as a substitute for spacers.

3. Install minimum 3-inch cover around conduit and rebar.
4. Consolidation of encasement concrete around duct banks shall be by hand pudding, with no mechanical vibration.
5. Conduit is subject to temperature rise. As concrete cures, allow the free end to expand by pouring the concrete from the center of the run or from one tie in point.

G. Marking tape:
1. Install a detectable marking tape 12 inches above the duct bank the entire length of the duct bank.

H. For conduit installations beneath building slabs:
1. Install steel reinforced concrete duct banks under all building slabs as indicated on the Drawings:
a. Concrete for encasement under building slabs need not be colored red.
b. For duct banks crossing under building footers or foundations, install the top of the duct bank a minimum of 6 inches below the footer.
c. Where duct banks enter through building walls, foundation walls, stem walls, etc. make connections as indicated on the Drawings.
d. Where duct banks terminate with conduit risers entering building walls, install an expansion/deflection fitting or a flat-wise elbow (elbow parallel to building wall) in order to accommodate differential movement between the conduits and structure.

I. Restore all surfaces to their original condition, unless otherwise specified.

J. Marking piers:
1. Provide permanent concrete cylinder marking piers, on grade, centered on duct bank and located at every bend in duct bank or wherever duct bank enters a building, vault, or other structure:
a. Provide a cylinder, 6 inches in diameter:
1) Top of cylinder 1/2 inch below the top of finished grade.
b. Provide a 3-inch high "E" embossed in top of cylinder:
1) Minimum of 2 inches deep.
c. Provide 2-inch arrows embossed in top of cylinder showing the direction of the duct bank:
1) Minimum of 2 inches deep.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 FIELD QUALITY CONTROL

A. As specified in Section 16050.

3.08 ADJUSTING (NOT USED)

3.09 CLEANING

A. Clean conduits of dirt and debris by use of an appropriately sized steel mandrel no less than 1/2 inch smaller than the inside diameter of the conduit.

3.10 DEMONSTRATION AND TRAINING (NOT USED)

3.11 PROTECTION

A. As specified in Section 16050.

B. Provide shoring and pumping to protect the excavation and safety of workers.

C. Protect excavations with barricades as required by applicable safety regulations.

3.12 SCHEDULES (NOT USED)

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. As specified in Section 16050.

B. American National Standards Institute (ANSI).

C. ASTM International (ASTM):
   1. A 47 - Standard Specification for Ferritic Malleable Iron Castings.
   2. D 149 - Standard Test Method for Dielectric Breakdown Voltage and Dielectric Strength of Solid Electrical Insulating Materials at Commercial Power Frequencies.
   3. D 495 - Standard Test Method for High-Voltage, Low-Current, Dry Arc Resistance of Solid Electrical Insulation.
   4. D 570 - Standard Test Method for Water Absorption of Plastics.
   5. D 648 - Standard Test Method for Deflection Temperature of Plastics Under Flexural Load in the Edgewise Position.
   6. D 790 - Standard Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials.
   7. D 792 - Standard Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement.

D. Joint Industry Conference (JIC).

E. National Fire Protection Association (NFPA):
   1. 70 - National Electrical Code (NEC).

F. National Electrical Manufacturers Association (NEMA):
   1. 250 - Enclosures for Electrical Equipment (1000 V Maximum).

G. Underwriters Laboratories, Inc. (UL):
   1. 94 - Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances.

1.03 DEFINITIONS

A. As specified in Section 16050.

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 Sections 01330 and 16050.

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:
   1. Include identification and sizes of pull boxes.

1.06 QUALITY ASSURANCE

A. As specified in Section 16050.

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.

1.08 PROJECT OR SITE CONDITIONS

A. As specified in Section 16050.

1.09 SEQUENCING

A. As specified in Section 16050.

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

A. As specified in Section 16050.

1.12 SYSTEM START-UP

A. As specified in Section 16050.

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 COMMISSIONING (NOT USED)

1.15 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. One of the following or equal:
1. Pressed steel boxes:
   a. Steel City.
   b. Appleton.
   c. Crouse-Hinds.
   d. Thomas & Betts.
2. Plastic and/or fiberglass boxes:
   a. Hoffman.
   b. Carlon.
   c. Stahlin.
3. Plastic coated steel boxes:
   a. Rob Roy.
   b. OCAL.
4. Cast device boxes:
   a. Appleton.

b. Crouse-Hinds.
c. OZ/Gedney.

5. Floor outlet boxes with 1-inch conduit knockouts:
   a. Steel City, 640 Series.
   b. Hubbell type B25 with S2530 cover plate.
6. Floor outlet boxes in open areas:
   a. Hubbell SC-3098 with plate SS-309-D for power.
   b. Hubbell SC-3098 with plate SS-309-T for telephone.
7. Formed steel enclosures:
   a. Hoffman.
   b. Thomas & Betts.
   c. Stahlin.
   d. Rittal.
8. Stainless steel enclosures:
   a. Hoffman.
   b. Stahlin.
   c. Rittal.
9. Pressed steel boxes and concrete boxes:
   a. Appleton.
   b. Steel City.
   c. Cooper/Crouse Hinds.
   d. OZ/Gedney.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS (NOT USED)

2.04 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. Concrete boxes:
   1. For outlets and pull boxes in concrete construction.
   2. Pressed steel or cast construction, concrete tight.
   3. Knockout sizes range from 1/2 inch to 1 inch.
   4. Depth as needed.
   5. Types:
      a. Four-inch octagon.
      b. Four-inch octagon ceiling boxes with hanging bars.
      c. Gangable masonry boxes:
         1) 3-1/2-inch deep, 3-3/4-inch high, length as required:
            a) 2-1/2-inch deep boxes may be used where wall thickness precludes the use of the deeper boxes.
         2) With partitions as needed.

C. 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.

2. Aluminum (copper free) boxes:
   a. High strength copper free 4/10 of 1 percent maximum alloy for use with aluminum rigid conduit.
3. Malleable iron boxes:
   a. Conforming to ASTM A 47 Grade 32510.

D. 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. Double coated with a nominal 0.002-inch (2 mil) urethane on both the interior and exterior before application of PVC coating.
   f. With a minimum 0.040-inch (40 mil) PVC coating bonded to exterior.
   g. With pressure sealing sleeve to protect the connection with conduit.

E. 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:
   a. The approval ratings must be permanently marked on each item.

F. Class I, Division 2 areas:
1. For boxes not containing arcing parts:
   a. As specified in Section 16050.
   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. Cast-in-place 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. Provisions for mounting pan.
9. Ground lug.

G. Fiberglass boxes:
1. NEMA Type 4X.
2. Constructed of molded fiberglass reinforced polyester.
3. Integral neoprene gasket on cover attached with an oil-resistant adhesive.
4. Enclosures to have internal pads for mounting optional panels and terminal kits.
5. Covers:
   a. Screw cover enclosures:
      1) Covers held in place with captive, stainless steel, or monel screws.
      2) Covers attached to body with internal zinc-plated steel hinges.

b. Quick release latches covers:
   1) Corrosion resistant fiberglass hinges.
   2) Spring loaded fiberglass latches with a monel or stainless steel bail attached with monel or stainless steel screws.
   3) With a Type 316 stainless steel padlock hasp.

6. With external mounting feet.
7. Meeting the following minimum standards and tests:

Physical Property	Value	ASTM Method
Flexural strength	12,000 psi	D 790
Heat distortion	400 degrees F	D 648
Water absorption (24 hrs)	0.5 percent	D 570
Tensile strength	5,000 psi	D 651
Specific gravity	1.8	D 792
Flammability	94V-0	UL 94
Dielectric strength	4,000 V.P.M.	D 149
Arc resistance	180 second	D 495

H. 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 3 sides.
      2) Attached to enclosure by means of a continuous stainless steel hinge and pin.
   e. Neoprene door gasket to provide a watertight, dusttight, oiltight seal:
      1) Attached with an adhesive.
      2) Retained by a retaining strip.
   f. Fabricate all external removable hardware for clamping the door to the enclosure body from zinc-plated heavy gauge steel:
      1) With a hasp and staple for padlocking.
   g. Provide large enclosures with door and body stiffeners for extra rigidity.
   h. No holes or knockouts.
   i. Finish:
      1) ANSI-61 gray electrostatically applied polyester powder inside and out over cleaned and primed surfaces.
      2) White electrostatically applied polyester powder mounting plate.
   j. Heavy gauge steel external mounting brackets when surface mounted.
2. Stainless steel:
   a. NEMA Type 4X:
      1) Boxes in locations subject to flooding or temporary submersion:
         a) NEMA Type 6.
   b. Fabricated from 14-gauge Type 316 stainless steel.
   c. All seams continuously welded.

d. Door:
    1) Rolled lip around 3 sides.
    2) Attached to enclosure by means of a continuous stainless steel hinge and pin.
e. Neoprene door gasket to provide a watertight seal:
    1) Attached with an adhesive.
    2) Retained by a retaining strip.
f. Fabricate all external removable hardware for clamping the door to the enclosure body from heavy gauge stainless steel:
    1) With a hasp and staple for padlocking.
g. Provide large enclosures with door and body stiffeners for extra rigidity.
h. No holes or knockouts.
i. Finish:
    1) Brushed.
j. Stainless steel external mounting brackets when surface mounted.

I. Cast iron junction boxes:
    1. NEMA Type 4.
    2. Recessed cover boxes.
    3. Suitable for use outdoors where subject to rain, dripping, or splashing water.
    4. Designed for flush mounting in walls or floors:
        a. Can be surface mounted using mounting lugs.
    5. Construction:
        a. Cast iron box.
        b. Covers:
            1) Checkered plate covers suitable for foot traffic.
            2) When used in areas subject to vehicular traffic H-20 loading.
        c. Hot dip galvanized.
        d. Neoprene gasket.
        e. Stainless steel screw covers.

J. Floor outlet boxes:
    1. Watertight cast iron, semi adjustable.
    2. Telephone outlets shall be fitted with 6-inch bushed nipples.
    3. Provide a pedestal housing for floor outlets in open areas.
    4. Suitable for receptacles, communications, and data outlets as specified and indicated on the Drawings, complete with gaskets and cover plates:
        a. Dual-gang, heavy-duty cast iron, suitable for wiring devices to be installed to make a complete and operable system and installation.

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS (NOT USED)

2.07 ACCESSORIES

A. Fasteners:
    1. Electroplated or stainless steel in boxes with wiring devices.
    2. Screws, nuts, bolts, and other threaded fasteners:
        a. Stainless steel.

B. Provide breather and drain fittings where appropriate.

C. Internal panels:
   1. Provide internal panels where required for mounting of terminal strips or other equipment
   2. With plated steel shoulder studs.
   3. Steel with white polyester powder finish.

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 16050.

B. General:
   1. Provide materials and construction suitable for environmental conditions at the location of the box as specified in Section 16050.
   2. Provide outlet box materials to match the conduit system:
      a. EMT - Pressed metal boxes.
      b. GRC - Cast ferrous boxes.
      c. PCS - PVC coated cast ferrous boxes.
      d. PVC - PVC boxes.
   3. Solid type gang boxes:
      a. For more than 2 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. Use cast malleable iron boxes when box must support other devices.
   6. Boxes serving luminaires or devices:
      a. Use as pull boxes wherever possible.
   7. In finished areas:
      a. Provide specific pull or junction boxes only as indicated on the Drawings or as directed.
   8. Fit all cast boxes and pressed steel boxes for flush mounting in concrete with cast, malleable box covers and gaskets.

9. In terminal boxes, furnish terminals as indicated on the Drawings, with a minimum of 50 percent spare terminals:
    a. Furnish wireways for discrete and analog/DC wiring.
    b. Separate analog wiring from 120 V discrete or power wiring.
10. Size boxes in accordance with NEC requirements and to provide sufficient room for the future components and cables indicated on the Drawings.
11. For fire-rated construction, provide materials and installation for use in accordance with the listing requirements of the classified construction.

C. Outlet boxes:
    1. Locate outlet boxes as indicated on the Drawings:
        a. Adjust locations so as not to conflict with structural requirements or other trades.
    2. Use deep threaded-hub 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:
            1) 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 plastic coated malleable iron boxes in corrosive and NEMA Type 4X area and when the conduit system is PVC coated steel.
    4. Outlet boxes may be used as junction boxes wherever possible.

D. Pull boxes and junction boxes:
    1. Size pull boxes in accordance with NEC requirements and to provide sufficient room for any future conduits and cables as indicated on the Drawings.
    2. Install pull boxes such that access to them is not restricted.

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.
    2. Outlet, switch, and junction boxes for flush-mounting in general purpose locations:
        a. One-piece, galvanized, pressed steel.
    3. Ceiling boxes for flush mounting in concrete:
        a. Deep, galvanized, pressed steel.
    4. Outlet, switch, and junction boxes where surface mounted in exposed locations:
        a. Cast ferrous boxes with mounting lugs, zinc or cadmium plating finish.
    5. Outlet, control station, and junction boxes for installation in corrosive locations:
        a. Fiberglass reinforced polyester, stainless steel, or plastic coated steel to match the conduit system.
        b. Furnished with mounting lugs.

6. Boxes for concealed conduit system:
    a. Non-fire rated construction:
        1) Depth: To suit job conditions and comply with the NEC.
        2) For luminaries: Use outlet boxes designed for the purpose:
            a) 50 pounds or less: Box marked “For Fixture Support.”
            b) More than 50 pounds: Box listed and marked with the weight of the fixture to be supported (or support luminaire independent of the box.)
        3) For junction and pull boxes: Use galvanized steel boxes with flush covers.
        4) For switches, receptacles, etc:
            a) Plaster or cast-in-place concrete walls: Use 4-inch or 4-11/16-inch galvanized steel boxes with device covers.
            b) Walls other than plaster or cast-in-place concrete: Use type of galvanized steel box, which will allow wall plate to cover the opening made for the installation of the box.
7. Recessed boxes in fire rated (2 hours maximum) bearing and nonbearing wood or steel stud walls (gypsum wallboard facings):
    a. Use listed single and double gang metallic outlet and switch boxes.
        1) The surface area of individual outlet or switch boxes shall not exceed 16 square inches.
    b. The aggregate surface area of the boxes shall not exceed 100 square inches per 100 square feet of wall surface.
    c. Securely fasten boxes to the studs.
        1) Verify that the opening in the wallboard facing is cut so that the clearance between the box and the wallboard does not exceed 1/8 inch.
    d. Separate boxes located on opposite sides of walls or partitions by a minimum horizontal distance of 24 inches.
        1) This minimum separation distance may be reduced when wall opening protective materials are installed according to the requirements of their classification.
    e. Use wall opening protective material in conjunction with boxes installed on opposite sides of walls or partitions of staggered stud construction in accordance with the classification requirements for the protective material.
8. Other fire rated construction: Use materials and methods to comply with the listing requirements for the classified construction.

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:
        a. Fully or partially hammer-driven screws are not acceptable.

G. Hazardous locations:
    1. All metallic boxes, fittings, and joints shall utilize threaded connections to the conduit system.
    2. All threaded connections shall be wrench tightened so that at least 5 threads are fully engaged.

3. Conduits entering and exiting metallic boxes in Class I Division 2 areas shall utilize approved grounding bushings to bond the conduits together.
4. Provide the following types of conduit bodies and boxes:
   a. Malleable iron bodies and boxes with GRC or IMC conduit systems.
   b. PVC coated conduit bodies and boxes with PCS conduit systems.
   c. Aluminum conduit bodies and boxes with ARC conduit systems**.**

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 REINSTALLATION (NOT USED)

3.07 FIELD QUALITY CONTROL

A. As specified in Section 16050.

3.08 ADJUSTING (NOT USED)

3.09 CLEANING

A. As specified in Section 16050.

3.10 DEMONSTRATION AND TRAINING (NOT USED)

3.11 PROTECTION

A. As specified in Section 16050.

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 16136

WIREWAY

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Wireway systems.

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. As specified in Section 16050.

B. Underwriter's Laboratories (UL):
   1. Article 870 – Wireways, Auxiliary Gutters, and Associated Fittings.

C. National Electrical Manufacturers Association (NEMA):
   1. ICS-6 – Industrial Control and Systems: Enclosures.

1.03 DEFINITIONS

A. As specified in Section 16050.

1.04 SYSTEM DESCRIPTION

A. System includes horizontal and/or vertical straight runs of wireway, fittings, covers, splices, barriers, and related accessory and supports:
   1. Connected to form a complete system.

1.05 SUBMITTALS

A. Furnish submittals as specified in Sections 01330 and 16050.

B. Product data:
   1. Technical information:
      a. Catalog cut sheets.

b. Wireway construction and materials.
c. Maximum loading and span.
d. NEMA enclosure type.

2. Dimensions:
   a. Width.
   b. Depth.
3. Weight of wireway sections and fittings.
4. Complete bill of materials.
5. Manufacturer's installation instructions.

C. Shop drawings:
   1. Provide complete details and scaled drawings for the layout of the installed wireway system showing all components and proposed mounting details.

D. Calculations:
   1. Provide cross sectional area and fill calculations.
      a. Cross sectional area and fill shall be in accordance with the NEC.
   2. Provide structural calculations to ensure that the installed system meets all structural, seismic per Section 16050, wind per Section 16050 requirements at the Project Site with respect to support and mounting:
      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.

B. Manufacturer qualifications:
   1. Member of NEMA for the manufacturer of wireway systems and fittings of types and capacities required.

C. Wireway shall be UL listed and labeled.

1.07 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 16050.

1.08 PROJECT OR SITE CONDITIONS

A. As specified in Section 16050.

1.09 SEQUENCING

A. The Drawings indicate the general route of the wireway systems. Data presented on those drawings are as accurate as preliminary surveys and planning can determine until final equipment selection is made.

B. Specifications and Drawings are for assistance and guidance but exact routing, locations, distances, and levels will be governed by actual field conditions. Make field surveys as part of the work before ordering material.

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

A. As specified in Section 16050.

1.12 SYSTEM START-UP

A. As specified in Section 16050.

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 COMMISSIONING (NOT USED)

1.15 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Metallic wireway:
   1. One of the following or equal:
      a. B-Line.
      b. Hoffman.
      c. Hammond.
      d. Rittal Electromate.

B. Non-metallic wireway:
   1. One of the following or equal:
      a. Hoffman.
      b. Carlon.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS (NOT USED)

2.04 MANUFACTURED UNITS (NOT USED)

2.05 EQUIPMENT

A. Provide wireways as indicated on the Drawings with respect to:
   1. Type (lay-in or feed-through or trough).
   2. Dimensions.
   3. NEMA enclosure rating.
   4. Wireway material.

2.06 COMPONENTS

A. Fittings:
   1. Elbows, tees, and crossings:
      a. Of the same materials and construction as the straight runs.
   2. Expansion fittings:
      a. Provide flexible or sliding fittings.

B. Covers:
   1. Hinged on one side.
   2. Held closed with latches or bolts.

C. Gaskets:
   1. As required to meet NEMA enclosure requirements:
      a. Provide gaskets at each flange and door opening to assure complete seal between wireway components.
      b. Held in place with adhesive or formed in place.

2.07 ACCESSORIES

A. Barriers:
   1. To separate power, control and instrument wiring running within the same wireway as indicated on the Drawings.
   2. Same material and manufacturer as the wireway.

B. Mounting hardware:
   1. As specified in Section 16050.

2.08 MIXES (NOT USED)

2.09 FABRICATIONS (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL

A. Manufactured in accordance with NEMA ICS-6.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify all dimensions and route before ordering wireway:
   1. Make all necessary field measurements.
   2. Coordinate with all subcontractors and suppliers to determine structural dimensions and equipment dimensions to avoid all potential conflicts with other systems.

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 16050.

B. Install the wireway per the manufacturer's guidelines and submitted installation instructions to meet the seismic and wind requirements at the project site.

C. General:
   1. Install in straight runs as much as possible, minimizing the number of turns.

2. Expansion fittings:
   a. Install as recommended by the manufacturer to accommodate thermal expansion.
   b. Install where wireway crosses structural expansion joints.
3. Fittings:
   a. Not all fittings are indicated on the Drawings:
      1) Provide all fittings required to suit the installation.
4. Wireway supports:
   a. Support wireway in accordance with manufacturer's instructions and as required by the seismic conditions.
   b. Support bracket spacing shall meet the requirements of the wireway manufacturer, and NEC.
   c. Provide wireway supports with channels under the entire width of wireway.
   d. Secure wireway to supports with manufacturer-approved fittings.
5. Mounting:
   a. Oriented to allow hinged doors to be opened minimum 90 degrees.
   b. Oriented to allow safe access to doors for maintenance and future installations.
6. Wiring installation:
   a. In accordance the NEC.
   b. Begin wiring installation only after the complete raceway system is installed.
   c. Verify that all wireway surfaces and accessories are smooth, free from burrs or sharp edges.
   d. Only install wiring that is UL listed for wireway use.
7. Wall penetrations:
   a. Terminate wireway on both sides of penetration, and penetrate wall via conduits:
      1) Seal all open spaces inside and around conduits where they penetrate building exterior walls or fire-rated walls.
      2) Fill spare conduits with sealing compound.
      3) Provide sealing material in accordance with all applicable codes and regulations.

3.04 ERECTION, INSTALLATION, APPLICATION, AND CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 PRE-INSTALLATION (NOT USED)

3.07 FIELD QUALITY CONTROL

A. As specified in Section 16050.

B. Inspect entire wireway system for the following:
   1. Secure anchoring.
   2. Proper supports.
   3. Burrs or sharp edges.
   4. Sufficient clearance from ducts and piping, especially hot pipes.

3.08 ADJUSTING (NOT USED)

3.09 CLEANING

A. As specified in Section 16050.

3.10 DEMONSTRATION AND TRAINING (NOT USED)

3.11 PROTECTION

A. As specified in Section 16050.

3.12 SCHEDULES (NOT USED)

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. As specified in Section 16050.

B. Underwriters Laboratories Inc. (UL):
   1. 20 - General Use Snap Switches.
   2. 498 - Standard for Attachment Plugs and Receptacles.
   3. 514D - Cover Plates for Flush-Mounted Wiring Devices.
   4. 943 - Ground-Fault Circuit-Interrupters.
   5. 1472 - Solid State Dimming Controls.

C. National Electrical Manufacturers Association (NEMA):
   1. WD1 - General Color Requirements for Wiring Devices.
   2. ICS 5 - Industrial Control and Systems, Control Circuit and Pilot Devices.
   3. OS1 - Sheet-Steel Outlet Boxes, Device Boxes, Covers and Box Supports.
   4. WD6 - Wiring Devices Dimensional Specifications.

D. National Fire Protection Association (NFPA):
   1. 70 - National Electric Code (NEC).

E. Federal Specification:
   1. W-C 596.
   2. W-S 896.

1.03 DEFINITIONS

A. As specified in Section 16050.

B. Specific definitions:
   1. GFCI: Ground fault circuit interrupter.
   2. P-S: Pass and Seymour.
   3. CWD: Cooper Wiring Devices.
   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 Sections 01330 and 16050.

B. Product data:
   1. Catalog cut sheets.

C. Shop drawings:
   1. Engraving schedule:
      a. Furnish complete engraving schedule for engraved nameplates.

1.06 QUALITY ASSURANCE

A. As specified in Section 16050.

B. Wiring devices shall be UL listed and labeled.

1.07 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 16050.

1.08 PROJECT OR SITE CONDITIONS

A. As specified in Section 16050.

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

A. As specified in Section 16050.

1.12 SYSTEM START-UP

A. As specified in Section 16050.

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 COMMISSIONING (NOT USED)

1.15 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Switches:

1. General purpose toggle switches, one of the following or equal:
   a. Part numbers are for brown switches:

	1-pole	2-pole	3-way	4-way
Hubbell	HBL 1221	HBL 1222	HBL 1223	HBL 1224
Leviton	1221-2	1222-2	1223-2	1224-2
CWD	4901	4902	4903	4904

2. Switches for NEMA Type 4 and NEMA Type 4X locations, one of the following or equal:

	1-pole	2-pole	3-way	4-way
Hubbell	HBL 1281	HBL 1282	HBL 1283	HBL 1284
Cooper Wiring Devices	2291	2292	2293	2294

3. Switches for office areas, one of the following or equal:

	1-pole	2-pole	3-way	4-way
Hubbell	HBL 2121I	HBL 2122I	HBL 2123I	HBL 2124I
CWD	5621-2	5622-2	5623-2	5624-2

4. Switches for photocells, one of the following or equal:

	Single-pole, double-throw
Hubbell	HBL 1385
CWD	2226

5. Switches for hazardous areas, one of the following or equal:

	1-pole	2-pole	3-way	4-way
Appleton	EDS2129	EDS218	EDS2130	EDS2140
Crouse-Hinds	EDS2129	EDS218	EDS2130	EDS2140

6. Occupancy Sensor Switches:
   a. WattStopper DW-100-I for two-way switching applications.
   b. WattStopper DW-103-I for multi-way switching applications.
7. Dimmer switches:
   a. Rectangular design with LED light level indicators:
      1) Lutron MAESTRO™ MA-1000 controller for incandescent light.
      2) Lutron MAESTRO™ MALV-1000 controller for magnetic low-voltage lights.
      3) Lutron MAESTRO™ MA-R remote for additional control stations.

B. Receptacles:

1. General purpose receptacles, one of the following or equal:

	Single	Duplex	GFCI	Weather Resistant GFCI
Hubbell	HBL5361	HBL5362	GF5362A	GFR5362SG
Leviton	5361	5362	7899	W7899-W
CWD	5361B	5362B	HGF20B	WRVGF20W

   a. Part numbers are for brown receptacles.

2. Receptacles for hazardous areas, the following or equal:
   a. Crouse-Hinds: CPS152.
3. 250 VAC receptacles, one of the following or equal:
   a. Hubbell: HBL5462.
   b. Cooper wiring devices: 5462B.
4. 480-Volt, 3-phase receptacles:
   a. 30 ampere:
      1) Crouse-Hinds ARE3423.
      2) Hubbell Hubbellock® 21420.
      3) Russellstol™ DF3404FRAB.
   b. 60 ampere:
      1) Crouse-Hinds AREA6425.
      2) Hubbell Hubbellock® 26410 or 26420 with 26401 box and 26404 adapter.
      3) Russellstol™ DF6404FRAB.

C. Plates:

1. General location, one of the following or equal:
   a. Provide plates with number of gangs as required:

	Switches	Office Switches	Standard Duplex Receptacles	GFCI Receptacles
P-S	SS1-N	SS26	SS8	WPH26

2. Wet or corrosive areas, one of the following or equal:

	Switches	Outdoor Receptacles	Indoor Duplex Receptacles	Corrosive Locations
Hubbell	1750			
T&B	CCT	CKMU		
P-S	CAI-GL		CA8-GH	3780-SC

3. In-use covers:
   a. One of the following or equal:
      1) TayMac.
      2) Cooper.
      3) Pass & Seymour.
      4) T&B.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS (NOT USED)

2.04 MANUFACTURED UNITS

A. Switches:
   1. General:
      a. 120-277 VAC.
      b. 20 ampere.
      c. Specification grade.
      d. Back and side wired unless otherwise indicated.
      e. Integral grounding terminal.
      f. Totally enclosed:
         1) Color-coded body with color corresponding to ampere rating.
      g. Provide switches with the operator style and contact arrangement as indicated on the Drawings and as required for proper operation.
      h. Color:
         1) Ivory in all areas.
   2. General purpose switches:
      a. Toggle type.
   3. Corrosive and wet areas requiring NEMA Type 4 or NEMA Type 4X enclosures:
      a. Toggle switch.
      b. Back and side wired.
   4. Switches for office areas:
      a. Rocker type.
      b. Rectangular.
   5. Switches for use with photocell:
      a. Maintained contact.
      b. Two circuit.
      c. Three position:
         1) Center off.
   6. 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.
   7. Occupancy sensor switches:
      a. Wall switch with dual-technology passive infrared and ultrasonic sensor.
         1) Configured such that lights turn on only when both infrared and ultrasonic sensors detect activity, but do not turn off as long as either sensor detects activity.
      b. Selectable “automatic-on” mode activated by sensors or “manual-on” mode activated by pushbutton.
      c. Adjustable 5-30 minute time delay.
      d. Selectable audible alert as a warning before lights turn off.
      e. Rated for fluorescent lighting loads of up to 800W.
      f. True multi-way switching allowing identical controls at any location for multi-way switching applications.
   8. Dimmer switches shall be rectangular design with LED light level indicators:
      a. Lutron MAESTRO™ MA-1000 controller for incandescent light.

b. Lutron MAESTRO™ MALV-1000 controller for magnetic low-voltage lights.
c. Lutron MAESTRO™ MA-R remote for additional control stations.

B. Receptacles:
1. General purpose receptacles:
a. Single or duplex as indicated on the Drawings.
b. 125 VAC.
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. Specification grade.
g. Back wired.
h. One-piece mounting strap.
i. Color:
1) Ivory in all areas except:
a) Orange when powered by a UPS.
2. Ground fault interrupter receptacles (GFCI):
a. 125 VAC.
b. 20 ampere.
c. Trip level 4-6 milliampere.
d. Individual and feed through protection.
e. UL 943 and UL 498 listed.
f. NEMA Type 5-20R configuration.
g. For damp or wet locations:
1) Weather resistant, in accordance with UL 498.
3. Receptacles for hazardous areas:
a. 125 VAC.
b. 20 ampere.
c. Factory sealed.
d. Single receptacle.
e. 2-wire, 3-pole.
f. Grounded through extra pole and shell.
g. Dead-front construction.
h. Interlocked to prevent plug from being withdrawn until circuit has been broken.
4. 250 VAC receptacles:
a. 2-pole, 3-wire grounding for 240 VAC circuits.
b. 3-pole, 4-wire grounding for 208 VAC 3-phase circuits.
c. Ampere rating as indicated on the Drawings.
d. Provide NEMA configuration as required by the equipment connected to the outlet.

C. Plates:
1. General location:
a. Type 302 or 304 stainless steel.
b. Brushed satin finish.
c. Minimum thickness: 0.032 inch.
d. Rectangular or square shape.

e. Engraving:
    1) Engrave each plate with the following information:
        a) Area served.
        b) Circuit number.
    2) Treat engraving to improve visibility and, except for stainless steel plates, to prevent corrosion.
    3) Characters shall be block letter pantograph engraved with a minimum character height of 1/8-inch.
f. Coordinate the number of gangs, number and type of openings with the specific location.

2. Outdoor and wet areas requiring NEMA Type 4 or NEMA Type 4X enclosures:
    a. General:
        1) UL listed for wet locations.
        2) Gasketed.
        3) Die cast metal:
            a) Match material to box material.
    b. Switches:
        1) Lever operated.
    c. Receptacles:
        1) Weather proof 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.

D. Data and communications jacks:
1. Process network jacks - panel/enclosure mounted:
    a. Network jacks located in process areas shall have a NEMA Type 4 rating (with closure cap).
    b. Mounting of network jacks in control panels shall be accomplished using bulkhead connectors and environmental enclosure caps, which are permanently attached to the bulkhead fitting.
    c. Network jacks shall have RJ-45 connections on both sides of connector (bulkhead pass through) allowing for direct connection to the network switch and computer with standard patch cords. No punch down PC board connections shall be allowed.
    d. Manufactured by Woodhead Connectivity RJLNXX.
2. Process network jacks - conduit body mounted:
    a. Network jacks located in process areas shall have a NEMA Type 4 rating (with closure cap).
    b. Mounting of network jacks in conduit bodies adapter (with minifast connector) shall be accomplished using conduit body insert and environmental enclosure caps.
    c. PC board connections are not to be allowed.
    d. Furnish 10 RJ-45 to minifast connector patch cable 3 feet in length.
    e. Manufactured by InterlinkBT RSS series.

3. Network/phone jacks:
    a. Network jacks located in computer rooms shall be installed per the installation details indicated on the Drawings.
    b. Standard Decora wall plates shall be used with QuickPort modules and inserts.
    c. Plugs shall be color coded as indicated in the installation details indicated on the Drawings.
    d. Manufactured by Leviton Quickport series.

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS (NOT USED)

2.07 ACCESSORIES (NOT USED)

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 16050.

B. Mounting heights:
    1. Process and production areas:
        a. Switches and receptacles 48 inches from finished floor to top of plate.
    2. Offices and finished areas:
        a. Switches: 48 inches from finished floor to top of plate.
        b. Receptacles: 18 inches from finished floor to center of plate.

C. Switches:
    1. Over 300 volts:
        a. Where switches used in systems of more than 300 volts between conductors, are to be ganged in outlet boxes, provide switches having no exposed live parts or use barriers between the individual switches.

D. Receptacles:
    1. Provide GFCI receptacles as indicated on the Drawings.
        a. Provide weather resistant GFCI receptacles in all wet or damp areas.
            1) As specified in Section 16050.
    2. Mount non-weatherproof receptacles vertically:
        a. Ground slot down.

3. Mount weatherproof receptacles horizontally:
   a. Neutral slot up.
4. 3-phase receptacles shall be consistent with respect to phase connection at the receptacle terminals. Correct errors in phasing at the source and not the receptacle.

E. Ensure all plates make a firm seal with wall for recessed mounted devices:
   1. Outside edges of plates parallel with building lines.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 REINSTALLATION (NOT USED)

3.07 FIELD QUALITY CONTROL

A. As specified in Section 16050.

3.08 ADJUSTING (NOT USED)

3.09 CLEANING (NOT USED)

3.10 DEMONSTRATION AND TRAINING

A. As specified in Section 16050.

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.

3.11 PROTECTION

A. As specified in Section 16050.

3.12 SCHEDULES (NOT USED)

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.

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 16123 - 600 Volt or Less Wires and Cables.

1.02 REFERENCES

A. As specified in Section 16050.

B. ASTM International (ASTM):
   1. D 3005 - Standard Specification for Low-Temperature Resistant Vinyl Chloride Plastic Pressure-Sensitive Electrical Insulating Tape.

C. CSA International (CSA):
   1. C22.2 - No. 197-M1983 (R2208) – PVC Insulating Tape.

D. Underwriters Laboratories, Inc. (UL):
   1. 510 - Standard for Polyvinyl Chloride, Polyethylene, and Rubber Insulating Tape.

1.03 DEFINITIONS

A. As specified in Section 16050.

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 Sections 01330 and 16050.

B. Product data:
   1. Catalog cut sheets.
   2. Installation instructions.

1.06 QUALITY ASSURANCE

A. As specified in Section 16050.

B. All materials shall be UL listed.

1.07 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 16050.

1.08 PROJECT OR SITE CONDITIONS

A. As specified in Section 16050.

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

A. As specified in Section 16050.

1.12 SYSTEM START-UP

A. As specified in Section 16050.

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 COMMISSIONING (NOT USED)

1.15 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Manufacturers for each type of technology are specified with the equipment in this Section.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS (NOT USED)

2.04 MANUFACTURED UNITS (NOT USED)

2.05 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. Manufacturer: One of the following or equal:
         1) Thomas and Betts, Stakon.
   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:
         1) 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: One of the following or equal:
            a) Buchanan 2006S or 2011S, with 2007 or 2014 insulating caps.
      e. For wire Number 8 AWG and larger, use heavy duty copper compression connectors:
         1) Manufacturer: One of the following or equal:
            a) Burndy.
            b) Thomas and Betts.
      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: -55 degrees Celsius to 110 degrees Celsius.
         4) Internally applied adhesive sealant.
         5) Cross-linked polyolefin:
            a) Manufacturers, one of the following or equal:
               (1) 3M ITCSN.
               (2) Thomas & Betts Shrink-Kon.
   2. Instrumentation class cable splices:
      a. Suitable for indoor, outdoors, weather exposed, direct buried, or submersed applications.
      b. Utilizing an epoxy, polyurethane, and re-enterable compounds.
      c. For use with shielded or unshielded plastic- and rubber-jacketed, signal, control, and power cables rated up to 1 kilovolt.
      d. Two-part mold body with tongue and groove seams and built in spacer webbing.
      e. Manufacturer: One of the following or equal:
         1) 3M - Scotchcast 72-N.

C. Insulating tape:
   1. General purpose insulating tape:
      a. Minimum 7 mil vinyl tape.
      b. Suitable for application in an ambient of -18 degrees Celsius (0 degrees Fahrenheit).
      c. Operating range up to 105 degrees Celsius (220 degrees Fahrenheit).
      d. Flame retardant, hot- and cold- weather resistant, UV resistant.
      e. For use as a primary insulation for wire cable splices up to 600 VAC.
      f. Meeting and complying with:
         1) ASTM D 3005 Type I.
         2) UL 510.
         3) CSA C22.2.
      g. Manufacturer: One of the following or equal:
         1) 3M - Scotch Number Super 33+.
   2. General-purpose color-coding tape:
      a. Minimum 7 mil vinyl tape.
      b. Suitable for application on PVC and polyethylene jacketed cables.
      c. For use indoors and outdoors in weather protected enclosures.
      d. Available with the following colors:
         1) Red.
         2) Yellow.
         3) Blue.
         4) Brown.
         5) Gray.
         6) White.
         7) Green.
         8) Orange.
         9) Violet.
      e. For use as phase identification, marking, insulating, and harnessing.
      f. Meeting and complying with:
         1) UL 510.
         2) CSA C22.2.
      g. Manufacturer: One of the following or equal:
         1) 3M - Scotch Number 35.

2.06 COMPONENTS (NOT USED)

2.07 ACCESSORIES (NOT USED)

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 16050.

B. Load connections:
   1. Connect loads to the circuits as indicated. Color-code all branch circuits as specified in Section 16123.

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 pre-molded 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: One of the following or equal:
      a. Raychem MCK.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 FIELD QUALITY CONTROL

A. As specified in Section 16050.

3.08 ADJUSTING (NOT USED)

3.09 CLEANING (NOT USED)

3.10 DEMONSTRATION AND TRAINING (NOT USED)

3.11 PROTECTION

A. As specified in Section 16050.

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 16210

UTILITY COORDINATION

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Coordination with the utility companies to provide service.
   2. CONTRACTOR's responsibilities for connecting to utilities and providing utility service to the facilities.
   3. Descriptions of utility services required.

B. 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. As specified in Section 16050.

1.03 DEFINITIONS

A. As specified in Section 16050.

B. Utility contacts: Refer to Sheet 00G13.

1.04 SYSTEM DESCRIPTION

A. Electrical service:
   1. Provide all Work and materials and bear all costs for providing temporary construction power and the permanent electrical service, including but not limited to:
      a. All Work and materials not provided by the electric utility.
      b. All permits and fees required by the electric utility.

2. Provide electrical ducts, raceways, conductors and connections indicated on the Drawings, and all other Work and materials required for a complete electrical service, including but not limited to the following:
   a. Electrical service conduits and conductors from the point of electric utility connection to the service entrance equipment.

B. Telephone service:
   1. Provide all Work and materials and bear all costs for the telephone service during construction:
      a. All permits and fees required by the telephone utility.
   2. Provide the telephone entrance conduit(s) from the terminal pole or pedestal to the telephone board in Computer Server Room in the Administration Building, and all other work and materials required for a complete telephone service.

C. General:
   1. Coordinate and obtain inspections and final installation approval from the serving utilities and other authorities having jurisdiction.

1.05 SUBMITTALS

A. Furnish submittals as specified in Sections 01330 and 16050.

B. Certification:
   1. Submit certification that the intended installation has been coordinated with the utility companies.
   2. Include a narrative description of the utility's requirements and points of connection, names and telephone numbers for contacts at the utilities.

1.06 QUALITY ASSURANCE

A. As specified in Section 16050.

B. Materials and equipment used in performance of Electrical Work shall be listed or labeled by Underwriter's Laboratories, or other equivalent recognized independent testing laboratory, for the class of service intended.

1.07 DELIVERY, STORAGE, AND HANDLING (NOT USED)

1.08 PROJECT OR SITE CONDITIONS

A. As specified in Section 16050.

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING

A. General:
   1. Before start of Site Work, make arrangements for temporary telephone and electrical service as required.

B. Electrical systems:
   1. Before bidding, the electrical contractor shall contact the utilities to determine the Work and materials that will be required from the CONTRACTOR, and all fees and permits that will be required, so that all utility systems furnished by the CONTRACTOR will be included in the bid.
   2. Coordinate Work with ENGINEER to minimize downtime of existing operating equipment and electrical distribution systems and to preclude unsafe operation:
      a. Notify OWNER 10 days before power interruptions.
      b. Coordinate downtime with OWNER and local electric utility.
   3. Before commencing Work, coordinate electric service entrance requirements with local electric utility to assure that the installation will be complete as specified in these Contract Documents:
      a. Ensure power transformer size, electrical characteristics, and location are consistent with the design and service voltage provided by the electric utility coordinated with other trades.
      b. Arrange for utility revenue meter.
      c. Coordinate installation of metering CTs and PTs furnished by the electric utility.
      d. Pay any charges required by the electric utility for connection and turn-on.

C. Telephone systems:
   1. Before commencing Work, coordinate complete telephone service:
      a. Verify compliance with telephone utility requirements.
      b. Verify exact location of each service point and type of service.
      c. Pay any charges required by the telephone utility for connection and turn-on.
   2. Coordinate complete telephone line connections at locations indicated on the Drawings with the local telephone utility.

D. Before commencing Site Work, coordinate underground conduit installations with other Work to eliminate conflicts and avoid interferences with other underground systems.

1.11 WARRANTY

A. As specified in Section 16050.

1.12 SYSTEM START-UP

A. As specified in Section 16050.

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 COMMISSIONING (NOT USED)

1.15 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS (NOT USED)

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS

A. Furnish materials in accordance with the applicable requirements of the utilities and as specified in these Specifications.

2.04 MANUFACTURED UNITS (NOT USED)

2.05 EQUIPMENT

A. Furnish equipment in accordance with the applicable requirements of the utilities and as specified in these Specifications.

2.06 COMPONENTS (NOT USED)

2.07 ACCESSORIES (NOT USED)

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 16050.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 FIELD QUALITY CONTROL

A. As specified in Section 16050.

3.08 ADJUSTING (NOT USED)

3.09 CLEANING

A. As specified in Section 16050.

3.10 DEMONSTRATION AND TRAINING (NOT USED)

3.11 PROTECTION

A. As specified in Section 16050.

3.12 SCHEDULES (NOT USED)

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 horsepower:
      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. As specified in Section 16050.

B. American Bearing Manufacturers Association (ABMA):
   1. 9 - Load Ratings and Fatigue Life for Ball Bearings.
   2. 11 - Load Ratings and Fatigue Life for Roller Bearings.

C. American Petroleum Institute (API):
   1. 670 - Vibration, Axial Position, and Bearing Temperature Monitoring Systems.

D. ASTM International (ASTM).
   1. B-117 - Standard Practice for Operating Salt Spray (Fog) Apparatus.

E. Institute of Electrical and Electronic Engineers (IEEE):
   1. 43 - IEEE Recommended Practice for Testing Insulation Resistance of Rotating Machinery.
   2. 112 - IEEE Standard Test Procedure for Polyphase Induction Motors and Generators.
   3. 114 - Standard Test Procedure for Single-Phase Induction Motors.
   4. 303 - Recommended Practice for Auxiliary Devices for Rotating Electrical Machines in Class 1, Division 2 and Zone 2 Locations.

5. 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 (500 hp).
6. 1349 - Guide for Application of Electric Motors in Class I, Division 2 Hazardous (Classified) Locations.

F. National Electrical Manufacturers' Association (NEMA):
1. MG-1 - Motors and Generators.
2. MG-2 - Safety Standard for Construction and Guide for Selection, Installation, and Use of Electric Motors and Generators.

G. Underwriters Laboratories Inc. (UL):
1. 674 - Electric Motors and Generators for Use in Division 1 Hazardous (Classified) Locations.

1.03 DEFINITIONS

A. As specified in Section 16050.

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 Sections 01330 and 16050.

B. Submit completed motor data sheets for each motor supplied:
1. Conform to data sheet in the appendix of this Section.
2. Manufacturer’s 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.
4. Torque, current, and power factor vs. 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, 80, 90, and 100 percent rated voltage
5. 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 VFDs, provide manufacturer’s certification that the motor is suitable for operation in the hazardous area when driven by a VFD.
6. Accessories data:
   a. Power factor correction capacitors (if called for on the Contract Documents):
      1) Size in KVAR, for all motors not connected to VFDs.

b. Motor winding heaters:
   1) Voltage.
   2) Watts.
c. Winding temperature detectors:
   1) Type.
   2) Rating.
d. Moisture detectors.

7. Mechanical data:
   a. Bearing design and bearing life calculations.
   b. Resonant frequencies for all VFD-driven motors 50 horsepower or greater.

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:
   1. 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 VFD specified.

G. Calculations:
   1. Where site conditions specified in Section 16050 exceed manufacturer's ratings, provide derating calculations for each motor.

1.06 QUALITY ASSURANCE

A. As specified in Section 16050.

1.07 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 16050.

B. Motors 200 hp and larger:
   1. Rotate shaft 90 degrees once per month.

1.08 PROJECT OR SITE CONDITIONS

A. As specified in Section 16050.

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

A. As specified in Section 16050.

1.12 SYSTEM START-UP

A. As specified in Section 16050.

1.13 OWNER'S INSTRUCTION (NOT USED)

1.14 COMMISSIONING (NOT USED)

1.15 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. One of the following or equal:
   1. US Motors.
   2. General Electric.
   3. Reliance.
   4. Toshiba.
   5. Baldor.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS (NOT USED)

2.04 MANUFACTURED UNITS (NOT USED)

2.05 EQUIPMENT

A. 3-phase induction motors - general:
   1. Voltage:
      a. All motors 1/2 hp and larger shall be rated 460 V, 3 phase unless otherwise indicated on the Drawings.
      b. Dual voltage motors rated 230/460 V, 3 phase are acceptable provided all leads are brought to the conduit box.
   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 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 286T and smaller, and automatic breather and drain devices for frames 324T and larger.
    c. Explosion-proof:
        1) Tapped drain holes with corrosion resistant plugs for frames 286T and smaller and automatic breather and drain devices for frames 324T 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:
    a. 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.
        1) Where available based on the size of the conduit box.
    e. Exceeding the dimensions defined in NEMA MG-1.
    f. Provide grounding lugs inside conduit boxes for motor frame grounding.
12. Motor bearings:
    a. Antifriction.
    b. Regreasable and initially filled with grease for horizontal motors, vertical motors per manufacturer's standard design.
    c. Bearings and lubrication suitable for ambient temperature and temperature rise.
    d. Suitable for intended application and have ABMA L-10 rating life of 60,000 hours or more.

e. Fit bearings with easily accessible grease supply, flush, drain, and relief fittings using extension tubes where necessary.
f. 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 installed in ambient temperatures 40 degrees Celsius or less:
        1) Provide Class F insulation.
        2) Design temperature rise consistent with Class B insulation.
        3) Rated to operate at an ambient temperature of 40 degrees Celsius at the altitude where the motor will be installed.
    b. Motors installed in ambient temperatures between 40 degrees Celsius and 50 degrees Celsius:
        1) Provide Class F insulation.
        2) Design temperature rise consistent with Class B insulation.
        3) Rated to operate at an ambient temperature of 50 degrees Celsius at the altitude where the motor will be installed.
    c. Motors installed in ambient temperatures between 50 degrees Celsius and 65 degrees Celsius:
        1) Provide Class H insulation.
        2) Design temperature rise consistent with Class F insulation.
        3) Rated to operate at an ambient temperature of 65 degrees Celsius at the altitude where the motors will be installed.
14. Motor leads:
    a. Insulated leads with non-wicking, non-hydroscopic material. Class F insulation.
15. Noise:
    a. Maximum operating noise level in accordance with NEMA MG-1.

B. Submersible motors:
1. Enclosures:
    a. Totally enclosed non-ventilated (TENV) watertight casing.
    b. Inner and outer shaft seals separated by an oil chamber.
2. Cooling:
    a. Suitable for continuous operation in totally, partially or nonsubmerged condition without overheating.
    b. Convection cooling by the surrounding environment or pump cooling by circulating a portion of the pumped media through a cooling water jacket as recommended by the manufacturer based on horsepower and application.
3. Electrical cables:
    a. Wire unit without splices. Coordinate with Contractor to ensure cables of adequate length.
    b. Epoxy encapsulated cable entry into terminal box.
4. Insulation:
    a. Sealed moisture resistant windings.
    b. Class H.
5. Motor protection:
    a. Provide temperature detection in motor windings.
    b. Provide moisture detection in motor housing.
    c. Other detection and protection functions specified in the in the driven equipment Section.

C. Vertical motors:
   1. Enclosures:
      a. Totally enclosed fan cooled (TEFC) for motors 200 horsepower and less installed outdoors.
      b. Weather protected Type II (WPII) for motors greater than 200 horsepower installed outdoors.
      c. Weather protected Type I (WPI) where installed indoors.
   2. Thrust bearings:
      a. Selected for combined rotor and driven equipment loads.
      b. Coordinate with driven equipment supplier for maximum vertical thrust of driven equipment.
   3. Anti-reverse ratchet.

D. Motors driven by VFDs:
   1. Compatible with the VFDs 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 or 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.

E. Motors installed in hazardous locations:
   1. Class I, Division 1 or Class II, Division 1 areas:
      a. Enclosures:
         1) Explosion proof for 3-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.

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 2 coats of epoxy paint.
   5. Withstand salt spray tests in accordance with ASTM B-117.
   6. Suitable for hose down areas.

G. Single-phase motors:
   1. Capacitor start type rated for operation at 115 volts, 60 hertz, unless otherwise specified or as indicated on the Drawings.
   2. Totally enclosed fan cooled (TEFC) motors manufactured in accordance with NEMA MG 1.
   3. Ball bearings: Sealed.
   4. 1/2 horsepower or less fan motors:
      a. Split-phase or shaded pole type when standard for the equipment.
      b. Open type when suitably protected from moisture, dripping water, and lint accumulation.
   5. Wound rotor or commutator type single-phase motors only when their specific characteristics are necessary for application and their use is acceptable to the Engineer.
   6. Integral overload protection.

H. Immersible motors:
   1. Meet all general requirements for 3-phase induction motors except as modified herein.
   2. Inverter duty as indicated on the Drawings or in the driven equipment Specifications.
   3. Enclosure:
      a. Cast iron.
      b. Designed and constructed to meet or exceed IP67.
      c. Epoxy paint finish:
         1) Withstands salt spray and corrosion tests in accordance with ASTM B 117.
      d. Furnished with lifting plates or lugs.
      e. Vertical or horizontal mounting as required by the application.
   4. Conduit box:
      a. Cast iron.
      b. Bolted and sealed cover.
      c. Rotatable in 90-degree increments.
      d. Watertight gland or potable hub for power cable entry.
   5. Power cable:
      a. Type SOOW or W cable, non-shielded.
      b. Length as required for the installation.
   6. Cooling blower:
      a. As required by the motor manufacturer.
      b. Washdown duty rated.
      c. Constant speed.
   7. Humidity moisture detector.

I. Direct current motors:
   1. Voltage as indicated on the Drawings.
   2. Provide with controller that accepts DC voltage as indicated on the Drawings.

2.06 COMPONENTS (NOT USED)

2.07 ACCESSORIES

A. Motor winding heaters:
   1. Provide all 3-phase motors with belted or cartridge space heaters mounted within the motor enclosure.
   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 the Drawings.
      b. RTD type, 2 per phase, 100-ohm platinum.
   2. Temperature switches with normally closed or normally open contacts as indicated on the Drawings.

C. Bearing temperature detectors:
   1. Where required by the driven equipment Specification or as indicated on the Drawings.
   2. RTD type and wiring matches the winding RTDs.

D. Vibration detectors:
   1. Where required by the driven equipment Specification.
   2. As specified in the driven equipment Specification.

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL

A. Factory testing:
   1. Motors less than 250 horsepower:
      a. Perform manufacturer's standard production tests including but not limited to:
         1) No load current.
         2) High potential test.
         3) Winding resistance.
      b. Furnish copies of standard test reports on prototype or identical units.
   2. Motors 250 horsepower and larger:
      a. Perform tests in accordance with IEEE 112 or IEEE 43.
      b. Tests shall include the following:
         1) Winding resistance (cold).
         2) Locked rotor test.
         3) Temperature rise test.
         4) Load test.
         5) Breakdown torque test.
         6) No-load test.

7) High-potential test.
8) Insulation resistance test.
9) Vibration test per NEMA MG-1.
10) Polarization index.
11) Speed-torque curve.
12) Shaft voltage.
13) Bearing insulation resistance.
14) Efficiency and power factor versus load test performed at rated speed and 50 percent, 75 percent, 90 percent, and 100 percent of rated load. The curves from the motor tests shall be submitted for information.
15) The maximum allowable residual unbalance in each correction plane (journal) shall be calculated using the following equation:

$$U = 4\ W/N$$

where:
U = residual correction plane unbalance, in ounces-inches
W = static correction plane journal loading, in pounds
N = maximum specified operating speed, in rpm.

c. Furnish copies of test reports.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 16050.

B. Install motors in accordance with manufacturer's instructions.

C. Install shaft grounding ring on VFD driven motors in accordance with the manufacturer’s instructions.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 FIELD QUALITY CONTROL

A. As specified in Section 16050.

B. Before start-up, perform insulation resistance test on each motor furnished or installed on this project:
1. Windings energized to 1,000 volts 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.

3.08 ADJUSTING (NOT USED)

3.09 CLEANING (NOT USED)

3.10 DEMONSTRATION AND TRAINING (NOT USED)

3.11 PROTECTION

A. As specified in Section 16050.

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 _____ DEGREES CELSIUS RECOMMENDED TRIP _____ DEGREES CELSIUS

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 16232

SINGLE DIESEL FUELED ENGINE GENERATOR ABOVE 200 KW

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Packaged automatic "emergency" diesel engine generator, classified as Level 1, Type 10, Class 24 per NFPA 110, system including:
      a. Diesel engine.
      b. Generator.
      c. Supporting and mounting skid.
      d. Engine liquid cooling system.
      e. Exhaust system.
      f. Control system.
      g. Engine starting batteries and battery charger.
      h. Generator remote annunciator system.
      i. Fuel storage tank, day tank, and fuel transfer equipment.
      j. All other equipment required for a complete and operable power generation system.

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 01410 - Regulatory Requirements.
      c. Section 01660 - Testing, Training, and Commissioning.
      d. Section 01612 - Seismic Design Criteria.
      e. Section 15082 - Piping Insulation.
      f. Section 15293 - Double Containment Piping.
      g. Section 16050 - Common Work Results for Electrical.
      h. Section 16075 - Electrical Identification.
      i. Section 16305 - Electrical System Studies.
      j. Section 16412 - Low Voltage Molded Case Circuit Breakers.

1.02 REFERENCES

A. As specified in Section 16050.

B. ASTM International (ASTM):
   1. A 53 - Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated Welded and Seamless.

2. A 106 - Standard Specification for Seamless Carbon Steel Pipe for High-Temperature Service.
3. A 181 - Standard Specification for Carbon Steel Forgings for General Purpose Piping.
4. A 240 - Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications
5. A 536 - Standard Specification for Ductile Iron Castings.
6. D 2310 - Standard Classification for Machine-Made Fiberglass (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe.

C. National Electrical Manufacturers Association (NEMA):
1. 250 - Enclosures for Electrical Equipment (1,000 Volts Maximum).
2. MG-1 - Motor and Generators.

D. National Fire Protection Association (NFPA):
1. 30 - Flammable and Combustible Liquids Code.
2. 37 - Standard for the Installation and Use of Stationary Combustion Engines and Gas Turbines.
3. 70 - National Electrical Code (NEC).
4. 110 - Standard for Emergency and Standby Power Systems.
5. 820 - Standard for Fire Protection in Wastewater Treatment and Collection Facilities.

E. Underwriters Laboratories (UL):
1. 142 - Standard for Steel Aboveground Tanks for Flammable and Combustible Liquids.
2. 508 - Standard for Industrial Control Equipment.
3. 1008 - Standard for Transfer Switch Equipment.
4. 1236 - Standard for Battery Chargers for Charging Engine-Starter Batteries.
5. 2200 - Standard for Stationary Engine Generator Assemblies.
6. 2085 - Protected Aboveground Tank for Flammable and Combustible Liquids.

1.03 DEFINITIONS

A. As specified in Section 16050.

B. Specific definitions:
1. Emergency rated duty: Continuous operation for the duration of any power outage of a utility power source.

1.04 SYSTEM DESCRIPTION

A. Provide a complete automatic diesel engine driven generator system, 1,500 kW or larger depending on loading calculations, with all necessary components and accessories to make a complete and operating emergency power supply.
1. Coordinate the generator control system with the transfer equipment specified in the Electrical Specifications and as indicated on the Drawings.

B. Provide such minor details of electrical, plumbing, or mechanical work not specified or indicated on the Drawings, which are necessary for the successful operation of the diesel engine-driven generator required by these Specifications.

C. Description of operation:
   1. As specified in Section 16433.

D. Step sequence: All motors are direct online unless otherwise noted.
   1. Step 1:
      a. 40-hp Fire Pump (60-PMP-720).
      b. 45-kVA Panel Board LP-D Transformer.
      c. 45-kVA Panel Board LP-F Transformer.
      d. 20-kW Tertiary Filter No. 1 (30-VCP-210).
      e. 1-hp Tertiary Filter No. 1 Inlet Valve (30-EDR-211).
      f. 20-kW Tertiary Filter No. 2 (30-VCP-220).
      g. 1-hp Tertiary Filter No. 2 Inlet Valve (30-EDR-221).
      h. 45-kVA Panel Board LP-C Transformer.
      i. 1-hp Fire Pump Jockey Pump (70-PMP-720).
   2. Step 2:
      a. 100-hp Soft Starter Effluent Pump No. 1 (40-PMP-301).
         NOTE: An effluent pump must be started as soon as possible after a power failure to prevent emptying the hydropneumatic surge tank, TNK-305.
      b. 5-hp Screen No. 1 (10-VCP-043).
      c. 2-hp Screen No. 1 Outlet Gate (10-EDR-042).
      d. 2-hp Screen No. 1 Inlet Gate (10-EDR-041).
      e. 5-hp Screenings Compactor No. 1 (10-VCP-044).
      f. 2-hp REW Pond No. 1 Outlet Gate (03-EDR-323).
      g. 2-hp REW Pond No. 1 Inlet Gate (03-EDR-321).
   3. Step 3:
      a. 75-hp VFD Mechanical Aerator No. 1 (20-AER-091).
      b. 15-hp VFD Plant Drain Pump No. 1 (04-PMP-501).
      c. 2-hp Screen No. 2 Inlet Gate (10-EDR-051).
      d. 5-hp Screen No. 2 (10-VCP-053).
      e. 5-hp Screenings Compactor No. 2 (10-VCP-054).
      f. 2-hp Screen No. 2 Outlet Gate (10-EDR-052).
      g. 2-hp REW Pond No. 2 Inlet Gate (03-EDR-324).
      h. 2-hp REW Pond No. 2 Outlet Gate (03-EDR-325).
      i. 100-hp Soft Starter Effluent Pump No. 2 (40-PMP-302).
      j. 13.07-kW UV Disinfectant Channel No. 1 VCP (31-UPDC-241A).
      k. 13.07-kW UV Disinfectant Channel No. 1 VCP (31-UPDC-241B).
      l. 13.07-kW UV Disinfectant Channel No. 1 VCP (31-UPDC-241C).
      m. 13.70-kW UV Disinfectant Channel No. 2 VCP (31-UVPDC-242A).
      n. 13.70-kW UV Disinfectant Channel No. 2 VCP (31-UVPDC-242B).
      o. 13.07-kW UV Disinfectant Channel No. 2 VCP (31-UVPDC-242C).
   4. Step 4:
      a. 75-hp VFD Mechanical Aerator No. 2 (20-AER-092).
      b. 1-hp Tertiary Filter to Waste Valve (31-EDR-240).
      c. 15-hp VFD Plant Drain Pump No. 2 (04-PMP-502).
      d. 100-hp Soft Starter Effluent Pump No. 3 (40-PMP-303).
   5. Step 5:
      a. 75-hp VFD Mechanical Aerator No. 3 (20-AER-101).
      b. 7.5-hp VFD RAS/WAS Pump No. 1 (50-PMP-121).
      c. 0.75-hp RAS Suction Valve No. 1 (50-EAM-124).
      d. 0.75-hp WAS Discharge Valve (50-EAM-127).
      e. 2-hp Ground Water Pressurization Pump No. 1 (60-PMP-731).

f. 1.5-hp Ground Water Well Pump No. 1 (60-PMP-711).
g. 2-hp Ground Water Well Pump No. 2 (60-PMP-732).
h. 10-hp VFD Filter Influent Pump No. 1 (28-PMP-181).
i. 2-hp Mix Liquor Splitter Weir Gate No. 1 (20-EDM-094).
j. 2-hp Mix Liquor Splitter Weir Gate No. 2 (20-EDM-104).
k. 0.75-hp WAS Isolation Valve No. 1 (50-EAM-128).
l. 0.75-hp WAS Isolation Valve No. 2 (50-EAM-129).
m. 1.5-hp Flocculator No. 1 (Future) (29-FLO-201).
n. 1.5-hp Flocculator No. 2 (Future) (29-FLO-202).
o. 1-hp Non Potable Water Storage Inlet Valve (60-EDR-713).
p. 1-hp Potable Water Storage Inlet Valve (60-EDR-730).

6. Step 6:
   a. 10-hp Cake Conveyor No. 1 (51-CNV-433).
   b. 7.5-hp VFD RAS/WAS Pump No. 3 (50-PMP-123).
   c. 0.75-hp RAS Suction Valve No. 2 (50-EAM-125).
   d. 75-hp VFD Mechanical Aerator No. 4 (20-AER-102).
   e. 1-hp Secondary Clarifier No. 1 Drive (21-CLR-111).
   f. 1.5-hp Flash Mix Pump No. 1 (28-PMP-185).
   g. 15-hp VFD Filter Influent Pump No. 2 (28-PMP-182).
7. Step 7:
   a. 10-hp Anoxic Mixer No. 1 (20-MIX-090).
   b. 1-hp Secondary Clarifier No. 2 Drive (21-CLR-112).
   c. 1.5-hp Flash Mix Pump No. 2 (28-PMP-186).
   d. 10-hp VFD Filter Influent Pump No. 3 (28-PMP-183).
   e. 0.5-hp Plant Water Supplemental Flow Valve (28-EAM-188).
8. Step 8:
   a. 12.5 Refrigerant Tons Dewatering Electrical Room AC Unit (51-ACU-470).
   b. 10-hp Anoxic Mixer No. 2 (20-MIX-100).
9. Step 9:
   a. 3-hp Odor Control Fan No. 1 (11-FAN-071).
   b. 50-hp Soft Starter Sludge Aeration Blower No. 1 (50-BLO-401).
   c. 1-hp Blower No. 1 Discharge Valve (50-EDR-404).
   d. 1-hp Blower Cross Tie Valve No. 1 (50-EDR-407).
   e. 1-hp Blower No. 2 Discharge Valve (50-EDR-405).
   f. 1-hp Dewatering Inlet Valve No. 1 (50-EDR-421).
   g. 20-hp VFD Dewatering Feed Pump No. 1 (50-PMP-423).
   h. 1-hp Dewatering Outlet Valve No. 1 (50-EDR-424).
   i. 5-hp Dewatering Feed Grinder No. 1 (50-GRI-422).
   j. 5-hp VFD Dewatering Screw Press No. 1 (51-PRE-431).
   k. 13.70-kW UV Disinfectant Channel No. 3 VCP (31-UVPDC-243A).
   l. 13.70-kW UV Disinfectant Channel No. 3 VCP (31-UVPDC-243B).
   m. 13.70-kW UV Disinfectant Channel No. 3 VCP (31-UVPDC-243C).
   n. 1-hp Sludge Storage Tank No. 1 Dewatering Feed Valve (50-EDR-417).
   o. 1-hp Sludge Storage Tank No. 2 Dewatering Feed Valve (50-EDR-418).
   p. 1-hp Sludge Storage Tank No. 1 WAS Feed Valve (50-EDR-411).
   q. 0.75-hp Sludge Storage Sump Pump No. 1 (50-PMP-419A).
   r. 0.75-hp Sludge Storage Sump Pump No. 2 (50-PMP-419B).
   s. 5-hp VFD Dewatering Screw Press No. 2 (51-PRE-432).
10. Step 10:
   a. 10-hp Cake Conveyor No. 1 (51-CNV-433).
   b. 10-hp Cake Conveyor No. 2 (51-CNV-434).
   c. 1.5-hp Dewater Polymer Blending Unit No. 1 (51-PBU-451).

d. 1.5-hp Dewater Polymer Blending Unit No. 2 (51-PBU-452).
e. 1.5-hp Secondary Treatment Polymer Feed System (51-PBU-453).

11. Step 11:
    a. 68-kVA Admin Building.
12. Step 12:
    a. 36-kVA Maintenance Building.
    b. 1-hp UV Disinfectant Channel No. 1 Valve (31-EDM-244).
    c. 1-hp UV Disinfectant Channel No. 2 Valve (31-EDM-245).
    d. 0.5-hp Service Entrance Gate (05-GAT-840).
    e. 0.5-hp Main Entrance Gate (06-GAT-820).
13. Step 13:
    a. 7.5 Refrigerant Tons Electrical Room Air Conditioning Unit (70-ACU-800).

1.05 SUBMITTALS

A. Furnish submittals as specified in Sections 01330 and 16050.

B. Product data:
1. General:
    a. Manufacturer of:
        1) Engine.
        2) Generator.
        3) Governor.
        4) Voltage regulator.
        5) Generator control panel.
        6) Radiator.
        7) Battery charger.
        8) Batteries.
        9) Silencer.
        10) Fuel storage tank.
    b. Wet weight of engine generator system.
        1) List weight of fuel separately.
    c. Dimensions of engine generator system:
        1) Length.
        2) Width.
        3) Height.
    d. Type and grade of fuel recommended.
    e. Fuel oil consumption at:
        1) 50 percent load.
        2) 75 percent load.
        3) 100 percent load.
    f. Type and grade lubricating oil recommended.
    g. Amount of lubricating oil required per oil change.
    h. Normal lubricating oil consumption.
    i. Recommended lubricating oil change periods:
        1) By hours run.
        2) By time.
    j. Heat rejection by engine generator to the room area.
    k. Time interval from start-up contact closure until full load capabilities are available.
2. Engine:
    a. Number of cylinders, bore, stroke, and piston speed.

b. Displacement in cubic inches.
c. Compression ratio.
d. Engine RPM at 60 hertz.
e. Combustion air required.
f. Cooling air required.
g. Size of exhaust outlet.
h. Gauges.
i. Jacket water heater:
    1) Rating.
    2) Voltage and phase requirements.

3. Emissions:
    a. Certification of EPA compliance.
    b. Other exhaust emissions as required by the local air quality management district issuing the permit for the engine generator system.
    c. Reported at rated speed and load as measured by SAE J177 and J215 or ISO 8178 recommended practices.

4. Generator (alternator):
    a. Rated output:
        1) kW emergency.
        2) power factor.
        3) Voltage.
        4) Current.
    b. Number of poles.
    c. Number of leads and wires per lead.
    d. Pitch.
    e. Stator and field ratings including temperature rise at full and overload conditions.
    f. Insulation system:
        1) Insulation class.
        2) Stator rise.
        3) Rotor rise.
        4) Heat dissipated (kW).
        5) Air flow (m^3/min).
    g. Impedances (per unit and ohms):
        1) Synchronous reactance - direct axis (X_d).
        2) Synchronous reactance - quadrature axis (X_q).
        3) Transient reactance - saturated (X'_d).
        4) Subtransient reactance - direct axis (X''_d).
        5) Subtransient reactance - quadrature axis (X''_q).
        6) Negative sequence reactance (X_2).
        7) Zero sequence reactance (X_0).
    h. Time constants:
        1) Open circuit transient – direct axis.
        2) Short circuit transient – direct axis.
        3) Open circuit subtransient – direct axis.
        4) Short circuit subtransient – direct axis.
        5) Open circuit subtransient – quadrature axis.
        6) Short circuit subtransient – quadrature axis.
        7) Exciter time constant.
        8) Armature short circuit.
    i. Short circuit ratio.
    j. Stator resistance.

k. Field resistance.
l. I^2t or K (heating time constant).
m. Voltage and frequency variation and duration with the step application and removal of 25 percent, 50 percent, 75 percent, and 100 percent of resistive load maximum.
n. Generator efficiency at:
    1) 25 percent load.
    2) 50 percent load.
    3) 75 percent load.
    4) 100 percent load.
o. Generator output characteristic curves:
    1) Open circuit.
    2) Short circuit.
    3) Zero power factor.
    4) Air gap.
p. Reactive capability curve.
q. Certified published engine horsepower curves showing manufacturer's engine rating for emergency generator set and prime power application.
r. Decrement curve.
s. Thermal damage curve.

5. Governor.
6. Voltage regulator.
7. Generator control panel:
    a. Dimensions:
        1) Length.
        2) Width.
        3) Height.
        4) Weight.
    b. Power requirements.
    c. Controls.
    d. NEMA 1 enclosure rating.
8. Space and ambient temperature requirements.
9. Battery system:
    a. Battery charger:
        1) Dimensions:
            a) Length.
            b) Width.
            c) Height.
            d) Weight.
        2) Input power requirements.
    b. Batteries:
        1) Number.
        2) Dimensions:
            a) Length.
            b) Width.
            c) Height.
            d) Weight.
        3) Amount of electrolyte.
        4) Enclosure or rack.

10. Silencer:
    a. Grade.
    b. Dimensions:
        1) Length.
        2) Width.
        3) Height.
        4) Weight.
11. Free field mechanical noise level at 23 feet. Provide overall decibels (dBA) rating referenced at 20 µPa.
12. Exhaust sound level in dBA at 5 feet from discharge end of silencer.
13. Recommended spare parts and special tools lists, specifying quantity of each item.
14. Remote annunciator:
    a. Annunciator lamps and colors.
    b. Dimensions:
        1) Length.
        2) Width.
        3) Height.
    c. NEMA rating.
    d. Wiring diagram.
    e. Strip heaters.
    f. Crank case heaters.
    g. Fuel heaters.

C. Shop drawings:
1. Provide detailed dimensional and to-scale layout drawings including:
    a. A single drawing incorporating all equipment furnished:
        1) Submittals that consist solely of individual drawings for each component and require that these sheets be compiled by the ENGINEER, in order to view the entire piece of equipment, are not acceptable.
    b. Conduit stub-out locations.
2. Detailed electrical wiring diagrams of the engine and generator including:
    a. Engine interconnection terminal box.
    b. Generator interconnection terminal box.
    c. Fuel system.
    d. All interfaces between the engine driven generator skid and the transfer equipment.
    e. All wire numbers and terminal block identifications:
        1) Wire numbers are to correspond to the wire number on the equipment.
        2) All wires are to be numbered.
    f. Complete interior and exterior control panel layout:
        1) Scaled.
        2) With device descriptions.
        3) With nameplates.
3. Piping connection and instrumentation diagrams.
4. Mounting and installation drawings:
    a. Detailing mounting requirements for the Project Site seismic requirements as specified in Section 16050.
    b. Prepared and sealed by a registered structural professional engineer in the state where the Project is being constructed.

5. Fuel systems accessories:
    a. Complete shop drawings of each components making up the fuel system accessories.
        1) No approvals will be made until the entire submittal is made.
    b. Engineering drawings containing complete dimensions with sufficient details to define tank, pump and equipment installation, anchor bolt layout, piping connections, wiring interconnections, control panel layout, and associated support,
    c. Tank, equipment, pump, valves, control components data sheets, piping schematic diagrams including connections and location, electrical schematic diagrams, and interconnecting wiring diagrams.
    d. List of special tools and spare parts.
    e. Manufacturer's installation instruction and Operation and Maintenance Data.
    f. Warranty.

D. Operation and maintenance manuals:
    1. Submit operating instructions and a maintenance manual presenting full details for care and maintenance of equipment of every nature furnished and/or installed under this Section.
    2. Operating manual:
        a. The manual must detail the operational functions of all normally used controls that have been placed on the front of the control equipment.
        b. Standard operational manuals normally furnished by the manufacturer.
    3. Maintenance manual:
        a. Printed and bound instructions covering all details pertaining to care and maintenance of all equipment as well as data identifying all parts.
        b. These manuals must include but are not limited to the following:
            1) Electrical controls:
                a) Adjustment and test instructions covering the steps involved in the initial test, adjustment, and start-up procedures.
                b) Detailed control instructions, which outline the purpose and operation of every control device used in normal operation.
                c) Description of the sequence of operation that outlines the steps the controls follow during normal power failure and normal power return conditions.
                d) All schematic, wiring, and external diagrams. Also, internal device wiring and schematic diagrams for all sub assemblies used in the equipment:
                    (1) Drawing to be furnished in a reduced 11-inch by 17-inch format and shall be fully legible at that drawing size.
            2) Engine and generator:
                a) Repair parts manuals normally furnished by the manufacturer.
                    (1) Detailing all parts and sub-assemblies, which are available as repair parts.
            3) Shop maintenance manuals:
                a) Provide 1 shop manual on-site that is equivalent to the manual used by factory-authorized shop repair personnel.
                b) Manuals for the following equipment:
                    (1) Engine.
                    (2) Radiator.

(3) Generator.
(4) Engine generator control panel.

c. Material safety data sheets:
1) Complete MSDS forms for all substances.
2) Located in O&M manual.
3) Include separate manual labeled MSDS with additional copies of all MSDS forms.

E. Test reports:
1. Furnish complete test reports as specified in this Section.

F. Certificates:
1. Certification of the emissions performance of the generator set engine by the engine manufacturer.
2. Certification that a torsional analysis between the engine and generator has been completed.
3. Seismic certification: IBC certified (or equal) per Section 01612.
4. Upon completion of installation, manufacturer must issue a certification of compliance with the Contract Documents.

G. Calculations:
1. Complete loading calculations to support the recommended size of the engine-generator based upon actual facility loads and specified maximum allowable voltage drop.
2. Supply documentation identifying the maximum static pressure acceptable for the radiator fan. It is the manufacturer's responsibility to then provide calculations as part of the layout drawings, to ensure that the transition ductwork at the discharge of the radiator does not exceed the maximum static pressure acceptable for the radiator fan.
3. Submit exhaust system silencer noise attenuation curves.
4. Structural support system, mounting, and seismic calculations to be signed and stamped by a licensed structural professional engineer, registered in the state where the Project is located:
a. Vibration isolator selection calculations.
b. Vibration isolator anchoring calculations.
c. Exhaust silencer structural support calculations on indoor applications.
5. Submit factory certification of the radiator ambient capability.
6. Submit governor and voltage regulator settings.
7. Submit exhaust system pressure loss calculations:
a. Include piping, fittings, silencer, and rain cap in loss calculations on indoor applications.

1.06 QUALITY ASSURANCE

A. As specified in Section 16050.

B. Manufacturer qualifications:
1. The manufacturer of the engine, generator, and all major items of auxiliary equipment must be in current production of such equipment.

2. A factory authorized parts and service facility located within 100 miles of the Project Site.
3. Manufacturer is responsible for furnishing, testing, installation supervising, testing, and guaranteeing the system.

C. Regulatory requirements:
1. In accordance with NFPA-110 Type 10 (10-second) transfer requirements.
2. Fuel tanks:
   a. UL listed.
   b. Primary and secondary tanks shall be tested under pressure per the manufacturer's recommendation to check for leaks.
   c. Comply with the following, if applicable:
      1) NFPA 30 – Flammable and Combustible Liquids.
      2) NFPA 37 – Standard for Installation and Use of Stationary Combustible and Gas Turbines.
      3) NFPA 110 – Standard for Emergency and Standby Power Systems.
3. Regulations of the Fire Prevention Bureau of the fire department having jurisdiction.
4. Fire Code as specified in Section 01410.
5. Other applicable state and local codes.
6. EPA approved.
7. Requirements of local Air Quality Management District or Air Pollution Control District. Contractor shall be responsible to provide Owner all emissions testing documentation required by the SLO APCD genset permitting process.
8. Comply with the Specifications that may be in excess of, and not contrary to, the regulations.

1.07 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 16050.

B. Furnish the generator skid with removable lifting and jacking angles, eye bolts, etc., attached to the structural base to facilitate unloading and move-in operations.

C. Provisions on skid for the use of "Multiton" type rollers for moving the generator skid into position and then removal of the "Multiton" rollers and then for setting the engine generator skid in place.

D. Provide the services of a manufacturer's authorized representative to:
1. Be present at the jobsite when the engine-driven generator arrives:
   a. Act as an advisor in assisting the CONTRACTOR regarding the unloading and move-in operations.
2. Coordinate the delivery of the shipment with the CONTRACTOR.

1.08 PROJECT OR SITE CONDITIONS

A. As specified in Section 16050.

1.09 SEQUENCING

A. Complete factory prototype and factory production tests in accordance with NFPA 110 before equipment is shipped.

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

A. As specified in Section 16050.

1.12 SYSTEM TESTING AND START-UP

A. As specified in Section 16050.

B. Furnish manufacturer services to include, but are not limited to:
   1. During the start-up and adjustment period to ensure that all items furnished are in proper operating condition:
      a. Engine technician must be completely knowledgeable in the operation, maintenance, and start-up of the mechanical system.
      b. Electrical technician must be completely knowledgeable in the operation, maintenance, and start-up of the electrical system.
      c. Provide training as specified in this Section.
      d. Engine technician and electrical technician may be the same individual if certified by the respective equipment manufacturers in both engine and electrical systems.
   2. Furnish a written report after the start-up:
      a. Report must state that the installation is complete and satisfactory:
         1) List the items requiring additional attention.
   3. Minimum required time on site by technician for start-up:
      a. One day to inspect entire installation, start-up, test operation, and conduct acceptance tests.

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 COMMISSIONING (NOT USED)

1.15 MAINTENANCE

A. Furnish the following spare parts:
   1. One set of lube oil filters, fuel filters, and gaskets.
   2. Two spare lamps of each different lamp type, unless lamps are LED. No spare LED lamps are required.
   3. Two fuses (for each control circuit).
   4. One set of crankcase breather filters, when used.

B. Special tools: Furnish a set of specialty tools necessary for routine maintenance of the equipment.
   1. Special tools are those that only the manufacturer provides, for special purposes, or to reach otherwise inaccessible parts.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. The following list of manufacturers is a general guideline and makes no statement as to the capability of the manufacturer to meet the Specification requirements. The

burden of proof of conformance with these Specifications lies with the CONTRACTOR and manufacturer. The CONTRACTOR must make special written application to use other than these named manufacturers:

1. Engine generators:
   a. One of the following:
      1) Caterpillar.
      2) Cummins Power Generation.
      3) Detroit Diesel.
2. Governor:
   a. One of the following or equal:
      1) Woodward.
      2) Isochronous electronic by engine manufacturer.
3. Engine starting battery:
   a. One of the following:
      1) Caterpillar.
      2) Auto Start.
      3) East Penn - Deka.
      4) Hawker.
4. Aboveground fuel storage tank:
   a. One of the following or equal:
      1) ACE Tank and Equipment of Dublin, California.
      2) Enviro-Vault by B.R.E. Products, Inc. of Huntington Beach, California.

B. Exhaust system:
   1. One of the following or equal:
      a. Silencer:
         1) GTE Industries.
         2) Harco Manufacturing.
         3) Silex Innovations.
      b. Corrugated, flexible engine connector:
         1) DME.
         2) GTE Industries.
         3) Engine-generator manufacturer's equivalent.
      c. Expansion joint:
         1) DME Inc.
         2) GTE Industries.
      d. Exhaust pipe insulation:
         1) As specified in Section 15082.
      e. Expansion joint insulation:
         1) Pittsburgh-Corning/JPS Composite Materials Corp., Temp-Mat.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS (NOT USED)

2.04 MANUFACTURED UNITS (NOT USED)

2.05 EQUIPMENT

A. Characteristics of assembled unit:
   1. The engine-driven generator consists of a diesel engine directly coupled to an electric generator providing electric power.

2. The engine shall start, attain full speed, voltage, and assume full load within a maximum of 10 seconds, with jacket water at 85 degrees Fahrenheit.
3. Furnish the engine-driven generator on a steel sub-base to support engine, generator, and accessories as a unit:
    a. Base: Welded construction.
    b. Engine direct connected through a flexible coupling to a single bearing generator.
    c. System free of injurious torsional and bending vibrations within a speed range from 10 percent below to 10 percent above synchronous speed.
    d. Engine-driven generator balanced such that the peak-to-peak amplitude of vibration velocity in any direction does not exceed the engine or generator manufacturer's published limits.
    e. If shims are required under the feet of the generator for alignment purposes, use 1-piece laminated shim stock that covers at least 90 percent of the foot.
    f. Provide a complete assembled engine-driven generator skid requiring only field electrical and mechanical connections.
4. Connections to engine-driven generator skid:
    a. Flexible connections are required on all connections to the engine generator.
    b. These connections include but are not limited to:
        1) Exhaust.
        2) Fuel lines.
        3) Radiator discharge air ductwork.
    c. The length of all flexible connections to exceed the flexible connector manufacturer’s minimum length recommendations for the diameter used and for the misalignment as measured after installation.

B. Generator system performance requirements:
1. Power output rating:
    a. Minimum kilowatts and voltage as indicated on the Drawings.
    b. 0.8 power factor.
    c. 3-phase, 4-wire, 60 hertz.
    d. In accordance with NEMA MG-1 temperature rise limits.
2. It is the manufacturer's responsibility to properly size the engine generator based upon site conditions and actual loads:
    a. Allowable voltage drop: 10 percent.
    b. The Drawings and Specifications indicate a minimum size that the ENGINEER has determined based upon non-certified information.
    c. No increase in Contract amount will be considered if the equipment size needs to be increased to meet the load requirements after bids have been submitted.
    d. Provide all changes to the electrical system as required as a result of manufacturers sizing including but not limited to:
        1) Conduit.
        2) Wire: Provide Nehr-McGrath calculations to verify appropriate cable sizing in accordance with NEC when additional wire is required.
        3) Circuit breakers.
        4) Transfer equipment.

3. Regulatory requirements:
   a. Specifically designed to meet the discharge of gaseous pollutants to the atmosphere as required by the EPA statute and local agency issuing the permit for the engine generator system.

2.06 COMPONENTS

A. Engine generator base:
   1. Support system:
      a. Bolt the engine-driven generator to steel pads that are an integral part of structural support base.
      b. Vibration isolators shall be provided with the engine-driven generator and be installed between the engine generator and structural support base or between the base and the floor:
         1) As recommended by the isolator manufacturer.
         2) Located for equal load distribution and deflection per isolator.
         3) Designed for the load and seismic conditions as identified for the site.

B. Engine:
   1. Full compression ignition, 4-cycle, turbocharged, and aftercooled meeting the required emissions rating.
   2. The rated net horsepower of the engine with all accessories, including radiator fan, must not be less than that required to produce the minimum specified generator capacity at site altitude and maximum ambient temperature.
   3. Equipped and designed as follows:
      a. Spin-on type replaceable lube oil filters.
      b. Spin-on type replaceable fuel filters.
      c. Heat treated forged steel crankshaft:
         1) Dynamically balanced.
      d. Forged steel connecting rods.
      e. Crankshaft driven gear type lubricating pump.
      f. Electric fuel shut-off valve.
      g. Engine air cleaner: Dry type replaceable filter.
      h. 12- or 24-VDC positive engagement solenoid shift-starting motor:
         1) The starting equipment must include the necessary devices to prevent an overcrank and lockout if the starter pinion fails to engage the flywheel ring gear on the initial crank attempt.
         2) This starter disconnect shall electronically sense the speed of the flywheel and when the flywheel setpoint speed has been reached, the electronic control signals the starter disconnect to disengage.
      i. Oil level dip stick and oil drain pipe with valve and pipe plug:
         1) Oil drainpipe and valve are to extend 3 inches beyond edge of engine base.
      j. Engines requiring glow plugs are not acceptable.
      k. Crankcase breather filter:
         1) Provide integral crankcase pressure regulator with an automatic internal filter bypass and bypass indicator:
            a) Racor Model CCV 4500 or equal.

C. Governor:
   1. The engine governor shall be an electronic Engine Control Module (ECM) with a 24-volt DC Electronic Actuator. The ECM shall be enclosed in an

environmentally sealed, die-cast aluminum housing which isolates and protects electronic components from moisture and dirt contamination. Speed droop shall be adjustable from 0 (isochronous) to 10 percent, from no load to full rated load. Steady-state frequency regulation shall be +/- 6 rpm. Speed shall be sensed by a magnetic pickup off the engine flywheel ring gear. A provision for remote speed adjustment shall be included. The ECM shall adjust fuel delivery according to exhaust smoke, altitude, and cold mode limits. In the event of a DC power loss, the forward acting actuator will move to the minimum fuel position.

D. Engine jacket water heater:
   1. Provide an in-line thermostat that disconnects power when coolant temperature exceeds the manufacturer's suggested setpoint.
   2. Contacts from an oil pressure switch or control panel contacts disconnect the heater power when the engine is running.
   3. Provided with shutoff valves and unions to allow heater replacement without draining the cooling system.
   4. Make all water heater connections with high temperature silicon type hoses and constant torque hose clamps.
   5. Size heater such that the engine block temperature is maintained at 85 to 100 degrees Fahrenheit in a 40-degree Fahrenheit ambient temperature.
   6. Provide 9,000 W forced circulation type heater with 96 W pump; thermal siphon tank heaters are not acceptable.
   7. Power supply:
      a. Water heaters greater than 3,000 watts shall be 480 volts, 3-phase or 208 volts, 1-phase.

E. Alternator (generator):
   1. Brushless synchronous alternator.
   2. 6 Lead.
   3. Self-ventilated.
   4. Full amortisseur windings.
   5. 2/3 pitch windings, skewed for smooth voltage waveform.
   6. With permanent magnet generator pilot exciter.
   7. Drip-proof enclosure.
   8. Protected against corrosion.
   9. Single bearing design.
      a. Alternators over 2,000 kW may be two bearing design.
   10. Insulation:
      a. Insulated for continuous operation at 40 degrees Celsius ambient temperature.
      b. Class H (125 degrees Celsius rise by resistance) for low voltage generators.
      c. Form wound and vacuum impregnated with epoxy varnish to be fungus resistant per MIL I-24092.
      d. Multiple dipped and baked with a non-hygroscopic varnish with a final dip of epoxy.
   11. Terminate alternator power leads using compression lugs on an insulator and bus bar system within the alternator junction box:
      a. Provide space on the insulator system to terminate the cables that extend to the load bank (for factory load testing).
      b. These terminations must not require any taping to complete the connection.

c. Utilize copper flexible, fine stranded type cables to connect from the alternator to the load bank:
   1) Sized for 125 percent of the alternator full load current.
   2) Neutral conductors shall be sized at 100 percent of the alternator full load rating.
d. Provide a ground terminal inside the junction box to terminate the ground cables between the alternator to the automatic transfer equipment ground bus:
   1) Minimum size of the equipment-grounding conductor: 12-1/2 percent of the size of the phase conductors.

12. 120 VAC integral alternator winding heaters.
13. Maximum balanced telephone interference factor not to exceed 50.
14. Designed to supply power to the non-linear loads as specified and as indicated on the Drawings.

F. Alternator digital voltage regulator:
1. Located in the engine control panel or auxiliary generator box per manufacturer standard.
2. Performance requirements:
   a. Maintain the steady state voltage within 1 percent:
      1) From 40 degrees Fahrenheit to 120 degrees Fahrenheit.
      2) From no load to full load conditions.
3. Adjustable volts per hertz characteristics with under frequency roll-off for better transient response.
4. Static type.
5. Sized to match the power requirements of the exciter circuit and power from the permanent magnet generator pilot exciter.
6. Include manual control to adjust voltage drop, voltage level, and voltage gain.
7. With 3-phase sensing.
8. Sealed from the environment and isolated from the load to prevent tracking when connected to SCR loads.
9. Include loss of sensing shutdown to protect the generator against uncontrolled voltage output when the sensing circuit to the regulator is opened.
10. Shut down regulator when the sensing circuit to the regulator does not have continuity.
11. Include over-excitation shutdown to protect the generator against thermal damage caused by prolonged field forcing.

G. Exhaust system:
1. General:
   a. Provide a complete exhaust system following as indicated on the Drawings and as specified.
   b. Back pressure:
      1) Provide components such that the maximum back-pressure in the exhaust system including piping and silencer is less than the maximum allowable back-pressure published by the engine manufacturer, measured at the exhaust manifold header:
         a) Reduce back-pressure when recommended by the engine manufacturer.
   c. Provide each exhaust manifold header with a plugged, tapped connection for the attachment of a test manometer.

2. Exhaust silencer:
   a. Heavy-duty industrial type fabricated of welded steel with ported tubes and snubbing chambers, and a rating meeting the specified sound attenuation.
   b. Mounting: As indicated on the Drawings.
   c. End connections: Steel flanges with Class 150-pound drilling pattern.
   d. Shell:
      1) Sufficiently heavy and reinforced to eliminate excessive vibration, stress, or deflection and to support all operating loads with the silencer at elevated temperatures and insulated as specified.
      2) Loads include insulation weight and connecting piping.
   e. Drain: Provide threaded, plugged condensate drain.
   f. Sound attenuation: Attain the following minimum sound attenuation at the listed octave band center frequencies with the engine at full load:

Frequency (Hz)	63	125	250	500	1,000	2,000	4,000	8,000
Attenuation (dB)	39	42	42	40	38	38	38	38

   g. Supports: Provide shell lug supports suitable for supporting and mounting the silencer as indicated on the Drawings; support design to account for elevated temperatures under insulated shell.
   h. Insulate as specified for engine exhaust piping in Section 15082.
   i. Pressure drop not to exceed manufacturer's recommendation (70 percent of limit) at maximum engine rating.
3. Exhaust piping:
   a. Schedule 10S Stainless Steel Pipe, conforming to ASTM A 358, Class 1, Type 321/347.
   b. Slope piping to a drain point and provide drain plug.
   c. Insulation: As specified in Section 15082 for engine exhaust piping.
4. Exhaust expansion joints:
   a. Type:
      1) Metal with convoluted portion of 0.038 inch thick Type 321 stainless steel.
      2) Non-convoluted portions of expansion joint to be Type 304 stainless steel, Schedule 10S pipe.
      3) Provide flanged ends with ASME B16.5, Class 150 bolt hole drilling.
   b. Length: Minimum of 18 inches in length.
   c. Movement:
      1) Rated for a minimum of 1 inch lateral movement, and 1/2 inch axial movement.
      2) Rated movement defined as plus or minus travel from neutral or free position.
   d. Infinite cycle life with 1,200 degrees Fahrenheit exhaust, no insulation over the expansion joint, and continuous duty service.
   e. Insulation:
      1) Insulate expansion joints with custom fitted, removable with reusable fastening system, ceramic fiber insulation blankets enclosed between inner and outer high temperature fabric cover rated for 1,200 degrees Fahrenheit continuous duty.
      2) Do not insulate expansion joints directly connected to turbocharger outlet.

H. Radiator and cooling system:
   1. Unit mounted:
      a. Furnish a skid mounted closed type radiator system for the engine driven generator:
      b. Sized and selected by engine manufacturer to cool the engine and turbo charge aftercooler under ambient conditions.
      c. Provide long-life coolant designed for a 6-year change interval at the location and conditions of service specified.
      d. Ship both the engine and the radiator with the coolant installed.

I. Generator control panel:
   1. Microprocessor-based control system that is designed to provide automatic starting, monitoring, protection and control functions for the generator set.
   2. Mounted on the generator set:
      a. Provide vibration isolation:
         1) Prototype tested to verify the durability of all components in the system under the vibration conditions encountered.
   3. Control system features and functions:
      a. Control switches:
         1) Mode selector switch:
            a) Provide a rotary switch or control panel keypads with status indicators.
            b) The mode select switch initiates the following control modes:
            c) RUN or Manual position:
               (1) Generator set starts, and accelerates to rated speed and voltage.
            d) OFF or STOP position:
               (1) Generator set immediately stops, bypassing all time delays.
            e) AUTO position:
               (1) Generator set accepts a signal from a remote device to start and accelerate to rated speed and voltage.
         2) EMERGENCY STOP switch:
            a) Red “mushroom-head” pushbutton.
            b) Activating the emergency stop switch causes the engine to immediately stop, and be locked out from automatic restarting.
         3) RESET switch:
            a) Clears all faults and allow restarting the engine generator after it has shut down for any fault condition.
         4) PANEL LAMP switch or automatic display panel illumination.
         5) RESET switch:
            a) Clears all faults and allows restarting the engine generator after it has shut down for any fault condition.
      b. Load bank control and monitoring:
         1) Provide alarm and status contacts for monitoring of the load bank:
            a) Load bank Running.
            b) Load Bank Failed.
         2) Provide alarm and status contacts for monitoring of the load bank:
            a) Provide control contacts to drop load bank “Load Bank Dump” during a utility power failure event.
      c. AC output metering: Provide the control system with metering including the following features and functions:
         1) Provide digital metering:
            a) 1.0 percent accuracy.

2) Voltmeter:
   a) RMS voltage.
   b) Line-to-line.
   c) Line-to-neutral.
3) Ammeter:
   a) RMS current.
4) Frequency.
5) Power factor.
6) Kilowatts (kW):
   a) kW-hours.
   b) Output kW.
7) Kilovars (kVars):
   a) kVar-hours.
   b) Output kVar.

d. Generator alarm and status display:
   1) Provide high-intensity LED alarm and status indication lamps. Functions indicated include:
      a) Red alarm-indicating lamps.
      b) Red common shutdown lamp.
      c) Green lamp to indicate the engine generator is running at rated frequency and voltage based on actual sensed voltage and frequency on the output terminals of the generator set.
      d) Flashing red lamp to indicate that the control is not in automatic state.
      e) Amber common warning indication lamp.
   2) Display the following alarm and shutdown conditions on an alphanumeric digital display panel:
      a) Low oil pressure (alarm).
      b) Low oil pressure (shutdown).
      c) Oil pressure sender failure (alarm or indication).
      d) Low coolant temperature (alarm).
      e) High coolant temperature (alarm).
      f) High coolant temperature (shutdown).
      g) High oil temperature (warning).
      h) Engine temperature sender failure (alarm or indication).
      i) Low coolant level (alarm or shutdown – selectable).
      j) Fail to crank (shutdown).
      k) Fail to start/overcrank (shutdown).
      l) Overspeed (shutdown).
      m) Low DC battery voltage (alarm).
      n) High DC battery voltage (alarm).
      o) Low fuel-day tank (alarm).
      p) High AC voltage (shutdown).
      q) Low AC voltage (shutdown).
      r) Under frequency (programmable for alarm or shutdown).
      s) Overcurrent (programmed for warning or shutdown).
      t) Short circuit – circuit breaker function (trip).
      u) Ground fault (alarm).
      v) Emergency stop (shutdown).
      w) Load Bank Failed (alarm).

e. Engine status monitoring:
   1) Display the following status conditions on an alphanumeric digital display panel:
      a) Engine oil pressure (pounds per square inch or kilopascal).
      b) Engine coolant temperature (degrees Fahrenheit or Celsius).
      c) Engine oil temperature degrees Fahrenheit
      d) Engine speed (revolutions per minute).
      e) Number of start attempts.
      f) Battery voltage (DC volts).
      g) Load Bank Running.
f. Data logging and display provision:
   1) Log the last 10 warning or shutdown indications on the engine generator.
   2) Monitor the total load on the generator:
      a) Maintain data logs of total operating hours at specific load levels ranging from 0 to 110 percent of rated load, in 10 percent increments.
      b) Display total hours of operation at less than 30 percent load and total hours of operation at more than 90 percent of rated load.
   3) The control system to log:
      a) Total number of operating hours.
      b) Total kW hours.
      c) Total control operational hours.
g. Engine control functions:
   1) Provide a cycle cranking system, which allows for user selected crank time, rest time, and number of cycles:
      a) Initial settings shall be for 3 cranking periods of 15 seconds each, with 15-second rest period between cranking periods.
   2) Provide an engine governor control, which functions to provide steady state frequency regulation as noted elsewhere in this Specification, including adjustments for gain, damping, and a ramping function to control engine speed and limit exhaust smoke while the unit is starting.
   3) Provide time delay start (adjustable 0 to 300 seconds) and time delay stop (adjustable 0 to 600 seconds) functions.
h. Battery monitoring system:
   1) Initiate alarms when the DC control and starting voltage is outside the manufacturer's tolerances.
   2) Disable the low voltage limit during engine cranking (starter engaged).
   3) Monitor DC voltage as load is applied to the battery, to detect impending battery failure or deteriorated battery condition.
i. Remote control interface:
   1) Provide a minimum of 4 programmable output relays:
      a) Configurable for any alarm, shutdown, or status condition.
   2) Provide a minimum of 4 programmable inputs:
      a) Label as indicated on the Drawings.
      b) Labels shall match other control labels.

4. Provide network hardware to allow communication of all data in the generator control panel to the plant's control system via Ethernet/IP.

J. Battery system:
   1. Installed on the engine-driven generator skid.
   2. Provide extra flexible minimum 4/0 welding cable to make the connection between the battery and the engine:
      a. Proper compression lugs and tooling must be used to terminate these cables.
   3. Provide a 12- or 24-volt lead acid recombination no maintenance engine start battery system:
      a. The battery shall have sufficient capacity, at the minimum and maximum temperature specified, to provide the specified cranking periods.
   4. Charger:
      a. Sized to provide sufficient power to both fully charge a drained battery.
      b. Location: On the engine skid. Pre-wire inputs, outputs, and alarms to terminal strips, I/O modules, starter motors as required.
      c. Pre-wired to generator control panel
      d. DC ammeter and DC voltmeter.
      e. On-Off switch.
      f. Solid-state device with adjustable float voltage control.
      g. Constant voltage design with current limit.
      h. With an equalize switch that will allow the battery to be overcharged for maintenance purposes or an automatic charging cycle that has an equalize period.
      i. Designed to meet the charge, float, and equalize requirement of the battery furnished.
      j. Overload and short circuit protection.
      k. Alarm contacts:
         1) Provide alarm contacts pre-wired to the generator control panel for remote monitoring of the following signals:
            a) Undervoltage.
            b) Overvoltage.
            c) Ground fault.

K. Discharge silencers:
   1. System requirements:
      a. Horizontal silencer.
      b. High performance, drainable, low friction loss panel.
      c. Maximum airflow rate: 80,000 cfm.
      d. Maximum length:
         1) Discharge silencer: 5 feet.
      e. Gross surface area: 196 square feet (14 feet by 14 feet).
      f. Attenuation and sound power requirement: Acoustical attenuation rating (dB) and pressure drop shall be as follows:

Silencer Length (feet)	**Face Velocity (fpm)**	**Maximum Static Pressure (inches WC)**	**Octave Band Mid. Frequency (Hz)**							
			63	**125**	**250**	**500**	**1,000**	**2,000**	**4,000**	**8,000**
5	650	0.05	6	11	21	31	47	38	24	17

2. Protection:
    a. Protect silencers and finishes from damages during delivery and installation.
    b. Protect adjacent surfaces, finishes, and materials from damage during installation of silencers.
3. Materials:
    a. Outer casings shall be of not less than 18-gauge galvanized steel construction.
    b. Interior partitions shall be of not less than 22-gauge galvanized steel.
    c. Acoustic material shall be of absorptive filler material made from an inorganic mineral wool. Material shall be inert and moisture proof.
4. Fabrication:
    a. All external seams shall be lockformed and filled with mastic or continuously welded and shall be airtight up to 10-inch water gauge pressure differential.
    b. Casings shall be rigidly supported from the supporting structural members and shall not vibrate audibly during operation.
    c. Interior partitions shall be rigidly supported within the casing.
    d. Acoustical material shall be compressed not less than 5 percent to eliminate voids and prevent settling. Filler material shall exhibit not more than the following fire hazard classification when tested in accordance with ASTM E84, NFPA 255, or UL-723 test methods.
        1) Flamespread: 15.
        2) Fuel contributed: 15.
        3) Smoke developed: 0.

L. Generator output circuit breaker, load bank breaker, and fire pump breaker:
1. All breakers skid mounted in NEMA 1 enclosure..
2. Manually resettable.
3. Line current sensing.
4. Inverse time versus current response.
5. Sized and coordinated to protect the generator from damage from overload and/or short circuit:
    a. Coordinated with downstream devices:
        1) As specified in Section 16305.
6. Breakers shall be as specified in Sections 16412 and 16414.
7. Provide breakers with proper number of lugs to match cables as indicated on the Drawings.
8. Provide generator breaker with ground fault trip.
9. Fire pump breaker to be in isolated compartment.

M. Wiring:
1. All wiring connections to and from the engine and alternator shall be made via two engine-mounted junction boxes:
    a. One box shall be used for all control and DC power connections.
    b. The other box shall be used for the alternator output connections:
        1) The alternator output breaker may be used for these connections.
2. Enclose wiring in an NEC approved and recognized conduit system selected and sized by the engine generator manufacturer:
    a. Suitable for the temperatures, vibrations, and conditions on the engine-driven generator skid.

3. Control wiring shall terminate on terminal blocks in the control junction box:
    a. All connections shall be made to terminal blocks:
        1) 600 volt rated.
        2) Wires terminated on box with compression type ring type lugs, installed with proper tooling.
        3) Terminal blocks shall be numbered.
        4) All wiring in terminal box both internal and field connections shall be routed in plastic wire duct.
4. Terminate alternator output connection wires using solderless compression type lugs when connecting to bus bar:
    a. Lug manufacturer's termination methods and tools must be used.
5. Splices are not allowed:
    a. All connections are to be made at the terminal blocks in the control junction boxes.

2.07 ACCESSORIES

A. Fuel day tank:
    1. Day tank/fuel supply system: Includes, but is not limited to, a day tank, fuel transfer pumps, fuel strainer/filter, float switches, and piping.
        a. Components of the system: Restrained to meet seismic requirements as specified in Section 01612; fully comply with NFPA requirements.
    2. Day tank capacity: 150 gallons.
    3. Day tank features:
        a. Constructed in accordance with Underwriters Laboratories, Inc. standard and bear the UL label.
        b. Day tank and rupture basin: Constructed of heavy-gauge steel, epoxy-coated interior and painted exterior.
        c. Include all the threaded pipe connections as indicated on the Contract Documents and as recommended by the manufacturer.
        d. Provide an open-top rupture tank having 150-percent capacity of the day tank.
        e. Include a 3-inch square gasketed inspection plate, high and low fuel level switches, a low-low fuel level switch (for shutting down the engine), a fuel level gauge, pump-motor covers, a 2-inch manual fuel fill cap, check or foot valve, a 0.012-inch fuel strainer, a vent pipe, vent pipe cap with insect screen, and a drain with petcock valve. The rupture tank shall contain a drain with petcock valve.
    4. Provide an enclosed day tank alarm/control panel with the following features as a minimum:
        a. Meets the Contract Documents requirements and is UL-listed.
        b. Is prewired and preconnected before delivery, including day tank.
        c. Alarms and lights powered from engine/generator 24 volts direct current batteries.
        d. Transfer switch marked RUN, OFF, AUTO.
        e. Push-to-test control switch and pump running indicator light, 1 for each pump.
        f. Indicator or alarm lights for:
            1) Power available indication.
            2) Low level alarm.
            3) High level alarm.

4) Tank rupture alarm.
5) Rupture basin leak.

g. Provide test/acknowledge button.

h. Relay contacts, rated 120 VAC, 1.0 amp, normally closed, for the following:
1) Low level.
2) High level.
3) Tank rupture.
4) Low-low level, which shall be wired to shutdown engine.

i. Supply and return pumps running time meter.

j. Level indicator scaled in percent of full.

5. Fuel pump system: Include a fuel pump system which includes, but is not limited to, the following:

a. Duplex fuel supply pumps: Each supply pump shall have a minimum capacity of 2 times the total fuel flow required by the engine including fuel consumption and recirculated flow from the engine at full load, bronze gears, and stainless steel shafts. Pump suction head shall be adequate to draw fuel from the bottom of the storage tank.

b. Fuel return pump: The return pump shall have a minimum capacity of 4 times the total fuel flow required by the engine including fuel consumption and recirculated flow from the engine at full load, bronze gears, and stainless steel shafts. Pump suction head shall be adequate to return fuel when the storage tank is full.

c. Motor: 120 volts alternating current, single-phase, 60 hertz, TEFC.

d. Mount fuel supply and return pumps on top of the fuel day tank.

e. Control fuel transfer pump by internal float switches.

f. Provide solenoid valve, normally closed, that opens when pump is operating.

g. Auxiliary fuel transfer hand pump: Hand pump shall be a rotary hand type, lift as required with check valves.

B. Aboveground fuel piping:

1. Provide Schedule 40 black steel supply and return piping from storage tank to generator as indicated on the Drawings.

2. Provide 18-inch long flexible connections where off-skid connects to the engine skid.

3. Provide a check valve located on the tank side of the flexible connection in the return fuel line.

4. Provide a 24-volt direct current solenoid shutoff valve, wire, conduit, and control interlock to close on engine shutdown; locate on the tank side of the flexible connection in the fuel supply line.

C. Below-grade fuel piping: When below-grade fuel piping is indicated on the Drawings, provide:

1. Primary fuel piping: Schedule 40 black steel piping, ASTM A 53, Grade B.

2. Secondary containment piping: Provide watertight fiberglass secondary containment piping with resin type resistant to the specified fuel and the ambient conditions specified per Specification Section 15293.

D. Fuel filters: Size filters for 10 percent above the engine fuel pump capacity.

1. Provide water/fuel separator.

2. Provide primary fuel filter.

3. Provide secondary fuel filter.

E. Engine fuel pump: Provide engine-driven fuel pump that transfers fuel from the fuel tank as indicated on the Drawings; provide fuel pressure gauges on the pump suction and discharge.

F. Fuel cooling: When a fuel day tank is specified and engine return fuel is indicated on the Drawings as routed back to the day tank, or when recommended by the engine manufacturer for the installation configuration indicated, provide a fuel cooling heat exchanger to limit the day tank fuel temperature to less than 120 degrees Fahrenheit after 24 hours continuous full load operation.

G. Aboveground fuel storage tank:
   1. Size: 3,000 gallons minimum usable volume or sufficient volume to operate the supplied generator for 24 hours at 100-percent rated power output, whichever is larger.
   2. Fuel tank: Manufacturers: One of the following or equal:
      a. ACE Tank and Equipment of Dublin, California.
      b. Enviro-Vault by B.R.E. Products, Inc. of Huntington Beach, California.
   3. Provide fuel tank with, but do not limit to, vents, vent return elbows, angle check valve-extractor assembly and suction pipe, liquid level monitoring system connection, fuel oil return connection, fill pipe connection with lock cap, and a leak monitor insert connection.
   4. Provide an interstitial space between the primary storage vessel and the secondary outer wall with a high/low profile to allow 100-percent fluid migration, under maximum loads, between the walls.
   5. Provide secondary containment vessel to ensure total isolation of the primary storage from electrical currents as well as the environment.
   6. Secondary containment vessel: With a monitoring access fitting for insertion of continuous monitoring probes to the bottom of the tank.
      a. Locate fitting at the lower end of the sloped tank.
      b. Provide monitor connection with the proper fittings so that the tank leak probes may be inserted yet the connection is watertight.
   7. Provide one 20-inch diameter minimum manway for access into the inside of the tank.
      a. Seal annular spaces for the piping openings in the steel covers to be watertight.
      b. Manway shall not be used as an emergency vent for these installations.

H. Diesel fuel port:
   1. Manufacturers: One of the following or equal:
      a. Simplex Automatic Fuel Port with HMI
   2. The diesel fuel port shall be a packaged system designed to control fueling operations of an above ground diesel fuel storage tank from a pumper truck.
      a. The system: Complete with control panel, containment sump, hand pump, and motorized ball valve.
      b. The control panel shall contain:
         1) Diesel storage tank level in percent full.
         2) Status lamps for control power available, fill valve open, fill valve closed, high level, and tank full.
         3) Pushbuttons to open and close the fill valve and silence the alarm horn.

c. The motor operated ball valve shall be designed to automatically shutoff flow to the diesel fuel storage tank when the tank level reaches the high level setpoint.
d. The inlet fitting shall be 3 inches.
e. The containment sump shall be 20 gallons. A hand pump rated for 1 gpm shall be included to empty the sump.

I. Tank and pipe leak detectors:
1. System manufacturers: One of the following or equal:
a. Veeder-Root, Guardian AST Monitoring System.
2. The installed fuel leak detector system shall detect leaks in the annular space between the tank walls and in the containment chambers to which secondary contained fuel pipelines drain.
a. The system: Complete with probes, control panel, wiring, and caps.
b. Install control panel for system as indicated on the Drawings.
c. Size the control panel for system to handle signals from a minimum of 8 sensors from the leak detection probes for the total system.
d. Leak detection system:
1) Expandable to handle up to a total of 8 sensor probes.
2) Self-diagnostic with an MPU failure visual alarm.
3) Permanent memory backup.
4) Power indicating switch.
5) Diagnostic test switch.
6) Audible alarm silence switch with indicating light.
e. Each failure alarm:
1) Individually silenced while the remaining system operates uninterrupted.
2) Provide RS232C data output port for the system alarms.
f. Alarms: Include a field adjustable set point for background vapor screening for each probe sensor.
g. Provide a vapor probe for complete testing of vapor probe alarms during start-up.
3. For the purposes of remote alarm and status indication, provide the following 120-volt alternating current dry contacts prewired to external terminal strips at tank leak detection control panel:
a. "Leakage in underground diesel fuel storage tank" alarm contact.
b. "Leakage in storage tank manhole box" alarm contact.
4. The probes to detect water or hydrocarbons trigger an alarm at the control panel.
a. Provide and install liquid sensors in the annular space of each fuel tank and in each piping containment chamber.
1) The system to provide an audible and a visual warning of leaking vapors and liquids as soon as they occur.
2) Probes: Noncorrosive in an environment of Number 2 diesel fuel and/or water.
3) Supply and install required flexible cable in conduits to connect probe sensors to alarm panel.

J. Tank level monitoring system:
   1. Level gauge: Probe type.
      a. Manufacturers: One of the following or equal:
         1) Simplex TC-25 Tank Commander
         2) Veeder Root.
   2. Provide a tank level monitoring system capable of monitoring the liquid level in the aboveground fuel storage tank.
      a. The probe shall be capable of indicating fuel level and water level within the storage tank.
      b. Provide fuel tank with a liquid level probe and all appurtenances for remote indication and actuation of alarms.
   3. Provide fuel probe with 2 adjustable contacts rated at 120-volt alternating current for actuation of a low-level alarm, and a high-level alarm:
      a. Contacts:
         1) Single pole double throw type, located in the level indicator case.
         2) High level alarm
      b. Low-level alarm: Sent to the tank control panel.
   4. For the purposes of remote alarm and status indication, provide the following 120-volt alternating current dry contacts prewired to external terminal strips at aboveground fuel storage tank level indicator case:
      a. "Low-level in aboveground fuel storage tank" alarm contact.
   5. Remote alarm contacts: Normally closed, to open when the alarm conditions occur.
   6. Level gauge indicator: Minimum 14 inch by 14-inch size, mounted on or near the tank.
   7. Install level indicating transmitter as recommended by the tank level monitor system manufacturer.
      a. Install system so that operation is not hindered by fill lines, fuel pumps, or draw-off lines in the tank.
      b. System: Monitor the entire depth of the tank.
      c. Install standpipe mounts, standpipe, couplings, and other recommended fittings for a watertight installation and connection to the tank for the level transmitter.
   8. Design fuel volume probe to measure Number 2 diesel fuel volume and differentiate between diesel fuel and water that may be at the bottom of the tank.
      a. The probe shall be connected to the diesel fuel port and provide a high level signal which will close the fill isolation valve.

K. Diesel fuel system accessories:
   1. Manufacturers: One of the following or equal:
      a. Emco Wheaton.
   2. Provide the following accessories for the fuel storage system.
      a. Two A563-0004 angle check valve extractors, double poppet with 1 extractor wrench.
      b. Adapter, Series A30-014.
      c. Tight fill cap, Series A97-004.
      d. Fill limiter specifically designed for aboveground tanks to prevent overfill.
         1) Manufacturers: One of the following or equal:
            a) Clay & Bailey Mfg. Co., Model 1228.
            b) Baker Industries, Model 8505C4-75.
      e. 3 extractor pipe caps, Model No. 584-003.

f. Spin-on element and head engine fuel filter.
   1) Manufacturers: One of the following or equal:
   2) Hydrosorb Cim-Tek filter with a 30-micron filter with drain plug.
g. Vent caps: Meeting all UL 2085 listing, and fire marshal requirements.
h. Sediment trap.

L. Flexible pipe connectors:
   1. Manufacturers: One of the following or equal:
      a. Teleflex, Inc.
   2. Provide and install flexible connectors including all required fittings for change of direction of fuel piping in the piping containment chamber.
      a. Do not use flexible connectors external to the piping containment chamber.
      b. The connectors shall utilize a continuous convoluted inner core of PTFE that is inert to methanol and diesel fuel, and an outer braid of stainless steel with permanently crimped stainless steel collars for leak-proof performance.
      c. Connectors shall be UL approved and in accordance with NFPA 30.

M. Generator system remote annunciator:
   1. Furnish and install in accordance with NFPA 110 requirements.
      a. Include all the audible and visual alarms required by NFPA Standard 110 for Level 1 systems.
      b. In addition, provide indications for:
         1) High battery voltage.
         2) Low battery voltage.
         3) Loss of power to the battery charger.
         4) Lamps for other alarm and status functions to the annunciator.
         5) Label the annunciator in a manner consistent with the specified functions.
         6) Alarm silence and lamp test switch(es).
         7) Replacement of the LED lamps.
         8) Changing indicating lamp color for specific application requirements.
         9) Switchable alarm horn for all annunciation points.
         10) Alarm horn (when switched on) shall sound for first fault, and all subsequent faults, regardless of whether first fault has been cleared, in compliance with NFPA 110 3-5.6.2.
   2. Mounting and location as indicated on the Drawings.
   3. Power supply for the remote annunciator: 24-VDC battery system at the generator.
   4. Install 24-VDC power and signal wiring in separate conduit from other wiring.
   5. Monitor the interconnecting wiring between the annunciator panel and the monitored components.
   6. Alarm wire failure on the annunciator panel.

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL

A. Design prototype tests as follows:
   1. Use design prototypes similar to the equipment specified in this Section for testing, and not the actual equipment for the Project.
   2. Minimum testing requirements:
      a. As required by NFPA 110 for Level 1, Type 10 installations.
         1) Prototype shall be tested to accept full rated load in 10 seconds.
         2) Prototype shall be tested for the adverse conditions listed in NFPA 110.
      b. Maximum power in kW.
      c. Maximum starting kilovolt-ampere at 35 percent instantaneous voltage dip.
      d. Alternator temperature rise:
         1) By embedded thermocouple.
         2) By resistance method.
         3) Per NEMA MG1-22.40 and 16.40.
      e. Governor speed regulation under steady state and transient conditions.
      f. Fuel consumption at 25 percent, 50 percent, 75 percent, and 100 percent load.
      g. Harmonic analysis, voltage wave form deviation, and telephone influence factor.
      h. Cooling airflow.
      i. Torsional analysis testing to verify that the generator set is free of harmful torsional stresses.
      j. Endurance testing.
      k. A certified copy of the test results will be furnished to the OWNER.

B. Test each engine generator under varying loads with all machine safety guards and exhaust system in place.

C. The complete engine generator system is to be tested at full load in the manufacturer's factory:
   1. Test must include:
      a. Radiator.
      b. Engine control panel.
      c. Single-step load pickup.
      d. Transient and steady-state governing.
      e. Safety shutdown device testing.
      f. Rated power.
      g. Maximum power.
   2. During the full load tests, re-circulate the radiator cooling air through the radiator as necessary to test the system under the maximum ambient conditions specified in this Section.
   3. Run the unit for 2 hours at 100 percent load with the following recordings made hourly:
      a. Frequency.
      b. Voltage.
      c. Amperage.
      d. Kilowatts.
      e. Room temperature as measured at the generator end of the unit.
      f. Radiator air inlet temperature.

g. Coolant temperature.
h. Oil pressure.

4. Record the following items:
   a. Time required for the engine/generator to start and reach rated voltage and frequency in seconds.
   b. Maximum block load capabilities of the unit.
   c. Point at which overtemperature shutdown occurs.
   d. Point at which overspeed shutdown occurs.
   e. Point at which low oil pressure shutdown occurs:
   f. Point at which overcrank shutdown occurs.
   g. Point at which overspeed shutdown occurs.
   h. Low water temperature alarm.
   i. Low fuel level alarm.
   j. Fuel leak alarm.
   k. Overvoltage alarm and shutdown.
   l. Undervoltage alarm and shutdown.
   m. Under frequency alarm and shutdown.
   n. Low battery voltage alarm.
5. Furnish a certified copy of the test results to the OWNER:
   a. These test results must record any minor adjustments made during the test.
   b. If major changes, as determined by the ENGINEER, are made, the 2-hour test must be repeated.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 16050.

B. General:
   1. Install the equipment as indicated on the Drawings.
   2. Perform all Work in accordance with manufacturer’s instructions and shop drawings.
   3. Before start-up, furnish written certification that the entire installation and all connections, both mechanical and electrical, have been inspected and are proper and consistent with the Drawings and Specifications.

C. Installation shall be by personnel experienced and regularly engaged in field installation of power generation systems:
   1. Make all field mechanical and electrical connections.

D. Fuel system components:
   1. Installation shall be by competent personnel experienced and regularly engaged in field installation of double-contained fuel storage systems.
   2. Install aboveground fuel storage tank with bottom concrete slab as indicated on the Drawings and in accordance with the tank manufacturer's written instructions.

3. Install tank tie-downs, type, and number as recommended by tank manufacturer, to anchor the tank to the concrete slab as indicated on the Drawings.
4. Connect secondary contained piping to the piping containment chamber or the tank as recommended by the manufacturer.
   a. All connections shall be watertight and shall allow system pressure tests.
5. Slope product lines of the pipe jacket secondary containment system to the low point of the system as recommended by the manufacturer.
6. Install pipe jacket components as recommended by the manufacturer.
7. Install fuel tanks and associated systems in accordance with NFPA 30, 37, and 110.
8. Mount fuel day tank at the elevation relative to the engine recommended by the manufacturer to achieve proper engine fuel pump suction conditions while avoiding fuel flooding in the engine return system to comply with NFPA 110.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 FIELD QUALITY CONTROL

A. As specified in Section 16050.

B. Test actual backpressure during acceptance testing of the system.

C. Provide the services of a manufacturer’s representative for the following:
   1. Before start-up, furnish written certification that the entire installation and all connections, both mechanical and electrical, have been inspected and are proper and consistent with all Drawings and Specifications.
   2. Furnish the services of factory-certified technicians during the start-up and adjustment period to make sure all items furnished are in proper operating condition:
      a. Engine technician must be completely knowledgeable in the operation, maintenance, and start-up of the mechanical system.
      b. Electrical technician must be completely knowledgeable in the operation, maintenance, and start-up of the electrical system.
      c. These technicians to instruct the OWNER's personnel regarding the operation and maintenance of all items supplied:
         1) Supply written handouts during the training period, and these handouts should be suitable for future reference after the training period is completed.
      d. Furnish a written report after the start-up:
         1) Report must state that the installation is complete and satisfactory.
         2) List the items requiring additional attention.

D. Manufacturer to perform installation check, start-up, and load test.

E. Certify that fuel, lubricating oil, and antifreeze conform with the manufacturer's recommendations under the environmental conditions present.

F. Check accessories that normally function while the equipment is in standby mode for proper operation, before cranking the engine:
   1. These accessories include but are not limited to:
      a. Engine heaters.
      b. Fuel heaters, when used.
      c. Battery charger.
      d. Generator strip heaters, when used.

G. Start-up under manual mode:
   1. Check for the following items:
      a. Exhaust leaks.
      b. External path for exhaust gases.
      c. Cooling airflow.
      d. Movement during starting and stopping.
      e. Vibration during running.
      f. Normal and emergency line-to-line voltage and phase rotation.

H. Automatic start-up:
   1. By means of simulated power outage test the following:
      a. Set all timers for proper system coordination.
      b. Remote automatic starting.
      c. Transfer of load.
      d. Automatic shutdown.
   2. Continuously monitor the following parameters during this test:
      a. Engine temperature.
      b. Oil pressure.
      c. Battery charge level.
      d. Generator voltage.
      e. Generator amperes.
      f. Frequency.

3.08 ADJUSTING

A. Make adjustments as necessary and recommended by the manufacturer, ENGINEER, or testing firm.

3.09 CLEANING (NOT USED)

3.10 DEMONSTRATION AND TRAINING

A. As specified in Section 16050.

B. Demonstrate operation of equipment as specified in Section 01660.

C. Generating system:
   1. Test the generator to the requirements of NFPA 110 for a Level 1 generator, as modified below, at the site in the presence of the ENGINEER:
      a. Test the generator for a minimum of 4 hours using the plant loads listed in Article 1.04, Paragraph D, or a load bank of equivalent KVA. Test time shall start when the maximum loading is reached. The generator shall be started by simulating a utility power failure.
      b. Record the following:
         1) Time delay on start.

2) Cranking time until the prime mover starts and runs.
3) Time to reach operating speed.
4) Time taken to achieve a steady-state condition.
5) Voltage, frequency, and amperes.
6) Engine oil pressure and water temperature.

c. After completion of the 4-hour test, the generator shall be allowed to cool for no longer than 5 minutes and started again. The generator shall be loaded to the maximum rated power using a load bank or combination of a load bank and plant loads. A unity power factor is allowed for this test. Run the generator for a minimum of 2 hours.

d. Record the data listed in Paragraphs C.1.b.5) and C.1.b.6) above at intervals of 15 minutes starting at first load acceptance.

e. Correct defects that become evident during testing.

f. Measure flows, pressures and temperatures of fuel, coolant, exhaust gas, and radiator air at inlets and outlets to system components.

g. Measure radiator performance at full load including airflow, air inlet temperature and air outlet temperature.

h. Measure emissions as required by the SLO County Air Pollution Control District and submit required information to the SLO APCD for permit approval. Provide copies of test information to OWNER.

i. Provide test report.

D. Upon completion of the work, at a time to be designated by the OWNER's representative, manufacturer to demonstrate for the OWNER the operation of the engine installation, including any and all special systems furnished by them, or installed under their supervision.

E. Test all control functions in conjunction with the engine generator start-up:

1. These tests must include all normal starting and stopping functions as outlined in these Specifications.

F. Training:

1. Provide training of Owner personnel in accordance with Section 01660.
2. Manufacturer’s technicians must provide all training:
   a. Technicians to instruct the OWNER's personnel regarding the operation and maintenance of all items supplied:
      1) Supply written handouts during the training period that are suitable for future reference after the training period is completed.
   b. Operations training covering and detailing the normal, exercising, and day to day operations of the equipment:
3. Furnish complete manuals, and training DVD for training up to 6 plant personnel.

3.11 PROTECTION

A. As specified in Section 16050.

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 16240

BATTERY SYSTEMS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Nickel-cadmium battery systems.

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 01610 - Project Design Criteria.
      c. Section 01612 - Seismic Design Criteria.
      d. Section 16050 - Common Work Results for Electrical.
      e. Section 16445 - Panelboards.

1.02 REFERENCES

A. As specified in Section 16050.

B. Institute of Electrical and Electronics Engineers (IEEE):
   1. 693 - Recommended Practice for the Seismic Design of Substations.
   2. 1115 - Recommended Practice for Sizing Nickel-Cadmium Batteries for Stationary Applications.
   3. 1375 - Guide for Protection of Stationary Battery Systems.
   4. 1491 - Guide for Selection and Use of Battery Monitoring Equipment in Stationary Applications.

C. National Electrical Manufacturer's Association (NEMA):
   1. PE 5-1997 - Utility-Type Battery Chargers.

D. National Fire Protection Association (NFPA):
   1. 70E Article 320 - Safety Requirements Related to Batteries and Battery Rooms.

E. Occupational Health and Safety Administration (OSHA):
   1. 1926.441 - Batteries and Battery Charging.

F. Underwriter's Laboratories (UL):
   1. 94 - Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances.
   2. 1564 - Standard for Industrial Battery Chargers.
   3. 1989 - Standard for Standby Batteries.

1.03 DEFINITIONS

A. As specified in Section 16050.

1.04 SYSTEM DESCRIPTION

A. Design requirements:
   1. Battery systems to provide DC power to equipment under normal and emergency conditions as specified in the Contract Documents or indicated on the Drawings.
   2. Switchgear battery systems:
      a. Voltage: 24 VDC.

B. Performance requirements:
   1. Size battery system to meet the functional requirements of the equipment in accordance with IEEE 1115 using the following factors:
      a. Design margin: 1.15.
      b. Aging factor: 1.25.
      c. Temperature correction factor:
         1) Select the temperature correction factor from the IEEE table based on the temperature range specified in Section 01610.
   2. Size the switchgear battery system to meet the following criteria for the actual equipment provided:
      a. Operate all continuous loads for a period of 4 hours.
      b. After a period of 4 hours:
         1) Operate all main, tie, and generator breakers through two complete cycles of close, trip, and spring charge.

1.05 SUBMITTALS

A. Furnish submittals as specified in Sections 01330 and 16050.

B. Product data:
   1. Complete bill of material including quantity, description, manufacturer, and part number.
   2. Battery cells:
      a. Manufacturer.
      b. Type.
      c. Amp-hour rating.
      d. Volts per cell/volts per string.
      e. Hydrogen off-gassing rate per amp of charging current.
      f. Volume of electrolyte.
   3. Battery charger:
      a. Input power requirements.
      b. Output voltage.
      c. Maximum output current.

d. Enclosure type.
e. Alarm and status contacts.
4. Anchorage hardware.
5. Spill containment hardware.
6. Chemical neutralization.
7. MSDS data sheets.
8. Panelboard.
9. Warning signs.
10. Warranty.

C. Shop drawings:
1. Plan, elevation, and section drawings for:
a. Battery cells.
b. Racks.
c. Spill containment.
2. Point-to-point wiring diagrams including all components of the battery system, with each component and terminal number labeled.

D. Installation instructions:
1. Complete written instructions detailing the complete installation of the battery system assembly, setting into place, and wiring connections.
2. Provide anchorage instructions and requirements for the battery racks based on the seismic conditions of the site as specified in Section 01612.

E. Operation and maintenance manuals:
1. Furnish the manufacturer's standard shop manual for troubleshooting and maintenance tasks.
2. Include a table listing each maintenance task and the recommended interval for the task.

F. Test reports:
1. Provide a report indicating that each unit shipped has been factory tested to verify initial system capacity and performance of all electrical connections.

G. Certification letter:
1. Provide a certificate indicating that the battery rack(s) supplied comply with the seismic requirements of IEEE 693 under the criteria specified in Section 01612.

H. Calculations:
1. Complete calculations used to size the battery system in accordance with IEEE 1115.
a. Use manufacturer's load data for the actual equipment provided, including the actual demand for protective relays, lights, etc. and the trip, close, and spring charge currents for the circuit breakers provided:
1) Provide a table showing the load for each piece of equipment used in the calculations (including trip, close, and spring charge actions for circuit breakers).

1.06 QUALITY ASSURANCE

A. As specified in Section 16050.

1.07 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 16050.

B. Store batteries in a climate-controlled environment until installation in their final location.

1.08 PROJECT OR SITE CONDITIONS

A. As specified in Section 16050.

B. Environmental requirements:
   1. The equipment shall be de-rated in accordance with the manufacturer's guidelines for the project altitude and ambient temperature as specified in Section 16050.

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

A. As specified in Section 16050.

B. Provide 20-year pro-rata warranty on the battery units. An individual unit shall be considered defective if its capacity degrades to less than 80 percent of its published capacity within 20 years from the data specified in Section 16050.

1.12 SYSTEM START-UP (NOT USED)

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 COMMISSIONING (NOT USED)

1.15 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Nickel-cadmium batteries:
   1. Manufacturers: One of the following or equal:
      a. Alcad.
      b. HBL Power Systems.
      c. SENS.

B. Battery chargers:
   1. One of the following or equal:
      a. EnerSys.
      b. SAFT.
      c. SENS.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS (NOT USED)

2.04 MANUFACTURED UNITS (NOT USED)

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS

A. Nickel-cadmium batteries:
   1. Plates:
      a. Sealed pocket plates.
      b. Welded connections to plates.
      c. Plastic grid plate separators.
   2. Jar and cover:
      a. Constructed of flame-retardant, translucent material, marked on the sides to indicate electrolyte levels.
      b. Safety venting cap:
         1) Flame arresting type.

2.07 ACCESSORIES

A. Battery racks (if required):
   1. Designed and certified to conform to IEEE 693.
   2. Welded steel support frames and rails.
   3. Provisions for attachment of a grounding lug.
   4. Flame-retardant spacers between each unit.
   5. Seismic anchoring hardware.

B. Battery charger:
   1. Designed to float and equalize the batteries per manufacturer's requirements and recommendations.
   2. Sized to recharge the batteries from a fully discharged state to a fully charged state in a period of 8 hours, while operating all continuous DC loads.
   3. Input voltage as indicated on the Drawings.
   4. AC input circuit breaker.
   5. DC output circuit breaker.
   6. DC output ammeter and voltmeter.
   7. Battery temperature compensation sensor, configured to automatically adjust recharge current based on battery temperature.
   8. Voltage surge suppressors.
   9. Contacts rated 5 A at 120 VAC for remote monitoring of the following signals:
      a. Low battery voltage.
      b. Battery charger fail.
   10. Enclosure rating as specified in Section 16050 for the area of installation.

C. Signage:
   1. Provide warning signs meeting the requirements of OSHA 1926.441 at all entrances to spaces containing batteries or battery chargers.

D. DC panelboard (if required):
   1. Provide a DC panelboard as specified in Section 16445 with one circuit breaker for each of the following:
      a. Battery system.
      b. Battery charger.
      c. Each switchgear cubicle (if required).
      d. Each separate DC device not powered from a switchgear cubicle.
   2. Size circuit breakers based on the DC load of the actual equipment provided.

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES

A. Finish battery racks with an acid-resistant, electrostatically applied epoxy powder coat, ANSI-61 gray in color.

2.11 SOURCE QUALITY CONTROL

A. Factory test each unit shipped to verify initial system capacity and performance of all electrical connections.
   1. “Lot” testing or testing of a typical unit is not acceptable.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 16050.

B. Install battery system in accordance the manufacturer’s guidelines and submitted installation instructions.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 FIELD QUALITY CONTROL

A. Provide the services of a qualified manufacturer’s representative to inspect the battery system and verify that the installation complies with the manufacturer’s guidelines and written installation instructions.

3.08 ADJUSTING (NOT USED)

3.09 CLEANING

A. As specified in Section 16050.

3.10 DEMONSTRATION AND TRAINING

A. As specified in Section 16050.

3.11 PROTECTION

A. As specified in Section 16050.

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 16245

LOAD BANK - STATIONARY RESISTIVE

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Stationary resistive load banks for permanent 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 16075 - Electrical Identification.

1.02 REFERENCES

A. As specified in Section 16050.

1.03 DEFINITIONS

A. As specified in Section 16050.

1.04 SYSTEM DESCRIPTION

A. Design requirements:
   1. Provide a fan-cooled resistive load bank for permanent, on-site installation as a component of the emergency engine generator power system. The load bank is to be used for periodic, scheduled, supervised maintenance, exercise, and testing of the engine generator power system.

B. Performance requirements:
   1. Capacity:
      a. 1,000 kilowatts.
   2. Power factor: 1.0.
   3. Load steps: 50-kilowatt resolution (or per vendor recommendation.).
   4. Voltage: 480 VAC.
   5. Phase: 3-phase.
   6. Frequency: 60 hertz.

7. Ambient operating temperature: 15 to 120 degrees Fahrenheit:
    a. Temperature rise of the control and load bank resistor compartments: Less than 68 degrees Fahrenheit above ambient.
8. Duty cycle: Continuous.
9. Control voltage: 120 VAC.

1.05 SUBMITTALS

A. Furnish submittals as specified in Sections 01330 and 16050.

B. Product data:
    1. Manufacturer of load bank.
    2. Manufacturer of load bank parts.
    3. Nameplate schedule.
    4. Bill of material.
    5. Enclosure NEMA rating and color.
    6. Ratings:
        a. Voltage.
        b. Phase.
        c. Current.
        d. Short circuit withstand rating.
        e. Protective device interrupting rating.
        f. Kilowatts.
    7. List of recommended spare parts.
    8. Catalog cut sheets:
        a. Submit complete manufacturer's catalog information:
            1) Clearly indicate the features of the equipment including any options necessary to meet the required functionality.

C. Shop drawings:
    1. Provide fully dimensioned and to scale layout drawings which include:
        a. Dimensions:
            1) Length.
            2) Width.
            3) Height.
            4) Weight.
    2. Allowable top and bottom conduit windows.
    3. Elementary schematics:
        a. Provide complete schematic diagram for entire load bank:
            1) Include all remote devices.
            2) Show wire numbers on the schematics:
                a) Provide wire numbering as specified in Section 16075.

D. Installation instructions:
    1. Detail the complete installation of the load bank including rigging, moving, and setting into place.
    2. Provide anchorage instructions and requirements for the load bank based on the seismic requirements of the Project Site as specified in Section 16050:
        a. Stamped by a professional engineer licensed in the state where the Project is being constructed.

E. 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. Manufacturer's operating and maintenance instructions for the load bank and all component parts, including:
         1) Resistor contactors.
         2) Overload relays and heater elements.
         3) Protective devices including, but not limited to, fuses, circuit breakers and protective relays.
         4) Pilot devices.
      b. Complete renewal parts list.

F. Record documents:
   1. Elementary schematics:
      a. Provide a single-line diagram.
      b. Provide complete custom schematic diagram for the load bank:
         1) Include all remote devices.
         2) Show wire numbers on the schematics.
   2. Layout drawings:
      a. Provide complete dimensioned component and unit layout drawings.
   3. The record documents shall reflect all modifications made during the submittal review process and during construction.

G. Calculations:
   1. Detailed calculations or details of the actual physical testing performed on the load bank to prove that the equipment is suitable for the Project Site seismic requirements.

1.06 QUALITY ASSURANCE

A. As specified in Section 16050.

B. Perform Work to meet the requirements of legally constituted authorities having jurisdiction. Comply with the latest editions, amendments, practices, and rulings of the following documents and organizations, except where these Contract Documents are more stringent:
   1. National Electrical Code (NFPA No. 70).
   2. Emergency and Standby Power Systems (NFPA 110).
   3. Standard for Health Care Facilities (NFPA 99).
   4. Institute of Electrical and Electronic Engineers.
   5. National Electrical Manufacturers Association.
   6. Insulated Power Cable Engineers Associations.
   7. American National Standards Institute.
   8. American Society of Testing Materials.
   9. Rules of the National Board of Fire Underwriters.
   10. Underwriters Laboratories, Inc.

C. Furnish UL Listed and labeled equipment.

1.07 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 16050.

B. Deliver equipment to permit the CONTRACTOR to use off loading equipment that they have on-site.

C. Furnish chains, slings, and spreader bars that will not distort or damage the load bank.

D. Deliver equipment properly packaged and mounted on pallets or skids, utilizing factory fabricated type containers or wrapping to protect the equipment from damage.

E. Store units in original packaging and protect from weather as directed by manufacturer, until installation is complete.

1.08 PROJECT OR SITE CONDITIONS

A. As specified in Section 16050.

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING

A. Schedule the delivery of equipment to permit building ingress for large equipment components to their designated installation locations.

1.11 WARRANTY

A. As specified in Section 16050.

1.12 SYSTEM STARTUP

A. As specified in Section 16050.

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 COMMISSIONING (NOT USED)

1.15 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. One of the following or equal:
   1. Sephco.
   2. Avtron.
   3. Mosebach.
   4. Simplex.
   5. LoadTec.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS (NOT USED)

2.04 MANUFACTURED UNITS (NOT USED)

2.05 EQUIPMENT

A. Provide a completely self-contained, free-standing floor-mounted unit for incorporation into the end radiator and silencer of a 1,500-kVA diesel generator, incorporating all below:
   1. Resistive elements.
   2. Load contactors for each load group.
   3. Individual load group circuit breakers or fuses.
   4. Load bank protective devices.
   5. Main load bus bars.
   6. Auxiliary terminals.
   7. Malfunction detection system.
   8. Unit controller.

B. Operation:
   1. Complete operation of the load bank through the local control panel.
   2. Load bank operation interlocked with the power circuit breaker that is connecting the load bank to the generator:
      a. Load bank can only operate when auxiliary contact from generator breaker reports that the power poles of the circuit breaker are closed.
      b. When manual operation is in progress and standby power is called for:
         1) Initiate load bank cool down cycle.

2.06 COMPONENTS

A. Enclosure:
   1. Furnish a control enclosure with fully opening hinged doors to provide full and clear access to all resistor connections and power control equipment.
   2. Lift-off type hinges.
   3. Lockable door operator.
   4. Door complete with a gutter surround and a neoprene rubber gasket for sealing.
   5. NEMA Type 1 Enclosure:
      a. Resistor chamber and materials including resistors to withstand windblown rain.
   6. With forklift channels and approved lifting hooks.

B. Protection, control, and wiring:
   1. Resistor groups shall be limited to the specified resolution, and evenly balanced over the 3 phases:
      a. Terminated at and switched by a contactor.
      b. Protected by 3-pole circuit breaker or 3 matched fuses.
      c. Minimum interrupting rating 65 KACI.
   2. Contactors sized to mach the protective device and rated for 120 degrees Fahrenheit operation.

3. Flexible multi-stranded copper cable rated 150 degrees Celsius wiring to resistors:
    a. Do not make bus connection directly to resistors.
4. Tin-plated copper main bus.
5. Engine driven cooling fan, cooling system:

C. Controller:
1. Provide and fully function local and remote mounted controller.
2. Furnish the following functions:
    a. Load value kilowatts.
    b. Kilowatt load increase/decrease.
    c. Emergency stop button.
    d. Load Bank “On” indication.
    e. Load Bank “Cooling Fault” alarm.
    f. Load Bank “Cool Down Cycle” indication.
    g. Cooling Fan “Start-Up” indication.
    h. Cooling Fan “Automatic Shutdown” indication.
    i. Cooling Fan “Running” indication.
    j. Load Dump command.

D. Load resistors:
1. Impervious to light windblown rain
2. Corrosion resistant chromium alloy wire.
3. Accurate to 2.5 percent of rated value:
    a. Rated value not to vary by more than 2.5 percent at full operating temperature.
4. Fully supported and insulated resistors.
5. Fully accessible terminals, segregated from the power control section.

2.07 ACCESSORIES (NOT USED)

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES

A. Enclosure:
1. Zinc coated steel for all construction of body panels and doors.
2. Hot dipped galvanized after construction of the load bank chassis and framework.
3. Type 316 stainless steel for all screws, securing devices, nuts, and bolts.
4. Finish:
    a. Polyurethane primer.
    b. Two coats of polyurethane marine grade enamel.

2.11 SOURCE QUALITY CONTROL

A. Minimum resistor lifetime of 10 years. Warranty period per specification 16050.

PART 3 EXECUTION

3.01 EXAMINATION

A. As specified in Section 16050.

3.02 PREPARATION

A. As specified in Section 16050.

B. Coordinate the size and location the concrete pads that the equipment must set upon.

C. Coordinate with other electrical work including location of raceway entries and fittings, and cabling/wiring work, as necessary to interface installation of the load bank with other work.

3.03 INSTALLATION

A. As specified in Section 16050.

B. Install the load bank per the manufacturer's guidelines and submitted installation instructions to meet the seismic requirements at the Project Site.

C. Install units on re-enforced concrete pads that are a minimum of 6 inches above finished grade.

D. Make all interconnections both power and control between load bank components as well as with the switchgear.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 FIELD QUALITY CONTROL

A. Before energizing torque all connections to manufacturer's torque values.

B. Before energizing measure all phase to phase and phase to ground resistance values with a Meggar and verify that values are consistent with manufacturer's published values.

C. Before energizing, verify continuity of all circuits.

D. Before energizing, verify that there are no short circuits.

E. After complete installation manufacturer to verify and provide written certification of that the installation is complete and meets the manufacturer's requirements.

3.08 ADJUSTING

A. Adjust operating mechanisms for free mechanical movement.

3.09 CLEANING

A. As specified in Section 16050.

3.10 DEMONSTRATION AND TRAINING

A. As specified in Section 16050.

B. Manufacturer to energize load bank and demonstrate complete operation of the equipment.

C. Provide manufacturer’s training to the OWNER’s staff.

3.11 PROTECTION

A. Protect equipment from damage or degradation after testing is complete until the Project is substantially completed.

B. Repair or replace damaged equipment to the OWNER's satisfaction.

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 16262

VARIABLE FREQUENCY DRIVES 0.50 - 50 HORSEPOWER

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Variable frequency drives (VFD) 0.5 to 50 horsepower for control of NEMA Design B squirrel cage induction motors installed in:
      a. Standalone enclosures.
      b. Motor control centers.
      c. Vendor furnished equipment.

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. As specified in Section 16050.

B. National Electrical Manufacturers Association (NEMA):
   1. 250 - Enclosures for Electrical Equipment (1,000 volts maximum).
   2. MG 1, Part 31 - Definite-Purpose Inverter-Fed Polyphase Motors.

C. Institute of Electrical and Electronics Engineers (IEEE):
   1. 519 – 1992 Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems.

D. Underwriters' Laboratories (UL):
   1. 50 - Standard for Enclosures for Electrical Equipment.
   2. 508A - Standard for Industrial Control Panels.

1.03 DEFINITIONS

A. As specified in Section 16050.

B. Specific definitions:
   1. Point of common coupling: the point of common coupling for all harmonic calculation and field measurements for both voltage and current distortions is

defined as the closest directly connected panelboard or motor control center bus supplying power to the VFD.

1.04 SYSTEM DESCRIPTION

A. Design requirements:
   1. Each VFD system consists of all components required to meet the performance, protection, safety, testing, and certification criteria of this Section.
   2. The VFD system:
      a. Is a fully integrated package.
      b. Includes all material necessary to interconnect all VFD system elements, even if shipped separately.

B. Any modifications to a standard product necessary to meet this Section shall be made only by the VFD manufacturer:
   1. Each VFD shall be completely factory pre-wired, assembled, and then tested as a complete system by the VFD manufacturer to ensure a properly coordinated, fully integrated drive system.
   2. The VFD shall be capable of operating standard NEMA Design B motors. It is the responsibility of the VFD manufacturer to ensure that the drive will not damage motor insulation due to high carrier frequency, reflected wave, dv/dt or other drive electrical characteristics based upon the installed conditions:
      a. Provide equipment necessary to mitigate potential damage to motor insulation.

C. Performance:
   1. Operating envelope:
      a. Speed and torque requirements:
         1) Provide a variable torque or constant torque VFD as required by the driven load.
         2) The VFD shall be capable of producing a variable alternating voltage/frequency output to provide continuous operation over the 40 to 200 percent (25 to 120 hertz) speed range.
      b. Current requirements:
         1) 100 percent of rated current output on a continuous basis.
         2) Variable torque VFD:
            a) Minimum 110 percent current overload for 1 minute.
         3) Constant torque VFD:
            a) Minimum 150 percent current overload for 1 minute.
   2. Minimum VFD system efficiency:
      a. 96 percent.
      b. VFD system efficiency shall be calculated as follows:

$$\text{Efficiency (\%)} = \frac{\text{Power (Load)}}{\text{Power (Supply)}} \times 100$$

Power (Load) is the total power measured at the output terminals of the drive system, including VFD, output filters or transformers. Power (Supply) is the total power measured at the input terminals of the VFD including input filters, line reactors, isolation transformers, harmonic distortion attenuation equipment and auxiliary equipment (e.g., controls, fans) for complete system operation.

3. Total power factor:
    a. Minimum of 0.96 lagging across the entire speed range.
    b. At no speed shall the VFD have a leading power factor.
4. Frequency accuracy:
    a. Minimum of within 0.01 percent.
5. Speed regulation:
    a. Minimum of within 0.5 percent across the entire speed range.

1.05 SUBMITTALS

A. Furnish submittals as specified in Sections 01330 and 16050:
    1. Custom prepared by the VFD manufacturer and specific for the equipment furnished.

B. Product data:
    1. Manufacturer of the VFD.
    2. Manufacturer of all components of the VFD.
    3. Dimensions:
        a. Height.
        b. Width.
        c. Depth.
        d. Weight.
    4. Nameplate schedule.
    5. Bill of material.
    6. Ratings:
        a. Voltage.
        b. Phase.
        c. Input current.
        d. Output current.
        e. Interrupting rating.
        f. Momentary current rating.
    7. List of recommended spare parts.
    8. Catalog cut sheets for major components.
    9. Design data:
        a. Efficiency and power factor values.
        b. Certification that the drive is sized for the full nameplate motor horsepower and current of the driven load at the installed altitude and ambient temperature.
        c. Certification that based upon VFD design, cable length to motor, and motor dielectric insulation level that the VFD will not damage motor insulation due to carrier frequency, reflected wave, dv/dt, or other VFD produced characteristics.
        d. Certification that all electronic circuits and printed circuit boards are conformally coated.

C. Shop drawings:
    1. Complete plan and elevation drawings showing:
        a. All dimensions.
        b. Panel, sub-panel and component layout indexed to the bill of material.
        c. Conduit connections.

2. Block diagram showing the basic control and protection systems specifying the protection, control, trip and alarm functions, the reference signals and commands and the auxiliary devices.
3. Complete schematic, wiring and interconnection diagrams showing connections to both internal and external devices:
    a. Include terminal number and wire numbers.
4. Complete single-line and 3-line diagrams including, but not limited to, circuit breakers, motor circuit protectors, contactors, instrument transformers, meters, relays, timers, control devices, and other equipment comprising the complete system:
    a. Clearly indicate device electrical ratings on the drawings.

D. Installation instructions:
1. The written instructions must detail the complete installation of the VFD including moving, and setting into place.
2. Provide anchorage instructions and requirements for the VFD based on the seismic requirements at the project site as indicated in Section 16050:
    a. Stamped by a professional engineer registered in the state where the Project is being constructed.

E. Operation and maintenance manuals:
1. Spare parts list with supplier names and part numbers.
2. Startup and commissioning instructions and data.
3. Operating manuals:
    a. Submit operating instructions and a maintenance manual presenting full details for care and maintenance of each model of VFD provided under this Contract.
4. Operating instructions:
    a. Written descriptions detailing the operational functions of all controls on the front panel.
5. Maintenance manual:
    a. Furnish maintenance manuals with instructions covering all details pertaining to care and maintenance of all equipment as well as identifying all parts.
    b. Manuals shall include, but are not limited to the following:
        1) Adjustment and test instructions covering the steps involved in the initial test, adjustment and start-up procedures.
        2) Detailed control instructions, which outline the purpose and operation of every control device used in normal operation.
        3) All schematic wiring and external diagrams:
            a) Furnish drawings in a reduced 11-inch by 17-inch format that are fully legible at that size.

F. Test reports.

G. Manufacturer’s field reports:
1. Certification letter from the VFD manufacturer that the VFD(s) has been inspected and installed in accordance with the manufacturer’s requirements.
2. Report listing the setting of all VFD adjustable parameters and their values after start-up.

H. Record Documents:
   1. Certified Record Documents of equipment with information listed above.

1.06 QUALITY ASSURANCE

A. As specified in Section 16050.

B. Qualifications:
   1. Any third-party certification, safety or protection requirements shall be applied to the VFD system as a whole. Certification or protection of system elements or individual components by themselves is not acceptable.
   2. VFD systems shall be UL 508C listed and labeled.
   3. Variable frequency drives shall be manufactured by the VFD manufacturer at its own facility, which shall have a quality assurance program that is certified in conformance with ISO 9001.

1.07 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 16050.

B. Ship the VFDs and associated equipment to the job site on a dedicated air ride vehicle that will allow the CONTRACTOR to utilize on-site off-loading equipment:
   1. VFDs shall be delivered to the site preassembled and wired.
   2. Furnish temporary equipment heaters within the VFD to prevent condensation from forming.

1.08 PROJECT OR SITE CONDITIONS

A. As specified in Section 16050.

1.09 SEQUENCING

A. Submit equipment for review.

B. Following approved submittal, conduct internal factory test to ensure that all systems and equipment are functional and submit certified test results for ENGINEER's review.

C. Conduct factory acceptance test.

D. Ship equipment to project site after successful completion of factory acceptance test.

E. Install equipment in the field.

F. Submit manufacturer's certification that all equipment has been properly installed and is fully functional for ENGINEER's review.

G. Conduct field acceptance test and submit results for ENGINEER's review.

H. Conduct OWNER's training sessions.

I. Formally energize, start-up, and commission equipment.

1.10 SCHEDULING

A. As specified in Section 16050.

1.11 WARRANTY

A. As specified in Section 16050.

1.12 SYSTEM START-UP

A. As specified in Section 16050.

B. The VFD manufacturer shall be responsible for start up of the VFDs in the presence of the equipment suppliers, CONTRACTOR, ENGINEER, and OWNER.

1.13 OWNERS INSTRUCTIONS (NOT USED)

1.14 COMMISSIONING

A. After startup and training has been completed, the VFDs shall be commissioned by the VFD manufacturer:
   1. The VFDs shall operate the driven load without failure under normal operating conditions for a period of 30 days.
   2. Any failures shall be repaired by the VFD manufacturer.
   3. Following repair, the commissioning period shall be restarted. Commissioning shall only be complete once an uninterrupted 30-day period has been completed.

1.15 MAINTENANCE

A. Spare parts:
   1. The following spare parts shall be furnished:
      a. One set of all power and control fuses for each VFD.
      b. One complete main control key pad for each type and rated size of VFD.
      c. One spare fan for each VFD unit.
      d. Two sets of ventilation filters for each VFD unit (if applicable in VFD cabinet louvers).
      e. Any special dedicated tools for emergency service and troubleshooting.
      f. One set of thyristors or power electronics for each type and rated size of VFD.
      g. All hardware and software required for configuration, maintenance, troubleshooting and inquiry of all drive parameters.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. One of the following or equal:
   1. Eaton/Cutler-Hammer (Freedom 2000).
   2. Allen-Bradley (Centerline).
   3. Schneider Electric/Square D (Model 6 Industrial).
   4. General Electric (Evolution).

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS (NOT USED)

2.04 MANUFACTURED UNITS (NOT USED)

2.05 EQUIPMENT

A. General:
   1. Sinusoidal pulse width modulated (PWM) type drive.
      a. Six-pulse insulated gate bipolar transistor (IGBT) power section.
      b. Microprocessor based controls.
      c. Line and load reactors.

B. Ratings:
   1. Voltage:
      a. Input voltage: 480 volts within 10 percent, 3-phase, 60 hertz.

C. Operational features:
   1. Protective features:
      a. Provide the following minimum protective features:
         1) Motor overload protection.
         2) Instantaneous overcurrent.
         3) Instantaneous overvoltage.
         4) Undervoltage.
         5) Power unit overtemperature.
         6) Phase loss.
         7) VFD output short circuit.
   2. Control mode:
      a. Operation in either a constant volts/hertz or sensorless vector mode:
         1) The control mode selectable using the programming keypad.
   3. Frequency control:
      a. Minimum of 3 selectable skip frequencies with adjustable bandwidths.
      b. Programmable minimum frequency.
      c. Programmable maximum frequency.
   4. Acceleration/deceleration:
      a. Separately adjustable acceleration and deceleration rates:
         1) Each rate adjustable from 0.01 to 3,600 seconds.
   5. Spinning load:
      a. The VFD shall be capable of determining the speed and direction of a spinning load, “catch” the load and accelerate or decelerate it without damage to the load.
   6. Programmable loss of signal:
      a. Upon loss of speed reference the VFD shall be programmable to either:
         1) Stop.
         2) Maintain current speed.
         3) Default to pre-selected speed.
   7. Power interrupt ride-through:
      a. The VFD shall be capable of continuous operation in the event of a power loss of 5 cycles or less.

8. Inputs/Outputs:
    a. Manufacturer's standard number the following:
        1) Analog inputs:
            a) Configurable as either 0-10 volts or 4-20 mA.
        2) Analog outputs:
            a) Programmable 4-20 mA isolated.
        3) Discrete inputs:
            a) Programmable.
        4) Discrete outputs:
            a) Programmable.
            b) Form C relay contacts.
        5) Potentiometer 3-wire input.
    b. Provide additional inputs/outputs as required to meet the control functions indicated on the Drawings.
9. Automatic control:
    a. PID capability utilizing an internal or external setpoint:
        1) Selectable setpoint source.
10. Diagnostics:
    a. Store a minimum of 4 fault conditions in non-volatile memory on a first in-first out basis.
    b. Operational parameters stored at the time of a the fault:
        1) Operating frequency.
        2) Drive status.
        3) Power mode.
    c. Fault memory accessible via RS-232, RS-422, or RS-485.
11. Automatic restart:
    a. User selectable automatic restart feature allowing the VFD to restart following a momentary power failure or other VFD fault:
        1) Programmable for up to 9 restart attempts.
        2) Adjustable time delay between restart attempts.

2.06 COMPONENTS

A. Enclosure:
    1. Motor control center.
    2. Provide cooling devices required to maintain the VFD within the manufacturer's specified temperature limits for the Project conditions:
        a. Provide cooling device failure alarm.

B. Power disconnect:
    1. Flange mounted motor circuit protector, MCP.
    2. Lockable in the OFF position.

C. Reactors:
    1. 3 percent input and 3 percent output line reactors.

D. Keypad:
    1. Provide each VFD with a keypad for programming and control.
    2. Keypad requirements:
        a. Password security to protect drive parameters.

b. Mounted on the door of the motor control center.
c. Back-lit LCD:
1) Minimum of 2 lines with a minimum of 16 characters per line.
d. Programming and display features language: English.
e. Capable of displaying the following parameters:
1) Speed (percent).
2) Output current (amperes).
3) Output frequency (hertz).
4) Input voltage.
5) Output voltage.
6) Total 3-phase kilowatt.
7) Kilowatt-hour meter.
8) Elapsed run time meter.
9) Revolutions per minute.
10) Direct current bus voltage.

3. In addition to all keys required for programming, provide the following controls on the keypad:
a. Auto/manual selector.
b. Start pushbutton.
c. Stop pushbutton.
d. Jog pushbutton.
e. Speed increment.
f. Speed decrement.
g. Forward/reverse selector.
h. Run LED indicator.
i. Program LED indicator.
j. Fault LED indicator.

4. Provide the VFD with the following controls:
a. Emergency Stop mushroom head pushbutton.
b. Automatic/Manual selector switch for speed reference control.
c. Control Power On pilot light.
d. Run pilot light.
e. Common Fail pilot light.
f. Speed potentiometer.
g. Elapsed run time meter.

E. Control power transformer:
1. Furnish a control power transformer mounted and wired inside the VFD enclosure.
2. With primary and secondary fusing.
3. Sized to power all VFD controls and options as well as any external devices indicated on the Drawings including the motor winding heater.

2.07 ACCESSORIES

A. Metal oxide varistors:
1. Provide protection for the VFD against:
a. Line transients: 5,000 volt peak minimum.
b. Line to ground transients: 7,000 peak minimum.

B. Conformal coating:
   1. Provide conformal coating material applied to electronic circuitry and printed circuit boards to act as a protection against moisture, dust, temperature extremes, and chemicals such as H_2S and chlorine.

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES

A. Enclosure finish shall be ANSI 61.

2.11 SOURCE QUALITY CONTROL

A. VFDs, factory testing:
   1. General:
      a. Incoming inspection of components and raw materials based on strategic supplier base and experience.
      b. All VFDs furnished under this Section shall be tested and inspected as specified below. Testing of VFDs based on sampling plans is not allowed.
      c. The testing procedures specified are the minimum acceptable requirements. The manufacturer may perform additional tests at its discretion.
   2. Failure of any component during testing requires repair of the faulted component and complete retest.
   3. Testing sequence:
      a. Submit a detailed test procedure for the VFD factory test:
         1) A minimum of 8 weeks in advance of the proposed testing date.
         2) No tests shall be performed until the test procedure is reviewed and accepted by the ENGINEER.
   4. Component tests:
      a. Preliminary inspection:
         1) Verify that all components are correct.
         2) Verify that all connections are properly torqued.
      b. Printed circuit boards:
         1) Test for correct component placement and value and complete board functional test to ensure proper performance with specified tolerances.
         2) Heat cycle test for 48 hours at 60 degrees Celsius.
         3) Apply control power to microprocessors, printed circuit boards, diagnostic boards, and similar devices including software to test for proper operation, sequencing, logic, and diagnostics.
         4) Test operation of all analog and discrete inputs and outputs.
      c. Wiring:
         1) Control and power wiring continuity verified point-to-point.
         2) Hi-pot power and control wiring at manufacturer's recommended levels.
         3) Verify ground bond resistance.

d. Load testing:
    1) No load testing in accordance with the manufacturer's standard factory test procedure.
    2) Full load testing:
        a) Test each VFD and a representative motor with the system logic and a dynamometer load to simulate field operation conditions at 25 percent, 50 percent, and 100 percent full load current.
        b) Load test each VFD at a minimum ambient temperature of 40 degrees Celsius.
            (1) Monitor and record temperature rise.
            (2) Once temperature rise stops continue to operate the VFD for a minimum of 2 hours.
                (a) If operating temperature exceeds the rated value, repair or replace the VFD and retest.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 16050.

B. Install the VFD per the manufacturer's guidelines and submitted installation instruction to meet the seismic requirements at the Project Site.

C. General:
    1. Furnish all cables, conduit, lugs, bolts, expansion anchors, sealants, and other accessories needed to complete the installation of the VFD (free-standing or within motor control center).
    2. Assemble and install the VFD in the locations and with the layouts indicated on the Drawings.
    3. Perform work in accordance with manufacturer's instructions and shop drawings.
    4. Furnish components and equipment as required to complete the installation.
    5. Replace any hardware lost or damaged during the installation or handling to provide a complete installation.
    6. Install free-standing enclosures on 3-1/2 inch raised concrete house keeping pad:
        a. Provide structural leveling channels in accordance with the manufacturer's recommendations to provide proper alignment of the units.
        b. Weld and/or bolt the VFD frame to the leveling channels.
    7. Provide openings in top or bottom of the VFD (free-standing or within motor control center) enclosure for conduit only, no additional openings will be allowed:
        a. Improperly cut holes will require that the entire panel be replaced:
            1) No hole closers or patches will be allowed.
    8. Bundle circuits together and terminate in each unit:
        a. Tie with nylon wire ties.

b. Label all wires at each end with wire numbers shown on the approved control drawings.
c. All connections to and from the VFD (free-standing or within motor control center) enclosure must be made via terminal blocks.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 FIELD QUALITY CONTROL

A. As specified in Section 16050.

B. Provide the services of a VFD manufacturer representative for startup assistance and training:
1. Inspection and field adjustment:
a. Supervise the following and submit written certification that the equipment and controls have been properly installed, aligned, adjusted, and readied for operation.
2. Start-up field testing:
a. Provide technical direction for testing, checkout, and startup of the VFD equipment in the field.
b. Under no circumstances are any portions of the drive system to be energized without authorization from the manufacturer's representative.

3.08 ADJUSTING

A. Make all adjustments as necessary and recommended by the manufacturer, ENGINEER, or testing firm.

B. Provide the services of a VFD manufacturer factory technician to make all drive parameters and protective device settings:
1. Protective device settings provided by the VFD manufacturer in accordance with the manufacturer of the driven equipment requirements.
2. Provide documentation of VFD settings included but not limited to:
a. Minimum speed.
b. Maximum speed.
c. Skip speeds.
d. Current limit.
e. Acceleration time.
f. Deceleration time.

3.09 CLEANING

A. As specified in Section 16050.

3.10 DEMONSTRATION AND TRAINING

A. As specified in Section 16050.

B. Demonstrate the operation of each VFD to the ENGINEER's and OWNER's satisfaction.

C. Training:
   1. Provide instruction of the OWNER’s operation and maintenance staff on the operation and maintenance of the VFD.
   2. Separate classes are required for the operations staff and maintenance staff:
      a. Instruction shall occur at the OWNER’s facility and shall utilize the actual VFDs installed at the site.
   3. Provide training as specified in Section 16050.

3.11 PROTECTION

A. As specified in Section 16050.

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 16264

VARIABLE FREQUENCY DRIVES 60-500 HORSEPOWER

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Clean power 18 pulse variable frequency drives (VFD), 60 to 500 horsepower for control of standard NEMA Design B squirrel cage induction motors.

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 - Seismic Design Criteria.
      c. Section 16050 - Common Work Results for Electrical.
      d. Section 16123 - 600 Volt or Less Wires and Cables.

1.02 REFERENCES

A. As specified in Section 16050.

B. National Electrical Manufacturers Association (NEMA):
   1. 250 - Enclosures for Electrical Equipment (1,000 volts maximum).
   2. MGI, Part 31 - Motors with higher peak voltage capability.

C. Institute of Electrical and Electronics Engineers (IEEE):
   1. 519-1992 - IEEE Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems.

D. Underwriters' Laboratories (UL):
   1. 50 Standards for Enclosures for Electrical Equipment.
   2. 508A Standard for Safety for Industrial Control Panels.
   3. 508C Standard for Power Conversion Equipment.

1.03 DEFINITIONS

A. As specified in Section 16050.

B. Specific definitions:
   1. PCC: Point of common coupling: The point of common coupling for all harmonic calculations and field measurements for both voltage and current distortion is defined as the input terminals to the VFD.

1.04 SYSTEM DESCRIPTION

A. Design requirements:
   1. Each VFD system shall consist of all components required to meet the performance, protection, safety, testing and certification criteria of this Section.
   2. The VFD system:
      a. Is a fully integrated package.
      b. Includes all material necessary to interconnect VFD system elements, even if shipped separately.
   3. Any modifications to a standard product necessary to meet this Section shall be made only by the VFD manufacturer.
   4. Each VFD shall be completely factory pre-wired, assembled and then tested as a complete package by the VFD manufacturer to ensure a properly coordinated, fully integrated drive system.
   5. The VFD shall be capable of operating standard NEMA Design B motors. It is the responsibility of the VFD manufacturer to ensure that the drive will not damage motor insulation due to high carrier frequency, reflected wave, dv/dt or other drive electrical characteristics:
      a. The VFD manufacturer shall furnish equipment necessary to mitigate potential damage to motor insulation.

B. Performance:
   1. Operating envelope:
      a. Speed and torque requirements:
         1) Provide a variable torque or constant torque VFD as required by the driven load.
         2) The VFD shall be capable of producing a variable alternating voltage/frequency output to provide continuous operation over the 40 to 110 percent (25 to 66 Hertz) speed range.
      b. Current requirements:
         1) Provide 100 percent of rated output current on a continuous basis.
         2) Variable torque VFD:
            a) Minimum 110 percent current overload for 1 minute.
         3) Constant torque VFD:
            a) Minimum 150 percent current overload for 1 minute.
   2. Harmonics:
      a. The VFD shall comply with IEEE 519-1992 for total harmonic and current distortion calculations and measurements. The VFD shall meet the following distortion limits:
         1) Voltage harmonics: Individual or simultaneous operation of the VFD(s) shall not add more than 3 percent total harmonic voltage distortion while operating from the utility source or more than

5 percent total harmonic voltage distortion while operating from standby generation at the PCC.

2) Current harmonics: The maximum allowable total harmonic current distortion limit for each VFD shall not exceed 5 percent as measured at the PCC.

3. Efficiency:
   a. VFD system minimum efficiency shall be 95 percent at rated output. VFD system efficiency shall be calculated as follows:

$$Efficiency\ (\%) = \frac{Power\,(Load)}{Power\,(Supply)}\ x\ 100$$

   b. Power:
      1) Load power is the total 3-phase power measured at the output terminals of the drive system, including VFD, output filters or transformers.
      2) Supply power is the total power measured at the input terminals of the VFD including input filters, line reactors, phase shifting transformer, harmonic distortion attenuation equipment and auxiliary equipment (e.g., controls, fans) for complete system operation.
4. Total power factor:
   a. Minimum of 0.96 lagging across the entire speed range.
   b. Under no operating conditions shall the VFD have a leading power factor.
5. Frequency accuracy:
   a. Minimum of within 0.01 percent.
6. Speed regulation:
   a. Minimum of within 0.5 percent across the entire speed range.

1.05 SUBMITTALS

A. Furnish submittals as specified in Sections 01330 and 16050:
   1. Custom prepared by the VFD manufacturer and specific for the equipment furnished.

B. Product data:
   1. Manufacturer of the VFD.
   2. Manufacturer of all components of the VFD.
   3. Dimensions:
      a. Height.
      b. Width.
      c. Depth.
   4. Weight.
   5. Nameplate schedule.
   6. Bill of material.
   7. Ratings:
      a. Voltage.
      b. Phase.
      c. Input current.
      d. Output current.
      e. Interrupting rating.
      f. Momentary current rating.
   8. Catalog cut sheets for major components.
   9. Design data:
      a. Efficiency and power factor values.

b. Certification that the drive is sized for the full nameplate motor horsepower and current of the driven load at the installed altitude.
c. Certification that based upon VFD design, cable length to motor, and motor dielectric insulation level that the VFD will not damage motor insulation due to carrier frequency, reflected wave, dv/dt, or other VFD produced characteristics.
d. Certification that all electronic circuits and printed circuit boards are conformally coated.

10. List of recommended spare parts.

C. Shop drawings:
1. Complete plan and elevation drawings showing:
a. All dimensions.
b. Panel, sub-panel and component layout indexed to the bill of material.
c. Conduit connections.
d. Required clearance around equipment.
2. Block diagram showing the basic control and protection systems specifying the protection, control, trip and alarm functions, the reference signals and commands and the auxiliary devices.
3. Complete schematic, wiring and interconnection diagrams showing connections to both internal and external devices:
a. Wiring diagrams shall include terminal number and wire numbers.
4. Complete 1-line and 3-line diagrams including, but not limited to, circuit breakers, motor circuit protectors, contactors, instrument transformers, meters, relays, timers, control devices, and other equipment comprising the complete system:
a. Device electrical ratings shall be clearly indicated on the Drawings.

D. Installation instructions:
1. The written instructions must detail the complete installation of the VFD including moving, and setting into place.
2. Provide anchorage instructions and requirements for the VFD based on the seismic requirements at the Project Site as specified in Section 16050:
a. Stamped by a Professional Engineer licensed in the state where the Project is being constructed.

E. Calculations:
1. Harmonic study:
a. A preliminary harmonic analysis shall be performed. A power system short circuit ratio of 20 shall be used. All VFDs shall be assumed to be operating at maximum speed and maximum load. The short circuit current (ISC) utilized for the harmonic analysis calculations is defined as:
1) ISC = 20 * (Sum Total Full Load Amps of all VFDs).
b. A separate harmonic analysis shall be performed based on the standby generator system. Coordinate with the generator manufacturer and the VFD manufacturer so the actual characteristics for the generator supplied for this Project are used in the harmonic analysis.
2. Detailed calculations or details of the actual physical testing performed on the VFD to prove the VFD is suitable for the seismic conditions at the Project Site.

F. Test reports.
   1. Provide the following certified test reports for the actual VFDs being furnished:
      a. Efficiency at 25 percent, 50 percent, 75 percent, and 100 percent speed.
      b. Power factor at 0 percent, 25 percent, 50 percent, 75 percent, and 100 percent speed.
      c. Certification that the actual measured harmonic distortion for both voltage and current is within the specification limits at the installed site.
      d. Certification that the actual measured voltage at the motor terminations is less than 90 percent of the motor insulation dielectric withstand level.

G. Record documents:
   1. Certified record documents of all equipment with information listed above.

H. Manufacturer's field reports:
   1. Certification letter from the VFD manufacturer that the VFD(s) has been inspected and installed in accordance with the manufacturer's requirements.
   2. Report listing the setting of all VFD adjustable parameters and their values after start-up.

I. Operation and maintenance manuals:
   1. Spare parts list with supplier names and part numbers.
   2. Start-up and commissioning instructions and data.
   3. Complete bill of material indexed to the drawings, identifying the catalog or part numbers, manufacturer, and quantities of components of the VFD system.
   4. Operating manuals:
      a. Submit operating instructions and a maintenance manual presenting full details for care and maintenance of each model of VFD provided under this Contract.
   5. Operating instructions:
      a. The written descriptions shall detail the operational functions of all controls on the front panel.
   6. Maintenance manual:
      a. Furnish maintenance manuals with instructions covering all details pertaining to care and maintenance of all equipment as well as identifying all parts.
      b. Manuals shall include but are not limited to the following:
         1) Adjustment and test instructions covering the steps involved in the initial test, adjustment and start-up procedures.
         2) Detailed control instructions, which outline the purpose and operation of every control device used in normal operation.
         3) All schematic wiring and external diagrams:
            a) Furnish drawings in a fully legible reduced 11-inch by 17-inch format.

1.06 QUALITY ASSURANCE

A. As specified in Section 16050.

B. Qualifications:
   1. Any third party certification, safety or protection requirements shall be applied to the VFD system as a whole. Certification or protection of system elements or individual components by themselves is not acceptable.

2. VFD systems shall be UL 508C listed and labeled.
3. VFDs shall be manufactured by the VFD manufacturer at its own facility, which shall have a quality assurance program that is certified in accordance with ISO 9001.

1.07 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 16050.

B. Ship VFDs to the job site on a dedicated air ride vehicle that will allow the CONTRACTOR to utilize on site off loading equipment:
1. VFDs shall be delivered to the site pre-assembled and wired.
2. Furnish temporary equipment heaters within the VFD to prevent condensation from forming.
3. Ship each VFD with 2 non-tamperable accelerometers that record the maximum shock and vibration experienced by the VFD during shipping and handling.

1.08 PROJECT OR SITE CONDITIONS

A. As specified in Section 16050.

1.09 SEQUENCING

A. Furnish complete submittals for review.

B. Following approved submittal, conduct internal factory test to ensure that all systems and equipment are functional and submit certified test results for ENGINEER's review.

C. Conduct factory acceptance test. The factory acceptance test shall be witnessed by OWNER and/or OWNER's representative at the OWNER's discretion.

D. Ship equipment to Project Site after successful completion of factory acceptance test.

E. Install equipment in the field.

F. Conduct field acceptance tests including harmonic testing and submit results for ENGINEER's review.

G. Submit manufacturer's certification that all equipment has been properly installed and is fully functional for ENGINEER's review.

H. Conduct OWNER's training sessions.

I. Formally energize, start up, and commission equipment.

1.10 SCHEDULING

A. As specified in Section 16050.

1.11 WARRANTY

A. As specified in Section 16050.

B. Performance guaranty:
   1. Guaranty that the harmonics at the PCC, as defined herein, are at or below the levels specified.
   2. Guaranty that the power factor at the input to the VFD meets the levels as specified herein.
   3. Guaranty that the measured reflected voltage at the motor is below the motor insulation dielectric withstand level as specified herein.
   4. VFDs that fail to meet the specified harmonics, power factor or reflected voltage criteria shall be repaired or replaced at the OWNER's discretion.
   5. Guaranty that the efficiency of VFD is at or greater than the levels specified.
      a. For each VFD that fails to meet the specified efficiency, the OWNER shall be reimbursed for the difference between the specified efficiency and measured efficiency at the rate of $0.05 per kilowatt hour, for operation at 24 hours per day, 365 days per year, for 10 years.

1.12 SYSTEM START-UP

A. As specified in Section 16050.

B. The VFD manufacturer shall be responsible for start-up of the VFDs in the presence of the equipment suppliers, CONTRACTOR, ENGINEER and OWNER.

1.13 OWNERS INSTRUCTIONS (NOT USED)

1.14 COMMISSIONING

A. After start-up and training has been completed, the VFDs shall be commissioned by the VFD manufacturer:
   1. The VFDs shall operate the driven load without failure under normal operating conditions for a period of 30 days.
   2. Any failures shall be repaired by the VFD manufacturer. Following repair, a new 30-day period shall start.
   3. Commissioning shall only be complete once an uninterrupted 30-day period has been completed.

1.15 MAINTENANCE

A. Maintenance service: Manufacturer shall describe the field service system available to support the proposed VFD system. As a minimum describe:
   1. Type of technical support available (e.g., system engineering and technician).
   2. Location of field service personnel.
   3. Field service daily rates in dollars per hour and dollars per day.
   4. Guaranteed response times to service requests.

B. Spare parts:
   1. Furnish the following spare parts:
      a. 1 set of all power and control fuses for each VFD.
      b. 1 complete main control keypad for each type and rated size of VFD.
      c. 1 spare fan for each VFD unit.

d. 2 sets of ventilation filters for each VFD unit (if applicable in VFD cabinet louvers).
e. Any special dedicated tools for emergency service and troubleshooting.
f. Supply all hardware and software required for configuration, maintenance, troubleshooting and inquiry of all drive parameters.
g. 1 complete set of power electronics for each size of VFD supplied, including rectifier assemblies, inverter assemblies.
h. 1 complete set of control electronics for each size of VFD supplied, including microprocessor boards, firing boards, etc.
i. 1 complete set of DC link capacitors for each size of VFD supplied.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. One of the following or equal:
1. Eaton/Cutler-Hammer.
2. Allen-Bradley.
3. Schneider-Electric/Square D.
4. General Electric.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS (NOT USED)

2.04 MANUFACTURED UNITS (NOT USED)

2.05 EQUIPMENT

A. General:
1. Sinusoidal pulse width modulated, (PWM), voltage source type drive shall consist of the following:
a. Input line reactors.
b. Integral phase shifting auto-transformer:
1) Converts 3-phase utility power to 3 sets of 3 power circuits with each set phase shifted and powering its own 3-phase bridge rectifier.
c. Direct current link with capacitors.
d. Minimum 18-pulse diode rectifier section consisting of 3 three-phase bridge rectifiers.
1) Specifically designed as a system to share currents between the bridges to within 1 percent.
2) VFD designs utilizing the 6 diodes internal to the inverter and 12 diodes external to the inverter unit are not allowed.
e. Insulated gate bipolar transistor (IGBT), inverter section.
f. Microprocessor based controls.
g. Load reactors.
2. VFDs that have an active input section for either harmonic or voltage control are not acceptable.

B. Ratings:
1. Voltage:
a. Input voltage: 480 Volts plus or minus 10 percent, 3-phase 60 hertz.

C. Operational features:
   1. Protective features:
      a. Include the following protective features:
         1) Motor overload protection.
         2) Instantaneous overcurrent.
         3) Instantaneous overvoltage.
         4) Undervoltage.
         5) Power unit overtemperature.
         6) Phase loss.
         7) VFD output short circuit.
         8) VFD output ground fault.
         9) Blown fuse.
         10) Motor overtemperature protection:
            a) Motor temperature switch.
   2. Control mode:
      a. The VFD shall operate in a either a constant volts/hertz or sensorless vector mode. The control mode selectable using the programming keypad.
   3. Frequency control:
      a. Minimum of 3 selectable skip frequencies with adjustable bandwidths for variable torque applications.
      b. Programmable minimum frequency.
      c. Programmable maximum frequency.
   4. Acceleration/Deceleration:
      a. Separately adjustable acceleration and deceleration rates.
      b. Each rate shall be adjustable from 0.01 to 3,600 seconds.
   5. Spinning load:
      a. Capable of determining the speed and direction of a spinning load, “catch” the load and accelerate or decelerate it without damage to the load.
   6. Programmable loss of signal:
      a. Upon loss of reference speed signal the VFD shall be programmable to either stop, maintain current speed, or default to preselected speed.
   7. Power interrupt ridethrough:
      a. Capable of continuous operation in the event of a power loss of 5 cycles or less.
   8. Input/Output:
      a. Manufacturer’s standard number the following:
         1) Analog inputs.
            a) Configurable as either 0 to 10 volts or 4 to 20 milliamperes.
         2) Analog outputs.
            a) Programmable 4 to 20 milliamperes isolated.
         3) Discrete inputs.
            a) Programmable.
         4) Discrete outputs.
            a) Programmable.
            b) Form C relay contacts.
         5) Potentiometer 3-wire input.
      b. Provide additional inputs/outputs as required to meet the control functions indicated on the Drawings.
   9. Diagnostics:
      a. Minimum of 4 fault conditions in memory on a first in - first out basis.

b. Operating frequency, drive status, and power mode shall also be stored at the time of the fault.
c. Fault memory shall be maintained in the event of a power outage.
d. The fault memory shall be accessible via RS-232, RS-422, or RS-485.

10. Automatic restart:
    a. User selectable, automatic restart feature allowing the VFD to restart following a momentary power failure or other VFD fault:
        1) Programmable for up to 9 automatic restart attempts with an adjustable time delay between restart attempts.

2.06 COMPONENTS

A. Enclosure:
1. NEMA Type 1 enclosure.
2. Provide cooling devices required to maintain the VFD within the manufacturer's specified temperature limits for the Project conditions:
    a. Provide cooling device alarm.

B. Power disconnect:
1. Flange mounted motor circuit protector, MCP:
    a. Lockable in the OFF position.

C. Phase shifting transformer:
1. Auto-transformer.
2. Integral part of the VFD assembly and factory mounted and wired within the VFD enclosure.
3. Rated for rectifier duty.
4. Copper windings with 220-degree Celsius insulation.

D. Reactors:
1. Provide 3 percent output load reactors.
2. Provide input line reactors.

E. Keypad:
1. Furnished with a keypad for programming and control.
2. Password security to protect drive parameters.
3. Mounted on the door of the VFD.
4. Back-lit LCD with a minimum of 2 lines of a minimum of 16 characters each.
5. Programming and display features language: English.
6. Capable of displaying the following parameters:
    a. Speed (percent).
    b. Output current (Amperes).
    c. Output frequency (Hertz).
    d. Input voltage.
    e. Output voltage.
    f. Total 3-phase kilowatt.
    g. Kilowatt hour meter.
    h. Elapsed run time meter.
    i. Revolutions per minute.
    j. Direct current bus voltage.

7. In addition to all keys required for programming, the keypad shall have the following:
    a. Automatic/Manual selector.
    b. Start pushbutton.
    c. Stop pushbutton.
    d.
    e. Speed increment.
    f. Speed decrement.
    g. Forward/Reverse selector.
    h. RUN led indicator.
    i. PROGRAM led indicator.
    j. FAULT led indicator.
8. Provide the VFD with the following controls:
    a. Emergency Stop mushroom head pushbutton.
    b. Automatic/Manual selector switch for speed reference control.
    c. Control Power On pilot light.
    d. Run pilot light.
    e. Common Fail pilot light.
    f. Speed potentiometer.
    g. Elapsed time meter.

F. Control power transformer:
1. Furnish a control power transformer mounted and wired inside the drive enclosure.
2. Primary and secondary fusing.
3. Size the transformer to supply power to all VFD controls and options as well as any external devices indicated on the Drawings including the motor winding heater.

2.07 ACCESSORIES

A. Metal oxide varistors:
1. Provide protection for the VFD against:
    a. Line transients: 5,000 volt peak minimum.
    b. Line to ground transients: 7,000 peak minimum.

B. Conformal coating:
1. Provide conformal coating material applied to electronic circuitry and printed circuit boards to act as protection against moisture, dust, temperature extremes, and chemicals such as H_2S and chlorine.

C. Air filters:
1. Mounted on the outside of the VFD enclosure:
    a. Replaceable without requiring that the VFD be turned off or the door opened.
2. Located on the front or top of the VFD enclosure.
    a. Side or rear mounted air filters are not acceptable.

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES

A. Enclosure finish shall be ANSI 61.

2.11 SOURCE QUALITY CONTROL

A. Factory testing:
   1. General:
      a. Incoming inspection of components and raw materials based on strategic supplier base and experience.
      b. All VFDs furnished under this Section shall be tested and inspected as specified below. Testing of VFDs based on sampling plans is not allowed.
      c. The testing procedures specified are the minimum acceptable requirements. The manufacturer may perform additional tests at its discretion.
   2. Failure of any component during testing requires repair of the faulted component and complete retest.
   3. Testing sequence:
      a. Submit a detailed test procedure for the VFD factory test:
         1) A minimum of 8 weeks in advance of the proposed testing date.
         2) No tests shall be performed until the test procedure is reviewed and accepted by the ENGINEER.
   4. Component tests:
      a. Preliminary inspection:
         1) Verify that all components are correct.
         2) Verify that all connections are properly torqued.
      b. Printed circuit boards:
         1) Test for correct component placement and value and complete board functional test to ensure proper performance with specified tolerances.
         2) Heat cycle test for 48 hours at 60 degrees Celsius.
         3) Apply control power to microprocessors, printed circuit boards, diagnostic boards, and similar devices including software to test for proper operation, sequencing, logic, and diagnostics.
         4) Test operation of all analog and discrete inputs and outputs.
      c. Wiring:
         1) Control and power wiring continuity verified point-to-point.
         2) Hi-pot power and control wiring at manufacturer's recommended levels.
         3) Verify ground bond resistance.
      d. Load testing:
         1) No load testing in accordance with the manufacturer's standard factory test procedure.
         2) Full load testing:
            a) Test each VFD and a representative motor with the system logic and a dynamometer load to simulate field operation conditions at 25 percent, 50 percent, and 100 percent full load current.

b) Load test each VFD at a minimum ambient temperature of 40 degrees Celsius.
   (1) Monitor and record temperature rise.
   (2) Once temperature rise stops continue to operate the VFD for a minimum of 2 hours.
      (a) If operating temperature exceeds the rated value, repair or replace the VFD and retest.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 16050.

B. Install the VFD per the manufacturer's guidelines and submitted installation instructions to meet the seismic requirements at the Project Site.

C. General:
   1. Furnish all cables, conduit, lugs, bolts, expansion anchors, sealants, and other accessories needed to complete installation of the VFD (free-standing or within motor control center).
   2. Assemble and install the VFD in the locations and with the layouts indicated on the Drawings.
   3. Perform Work in accordance with the manufacturer's instructions and shop drawings.
   4. Furnish components, and equipment as required to complete the installation.
   5. Replace any hardware lost or damaged during the installation or handling to provide a complete installation.
   6. Install free-standing enclosures on 3-1/2-inch raised concrete house keeping pad:
      a. Provide structural leveling channels in accordance with the manufacturer's recommendations to provide proper alignment of the units.
      b. Weld and/or bolt the VFD frame to the leveling channels.
   7. Provide openings in top or bottom of the VFD (free-standing or within motor control center) enclosure for conduit only, no additional openings will be allowed:
      a. Improperly cut holes will require that the entire panel be replaced:
         1) No hole closers or patches will be allowed.
   8. Bundle circuits together and terminate in each unit:
      a. Tie with nylon wire ties. As specified in Section 16123.
      b. Label all wires at each end with wire numbers shown on the approved Control Drawings.
      c. All connections to and from the VFD (free-standing or within motor control center) enclosure must be made via terminal blocks.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 FIELD QUALITY CONTROL

A. As specified in Section 16050.

B. Provide the services of a VFD manufacturer representative for start-up assistance and training:
   1. Inspection and field adjustment:
      a. Supervise the following and submit written certification that the equipment and controls have been properly installed, aligned, adjusted, and readied for operation.
   2. Start-up field testing:
      a. Provide technical direction for testing, checkout, and start-up of the VFD equipment in the field.
      b. Under no circumstances are any portions of the drive system to be energized without authorization from the manufacturer's representative.
      c. Compliance with the following specified parameters shall be verified by the VFD manufacturer:
         1) Power factor:
            a) Make field measurements at the input terminals of the VFD with and without the VFD in operation.
            b) Make measurements at 0 percent, 25 percent, 50 percent, 75 percent and 100 percent of rated speed and rated power.
            c) Measurements shall be made with a recording type power factor meter.
         2) Efficiency:
            a) Make field measurements at the input terminals of the VFD.
            b) Make measurements at rated speed and rated power.
            c) Make measurements with a recording type kilowatt hour meter.
         3) Motor terminal voltage:
            a) Make field measurements at the motor connection box.
            b) Make measurements of the full speed range of the VFD.
            c) Make measurements with a recording tye oscilloscope.
         4) Harmonics:
            a) Make field measurements at the input terminals of the VFD with and without the VFD in operation.
            b) Make measurements at rated speed and rated power.
            c) Harmonic testing shall include utility power as well as generator standby power.
            d) Make measurements with a recording type harmonic analyzer displaying individual and total harmonic currents and voltages:
               (1) Record currents and voltages for a minimum of 10 minutes.
               (2) Analyzers using snapshots are not acceptable.

3.08 ADJUSTING

A. Make all adjustments as necessary and recommended by the manufacturer, ENGINEER, or testing firm.

B. Provide the services of a VFD manufacturer factory technician to make all drive parameter and protective device settings:

1. Protective device settings provided by the VFD manufacturer in accordance with the manufacturer of the driven equipment requirements.
2. Provide documentation of VFD settings included but not limited to:
   a. Minimum speed.
   b. Maximum speed.
   c. Skip speeds.
   d. Current limit.
   e. Acceleration time.
   f. Deceleration time.
   g. Carrier frequency.

3.09 CLEANING

A. As specified in Section 16050.

3.10 DEMONSTRATION AND TRAINING

A. As specified in Section 16050.

B. Demonstrate the operation to the ENGINEER's and OWNER's satisfaction.

C. Training:
   1. Provide instruction of the OWNER’s operation and maintenance staff on the operation and maintenance of the VFD.
   2. Separate classes shall be held for the operations staff and maintenance staff:
      a. Instruction shall occur at the OWNER’s facility and shall utilize the actual VFDs installed at the site.

3.11 PROTECTION

A. As specified in Section 16050.

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 16272

DRY TYPE TRANSFORMERS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Enclosed dry-type transformers:
      a. Standalone units.
      b. Units located in motor control centers.
      c. Units located in packaged power supply centers.
      d. Drive isolation transformers.
      e. Rated 1 to 1,000 kilovolt-amperes, single and 3-phase.
      f. Primary voltage 600 volts and below.

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 - Seismic Design Criteria.
      c. Section 16050 - Common Work Results for Electrical.

1.02 REFERENCES

A. As specified in Section 16050.

B. American National Standards Institute (ANSI):
   1. C57.96 - Distribution and Power Transformers, Guide for Loading Dry-Type.
   2. 389 - IEEE Recommended Practice for Testing Electronics Transformers and Inductors.

C. Institute of Electrical and Electronics Engineers (IEEE):
   1. C57.12.01 - Standard General Requirements for Dry-Type Distribution and Power Transformers Including Those with Solid Cast and/or Resin Encapsulated Windings.

D. National Electrical Manufacturers Association (NEMA):
   1. TP-1 - Guide for Determining Energy Efficiency for Distribution Transformers.
   2. TP-2 - Standard Test Method for Measuring the Energy Consumption of Distribution Transformers.

E. Underwriters Laboratory (UL):
   1. 1561 - Standard for Dry-Type General Purpose and Power Transformers.

1.03 DEFINITIONS

A. As specified in Section 16050.

1.04 SYSTEM DESCRIPTIONS

A. Provide 3-phase or 1-phase, 60 hertz dry-type with voltage ratings, kilovolt-ampere capacities, and connections as indicated on the Drawings:
   1. Transformers shall provide full capacity at the Project elevation and environmental conditions as specified in Section 16050 after all derating factors have been applied.
   2. Suitable for continuous operation at full rating with normal life expectancy in accordance with ANSI C57.96.

1.05 SUBMITTALS

A. Furnish submittals as specified in Sections 01330 and 16050.

B. Product data:
   1. Catalog cut sheets.
   2. Nameplate data.
   3. Dimensions:
      a. Height.
      b. Width.
      c. Depth.
   4. Inrush current.
   5. Insulation system and temperature constraints.
   6. Number and rating of taps.
   7. Sound levels.
   8. Connection diagrams:
      a. Primary.
      b. Secondary.
   9. BIL rating.
   10. Required clearances.
   11. Percent impedance.
   12. Efficiency.
   13. Certification of full capacity capability at the Project elevation and ambient conditions.

C. Installation instructions:
   1. Provide anchorage instructions and requirements for the transformer based on the seismic requirements at the Project Site as specified in Section 16050.
   2. Drawings and calculations stamped and signed by a professional engineer registered in the state where the Project is located.

1.06 QUALITY ASSURANCE

A. As specified in Section 16050.

1.07 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 16050.

1.08 PROJECT OR SITE CONDITIONS

A. As specified in Section 16050.

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

A. As specified in Section 16050.

1.12 SYSTEM STARTUP

A. As specified in Section 16050.

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 COMMISSIONING (NOT USED)

1.15 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. One of the following or equal:
   1. General Electric.
   2. Jefferson.
   3. Schneider Electric/Square D.
   4. Eaton/Cutler-Hammer.
   5. ABB.

B. Drive isolation transformers: One of the following or equal:
   1. General Electric.
   2. Schneider Electric/Square D.
   3. Eaton/Cutler-Hammer.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS

A. Cores:
   1. Non-aging, grain-oriented silicon steel.
   2. Magnetic flux densities below the saturation point.

B. Windings:
   1. High-grade magnet wire.
   2. Impregnated assembly with non-hydroscopic, thermo-setting varnish:
      a. Cured to reduce hot-spots and seal out moisture.
   3. Material electrical grade:
      a. Copper.

2.04 MANUFACTURED UNITS (NOT USED)

2.05 EQUIPMENT

A. General:
   1. 10 kilovolts BIL for 600-volt class windings.
   2. Sound levels, in accordance with ANSI 389 test conditions, not to exceed:

Kilovolt-Amperes Range	Audible Sound Level (db)
1-9	40
10-50	45
51-150	50
151-300	55
301-500	60
501-700	62
701-1000	64

   3. Taps:
      a. 15 kilovolt-amperes and less:
         1) Two 5 percent full capacity primary taps below rated voltage.
      b. 25 kilovolt-amperes and larger:
         1) Four 2.5 percent full capacity primary taps below rated voltage.
         2) Two 2.5 percent full capacity primary taps above rated voltage.
      c. Operated by a tap changer handle or tap jumpers accessible through a panel.
   4. Terminals:
      a. UL listed for either copper or aluminum conductors.
      b. Rated for 75 degrees Celsius.
   5. Daily overload capacities, at rated voltage and without reduction in life, in accordance with ANSI C57.96.

B. Transformers less than 15 kilovolt-amperes:
   1. Insulation class: 185 degrees Celsius.
   2. Temperature rise: 115 degrees Celsius.

C. Energy efficient transformers 15 kilovolt-amperes and larger:
   1. Insulation class: 220 degrees Celsius.

2. Temperature rise: 80 degrees Celsius, except as noted below:
   a. 150-degree Celsius rise for dry-type transformers located in motor control centers.
3. Efficiency:
   a. In accordance with NEMA TP-1.
   b. Measured in accordance with NEMA TP-2.

D. Drive isolation transformers:
1. Specifically designed to power adjustable speed drives:
   a. Direct current drives with silicon-controlled rectifiers.
   b. Variable frequency drives with IGBTs.
2. Provide line isolation.
3. With added coil bracing and symmetrically placed taps to minimize mechanical forces caused by the severe and high frequency firing of solid-state devices on the input stages of the variable frequency drives.
4. Mechanically designed to protect the transformer from the regenerative duty and frequent short circuits associated with drives.
5. Delta-Wye connection:
   a. Designed to trap the triplen harmonics generated by the drives from reaching the power lines.
   b. Provide a grounded connection from the secondary to the drives that isolate the secondary neutral from the primary neutral.
6. UL listed and recognized:
   a. UL 1561.

E. Enclosures:
1. Heavy gauge steel:
   a. Outdoor: Moisture and water resistant with rodent screens over all openings and in a weather-protected enclosure, NEMA Type 4X.
   b. Indoor: NEMA Type 2.
2. Louvers to limit coil temperature rise to the value stated above, and case temperature rise to 50 degrees Celsius.
3. Built-in vibration dampeners to isolate the core and coils from the enclosure:
   a. Neoprene vibration pads and sleeves.

2.06 COMPONENTS (NOT USED)

2.07 ACCESSORIES

A. Nameplates:
1. Non-corrosive metal or UL listed non-metallic:
   a. Stamped, engraved or printed with the following information:
      1) Phases.
      2) Frequency.
      3) Kilovolt-ampere rating.
      4) Voltage ratings.
      5) Temperature rise.
      6) Impedance.
      7) Insulation class.
      8) BIL rating.
      9) Connection diagram.
      10) Weight.

11) Manufacturer.
12) The identification “transformer.”
13) Classes of cooling.
14) Tap voltage(s).
15) Vector diagram.

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES

A. Finish to consist of de-greasing, phosphate cleaning, and an electrodeposited ANSI 61 gray enamel rust-inhibiting paint.

2.11 SOURCE QUALITY CONTROL

A. Factory tests:
   1. Applied voltage test to each winding and from each winding to the core:
      a. 600-volt class winding 4.5 kilovolt.
   2. Induced voltage test at 2 times normal voltage and 400 hertz for 1,080 cycles.
   3. Voltage ratio and polarity.
   4. Sound level, performed in a test room with ambient sound level not exceeding 24 db.
   5. Perform all tests in accordance with UL 1561.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 16050.

B. General:
   1. Floor, wall, platform, motor control center, packaged power supply, or roof mounted, as indicated on the Drawings.
   2. Locate where not in direct contact with building structure.
   3. Install on double-deflection mounts selected for maximum isolation manufactured by Korfund or equal.
   4. Make any necessary connections to the enclosure with liquidtight flexible conduit having neoprene gaskets and insulated ground bushings.
   5. Ground the enclosure:
      a. To an equipment ground conductor in the conduit.
      b. To the facility grounding electrode system.
   6. Floor mounted transformers:
      a. Install transformers on 3-1/2-inch housekeeping pads.
      b. Install transformers with adequate space from walls or other enclosures for proper ventilation in accordance with the manufacturer’s recommendations.

3.04 ERECTION, INSTALLATION, APPLICATIONS, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 FIELD QUALITY CONTROL

A. As specified in Section 16050.

3.08 ADJUSTING

A. Set the transformer taps as required to obtain nominal output voltage on the secondary terminals.

3.09 CLEANING

A. As specified in Section 16050.

3.10 DEMONSTRATION AND TRAINING (NOT USED)

3.11 PROTECTION

A. As specified in Section 16050.

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 16285

SURGE PROTECTIVE DEVICES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. High-energy surge protective devices.

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 01740 - Warranties and Bonds.
      c. Section 16050 - Common Work Results for Electrical.
      d. Section 16950 - Field Electrical Acceptance Tests.

1.02 REFERENCES

A. As specified in Section 16050.

B. Institute of Electrical and Electronics Engineers (IEEE):
   1. C62.41 – Recommended Practice on Surge Voltages in Low Voltage AC Power Circuits.
   2. C62.45 –Guide on Surge Testing for Equipment Connected to Low-Voltage (1000 V and Less) AC Power Circuits.
   3. C62.62- Standard Test Specifications for Surge Protective Devices for Low Voltage AC Power Circuits.

C. Underwriters Laboratory:
   1. 1449, 3rd Edition, Standard for Surge Protective Devices.

1.03 DEFINITIONS

A. As specified in Section 16050.

B. Specific definitions:
   1. SPD: Surge protective device.
   2. SAD: Silicon avalanche diode.
   3. MOV: Metal oxide varistor.
   4. MCOV: Maximum continuous operating voltage.
   5. I_n: Nominal discharge current.

6. VPR: Voltage protection rating.
7. SCCR: Short circuit current rating.

1.04 SYSTEM DESCRIPTION

A. Surge protective devices as an integral component of the electrical equipment or externally mounted as indicated on the Drawings.

1.05 SUBMITTALS

A. Furnish submittals as specified in Sections 01330 and 16050.

B. Product data:
1. Furnish complete product data confirming detailed compliance or exception statements to all provisions of this Section.
2. Manufacturer's catalog cut sheets indicating:
   a. Manufacturer and model numbers.
   b. Ratings of each SPD including but not limited to:
      1) Short circuit current rating.
      2) Nominal discharge current.
      3) Maximum continuous operating voltage.
      4) Voltage protection rating.
      5) System voltage.
      6) System frequency.
      7) Surge current capacity.
3. Submit independent test data from a nationally recognized testing laboratory verifying the following:
   a. Overcurrent protection.
   b. UL 1449.

C. Shop drawings:
1. Provide electrical and mechanical drawings by the manufacturer that detail:
   a. Unit dimensions.
   b. Weights.
   c. Components.
   d. Field connection locations.
   e. Mounting provisions.
   f. Connection details.
   g. Wiring diagram.

D. Operation and maintenance manuals:
1. Provide the manufacturer's manual with installation, start-up, spare parts lists, and operating instructions for the specified system.

1.06 QUALITY ASSURANCE

A. As specified in Section 16050.

B. Provide SPD units that are designed, manufactured, tested and installed in compliance with the following codes and standards:
1. Institute of Electrical and Electronics Engineers (IEEE C62.41, C62.45, C62.62).
2. Federal Information Processing Standards Publication 94 (FIBS PUB 94).
3. National Electrical Manufacturer Association.

4. National Fire Protection Association (NFPA 20, 75 and 780).
5. National Electric Code (NFPA 70).
6. Underwriters Laboratories (UL 1449 3rd Edition and UL 1283).
7. International Electrotechnical Commission (IEC 801).

1.07 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 16050.

1.08 PROJECT OR SITE CONDITIONS

A. As specified in Section 16050.

1.09 SEQUENCING

A. Coordinate with and provide SPD equipment to the electrical equipment manufacturer before final assembly and factory testing.

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

A. As specified in Section 16050.

B. Extended warranty:
   1. Furnish a manufacturer’s full 5-year parts and labor warranty against any part failure when installed in compliance with manufacturer's written instructions, UL listing requirements, and any applicable national, state, or local electrical codes. The warranty shall commence from the date specified in Section 01740.
   2. Warranty shall include:
      a. Direct, factory trained employees must be available within 48 hours for assessment of the problem.
      b. A 24-hour toll-free 800-number for warranty support.

1.12 SYSTEM START-UP

A. As specified in Section 16050.

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 COMMISSIONING (NOT USED)

1.15 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. One of the following or equal:
   1. Liebert.
   2. Eaton/Cutler-Hammer.

3. Schneider Electric/Square D.
4. General Electric.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS (NOT USED)

2.04 MANUFACTURED UNITS

A. Provide SPD units as required for the locations indicated on the Drawings.

B. Electrical requirements:
1. SPD ratings are to be consistent with the nominal system operating voltage, phase, and configuration as indicated on the Drawings.
2. MCOV:
   a. For the SPD and all components in the suppression path (including all MOVs, SADs, and selenium cells): Greater than 115 percent of the nominal system operating voltage.
3. Operating frequency:
   a. 47 to 63 hertz.
4. SCCR:
   a. 65 kAIC minimum, but not less than the equipment it is connected to as indicated on the Drawings.
   b. The SCCR shall be marked on the SPD in accordance with UL 1449 and the NEC.
5. Nominal discharge current I_n:
   a. 20 kA.
6. Maximum VPR:

Modes	240/120	208Y/120	480Y/277
L-N, L-G, N-G	900	900	1,500
L-L	1,200	1,200	2,000

7. Peak surge current:
   a. Service entrance locations:
      1) 240 kA per phase minimum.
      2) 120 kA per mode minimum.
   b. Branch locations:
      1) 120 kA per phase, minimum.
      2) 60 kA per mode minimum.

C. Protection modes:
1. Provide SPD protection modes as follows:
   a. Line to Neutral (L-N) where applicable.
   b. Line to Ground (L-G).
   c. Neutral to Ground (N-G), where applicable.

D. Environmental requirements:
1. Storage temperature:
   a. -40 degrees to +50 degrees Celsius.
2. Operating temperature:
   a. -0 degrees to +60 Celsius.

3. Relative humidity:
   a. 5 percent to 95 percent.
4. Audible noise:
   a. Less than 45 dBa at 5 feet (1.5 m).
5. Operating altitude:
   a. Zero to 12,000 feet above sea level.

E. Provide surge protective devices that are suitable for application in IEEE C62.41 Category A, B, and C3 environments, as tested to IEEE C62.45.

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS

A. Enclosure:
   1. Located in electrical equipment as indicated on the Drawings.

B. Internal connections:
   1. Provide low impedance copper plates for intra-unit connections:
      a. Attach surge modules using bolted connections to the plates for low impedance connections.
   2. Size all connections, conductors, and terminals for the specified surge current capacity.

C. Surge diversion modules:
   1. MOV:
      a. Where multiple MOVs are used in parallel, utilize computer matched MOVs to within 1 volt variance and tested for manufacturer's defects.

D. Overcurrent protection:
   1. Individually fuse all components, including suppression, filtering, and monitoring components:
      a. Rated to allow maximum specified nominal discharge current capacity.
      b. Overcurrent protection that limits specified surge currents is not acceptable.

E. Connections:
   1. Provide terminals to accommodate wire sizes up to #2 AWG.

2.07 ACCESSORIES

A. Unit status indicators:
   1. Provide red and green solid-state indicators, with printed labels, on the front cover to redundantly indicate on-line unit status:
      a. The absence of the green light and the presence of the red light indicates that surge protection is reduced and service is needed to restore full operation.
      b. Indicates the status of protection on each mode or phase.

B. Dry contacts for remote monitoring where indicated on the Drawings:
   1. Electrically isolated Form C dry contacts (1 A/125 VAC) for remote monitoring of system integrity, and indication of under voltage, phase and/or power loss.

C. Provide an audible alarm which activates under any fault condition.
   1. Provide an alarm On/Off switch to silence the alarm.

2. A visible LED will confirm whether alarm is On or Disabled.
3. Locate both switches and the audible alarm on the unit's front cover.

D. Provide transient counter to count transient voltage surges:
1. LCD readout located on the unit's front cover.
2. Counter to utilize batteries with a 10-year nominal life or non-volatile memory to maintain accurate counts in the event of power loss.

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL

A. Permanently affix surge rating to the SPD.

B. Perform manufacturer's standard factory test.
1. Perform testing in accordance with UL 1449.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 16050.

B. Follow the manufacturer's recommended installation practices and comply with all applicable codes.

C. Special techniques:
1. Install the SPD with as short and straight conductors including ground conductor as practically possible:
a. Twist the input conductors together to reduce input conductor inductance.
2. Do not subject SPD to insulation resistance testing.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 FIELD QUALITY CONTROL

A. As specified in Section 16950.

3.08 ADJUSTING (NOT USED)

3.09 CLEANING (NOT USED)

3.10 DEMONSTRATION AND TRAINING (NOT USED)

3.11 PROTECTION

A. As specified in Section 16050.

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 16290

POWER METERS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Power meters.

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. As specified in Section 16050.

B. American National Standard Institute (ANSI):
   1. C12.20 - Electricity Meters - 0.2 and 0.5 Accuracy Classes.

C. Institute of Electrical and Electronics Engineers (IEEE):
   1. C57.13.6 – Standard for High Accuracy Instrument Transformers.

1.03 DEFINITIONS

A. As specified in Section 16050.

B. Specific definitions:
   1. FS - Full Scale.
   2. RDG - Of Reading.
   3. SSM - Solid State Multifunction Power Meter.
   4. THD - Total Harmonic Distortion.

1.04 SYSTEM DESCRIPTION

A. Power meter Type SSM1, general voltage, power and energy (kWh).

1.05 SUBMITTALS

A. Furnish submittals as specified in Sections 01330 and 16050.

B. Product data:
   1. Power meter data including but not limited to:
      a. Power requirements.
      b. Communications protocols.
      c. Input/outputs.
      d. Dimensions.
      e. Measurement functions.
      f. Front panel controls.
      g. Display characteristics.

C. Operation and maintenance manuals:
   1. Descriptive and technical bulletins and sales aids edited to reflect only the equipment to be provided and covering each of the components in the system.
   2. A maintenance section including all instruction leaflets and technical data necessary to setup, change setup and maintain the power meters.
   3. Original licensed copies of all software and software manuals.

1.06 QUALITY ASSURANCE

A. As specified in Section 16050.

1.07 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 16050.

1.08 PROJECT OR SITE CONDITIONS

A. As specified in Section 16050.

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

A. As specified in Section 16050.

1.12 SYSTEM START-UP

A. As specified in Section 16050.

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 COMMISSIONING (NOT USED)

1.15 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. One of the following or equal:
   1. Allen-Bradley.
   2. Eaton/Cutler-Hammer.
   3. General Electric.
   4. Schneider Electric/Square D.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS (NOT USED)

2.04 MANUFACTURED UNITS (NOT USED)

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS

A. Power meters:
   1. Power meter type 1 (SSM1) device which shall include at a minimum:
      a. Individual phase currents, plus or minus 0.5 percent FS.
      b. Phase-to-phase and phase-to-neutral voltages, plus or minus 0.5 percent FS.
      c. Watts, VARs, VA, plus or minus 1 percent FS.
      d. Watt-hours, VAR-hours, VA-hours, plus or minus 1 percent FS.
      e. PF (apparent and displacement), plus or minus 2 percent FS.
      f. Frequency, plus or minus 1 percent hertz.
      g. Demand:
         1) Ampere, plus or minus 0.5 percent full scale.
         2) Watt, VAR, VA, plus or minus 1 percent full scale.
      h. Minimum and maximum values:
         1) Volts (L-L), volts (L-N), current, watts, VARS, VA.
         2) Power factor:
            a) Apparent.
            b) Displacement.
            c) Frequency.
      i. Synch-input kilowatts utility.
      j. LCD with LED backlight.

2.07 ACCESSORIES

A. Current transformers:
   1. Ring type current transformers:
      a. Suitable for service within low or medium voltage equipment as indicated on the Drawings.
      b. Designed to have a mechanical and thermal rating to withstand short-circuit current, stresses, and heating effects equal to the rating of the equipment of the application.

2. Current ratio: As indicated on the Drawings, for use as a guideline:
   a. It is the manufacturer's responsibility to size the current transformers to ensure that they will not saturate under the maximum available fault current at the installed location based upon the fault current study as specified in Section 16305.
3. Rated in accordance with IEEE C57.13.6 with accuracy of the current transformers suitable for relay accuracy class and rated for 200 percent burden for the required connected devices.
4. Identify polarity with standard marking or symbols.
5. Capable of carrying rated primary current continuously without damage.
6. Install secondary wiring from current transformers in a suitable wiring trough, or conduit to proper short-circuiting type terminal blocks for connection to relays, instruments, and other devices.

B. Potential transformers:
1. Indoor dry type, single-phase, 60 hertz, with a minimum thermal capacity of not less than 400 volt-amperes at 55 Celsius rise above 40 Celsius ambient.
2. Accuracy classification determined in accordance with IEEE C57.13.6, suitable for relay accuracy class, and 200 percent burden, for the required connected devices, with the secondary voltage 120 volts.
3. Insulation levels as required for the equipment system voltage but not less then:
   a. 600 VAC, 10 kV BIL for 480 VAC systems.
4. Identify polarity with standard markings or symbols.
5. Connect transformer secondary to potential buses as required.
6. Protect low voltage potential transformers on the primary side and secondary side with current-limiting fuses.

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 16050.

B. Install power meters in the electrical equipment as indicated on the Drawings.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 FIELD QUALITY CONTROL

A. As specified in Section 16050.

3.08 ADJUSTING (NOT USED)

3.09 CLEANING

A. As specified in Section 16050.

3.10 DEMONSTRATION

A. As specified in Section 16050.

3.11 PROTECTION

A. As specified in Section 16050.

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 16295

PROTECTIVE RELAYS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Protective relays.
   2. Current transformers.
   3. Potential transformers.

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 01660 - Testing, Training, and Commissioning.
      c. Section 16050 - Common Work Results for Electrical.
      d. Section 16075 - Electrical Identification.
      e. Section 16290 - Power Meters.
      f. Section 16305 - Electrical System Studies.

1.02 REFERENCES

A. As specified in Section 16050.

B. American National Standards Institute (ANSI):
   1. C39.1 - Requirements for Electrical Analog Indicating Instruments.

C. Institute of Electrical and Electronic Engineers (IEEE):
   1. C37.90 - IEEE Standard for Relays and Relay Systems Associated with Electric Power Apparatus.
   2. C37.90.1 - IEEE Standard Surge Withstand Capability (SWC) Tests for Relays and Relay Systems Associated with Electric Power Apparatus.
   3. C37.90.2 - IEEE Standard for Withstand Capability of Relay Systems to Radiated Electromagnetic Interference from Transceivers.
   4. C37.90.3 IEEE Standard Electrostatic Discharge Tests for Protective Relays
   5. C57.13 – IEEE Standard Requirements for Instrument Transformers.

D. International Electrotechnical Commission (IEC):
   1. 60255-5 – Electrical Relays Part 5: Insulation coordination for measuring relays and protection equipment – Requirements and tests.
   2. 60255-22-1 - Measuring relays and protection equipment – Part 22-1: Electrical disturbance tests – MHz burst immunity tests.

1.03 DEFINITIONS

A. As specified in Section 16050.

1.04 SYSTEM DESCRIPTION

A. General: Provide protective relays, current transformers, and potential transformers with the protective functions as indicated on the Drawings:
   1. Provide all relays from a single manufacturer unless otherwise noted.

1.05 SUBMITTALS

A. Furnish submittals as specified in Sections 01330 and 16050:
   1. Provide the Protective Relay submittal as part of the switchgear submittal.

B. Product data:
   1. Manufacturer of relay.
   2. Relay ANSI device functions.
   3. Power requirements.
   4. Communications provisions.
   5. Controls.
   6. Mounting.
   7. Nameplate schedule.
   8. Bill of material.
   9. Description of operation.
   10. Manufacturers time current curves for protective devices, printed on 11-inch by 17-inch log-log paper.
   11. List of recommended spare parts.
   12. Name, address, telephone number, and cell phone number of relay manufacturer's authorized local field service technician.

C. Shop drawings:
   1. Provide fully dimensioned and to scale equipment layout drawings which include:
      a. Equipment furnished: Plan, front and side views.
   2. Complete electrical wiring diagrams:
      a. Indicate wire numbers.

D. Operation and maintenance manuals:
   1. Submit operating and installation instructions and a maintenance manual presenting full details for care and maintenance of equipment of every nature furnished and/or installed under this contract.
   2. Maintenance manual:
      a. Furnish maintenance manuals with instructions covering details pertaining to care and maintenance of the equipment as well as data identifying the parts.

b. These manuals shall include but are not limited to the following:
   1) Adjustment and test instructions covering the steps involved in the initial test, adjustment, and start-up procedures.
   2) Detailed control instructions that outline the purpose and operation of every control device used in normal operation.

E. Test reports:
   1. Switchgear manufacturer to furnish a certified report after the shop tests.
   2. Switchgear manufacturer's start-up representative to furnish a written report after the start-up:
      a. Report must state that the installation is complete and satisfactory, or list items requiring additional attention and a proposal for the actions.
   3. If items require attention after the initial start-up, a final report is required stating that the installation is complete and satisfactory.

F. Calculations:
   1. Direct current power and current requirements needed to operate the protective relays and associated equipment.
   2. Current transformer sizing calculations to substantiate that the current transformers will not saturate under a maximum fault current event.

1.06 QUALITY ASSURANCE

A. As specified in Section 16050.

B. Relays, instrument transformers, and associated equipment shall be UL listed and labeled.

1.07 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 16050.

1.08 PROJECT/SITE CONDITIONS (NOT USED)

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

A. As specified in Section 16050.

1.12 SYSTEM START-UP

A. As specified in Section 16050.

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 COMMISSIONING (NOT USED)

1.15 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Distribution relays:
   1. One of the following or equal:
      a. Basler.
      b. Schweitzer.
      c. Multilin.

B. Motor protection relays:
   1. One of the following or equal:
      a. Multilin.
      b. Schweitzer.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS (NOT USED)

2.04 MANUFACTURED UNITS (NOT USED)

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS

A. Distribution relays:
   1. General:
      a. Furnish relays complete with devices and associated circuitry necessary to perform the required functions as specified or indicated on the Drawings.
      b. Manufacturers of relays and controls are listed to describe system operating requirements:
         1) Other manufacturers will be considered where equivalent relay operating characteristics can be provided that are acceptable to the Engineer.
      c. Furnish material not specifically listed or shown but necessary to perform required functions.
      d. Mounting:
         1) Mount relays on hinged panels secured to the metal-clad unit:
            a) Enclose cases with dull black finish, semi-flush mounting.
      e. Provide nameplates as specified in Section 16075.
   2. Lockout relay:
      a. Where indicated on the Drawings provide an ANSI function 86 lockout relay.
      b. Operating voltage: 48 VDC Trip control.
      c. Block close control.

d. Green LED for ready indication.
e. Red LED for tripped indication.
f. Black RESET target.
g. Orange TRIP target.
h. Manual reset.
i. Electroswitch Series 24 or equal.

3. Solid state digital relays:
   a. General:
      1) Multifunction, microprocessor based with monitoring and communications capabilities.
      2) Continuous self-diagnostics.
      3) Fault recording:
         a) The relay shall monitor and record fault data.
         b) Fault events shall be stored in event reports.
         c) Event reports saved to non-volatile memory.
      4) Front keypad and display for programming and configuration:
         a) One control pushbutton programmed to set relay protective functions to the minimum values.
         b) Password protection for security.
      5) A minimum of 2 programmable digital inputs and 4 form C programmable outputs.
      6) Installation and control connections, one of the following:
         a) Draw-out case that allows removal of the relay without having to disconnect wiring. CT circuits shall be self-shorting with make-before-break operation on removal of the relay.
         b) Connectorized terminals with shorting for each current input.
      7) ANSI curves.
      8) Power supply suitable for operation on 48 VDC.
   b. Main breaker protection relays:
      1) Provide the following functions as a minimum: The functions specified below are typical for multifunction relays. Relay functions not indicated on the Drawings are to be disabled:
         a) Undervoltage/Overvoltage 27/59.
         b) Instantaneous ground overcurrent - 50G.
         c) Negative sequence - 47N.
      2) Manufacturers:
         a) Basler BE1-951.
         b) Multilin 750.
         c) Schweitzer SE-451.
   c. Feeder breaker protection relays:
      1) Provide the following functions as a minimum:
         a) Phase time overcurrent - 51P.
         b) Instantaneous phase overcurrent - 50P.
         c) Ground time overcurrent - 51G.
         d) Instantaneous ground overcurrent - 50G.
      2) Manufacturers:
         a) Basler BE1-851.
         b) Schweitzer SEL-351S.
         c) Multilin 735.

d. Generator breaker protection relays:
   1) Provide the following functions as a minimum:
      a) Undervoltage - 27.
      b) Overfrequency/underfrequency - 81O/U.
      c) Overvoltage - 59.
      d) Voltage phase reversal - 47.
      e) Instantaneous ground overcurrent – 50.
   2) Manufacturers:
      a) Multilin 489.
      b) Schweitzer SEL-300G.

2.07 ACCESSORIES

A. Current transformers:
   1. Ring type current transformers:
      a. Suitable for service within low voltage switchgear as indicated on the Drawings.
      b. Designed to have a mechanical and thermal rating to withstand short-circuit current, stresses, and heating effects equal to the rating of the circuit breaker of the application.
   2. Current ratio:
      a. It is the switchgear manufacturer's responsibility to size the current transformers to ensure that they will not saturate under the maximum available fault current at the installed location based upon the fault current study as performed as specified in Section 16305.
   3. Rated in accordance with ANSI Standard C57.13 with accuracy of the current transformers suitable for relay accuracy class and rated for 200-percent burden for the required connected devices.
   4. Identify polarity with standard marking or symbols.
   5. Capable of carrying rated primary current continuously without damage.
   6. Install secondary wiring from current transformers in a suitable wiring trough, or conduit to proper short-circuiting type terminal blocks for connection to relays, instruments, and other devices.
   7. Located behind the breaker compartment mechanical safety shutter and shall be front accessible once the safety shutter is removed.

B. Potential transformers:
   1. Indoor dry type, single-phase, 60 hertz, with a minimum thermal capacity of not less than 400 volt-amperes at 55 degrees Celsius rise above 40 degrees Celsius ambient.
   2. Accuracy classification in accordance with ANSI Standard C57.13, suitable for relay accuracy class, and 200-percent burden, for the required connected devices, with the secondary voltage 120 volts.
   3. Insulation levels as required for the switchgear system voltage but not less then:
      a. 600 VAC, 10 kV BIL for 480 VAC systems.
      b. 5.6 kilovolts, 60 kilovolts BIL for 2300 and 4160 VAC systems.
      c. 15.5 kilovolts, 110 kilovolts BIL for 12.47 kilovolts and 13.2 kilovolts systems.
   4. Identify polarity with standard markings or symbols.
   5. Connect secondaries to potential buses as required.

6. Protect medium voltage potential transformers on the primary side with medium voltage current-limiting fuses.
7. Protect low voltage potential transformers on the primary side and secondary side with current-limiting fuses.
8. Mount medium voltage potential transformers in a separate compartment on a drawout device, which, when in the FULLY WITHDRAWN position, disconnects both primary and secondary terminals of the transformer and grounds the primary potential fuses.

C. Control wiring:
1. As specified in the switchgear specifications.

D. Miscellaneous:
1. Provide terminal blocks, wireways, wiring, device mounting brackets, and other miscellaneous items.

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. Provide the services of the switchgear manufacturer is to:
1. Inspect, verify, and certify that the mechanical installation meets the manufacturer's requirements.

3.04 ERECTION, INSTALLATION, APPLICATION CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 FIELD QUALITY CONTROL

A. As specified in Section 16050.

3.08 ADJUSTING

A. Adjust trip settings in accordance with the protective device coordination study as accepted by the Engineer and in accordance with the manufacturer's recommendations.

3.09 CLEANING

A. As specified in Section 16050.

3.10 DEMONSTRATION AND TRAINING

A. As specified in Section 16050.

B. Demonstrate the operation to the Engineers and Owner's satisfaction.

C. Training:
   1. Provide as specified in Section 01660 and supplemented by the conditions below:
      a. Training on the relays provided under this section shall be conducted as part of the associated switchgear training.

3.11 PROTECTION

A. As specified in Section 16050.

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 16305

ELECTRICAL SYSTEM STUDIES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Short circuit fault analysis study.
   2. Protective device coordination study.
   3. Arc-flash hazard study.

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. As specified in Section 16050.

B. Institute of Electrical and Electronics Engineers (IEEE):
   1. 141 - IEEE Recommended Practice for Electric Power Distribution for Industrial Plants (Red Book).
   2. 242 - IEEE Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems (Buff Book).
   3. 315 - IEEE Standards Electrical and Electronics Graphic and Letter Symbols and Reference Designations.
   4. 399 - IEEE Recommended Practice for Industrial and Commercial Power Systems Analysis (Brown Book).
   5. 902 - IEEE Guide for Maintenance, Operation and Safety on Industrial and Commercial Power Systems (Yellow Book).
   6. 1015 - IEEE Recommended Practice For Applying Low Voltage Circuit Breakers Used in Industrial and Commercial Power Systems - Corrigendum 1 (Blue Book).
   7. 1584 - IEEE Guide for Performing Arc Flash Hazard Calculations.

C. National Fire Protection Association (NFPA):
   1. 70E - Standard for Electrical Safety in the Workplace.

1.03 DEFINITIONS

A. As specified in Section 16050.

1.04 SYSTEM DESCRIPTION

A. General study requirements:
   1. Scope:
      a. The short-circuit fault analysis, protective device coordination and arc-flash hazard studies shall include all equipment in the power distribution system including but not limited to:
         1) Utility equipment.
         2) Switchgear.
         3) Switchboards.
         4) Generators.
         5) Transformers:
            a) Including all dry-type transformers.
         6) Motor control centers.
         7) Free standing variable frequency drives and starters.
         8) Disconnect switches.
         9) Motors.
         10) Panelboards:
            a) Including all 240 and 208 volt systems.
         11) Vendor control panels.
         12) HVAC equipment.
      b. Study scenarios:
         1) The studies shall include all possible electrical system configurations, for example:
            a) Operation on normal (utility) source.
            b) Operation on generator source.
   2. Obtain, for all equipment, the required data for preparation of the study, including, but not limited to:
      a. Transformer kilovolt-ampere (kVA) and impedances.
      b. Generator impedances.
      c. Generator decrement curves.
      d. Bus withstand ratings.
      e. Cable and bus data.
      f. Protective device taps, time dials, instantaneous pickups, and time delay settings.
   3. Obtain the Electric Utility information on the minimum and maximum available fault current, minimum and maximum utility impedances, utility protective device settings including manufacturer and model number, interrupting ratings, X/R ratios, and model information one level above the point of connection:
      a. Utility tolerances and voltage variations.
   4. The individual performing the studies shall visit the site and collect all necessary field data in order to perform and complete comprehensive electrical system studies.
   5. Obtain equipment layouts and configurations from the manufacturer's final submittal requirements and project layout drawings as required.
   6. Bus and conductor data:
      a. Use impedances of the actual installed or specified conductors, unless otherwise indicated.

b. Use cable and bus impedances calculated at 25 degrees Celsius, unless otherwise indicated.
c. Use 600-volt cable reactance based on typical dimensions of actual installed or specified conductors, unless otherwise indicated.
d. Use bus withstand values for all equipment having buses.
e. Use medium voltage cable reactances based on typical dimensions of shielded cables with 133 percent insulation levels, unless otherwise indicated.

7. Motors:
   a. Each motor shall be individually modeled:
      1) Grouping of motors for fault contribution current is not acceptable.
   b. Motors with variable frequency drives may be assumed to have no contribution to fault current.
8. Use the equipment, bus, and device designations as indicated on the Drawings for all studies.

B. Short-circuit fault analysis study additional requirements:
1. The short-circuit fault analysis shall be performed and submitted in 2 phases:
   a. Initial short-circuit fault analysis:
      1) Based on the Contract Documents and Electric Utility information.
      2) The initial short-circuit fault analysis report shall indicate the estimated available short-circuit current at the line side terminals of each piece of equipment covered by the scope of the study.
      3) Provide a list of assumptions used in the initial study.
   b. Final short-circuit analysis:
      1) The final short-circuit fault analysis shall modify the initial analysis as follows:
         a) Utilize the actual equipment provided on the project.
         b) Utilize conductor lengths based on installation.
2. Calculate 3-phase bolted fault, line-to-line fault, line-to-ground fault, double line-to-ground fault, short-circuit 1/2 cycle momentary symmetrical and asymmetrical RMS, 1-1/2 and 4 cycle, interrupting symmetrical RMS, and 30 cycle steady state short-circuit current values at each piece of equipment in the distribution system.
3. Evaluate bus bracing, short circuit ratings, fuse interrupting capacity and circuit breaker adjusted interrupting capacities against the fault currents, and calculate X/R values:
   a. Identify and document all devices and equipment as either inadequate or acceptable.
4. Calculate line-to-ground and double line-to-ground momentary short circuit values at all buses having ground fault devices.
5. Provide calculation methods, assumptions, one-line diagrams, and source impedance data, including Utility X/R ratios, typical values, recommendations, and areas of concern.

C. Protective device coordination study additional requirements:
1. Furnish protective device settings for all functions indicated on the Drawings, including, but not limited to:
   a. Current.
   b. Voltage:
      1) Provide settings for all voltage relays based upon actual Utility and generator tolerances and specifications.

c. Frequency:
    1) Provide settings for all frequency relays based upon actual Utility and generator tolerances and specifications.
d. Negative sequence.
e. Reverse power.
f. Machine protection functions:
    1) Provide settings for all motor and generator protective relays based on the manufacturer's recommended protection requirements.

2. Provide log-log form time-current curves (TCCs) graphically indicating the coordination proposed for the system:
    a. Include with each TCC a complete title and one-line diagram with legend identifying the specific portion of the system covered by the particular TCC:
        1) Typical time-current curves for identical portions of the system, such as motor circuits, are acceptable as allowed by the ENGINEER.
    b. Include a detailed description of each protective device identifying its type, function, manufacturer, and time-current characteristics:
        1) These details can be included on the TCC.
    c. Include a detailed description of each protective device tap, time dial, pickup, instantaneous, and time delay settings:
        1) These details can be included in the TCC.
3. TCCs shall include all equipment in the power distribution system where required to demonstrate coordination. Include Utility relay and fuse characteristics, medium voltage equipment protective relay and fuse characteristics, low-voltage equipment circuit breaker trip device characteristics, transformer characteristics, motor and generator characteristics, and characteristics of other system load protective devices:
    a. Include all devices down to the largest branch circuit and largest feeder circuit breaker in each motor control center, main breaker in branch panelboards and fused disconnect switches.
    b. Provide ground fault TCCs with all adjustable settings for ground fault protective devices.
    c. Include manufacturing tolerances and damage bands in plotted fuse and circuit breaker characteristics.
    d. On the TCCs show transformer full load currents, transformer magnetizing inrush, ANSI transformer withstand parameters and transformer damage curves.
    e. Cable damage curves.
    f. Terminate device characteristic curves at a point reflecting the maximum symmetrical or asymmetrical fault current to which the device is exposed based on the short-circuit fault analysis study.
4. Site generation: When site generation (including cogeneration, standby, and emergency generators) is part of the electrical system, include phase and ground coordination of the generator protective devices:
    a. Show the generator decrement curve and damage curve along with the operating characteristic of the protective devices.
5. Suggest modifications or additions to equipment rating or settings in a tabulated form.

D. Arc-flash hazard study additional requirements:
   1. Include the calculated arc-flash boundary and incident energy (calories/square centimeter) at each piece of equipment in the distribution system:
      a. Perform study with 15 percent arcing fault variation as defined by IEEE 1584.
      b. Perform arc-flash calculations at minimum and maximum utility and generator fault contributions.
      c. Perform arc-flash calculations for both the line side and load side of switchgear, switchboard, motor control center, and panelboard main breakers.
      d. Perform arc-flash calculations for all short-circuit scenarios with all motors on for 3 to 5 cycles and with all motors off.
      e. Protective device clearing time shall be limited to 2 seconds, maximum.
   2. Provide executive summary of the study results.
      a. Provide summary based upon worst case results.
   3. Provide a detailed written discussion and explanation of the tabulated outputs.
      a. Include all scenarios.
   4. Provide alternative device settings to allow the OWNER to select the desired functionality of the system:
      a. Minimize the arc-flash energy by selective trip and time settings for equipment maintenance purposes.
      b. Identify the arc-flash energy based upon the criteria of maintaining coordination and selectivity of the protective devices.

E. Electrical system study meetings:
   1. The individual conducting the short circuit analysis, protective device coordination, and the arc-flash hazard studies shall meet with the OWNER and ENGINEER 3 times.
   2. The purpose of the 3 meetings is as follows:
      a. Initial meeting:
         1) Meet with the OWNER and ENGINEER to discuss the scope of the studies.
         2) Discuss the OWNER's operational requirements for both normal operation and maintenance.
      b. Preliminary results meeting:
         1) This meeting will be held after the studies have been completed, reviewed, and accepted by the ENGINEER.
         2) The purpose of this meeting is to inform the OWNER of the results of the study and impacts on normal operation and maintenance including:
            a) Protective device coordination problems and recommended solutions.
            b) Explanation of the arc-flash study results and its potential impact on operations.
            c) Recommendations for reduction of arc-flash category levels including reduction of protective device settings or changes in operational practices.
      c. Final meeting:
         1) Discuss changes to the reports based on the previous meeting.
         2) Discuss with the OWNER how changes to the electrical system may change the arc-flash hazard category.
         3) Deliver the final electrical system studies report.

3. The meetings will be at the OWNER's facility:
    a. Provide a minimum of 3 weeks notice to the OWNER and ENGINEER in advance of the projected meeting date.
    b. Submit a draft of the meeting agenda when each meeting is requested.
4. Meeting materials:
    a. Prepare and provide the following materials:
        1) Meeting agenda. Include at a minimum the scope of the meeting, estimated time length for the meeting and meeting goals.
        2) 6 copies of the project one-line diagrams for the initial meeting.
        3) 6 copies of the studies of the submitted study.

F. By virtue of the fact that this is a professional study, the OWNER reserves the right to modify the requirements of the study to comply with its operational requirements. The protective device coordination study and the arc-flash study shall be modified based on the results of the meetings with the OWNER.

1.05 SUBMITTALS

A. Furnish submittals as specified in Sections 01330 and 16050.

B. Initial studies and reports:
1. Include the following in the initial short-circuit current report:
    a. List of all devices included in the studies.
    b. A description of all operating scenarios.
    c. Form and format of arc flash labels.

C. Final studies and reports:
1. Format and quantity:
    a. Provide 6 bound copies of all final reports.
    b. Provide 3 complete sets of electronic files on CD or DVD media, including the electrical system model(s), configuration files, custom libraries, any other files used to perform the studies and produce the reports. Also provide an electronic version of the bound reports in PDF format.
    c. Provide the number of copies specified in Section 01330**.**
2. Include the sections below in the final report:
    a. Copies of correspondence and data obtained from the Electric Utility Company.
    b. Letter certifying the inspection and verification of existing equipment.
    c. One-line diagrams:
        1) The following information shall be included at a minimum:
            a) Motor horsepower.
            b) Transformer data:
                (1) kVA.
                (2) Configuration.
            c) Cable data:
                (1) Insulation.
                (2) Size.
                (3) Length.
        2) One-line diagrams shall be fully legible at 11-inch by 17-inch size.
    d. Include in the short-circuit fault analysis study:
        1) Descriptions, purpose, basis, assumptions, recommendations, and scope of the study.

2) Normal system connections and those, which result in maximum fault conditions.
3) Tabulation of circuit breaker, fuse, and other protective device ratings compared to maximum calculated short-circuit duties.
4) Fault current calculations for the cases run including a definition of terms and guide for interpretation of computer software printouts.

e. Protective device coordination study shall include:
1) Descriptions, purpose, basis, assumptions, recommendations, and scope of the study.
2) List all requirements used in the selection and setting criteria for any protective devices.
3) Manufacturer's time-current curves for circuit breakers, fuses, motor circuit protectors, and other protective devices for all new equipment.
4) TCCs graphically indicating the coordination proposed for the system on log-log graphs. At least 3 of the copies shall be in color.
5) Tabulation of relay, fuse, circuit breaker, and other protective devices in graphical form with a one-line diagram to display area coordination.
6) Where coordination could not be achieved, an explanation shall be included in the report to support the statement along with recommendations to improve coordination. Recommended equipment modifications or settings shall be in a tabulated form.

f. Include in the arc-flash study:
1) Descriptions, purpose, basis, assumptions, recommendations, and scope of the study.
2) Normal system connections and those, which result in maximum arc-flash conditions.
3) Arc-flash raw data, calculations, and assumptions.
4) Arc-flash label data:
a) Identifying the content of each label.
b) Identifying the location of each label.

D. Certification:
1. Submit written certification, sealed, and signed by the professional engineer conducting the study, equipment supplier, and electrical subcontractor stating that the data used in the study is correct.

E. Submit the credentials of the individual(s) performing the study and the individual in responsible charge of the study.

F. The ENGINEER will review all studies and reports. After review, the ENGINEER will make recommendations and/or require changes to be made to the short-circuit analysis, protective device coordination or arc-flash studies. These changes shall be provided as part of the scope of work.

G. Submit course outline for OWNER's training.

1.06 QUALITY ASSURANCE

A. As specified in Section 16050.

B. Qualifications of the entity responsible for electrical system studies:
   1. The studies shall be performed, stamped, and signed by a professional engineer registered in the state where the project is located.
   2. A minimum of 5 years experience in power system analysis is required for the individual in responsible charge of the studies.
   3. The short-circuit analysis, protective device coordination, and arc-flash hazard studies shall be performed with the aid of a digital computer program:
      a. Point-to-point calculations are not acceptable.

C. The study shall be performed by an independent firm.

1.07 DELIVERY, STORAGE, AND HANDLING (NOT USED)

1.08 PROJECT/SITE CONDITIONS (NOT USED)

1.09 SEQUENCING

A. Submit the initial short-circuit analysis study before submittal of any electrical equipment.

B. Submit the short-circuit analysis and protective device coordination studies.

C. Initial arc-flash meeting.

D. Submit the arc-flash hazard study.

E. Second arc-flash meeting for preliminary results.

F. Final arc-flash meeting and final short-circuit analysis, protective device coordination, and arc-flash studies.

G. Label equipment with approved arc flash labels.

H. OWNER’s training.

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY (NOT USED)

1.12 SYSTEM START UP (NOT USED)

1.13 OWNER’S INSTRUCTIONS (NOT USED)

1.14 COMMISSIONING (NOT USED)

1.15 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Electrical system study software one of the following or equal:
   1. ETAP by Operation Technology Inc.
   2. Powertools by SKM Systems Analysis.
   3. Paladin DesignBase by Power Analytics Corporation.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS (NOT USED)

2.04 MANUFACTURED UNITS (NOT USED)

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS

A. Arc-flash hazard labels:
   1. Dimensions:
      a. Minimum 5 inches by 3.5 inches.
   2. Materials:
      a. Polyester with polyvinyl polymer over-laminate.
      b. Self-adhesive.
      c. Resistant to:
         1) UV.
         2) Chemicals and common cleaning solvent resistant.
         3) Scuffing.
         4) Wide temperature changes.
   3. Contents:
      a. Short-circuit bus identification.
      b. Calculated incident energy (calories/square centimeter) range.
         1) Based on worst case study results.
      c. Hazard/risk, personnel protective equipment category number.
      d. Arc-flash protection boundary.
      e. Shock hazard boundary:
         1) The CONTACTOR may provide separate labels for indication of the shock hazard boundary.
      f. Description of the combined level of personnel protective equipment.
   4. Color scheme:
      a. For locations above 40 calories/square centimeter:
         1) White label with red “DANGER” strip across the top.
         2) Black lettering.
      b. For locations below 40 calories/square centimeter:
         1) White label with orange “WARNING” strip across the top.
         2) Black lettering.

2.07 ACCESSORIES (NOT USED)

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 16050.

B. After review and acceptance of the arc-flash hazard study by the ENGINEER, install all arc-flash hazard labels:
   1. Install labels at all locations required by NFPA, ANSI, or IEEE standards.
   2. At a minimum install labels in the following locations:
      a. The front of each main or incoming service compartment.
      b. The front of each low voltage switchgear section.
      c. The front of each medium voltage circuit breaker door.
      d. The front of each accessible auxiliary or conductor compartment.
      e. Each accessible rear or side vertical section.
      f. Each motor control center compartment.
      g. Each panelboard covered by the study.
      h. Each control panel, individual starter or VFD or other equipment covered by the scope of the study.
   3. Install labels prior to equipment energization.

C. After review and acceptance of the arc-flash hazard study and coordination study by the ENGINEER, adjust protective device settings per final study prior to equipment energization.
   1. Devices which require power for configuration may be set during energization, but before any subfed loads are energized.
   2. Ensure that settings for upstream equipment are set prior to energizing downstream devices.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 FIELD QUALITY CONTROL

A. As specified in Section 16050.

B. The individual performing the arc-flash hazard study shall direct the installation of the arc-flash hazard labels:
   1. Remove and replace any improperly applied labels.

2. Repair the equipment finish damaged by removal of any label.
3. Install labels to within 1/64 inch of level or plumb across the entire dimension of the label.

3.08 ADJUSTING (NOT USED)

3.09 CLEANING (NOT USED)

3.10 DEMONSTRATION AND TRAINING

A. As specified in Section 16050.

B. Training:
   1. The training shall cover at a minimum:
      a. Hazards associated with arc-flash.
      b. Causes of arc-flash.
      c. Explanation of the arc-flash labels installed on the OWNER's electrical equipment.
      d. Proper use of personal protective equipment.
      e. PPE requirements for maintenance work.
   2. The individual in charge of the arc-flash study or qualified representative shall conduct the training sessions.

3.11 PROTECTION (NOT USED)

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 16411

DISCONNECT SWITCHES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Fusible and non-fusible 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.
   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 16075 - Electrical Identification.
      d. Section 16305 - Electrical System Studies.
      e. Section 16494 - Low Voltage Fuses.

1.02 REFERENCES

A. As specified in Section 16050.

B. Underwriters Laboratories Inc. (UL):
   1. 20 - General-Use Snap Switches.
   2. 98 - Enclosed and Dead-Front Switches.
   3. 508 - Standard for Industrial Control Equipment.

C. National Electric Manufacturer's Association (NEMA):
   1. 250 - Enclosures for Electrical Equipment.
   2. KS 1-2001- Enclosed and Miscellaneous Distribution Equipment Switches (600 Volts Maximum).

1.03 DEFINITIONS

A. As specified in Section 16050.

B. Specific definitions:
   1. 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**.**

1.05 SUBMITTALS

A. Furnish submittals as specified in Sections 01330 and 16050.

B. Product data:
   1. Manufacturer.
   2. Manufacturer's specifications and description.
   3. Ratings:
      a. Voltage.
      b. Current.
      c. Horsepower.
      d. Short circuit rating.
   4. Fused or non fused.
   5. NEMA enclosure type.
   6. Dimensions:
      a. Height.
      b. Width.
      c. Depth.
   7. Weight.
   8. Cross-referenced to the disconnect schedule indicated on the Drawings.

C. Shop drawings:
   1. Manufacturer's installation instructions:
      a. Indicate application conditions and limitations of use stipulated by product testing agency specified under Quality Assurance, Regulatory Requirements below.
      b. Include instructions for storage, handling, protection, examination, preparation, installation, and operation of product.
   2. Identify motor or equipment served by each switch; indicate nameplate inscription.

D. Installation instructions:
   1. Provide anchorage instructions and requirement based on the seismic requirements at the Project Site as specified in Section 16050 and calculations:
      a. Stamped by a professional engineer registered in the state where the Project is being constructed.

1.06 QUALITY ASSURANCE

A. As specified in Section 16050.

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 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 16050.

1.08 PROJECT OR SITE CONDITIONS

A. As specified in Section 16050.

1.09 SEQUENCING

A. Conduct the initial fault current study as specified in Section 16305 and submit results for ENGINEER's review.

B. After successful review of the initial fault current study, as specified in Section 16305, submit complete equipment submittal as specified in the Submittal article of this Section for ENGINEER's review.

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

A. As specified in Section 16050.

1.12 SYSTEM STARTUP

A. As specified in Section 16050.

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 COMMISSIONING (NOT USED)

1.15 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. One of the following or equal:
   1. Schneider Electric/Square D Company.
   2. Eaton/Cutler-Hammer.
   3. General Electric.

4. Siemens.
5. Appleton.
6. Crouse-Hinds.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS (NOT USED)

2.04 MANUFACTURED UNITS (NOT USED)

2.05 EQUIPMENT

A. Switch mechanism:
   1. Quick-make, quick-break heavy-duty operating mechanisms:
      a. Provisions for padlocking the switch in the Off position.
      b. A minimum of 90-degree handle travel position between Off and On positions:
         1) Provide handle position indicators to identify the handle position.
      c. 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:
         1) With an externally operated override.

B. Switch interior:
   1. Switch blades visible when the switch is Off and the cover is open.
   2. Lugs:
      a. Front accessible.
      b. Removable.
      c. UL listed for 60/75-degree Celsius copper conductors.
   3. Current carrying parts completely plated to resist corrosion.
   4. Removable arc suppressors to facilitate easy access to line side lugs.
   5. Furnish equipment ground kits for every switch.

C. Fused switches:
   1. Furnish with fuses as indicated on the Drawings:
      a. Provide fuses as specified in Section 16494.
   2. UL approved for field conversion from standard Class H fuse spacing to Class J fuse spacing:
      a. Ratings 100 amperes through 600 amperes at 240 volts.
      b. Ratings 30 amperes through 600 amperes at 600 volts.
      c. Provide spring reinforced and plated fuse clips.

D. Ratings:
   1. UL horsepower rated for AC or DC with the rating not less than the load served.
   2. Current:
      a. 30 to 1,200 amperes.
   3. Voltage:
      a. 250 volts AC, DC.
      b. 600 volts (30 A to 200 A, 600 volts DC).
   4. Poles:
      a. 2, 3, 4, and 6 poles.

5. UL listed short circuit ratings:
   a. 10,000 RMS symmetrical amperes when used with or protected by Class H or K fuses (30-600 amperes).
   b. 200,000 RMS symmetrical amperes when used with or protected by Class R or J fuses (30-600 amperes employing appropriate fuse rejection).
   c. 200,000 RMS symmetrical amperes when used with or protected by Class L fuses (800-1,200 amperes).
6. Where not indicated on the Drawings, provide switches with the NEMA ratings specified in Section 16050 for the installed location.

E. Size, fusing, and number poles as indicated on the Drawings or as required:
   1. Provide solid neutral where indicated on the Drawings.

2.06 COMPONENTS (NOT USED)

2.07 ACCESSORIES

A. Disconnect switches to have provisions for a field installable “B” type electrical interlock for position indication as indicated on the Drawings.

B. Disconnect switches to have provisions for a field installed insulated groundable neutral kit as indicated on the Drawings.

C. NEMA Type 7 and 9 enclosures furnished with drain and breather kit when used in outdoor applications.

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 16050.

B. Install disconnect switches per the manufacturer’s guidelines and submitted installation instructions to meet the seismic requirements at the Project Site.

C. General:
   1. Use Myers hubs or bolt-on hubs for all conduit penetrations on NEMA Type 12, Type 4, and Type 4X enclosures.

2. 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.
3. When possible, mount switches rigidly to exposed building structure or equipment structural members:
   a. For NEMA Type 4 and Type 4X locations, maintain a minimum of 7/8 inch air space between the enclosure and supporting surface.
   b. When mounting on preformed channel, position channel vertically so that water may freely run behind the enclosure.
4. Provide a nameplate for each disconnect switch:
   a. Provide per requirements specified in Section 16075.
   b. Identify voltage, circuit, fuse size, and equipment served on the nameplate.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 FIELD QUALITY CONTROL

A. As specified in Section 16050.

3.08 ADJUSTING (NOT USED)

3.09 CLEANING

A. As specified in Section 16050.

3.10 DEMONSTRATION AND TRAINING (NOT USED)

3.11 PROTECTION

A. As specified in Section 16050.

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 16412

LOW VOLTAGE MOLDED CASE CIRCUIT BREAKERS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Low voltage molded case circuit breakers as indicated on the Drawings and as specified.

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 16305 - Electrical System Studies.

1.02 REFERENCES

A. As specified in Section 16050.

B. National Electrical Manufacturers Association (NEMA):
   1. AB 3. - Molded Case Circuit Breakers and Their Application.

C. Underwriter's Laboratories (UL):
   1. 489 - Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit-Breaker Enclosures
   2. 943 - Ground Fault Circuit Interrupters.

1.03 DEFINITIONS

A. As specified in Section 16050.

B. In accordance with UL 489.

1.04 SYSTEM DESCRIPTION

A. Molded case thermal magnetic or motor circuit protector type circuit breakers as indicated on the Drawings and connected to form a completed system.

1.05 SUBMITTALS

A. Furnish submittals as specified in Sections 01330 and 16050.

B. Product data:
   1. Catalog cut sheets.
   2. Manufacturer's time-current curves for all molded case circuit breakers furnished.

1.06 QUALITY ASSURANCE

A. As specified in Section 16050.

B. Low voltage molded case circuit breakers shall be UL listed and labeled.

1.07 DELIVERY, STORAGE AND HANDLING

A. As specified in Section 16050.

1.08 PROJECT OR SITE CONDITIONS

A. As specified in Section 16050.

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

A. As specified in Section 16050.

1.12 SYSTEM START-UP

A. As specified in Section 16050.

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 COMMISSIONING (NOT USED)

1.15 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. One of the following or equal:
   1. Eaton/Cutler-Hammer.
   2. General Electric Company.
   3. Schneider Electric/Square D Company
   4. ABB.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS (NOT USED)

2.04 MANUFACTURED UNITS

A. General:
   1. Conforming to UL 489.
   2. Operating mechanism:
      a. Quick-make, quick-break, non-welding silver alloy contacts.
      b. Common Trip, Open and Close for multi-pole breakers such that all poles open and close simultaneously.
      c. Mechanically trip free from the handle.
      d. Trip indicating handle - automatically assumes a position midway between the manual ON and OFF positions to clearly indicate the circuit breaker has tripped.
      e. Lockable in the "OFF" position.
   3. Arc extinction:
      a. In arc chutes.
   4. Voltage and current ratings:
      a. Minimum ratings as indicated on the Drawings.
      b. Minimum frame size 100A.
   5. Interrupting ratings:
      a. Minimum ratings as indicated on the Drawings.
      b. Modify as required to meet requirements of the short circuit fault analysis - as specified in Section 16305.
      c. Not less than the rating of the assembly (panelboard, switchboard, motor control center, etc.).

B. Motor circuit protectors:
   1. Instantaneous only circuit breaker as part of a listed combination motor controller.
   2. Each pole continuously adjustable in a linear scale with ‘LO’ and ‘HI’ settings factory calibrated.

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS

A. Terminals:
   1. Line and load terminals suitable for the conductor type, size, and number of conductors in accordance with UL 489.

B. Case:
   1. Molded polyester glass reinforced.
   2. Ratings clearly marked.

C. Trip units:
   1. Provide thermal magnetic or solid-state trip units as indicated on the Drawings.
   2. Thermal magnetic:
      a. Instantaneous short circuit protection.
      b. Inverse time delay overload.
      c. Ambient or enclosure compensated by means of a bimetallic element.

3. Solid state:
    a. With the following settings as indicated on the Drawings.
        1) Adjustable long time current setting.
        2) Adjustable long time delay.
        3) Adjustable short time pickup.
        4) Adjustable short time delay.
        5) Adjustable instantaneous pickup.

D. Molded case circuit breakers for use in panelboards:
    1. Bolt-on type.
        a. Plug-in type breakers are not acceptable.
    2. Ground fault trip devices as indicated on the Drawings.

2.07 ACCESSORIES (NOT USED)

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL

A. Test breakers in accordance with:
    1. UL 489.
    2. Manufacturer's standard testing procedures.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. Install breakers to correspond to the accepted shop drawings.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 FIELD QUALITY CONTROL

A. As specified in Section 16050.

3.08 ADJUSTING

A. Adjust trip settings in accordance with Protective Device Coordination Study as accepted by the Engineer and in accordance with manufacturer's recommendations.

B. Adjust motor circuit protectors in accordance with NEC and the manufacturer's recommendation based on the nameplate values of the installed motor.

3.09 CLEANING (NOT USED)

3.10 DEMONSTRATION AND TRAINING (NOT USED)

3.11 PROTECTION

A. As specified in Section 16050.

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 16414

LOW VOLTAGE POWER CIRCUIT BREAKERS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Low voltage draw-out type power circuit breakers as indicated on the Drawings.

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 16305 - Electrical System Studies.

1.02 REFERENCES

A. As specified in Section 16050.

B. National Electrical Manufacturer's Association (NEMA):
   1. Standard SG 3 - Low Voltage Power Circuit Breakers.

C. American National Standards Institute (ANSI):
   1. Standard C37.13 - Low Voltage AC Power Circuit Breakers Used in Enclosures.
   2. Standard C37.16 - Low Voltage Power Circuit Breakers and AC Power Circuit Protectors - Preferred Ratings, Related Requirements, and Application Recommendations.
   3. Standard C37.17 - Trip Devices for AC and General Purpose DC Low Voltage Power Circuit Breakers.
   4. Standard C37.50 - Low Voltage AC Power Circuit Breakers Used in Enclosures - Test Procedures.

D. Underwriter's Laboratories (UL):
   1. Standard No. UL 1066 - Standard for Low Voltage AC and DC Power Circuit Breakers Used in Enclosures.

1.03 DEFINITIONS

A. As specified in Section 16050.

1.04 SYSTEM DESCRIPTION

A. Power circuit breakers as indicated on the Drawings and connect to form a completed system:
   1. Used to open and close a circuit, and to open a circuit automatically on a predetermined overload or overcurrent, without damage to itself when properly applied within its ratings.

1.05 SUBMITTALS

A. Furnish submittals as specified in Sections 01330 and 16050.

B. Product data:
   1. Catalog cut sheets.
   2. Manufacturer's time-current curves for all trip devices furnished.

1.06 QUALITY ASSURANCE

A. As specified in Section 16050.

1.07 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 16050.

1.08 PROJECT OR SITE CONDITIONS

A. As specified in Section 16050.

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

A. As specified in Section 16050.

1.12 SYSTEM START-UP

A. As specified in Section 16050.

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 COMMISSIONING (NOT USED)

1.15 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. One of the following or equal:
   1. Eaton/Cutler-Hammer.

2. General Electric Company.
3. Schneider Electric/Square D Company.
4. ABB.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS (NOT USED)

2.04 MANUFACTURED UNITS

A. Operating mechanism:
   1. Manual or electric as indicated on the Drawings:
      a. Manual operation:
         1) The circuit breaker closing spring is energized by no more than 6 operations of the constant-force charging handle.
         2) Pushing the “CLOSE (ON)” button will close the breaker’s contacts and pushing the “OPEN (OFF)” button will open the breaker’s contacts.
         3) The opening springs are automatically charged when the breaker is closed.
      b. Quick-make, quick-break, non-welding silver alloy contacts.
      c. Common trip, open and close for multi-pole breakers such that all poles open and close simultaneously.
      d. Lock to prevent closing or racking.
   2. Anti-pump feature: Prevents any attempts to reclose the breaker on a short circuit fault if the close signal is maintained.
   3. Equipped with an interlock to discharge the stored energy spring before the circuit breaker can be withdrawn from its cell.

B. Arc extinction:
   1. In arc chutes.

C. Voltage and current ratings:
   1. Minimum ratings as indicated on the Drawings.
   2. Minimum short time current ratings equal to the interrupting rating.

D. Interrupting ratings:
   1. Minimum ratings as indicated on the Drawings:
      a. Modify as required to meet requirements of CONTRACTOR’s Short-Circuit Fault Analysis as specified in Section 16305.
   2. Matching the rating of the equipment.

E. Circuit breaker mounting as indicated on the Drawings:
   1. Draw out type capable of being racked to the disconnect position with the door closed.
   2. Interlocks:
      a. To prevent connecting or disconnecting the circuit breaker unless the breaker is in the open position.
      b. To prevent breaker from being closed during any racking operation.
   3. Test position:
      c. Permits operating the breaker while it is disconnected from the power circuit.

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS

A. Case:
   1. Molded polyester glass reinforced.
   2. Double level of insulation between primary current-carrying parts and operating personnel.
   3. Ratings clearly marked.
   4. Open contact indication.
   5. Closed contact indication.
   6. Charging spring charged indication.
   7. Charging spring discharged indication.
   8. Open pushbutton.
   9. Close pushbutton.
   10. Retractable charging handle.

B. Trip units:
   1. Microprocessor based with positive action flux-shifting trip device and a solid-state type with the following functions:
      a. Adjustable ampere setting:
         1) Controls the value of current that the breaker will carry indefinitely.
         2) Adjustable from 0.5 to 1.0 in 0.05 increments.
      b. Adjustable long time delay:
         1) Varies the time it will take the breakers to trip under sustained overload.
      c. Adjustable short time pickup:
         1) Controls the level of high current the breaker will carry for short periods.
      d. Adjustable short time delay:
         1) Controls the length of time the breaker will carry a high current without tripping.
      e. Adjustable instantaneous pickup:
         1) Controls level at which immediate tripping of breaker occurs.
         2) This trip function may be disabled on the main breakers, based on CONTRACTOR's short circuit and fault analysis study.
      f. Adjustable ground fault pickup:
         1) Controls the level at which the breaker will trip under a ground fault condition.
      g. Adjustable ground fault delay:
         1) Controls the time that a ground fault can exist without tripping the breaker.
      h. Long time pickup indicator:
         1) Provides a visual indication that the breaker is experiencing an overload condition.
   2. Maintenance mode settings:
      a. Allows for remote input of alternative trip settings for arc flash hazard reduction during maintenance procedures.
      b. Enabled by the following:
         1) Remote hardwired input.
         2) Trip unit controls.
         3) Status:

4) Contact for remote indication.
5) Indication on trip unit.
6) Status communicated over trip unit network.

3. Fault indicators:
   a. Powered from a lithium battery.
   b. LED indicators for:
      1) Overcurrent fault trip on long-time feature.
      2) Overcurrent fault trip on short-time feature.
      3) Short circuit fault trip on the Instantaneous feature.

2.07 ACCESSORIES

A. Provide circuit breakers with the following accessories as indicated on the Drawings:
   1. Electrical operator (field convertible by adding a plug-in motor operator):
      a. The circuit breaker closing spring is energized by an electric motor-driven charging mechanism.
      b. Control voltage for electrically operated circuit breakers: 120 VAC.

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL

A. Test breakers in accordance with:
   1. UL 1066.
   2. ANSI C37.50
   3. Manufacturer’s standard testing procedures.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. Install breakers to correspond to the accepted shop drawings.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 FIELD QUALITY CONTROL

A. As specified in Section 16050.

3.08 ADJUSTING

A. Adjust trip settings in accordance with the Protective Device Coordination Study as accepted by the ENGINEER and in accordance with the manufacturer's trip unit instructions.

3.09 CLEANING (NOT USED)

3.10 DEMONSTRATION AND TRAINING (NOT USED)

3.11 PROTECTION

A. As specified in Section 16050.

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 16422

MOTOR STARTERS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Motor starters and contactors, installed in:
      a. Motor control centers.
      b. Control panels.
      c. Enclosed combination starters.
   2. Starter types:
      a. Magnetic starters.
      b. Solid-state starters.
      c. Contactors.
      d. Integral self-protected starters.
      e. Manual motor starters.

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 01660 - Testing, Training, and Commissioning.
      c. Section 16050 - Common Work Results for Electrical.
      d. Section 16070 - Hangers and Supports.
      e. Section 16075 - Electrical Identification.
      f. Section 16123 - 600 Volt or Less Wires and Cables.
      g. Section 16412 - Low Voltage Molded Case Circuit Breakers.
      h. Section 16444 - Low Voltage Motor Control Centers.
      i. Section 17710 - Control Systems - Panels, Enclosures, and Panel Components.

1.02 REFERENCES

A. As specified in Section 16050.

B. International Electrotechnical Commission (IEC):
   1. 60 947-4 - Low-Voltage Switchgear and Control Gear.
   2. 801-1 - Electromagnetic Compatibility for Industrial-Process Measurement and Control Equipment - Part 1: General Information.

C. National Electrical Manufacturer's Association (NEMA):
   1. ICS 2 - Industrial Control and Systems: Controllers, Contactors, and Overload Relays Rated 600 V.

D. Underwriters Laboratories (UL):
   1. 508 - Standard for Industrial Control Equipment.
   2. 508A - Standard for Industrial Control Panels.

1.03 DEFINITIONS

A. As specified in Section 16050.

B. Specific definitions and abbreviations:
   1. FVNR: Full voltage non-reversing.
   2. RVSS: Reduced voltage solid state.
   3. Overload relay class: A classification of an overload relay time current characteristic by means of a number, which designates the maximum time in seconds at which it will operate when carrying a current equal to 600 percent of its current rating.

1.04 SYSTEM DESCRIPTION

A. General requirements:
   1. Starters for motor control centers, individual enclosed starters, or control panels.

1.05 SUBMITTALS

A. Furnish submittals as specified in Sections 01330 and 16050:
   1. Submit motor starter data with equipment submittal.

B. Product data:
   1. Manufacturer.
   2. Catalog cut sheets.
   3. Technical information.
   4. Complete nameplate schedule.
   5. Complete bill of material.
   6. List of recommended spare parts.
   7. Confirmation that the overload relay class for each starter meets the requirements of the equipment and motor supplier.
   8. Electrical ratings:
      a. Phase.
      b. Wire.
      c. Voltage.
      d. Ampacity.
      e. Horsepower.
      f. Furnish circuit breaker submittals as specified in Section 16412.

C. Shop drawings:
   1. Elementary and schematic diagrams:
      a. Provide 1 diagram for every starter and contactor.

b. Indicate wire numbers for all control wires on the diagrams:
   1) Wire numbering as specified in Section 16075.
c. Indicate interfaces with other equipment on the drawings.

D. Installation instructions:
1. The written instructions must detail the complete installation of the freestanding starters including moving and setting into place.
2. Provide anchorage instructions and requirements for the free standing starter based on the seismic requirements at the Project site as specified in Section 16050:
   a. Stamped by a professional engineer registered in the state where the Project is being constructed.

E. Operation and maintenance manuals:
1. Submit complete operating and maintenance instructions presenting full details for care and maintenance of equipment furnished or installed under this Section. Including but not limited to:
   a. Electrical ratings:
      1) Phase.
      2) Wire.
      3) Voltage.
      4) Ampacity.
   b. Complete bill of material.
   c. Manufacturer's operating and maintenance instructions starter and/or contactor component parts, including:
      1) Protective devices (fuses, breakers, overload relays, heater elements, etc.).
      2) Pilot devices.
   d. Complete renewal parts list.
   e. As-built drawings:
      1) Furnish as-built drawings for each starter and contactor indicating final:
         a) Wire numbers.
         b) Interfaces with other equipment.
      2) 11-inch by 17-inch format.

F. Certifications:
1. Provide manufacturer's certification that the reduced voltage solid state starter will reliably control the acceleration and deceleration of the driven load at the installed conditions:
   a. Failure of the manufacturer to provide said certification will be interpreted to mean that the manufacturer has agreed that the reduced voltage solid state starter is matched to the driven load at the installed conditions and will function without fault.
   b. If the reduced voltage solid-state starter fails to perform as desired, replace or modify the reduced voltage solid-state starter in order to achieve the desired operational conditions, as directed by the Engineer.
2. Provide manufacturer's certification that all electronic circuits and printed circuit boards are conformally coated.

1.06 QUALITY ASSURANCE

A. As specified in Section 16050.

B. Regulatory requirements:
   1. All starters and components shall be UL listed and labeled:
      a. UL 508 - Industrial Control Equipment.
      b. UL 508A - Industrial Control Panels.
   2. NEMA ICS 2 - Industrial Control and System Controllers; Contactors and Overload Relays Rated: 600 Volts.
   3. Combination starters shall be UL listed and labeled.

1.07 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 16050.

1.08 PROJECT OR SITE CONDITIONS

A. As specified in Section 16050.

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING

A. Reduced voltage solid state starters:
   1. Submit certification that the RVSS will reliably accelerate and decelerate the driven load at the installed conditions as part of the equipment submittal.
   2. RVSS startup and testing by manufacturer after connection to equipment.
   3. RVSS training by manufacturer after startup and testing, and before plant commissioning.

1.11 WARRANTY

A. As specified in Section 16050.

1.12 SYSTEM START-UP

A. As specified in Section 16050.

B. RVSS:
   1. Provide the services of the manufacturer's technical representative for start-up, adjustment, and troubleshooting, a minimum of 2 hours per starter at the Owner's facility.

1.13 OWNER’S INSTRUCTIONS (NOT USED)

1.14 COMMISSIONING (NOT USED)

1.15 MAINTENANCE

A. Spare parts:
   1. Provide the following spare parts, suitably packaged and labeled with the corresponding equipment number:
      a. One spare fuse of each size and type per starter.
      b. One of each type of circuit board used in the RVSS starters, including but not limited to:
         1) Control board.
         2) Power board.
         3) Bridge rectifier.
         4) Inverter module.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. One of the following or equal:
   1. NEMA starters and contactors:
      a. Allen-Bradley.
      b. Schneider Electric/Square D.
      c. General Electric.
      d. Eaton/Cutler-Hammer.
   2. Reduced voltage solid state starters:
      a. Allen-Bradley.
      b. Eaton/Cutler-Hammer.
      c. General Electric.
      d. Benshaw.
      e. Schneider Electric/Square D.
   3. Manual motor starters:
      a. Schneider Electric/Square D.
      b. General Electric.
      c. Cutler-Hammer.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS (NOT USED)

2.04 MANUFACTURED UNITS

A. General:
   1. Provide combination type starters with motor circuit protector or thermal-magnetic circuit breaker and control power transformer with ratings as indicated on the Drawings.
   2. NEMA size, design, and rated:
      a. NEMA Size 1 minimum.
   3. Coordinate motor circuit protector, thermal magnetic circuit breaker, or fusible disconnect, and overload trip ratings with nameplate horsepower and current ratings of the installed motor:
      a. If motors provided are different in horsepower rating than those specified or indicated on the Drawings, provide starters coordinated to the actual motors furnished.

4. Provide starters NEMA Size 2 and larger with arc quenchers on load breaking contacts.
5. Mount extended overload reset buttons to be accessible for operation without opening starter enclosure door.

B. Full voltage starters (FVNR, FVR, TS1W, TS2W):
1. Across-the-line full voltage magnetic starters.
2. Rated for 600 volts.
3. Electrical characteristics as indicated on the Drawings.
4. Provide positive, quick-make, quick-break mechanisms, pad lockable enclosure doors.
5. Furnish starter with bi-metallic overload relays.
6. Double-break silver alloy contacts.
7. Reversing starters provided with both mechanical and electrical interlocks to prevent line shorts and energizing both contactors simultaneously.
8. Provide two-speed, two-winding motor starters consisting of two 3-pole contactors and two sets of overload relays assembled together:
   a. Provided with conductors that are both mechanically and electrically interlocked to prevent energizing both contactors simultaneously.

C. RVSS:
1. Manufactured and tested in accordance with the applicable requirements of IEEE, UL, and NEMA, including the following:
   a. Dielectric withstand per UL 508.
   b. Noise and RF immunity per NEMA ICS-2-230.
2. Furnish with a motor circuit protector or thermal magnetic circuit breaker as indicated on the Drawings.
3. Provide protection against internal faults and high SCR temperature during operation of the motor including starting, running (except when bypassed), and stopping modes.
4. Capable of continuously delivering full rated current of the motor plus the motor service factor in ambient temperatures from 0 degrees Celsius to 40 degrees Celsius at the installed altitude.
5. RVSS control module requirements:
   a. Microcomputer based, and contains the required circuitry to drive the power semiconductors in the power section of the starter.
   b. Integrally mounted on the power section and requires no additional panel space or wiring.
   c. Mounted for easy wiring, testing, service, and replacement.
   d. Provide 3-phase current sensing.
   e. Quick disconnect plug-in connectors for current transformer inputs, line and load voltage inputs, and SCR gate firing output circuits.
   f. Operates on power supplied from a control power transformer.
   g. Phase insensitive or with phase rotation protection.
   h. Control modes:
      1) Soft start with adjustable linear ramp time and a “kick start” or “boost” feature to provide a short time (typically 0.1 seconds) application of approximately full voltage.

2) Soft start with adjustable linear ramp time, with a current limit:
a) The current limit shall be adjustable over the range of 2 to 4 times normal full load current.
3) Reverse voltage ramp (line voltage to zero voltage):
a) Adjustable from 2 to 30 seconds to provide smooth stop.
b) Automatic shutdown at end of voltage ramp.

i. Protective functions:
1) Single phase protection.
2) Under voltage protection.
3) Short circuit electronic trip overcurrent protection. Time not to exceed 3 cycles.
4) Inverse time running overcurrent protection.
5) Auxiliary trip circuitry.
6) Gate firing circuit lockout protection on trip.
7) Jam and stall detection.
8) Fault relay lockout protection.
9) 100 percent to 130 percent full load running current trip adjustment.
10) 100 percent to 450 percent of starting current limit adjustment.
11) Dwell time at current limit with ramp continuation after acceleration.
12) Individual light emitting diodes (LEDs) for trip and phase loss.
13) Minimum and maximum initial starting voltage adjustments.
14) Initial torque adjustment.

6. RVSS power section requirements:
a. 3 sets of back-to-back phase controlled power semiconductors:
1) Minimum repetitive peak inverse voltage of 1,500 volts at 480 VAC.
2) Resistor/capacitor snubber networks to prevent false firing of the SCRs.
3) Equipped with individual heat sink assemblies.
4) Provide high-speed fuses for protection of the SCR stacks against short circuit conditions.
b. Provide metal oxide varistors for surge protection on the line side power terminal connections:
1) Rated for a minimum of 120 joules.
c. Capable of supplying the following current levels:
1) 600 percent of full load current for a minimum of 10 seconds.
2) 450 percent of full load for a minimum of 30 seconds.
d. Furnish ground lugs, one for incoming and one for outgoing ground connections.
e. Furnish pressure type terminals for top or bottom entry power terminations.

7. Remote indicators:
a. Provide Form C dry contacts for remote indication of:
1) System failure.

D. Manual motor starters:
1. General:
a. Provide with number of poles as indicated on the Drawings or as required by the connected load.
b. Provide handles that clearly indicate the On, Off (with lockout), and Tripped positions, and positive, quick-make, quick-break mechanisms.
2. With thermal overload switches:
a. Provide for all single-phase motors 1/3-hp and smaller.

b. Size heater elements for approximately 115 percent of the nameplate full load current, for motors with a 1.15 service factor.
c. Thermal overload units in all phase legs.
d. Overload conditions interrupts all ungrounded conductors.

3. Without thermal overload switches:
   a. Install only on equipment that requires no external motor overload protection.
4. Enclosure:
   a. Provide the enclosure type specified in Section 16050 for the starter location.

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS

A. Molded case circuit breakers:
   1. Circuit breaker type and ratings as indicated on the Drawings.
   2. Provide as specified in Section 16412.

B. Contactors:
   1. NEMA size as indicated on the Drawings.
   2. Electrically held:
      a. For lighting loads designed to withstand the initial inrush currents of ballast and lamp loads.
   3. Factory adjusted and chatter free.
   4. Auxiliary contacts:
      a. Contact ratings as per NEMA A 600 rating:
         1) Auxiliary contacts rated 10 amps at 600 volts.
      b. Provide all contacts indicated on the Drawings, and any additional contacts required for proper operation.
      c. Provide at least 1 normally open and 1 normally closed spare auxiliary contact.
   5. Constructed in accordance with the following standards:
      a. UL 508.
      b. IEC 947-4.
         1) Type 1 coordination when protected by a circuit breaker.
         2) Type 2 coordination when protected by a suitable UL listed fuse.
      c. IEC 801-1 parts 2 through 6.

C. Overloads:
   1. Bi-metallic overload relay:
      a. Class 20 protection.
      b. Ambient compensated.
      c. Interchangeable heater pack:
         1) One heater per phase.
         2) Coordinate with installed motor full load amps and service factor.
      d. Visible trip indicator.
      e. Push-to-trip test.
      f. Isolated normally open alarm contact.
      g. Normally closed trip contacts.
      h. Manual reset.

D. Control power transformer:
   1. Furnish integral control power transformer capacity to power:
      a. All motor controls indicated on the Drawings.
      b. Motor winding heaters, through a normally closed auxiliary contact on the starter.
      c. Cabinet heater.
   2. Primary and secondary fusing as indicated on the Drawings:
      a. Fusing sized by the manufacturer for the rating of the transformer furnished.
   3. Control power transformer secondary voltage:
      a. 120 VAC.

E. Enclosures for individually enclosed starters:
   1. NEMA type specified for the location as specified in Section 16050:
      a. Where not specified, provide NEMA Type 12 enclosure for indoor dry location, NEMA Type 4X enclosures for outdoor, wet, or corrosive areas, and NEMA Type 7 for Class I, Division 1 or 2 classified areas.
   2. Flange-mounted handle mechanism to operate disconnect switch or circuit breaker:
      a. Door mounted operators or operator handles are not acceptable.
      b. Handle mechanism features:
         1) Engaged with the disconnect device at all times as an integral part of the unit independent of the door position.
         2) Lockable in the Off position.
         3) Mechanically interlocked so that the disconnect cannot be switched to the On position with the door open:
            a) Provide a means for qualified personnel to defeat this interlock during maintenance and testing.
         4) Lockable in the On position:
            a) This feature shall not prevent the circuit breaker from operating during a fault condition.
   3. Provide a thermostatically controlled space heater for equipment located outdoors or in unheated areas:
      a. Powered from the starter or integral control power transformer.

2.07 ACCESSORIES

A. Lugs and terminals:
   1. For all external connections of No. 6 AWG and larger.
   2. UL listed for either copper or aluminum conductors.

B. Surge protective devices:
   1. Furnish surge protection devices across the coil of each starter, contactor, and relay.

C. Pilot devices:
   1. Provide pilot lights, switches, elapsed time meters, and other devices as specified or as indicated on the Drawings.
   2. As specified in Section 17710.

D. Nameplates:
   1. Provide nameplates as specified in Section 16075.

E. Conformal coating:
   1. Provide conformal coating material applied to electronic circuitry and printed circuit boards to act as protection against moisture, dust, temperature extremes, and chemicals such as H_2S and chlorine.

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL

A. RVSS starters:
   1. The manufacturer of the respective RVSS starter shall supply certified test results to confirm that the controller has been tested to substantiate designs according to applicable ANSI and NEMA standards.
   2. The tests shall verify not only the performance of the unit and integrated assembly, but also the suitability of the enclosure venting, rigidity, and bus bracing. In addition, the unit shall be factory tested in accordance with ANSI standards.
   3. The RVSS starter manufacturer shall test for noise immunity on both input and output power connections and provide test results to the Engineer. Noise testing shall be performed in accordance with NEMA ICS 2-230.40.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 16050.

B. Starters in motor control centers:
   1. Install as specified in Section 16444.

C. Starters in control panels:
   1. Install as specified in Section 17710.

D. Individually enclosed starters:
   1. Install the equipment per the manufacturer's guidelines and submitted installed instruction to meet the seismic requirements at the Project Site.
      a. Perform all Work in accordance with the manufacturer's instructions and accepted shop drawings.
   2. Furnish all cables, conduit, lugs, bolts, expansion anchors, sealants, mounting structures and other accessories needed to completely install the starters.

3. Assemble and install the starters in the locations and with the layouts indicated on the Drawings.
4. Install floor-standing starters on a 3-1/2-inch raised concrete housekeeping pad:
   a. Provide structural leveling channels in accordance with the manufacturer's recommendations to provide proper alignment of the units.
   b. Weld and/or bolt the starter frame to the leveling channels.
5. Install wall mounted starters as specified in Section 16070.
6. Provide openings in top or bottom of the enclosure for conduit only, no additional openings will be allowed:
   a. Mis-cut holes will require that the entire enclosure or removable panel be replaced. No hole closers or patches will be allowed.
7. Bundle circuits together and terminate in each unit:
   a. Tie with nylon wire ties as specified in Section 16123.
   b. Label all wires at each end with wire numbers shown on the approved control drawings.
   c. Make all connections to and from the motor starter via terminal blocks.
8. Furnish all mounting brackets, stands, etc. that may be required to physically mount the motor starter.

E. Manual motor starters:
   1. Provide complete mounting brackets and hardware as necessary for complete support of manual motor starter at locations indicated on the Drawings.
   2. Mount manual motor starter rigidly to exposed building or equipment structural members.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 FIELD QUALITY CONTROL

A. As specified in Section 16050.

3.08 ADJUSTING

A. Make all adjustments as necessary and recommended by the manufacturer, Engineer, or testing firm.

B. Set all overloads and motor circuit protectors based on the nameplate values of the installed motor.

3.09 CLEANING

A. As specified in Section 16050.

3.10 DEMONSTRATION AND TRAINING

A. As specified in Section 16050.

B. Demonstrate operation of equipment as specified in Section 01660:
   1. Demonstrate the operation of every motor starter to the Engineer's and Owner's satisfaction.

C. Training:
   1. Provide the services of the manufacturer’s technical representative for training purposes:

3.11 PROTECTION

A. As specified in Section 16050.

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 16430

LOW VOLTAGE SWITCHGEAR

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Indoor 600-volt, dead-front metal enclosed switchgear.

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- Seismic Design Criteria.
      c. Section 01660 - Testing, Training, and Commissioning.
      d. Section 16050 - Common Work Results for Electrical.
      e. Section 16075 - Electrical Identification.
      f. Section 16240 - Battery Systems.
      g. Section 16285 - Surge Protective Devices.
      h. Section 16290 - Power Meters.
      i. Section 16295 - Protective Relays.
      j. Section 16305 - Electrical System Studies.
      k. Section 16414 - Low Voltage Power Circuit Breakers.
      l. Section 16433 - Service Entrance Automatic Transfer Switchgear.
      m. Section 17710 - Control Systems - Panels, Enclosures, and Panel Components.

1.02 REFERENCES

A. As specified in Section 16050.

B. American National Standards Institute (ANSI):
   1. C37.13 - Standard for Low Voltage AC Power Circuit Breakers Used in Enclosures.
   2. C37.16 - Preferred Ratings, Related Requirements, and Application Recommendations for Low Voltage Power Circuit Breakers and AC Power Circuit Protectors.
   3. C37.20.1 - Standard for Metal-Enclosed Low-Voltage Power Circuit Breaker Switchgear.
   4. C37.51 - For Switchgear - Metal-Enclosed Low-Voltage AC Power Circuit Breaker Switchgear Assemblies - Conformance Test Procedures.

5. C39.1 - Requirements for Electrical Analog Indicating Instruments.
6. C57.13 - Standard Requirements for Instrument Transformers.

C. Institute of Electrical and Electronics Engineers (IEEE).

D. National Electrical Manufacturers Association (NEMA):
1. SG3 - Low-Voltage Power Circuit Breakers.
2. SG5 - Power Switchgear Assemblies.

E. Underwriters Laboratories, Inc. (UL):
1. UL 1558 - Standard for Metal-Enclosed Low-Voltage Power Circuit Breaker Switchgear.

1.03 DEFINITIONS

A. As specified in Section 16050.

1.04 SYSTEM DESCRIPTION

A. General:
1. Factory assembled, factory wired and factory tested switchgear.
2. Switchgear and major components to be products of a single manufacturer including, but not limited to:
   a. Circuit breakers.
   b. Control power transformers.
   c. Related equipment as specified and indicated on the Drawings.

B. Description of sections:
1. In addition to the specified basic equipment common to switchgear sections, equip the various individual sections with instruments and control devices as indicated on the Drawings and as specified below.
2. Incoming line compartment:
   a. Hinged door with lockable handle, bolted closed.
   b. Dimensions, ratings, spacing, and standards must conform to the requirements of the electric utility.
   c. Service entrance bus duct to enter the incoming line compartment, in a manner as indicated on the Drawings.
   d. Provide surge protective device.
3. Utility metering compartment:
   a. Furnish an integral utility current and potential transformer cabinet for Utility Company metering.
   b. Switchgear to include space for mounting Electric Utility's potential and current transformers.
   c. Instrument transformers to be supplied in accordance with the Electric Utility's requirements.
   d. Switchgear manufacturer to obtain necessary approvals from the Electric Utility.
   e. Bolted hinged door with lockable handle.
   f. Metering compartment barriers, rear, top, bottom, and sides.
   g. Dimensions, ratings, spacings, and standards must conform with the requirements of the Electric Utility.
   h. Current and potential transformers shall be configured for hot sequence metering.

4. Automatic Transfer Controller and Battery Backup Compartment:
    a. Furnish an automatic transfer controller compartment, backup batteries, and potential transformers in main breaker and generator breaker compartments.
5. Fire Pump Circuit Breaker Compartment.
    a. Protective devices as indicated on the Drawings. Compartment to conform to National Electrical Code Section 695.3.A.1.
6. Main breaker:
    a. Protective devices and interlocks as indicated on the Drawings.
7. Generator breaker:
    a. Protective devices and interlocks as indicated on the Drawings.
8. Power Monitor Relay Compartment:
    a. Provide power monitoring relay cabinet complete with potential and current transformers as indicated on the Drawings.
9. Feeder breakers:
    a. Protective devices and interlocks as indicated on the Drawings.
10. Space for future devices:
    a. Where indicated on the Drawings, space for future devices shall include:
        1) All necessary bus.
        2) Device supports.
        3) Device mounting equipment.
        4) Device connections to bus work.
        5) Wire troughs or raceway space.
        6) Covered with blank code gauge steel cover or door.

1.05 SUBMITTALS

A. Furnish submittals as specified in Sections 01330 and 16050.

B. Product data:
1. Manufacturer of switchgear.
2. Manufacturer of component parts of switchgear.
3. Dimensions:
    a. Height.
    b. Length.
    c. Width.
    d. Weight:
        1) Total switchgear weight.
        2) Weight of each circuit breaker of different frame sizes.
4. Nameplate schedule.
5. Bill of material.
6. Description of operation:
    a. Protective relaying.
    b. Automatic transfer system as specified in Section 16433.
7. Ratings:
    a. Voltage.
    b. Phase.
    c. Current.
    d. Interrupting rating (circuit breakers and fuses).
8. List of recommended spare parts.
9. Switchgear accessories.

10. Name of supplier's repair facility and parts stocking agreement with the factory outlining the following:
    a. The manufacturer's parts stocking requirements and the method by which the manufacturer verifies that the stock is at an acceptable level.
    b. The method by which the manufacturer determines that the service personnel meet factory standards.

C. Shop drawings:
1. Layout drawings:
    a. Furnish fully dimensioned and to scale equipment layout drawings which include:
        1) Plan, front and side views.
        2) Shipping splits.
        3) Bus layout.
        4) Interfaces with other equipment.
        5) Minimum distances to walls and breaker "roll-out" distances.
        6) Top and bottom conduit windows.
    b. Complete, detailed, and scaled switchgear layout:
        1) Front panel.
        2) Sub-panels.
        3) Interior panels.
        4) Assembly drawings, cross-section as a minimum for each cubicle with major dimensions indicated.
2. Detail of interface connections to automatic controller and breakers, engine generators, etc.
3. Internal schematics, elementary diagrams, and wiring diagrams of each unit or compartment, including wiring identification and terminals.
4. Internal cell-to-cell interconnection wiring diagrams, including wiring identification and terminal numbers.
5. Complete one-line diagrams for each switchgear line-up and complete 3-line diagrams for each cubicle:
    a. Indicate devices comprising the switchgear assembly including, but not limited to, circuit breakers, control power and instrument transformers, meters, relays, control devices, and monitoring devices.
    b. Clearly indicate device electrical ratings on drawings.
    c. Indicate lug sizes, type, and manufacturer based on the cable size specified and indicated on the Drawings.

D. Installation instructions:
1. Detail the complete installation of the switchgear including rigging, moving, and setting into place.
2. Provide anchorage instructions and requirements for the switchgear based on the seismic requirements at the Project Site as specified in Sections 16050 and 01612:
    a. Stamped by a professional engineer registered in the State where the Project is being constructed.

E. Operation and maintenance manuals:
1. Operating instructions:
    a. Printed and framed instruction chart suitable for wall hanging.
    b. Detail the operational functions custom controls that have been placed on the front of the switchgear.

2. Maintenance manual:
   a. Furnish maintenance manuals with instructions for maintenance of all equipment and data identifying all parts.
   b. Include all information needed to maintain the switchgear including but not limited to the following:
      1) Instructions for testing, adjustment, and start-up.
      2) Detailed control instructions that outline the purpose and operation of every control device used in normal operation.
      3) Description of the sequence of operation, which outlines the steps the switchgear follows during normal power failure, fault conditions, and return of normal power.
      4) Schematic and wiring diagrams:
         a) Showing all internal and external connections.
         b) Furnished in a reduced 11-inch by 17-inch fully legible format.

F. Test reports:
   1. Furnish a manufacturer's certified report after the factory tests.
   2. Furnish a manufacturer's written report after the start-up:
      a. Report must state that the installation is complete and satisfactory, or list items requiring additional attention and a proposal for the corrective actions.
      b. If items require attention after the initial start-up, a final report is required stating that the installation is complete and satisfactory.

G. Certification letters:
   1. Provide a letter from the switchgear manufacturer that lists every paragraph, subparagraph etc. of this Section and states compliance or non-compliance with said paragraph. If non-compliance is indicated, provide an explanation for the deviation and alternative method to address the non-compliance.
   2. Provide a letter from the Electric Utility stating that the utility metering compartment meets all serving utility requirements or provide switchgear shop drawings that have been reviewed, stamped, and signed by the Electric Utility.
   3. Seismic certification: IBC certified (or equal) per seismic requirements in Specification 01612.

H. Calculations:
   1. Detailed calculations or details of the actual physical testing performed on the switchgear to prove the switchgear is suitable for the seismic requirements at the Project Site.

1.06 QUALITY ASSURANCE

A. As specified in Section 16050.

B. Where indicated on the Drawings the switchgear shall be UL labeled and listed "Suitable for Service Entrance."

C. Manufacturer shall have supplied at least 4 systems of a similar nature and size, installed within a 500-mile radius of the project location.

D. The manufacturer have established an authorized dealer having a parts and service facility within a 200-mile radius of the project:
   1. Service personnel shall be available on a 24 hour-a-day basis. The personnel must be completely familiar with the items supplied to return the equipment to service in the shortest possible time.
   2. The authorized dealer must have no less than 80 percent of all switchgear parts and 100 percent of all recommended spare parts (as identified in the product data submittal) in its stock at all times:
      a. A personal inspection of the facility may be made by the Owner to substantiate claims of available replacement parts.

E. Sections and devices shall be UL listed and labeled.

1.07 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 16050.

B. Ship the switchgear 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. Furnish temporary equipment heaters within the switchgear to prevent condensation from forming.

1.08 PROJECT OR SITE CONDITIONS

A. As specified in Section 16050.

1.09 SEQUENCING

A. Submit complete equipment submittal as specified in this Section for Engineer's review.

B. Conduct initial fault current study as specified in Section 16305 and submit results for Engineer's review.

C. After successful review of the initial fault current study, submit complete equipment submittal as specified in the Submittals article 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 (FAT), to be witnessed by Owner and Engineer.

F. Ship equipment to project site after successful completion of FAT.

G. Assemble equipment in the field.

H. Conduct field acceptance tests and submit results for Engineer's review.

I. Submit manufacturer's certification that 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.

1.10 SCHEDULING

A. As specified in Section 16050.

1.11 WARRANTY

A. As specified in Section 16050.

1.12 SYSTEM START-UP

A. As specified in Section 16050.

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 COMMISSIONING (NOT USED)

1.15 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. One of the following or equal:
   1. General Electric.
   2. Eaton/Cutler-Hammer.
   3. Schneider Electric/Square D.
   4. ABB.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS (NOT USED)

2.04 MANUFACTURED UNITS (NOT USED)

2.05 EQUIPMENT

A. Switchgear:
   1. Furnish dead-front metal enclosed low voltage switchgear as specified and indicated on the Drawings.
   2. Provide complete and functional lineups of switchgear and respective controls.
   3. Arrange switchgear sections to form continuous lineups as indicated on the Drawings.
   4. Provide devices or accessories not described in this Section but necessary for the proper installation and operation of the equipment.

B. Voltage ratings:
   1. Design and construct switchgear for:
      a. Voltage level and configuration as indicated on the Drawings.
      b. Solidly grounded system.
   2. Maximum voltage rating: 600 VAC.

C. Main bus:
   1. High conductivity, flat, tin-plated copper bar:
      a. Bracing as indicated on the Drawings.
   2. Continuous current carrying capacity as indicated on the Drawings.
   3. Provide a bus compartment totally enclosed by metal plates.
   4. Insulate each bus with fluidized bed epoxy flame retardant and track resistance insulation.
   5. Mount insulated bus on flame retardant, track resistant supports.
   6. Bus connections:
      a. Plated.
      b. Bolted with Belleville spring washers.
      c. Install insulated boot or insulated cover over joint.
   7. Document temperature rise of the bus and connections by design tests.

D. Ground bus:
   1. Tin-plated copper bar, 1/4-inch by 2-inch minimum, extending through all vertical sections.
   2. Provide properly sized lugs for connection of the equipment ground wires to ground bus in each vertical section.

E. Stationary structure:
   1. Framework:
      a. Code gauge steel bolted together to form rigid assembly.
      b. Self-supporting.
      c. Vertical sections shall be front and rear aligned.
      d. Approximately 90 inches high with widths as required.
      e. Maximum dimensions as indicated on the Drawings.
      f. Provide suitable lifting means and means for setting into place.
   2. Covers:
      a. Sheet steel.
      b. Front covers:
         1) Formed edges.
         2) Held in place with quarter-turn latches.
         3) Hinged.
         4) Pad-lockable.
         5) Opening to allow access to devices.
      c. Side covers:
         1) Removable, bolt-on with captive hardware.
      d. Top and bottom:
         1) Open bottom.
         2) Removable top cover for each vertical section.
      e. Rear covers:
         1) Hinged door with provisions for padlocking.

3. Cable compartment:
    a. Separated from main and vertical bus by grounded sheet steel barrier.
4. NEMA type:
    a. NEMA Type 1 gasketed:
        1) Non-walk-in.

F. Circuit breaker compartment:
1. Individual compartments for each circuit breaker or other device.
2. Isolated on all sides by grounded metal barriers.
3. Track resistant glass reinforced insulating rear support barriers.
4. Shutters to cover bus and load connections when circuit breaker is withdrawn.
5. Drawout mechanism:
    a. Provide 4 distinct positions:
        1) Connect.
        2) Test.
        3) Disconnected.
        4) Withdrawn.
    b. Padlockable in the test and disconnected positions.
    c. Capable of being operated with the compartment door closed.
    d. Indicator on the door of the breaker compartment to show breaker position.
    e. Guiderails shall ensure proper alignment of the breaker primary and secondary contacts.
        1) Interlocked to prevent the breaker from being racked in or out unless the breaker is open.
        2) Padlockable to prevent a breaker from being inserted into an empty compartment.
    f. Breaker frame shall be grounded during the entire path of travel.
6. Mechanical interlock so only a breaker frame size that the cubicle was designed for can be inserted.

G. Compartments for automatic transfer system and switchgear batteries:
1. To come complete with switchgear batteries (24vDC) and Automatic Transfer System Controller.

2.06 COMPONENTS

A. Circuit breakers:
1. As specified in Section 16414.

B. Direct current battery systems:
1. As specified in Section 16240.

C. Instrument transformers:
1. As specified in Section 16295.

D. Automatic transfer system:
1. As specified in Section 16433.

E. Protective relays:
1. Provide protective relays complete with devices and associated circuitry necessary to perform the required functions as specified or as indicated on the Drawings.

2. As specified in Section 16295.
3. Provide nameplates as specified in Section 16075.

F. Control power transformers:
1. Provide 480- to 120-volt control power transformers as indicated on the Drawings.
2. Control power transformers to have capacity for 125 percent of the load served.
3. Protect control power transformers with both primary and secondary fuses. Protect primary side with current limiting fuses.

G. Control wiring:
1. National Electrical Code (NEC) Type SIS, single-conductor, stranded copper:
   a. Rated 600 volts.
   b. Bundle and secure with nylon ties.
2. Minimum wire size:
   a. Number 14 for control circuits.
   b. Number 12 for control power, potential and current transformer circuits.
3. Terminate control wiring in molded, screw-type terminal blocks.
   a. Compression type terminal blocks are not acceptable.
   b. Provide a minimum of 10 percent spare terminal blocks for each unit.
   c. Route outgoing control wires to master terminal blocks.
   d. Terminate external circuits entering the switchgear on “pull-apart” terminal blocks.
4. Number terminal blocks with machine printed strips consistent with the manufacturer’s detailed wiring diagrams:
   a. Duplication of terminal block numbers is not acceptable.
5. Number wiring with machine-printed tag devices at both ends consistent with the manufacturer’s detailed wiring diagrams:
   a. Duplication of wire numbers is not acceptable.
   b. Every wire shall be numbered.
6. When a power source, other than the source that is interrupted, is present in the switchgear compartment, provide a switch for each remote source inside the compartment to isolate the source in compliance with the NEC.
7. Terminate control wire with insulated barrel, ring type connectors.
   a. Manufactured by Stakon or equal.

2.07 ACCESSORIES

A. Surge protective devices:
1. As specified in Section 16285.

B. Metering system:
1. Provide metering as indicated on the Drawings and as specified in Section 16290.

C. Test blocks and plugs:
1. Molded polycarbonate material.
2. Make-before-break connections for CT circuits.
3. Provide cover for each test block.
4. 4-pole test blocks for current circuits.

5. 6-pole test blocks for voltage circuits.
6. Acceptable manufacturers:
   a. Multilin PK-2.
   b. ABB FT-1.

D. Remote maintenance mode switch:
1. Provide remote maintenance mode switch to override main incoming breaker and generator breaker trip settings for arc flash hazard reduction during maintenance procedures on main switchgear and MCC-C and MCC-D. Switch to come complete with contact for remote indication and pilot lamp. As specified in Section 16414..

E. Nameplates:
1. Provide engraved plastic nameplates to identify:
   a. Switchgear units.
   b. Door mounted components.
   c. Interior mounted devices.
2. As specified in Section 16075:
   a. Mounted using round head stainless steel screws.
3. Engraved with the circuit number and circuit name as indicated on the Drawings.

F. Warning signs:
1. Voltage:
   a. Provide a minimum of 2 warning signs on the front of the switchgear lineup and 2 on the back.
   b. Red laminated plastic engraved with white letters approximately 1/2 inch high.
   c. Signs shall read:
      1) “WARNING-HIGH VOLTAGE-KEEP OUT”.
2. Arc flash:
   a. Provide 1 warning sign for each switchgear compartment.
   b. Signs shall have read a minimum of:
      1) “DANGER ELECTRIC ARC FLASH HAZARD”.
      2) Signs shall meet the requirements of NFPA 70E and NEC Article 110.

G. Circuit breaker lifting device:
1. Rail mounted on top of the switchgear.
2. Provide lifting tools as required for each circuit breaker frame size.

H. Circuit breaker racking tool.

I. Portable test kit:
1. AC or DC powered.
2. Secondary injection to test and verify circuit breaker settings.

J. Removable cover:
1. Blocks the breaker compartment door opening when the breaker is removed.

K. Test cabinet:
1. Provide with receptacle, control cable and pushbuttons for testing electrically operated circuit breakers.

L. Mimic bus:
   1. Laminated plastic material fastened to the front surface of the switchgear reflecting bus routing and power devices.

M. Lugs:
   1. For all external connections of No. 6 AWG or larger:
      a. UL listed for copper or aluminum conductors.
   2. Mounted up or down at a 45-degree angle to facilitate cable termination with a minimum bending radius.
   3. Compression type requiring a hydraulic press and die for installation as manufactured by:
      a. Burndy.
      b. T&B.

N. Electrically operated remote racking mechanism for main and generator breaker:
   1. 120 V powered.
   2. Minimum 30-foot control cable.
   3. Mechanism shall rack the breaker between the connected and disconnect positions.

O. Remote breaker control panel:
   1. Provide the following controls for each breaker:
      a. Open pushbutton.
      b. Close pushbutton.
      c. Open pilot light.
      d. Closed pilot light.
   2. Provide pushbutton and pilot lights as specified in Section 17710.
   3. NEMA Type 12 enclosure.
   4. Provide space on the panel for future controls for all switchgear spaces.

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES

A. Steel shall be chemically cleaned and treated to ensure a bond between paint and metal and to inhibit rust formation under paint.

B. ANSI standard gray baked enamel exterior:
   1. Outdoor enclosures shall be finished in ANSI gray baked enamel.

2.11 SOURCE QUALITY CONTROL

A. Factory tests:
   1. Test the complete switchgear at the manufacturer's establishment:
      a. The test shall be witnessed by the Engineer .
      b. The Contractor shall bear all costs associated with this test except Engineer's travel, lodging and meals.
   2. Furnish a certified copy of the test results for review:
      a. Record minor adjustments made during the test.
      b. If major changes must be made, the test shall be repeated.

3. Completely assemble, wire and test switchgear at the factory:
   a. Detailed inspections before and after assembly to assure correctness of design and workmanship.
   b. Provide groups of wires leaving the shipping-assembled equipment with terminal blocks with suitable numbering strips.
4. In the event the equipment must be re-tested, the manufacturer shall comply with all of the testing requirements and treat the re-test the same as the initial test:
   a. Manufacturer shall bear all costs associated with the re-test including but not limited to: travel, lodging, meals, travel time and labor:
      1) A minimum of 8 hours per day per individual for 2 individuals shall be included.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 16050.

B. Install the switchgear per the manufacturer's guidelines and submitted installation instructions to meet the seismic requirements at the Project Site.

C. General:
   1. Furnish cables, conduit, lugs, bolts, expansion anchors, sealants, and other accessories needed to complete the installation of the switchgear.
   2. Assemble and install the switchgear in the location and layout indicated on the Drawings.
   3. Make bus splice connections.
   4. Perform Work in accordance with manufacturer's instructions and shop drawings.
   5. Furnish components and equipment as required to complete the installation.
   6. Replace hardware lost or damaged during the installation or handling to provide a complete installation.
   7. Install the switchgear on a 3-1/2-inch raised concrete housekeeping pad:
      a. Provide structural mounting channels in accordance with the manufacturer's recommendation to provide proper alignment of the units.
      b. Weld and/or bolt the switchgear frame to the leveling channels.

D. Provide the services of a qualified manufacturer's representative to:
   1. Make control connections across the shipping splits.
   2. Install and align all circuit breakers.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 REINSTALLATION (NOT USED)

3.07 FIELD QUALITY CONTROL

A. As specified in Section 16050.

B. Provide the services of a qualified manufacturer's representative to:
   1. Be present at the job site when the switchgear arrives.
   2. Act as an advisor in assisting the Contractor regarding the unloading, storage, and move-in operations.
   3. Furnish the services of a factory certified technician during the start-up and adjustment period to ensure that items furnished are in proper operating condition:
      a. Technician must be completely knowledgeable in the operation, maintenance, and start-up of the electrical system.
   4. Before start-up, furnish written certification that the entire installation and electrical connections have been inspected and are proper and consistent with the Contract Documents.
   5. Install and align all circuit breakers.
   6. Furnish a written report after start-up signed by the manufacturer:
      a. Report must state that the installation is complete and meets the manufacturer's requirements.
      b. List items requiring additional attention.

3.08 ADJUSTING

A. Make adjustments as necessary and recommended by the manufacturer, Engineer, or testing firm.

B. Provide the services of a qualified manufacturer's representative to:
   1. Adjust the carriages and racking mechanisms.
   2. Adjust doors for proper operation.
   3. Adjust shutters for proper operation.

3.09 CLEANING

A. As specified in Section 16050.

3.10 DEMONSTRATION AND TRAINING

A. As specified in Section 16050.

B. Demonstrate the operation to the Engineer's and Owner's satisfaction.

C. Training:
   1. Provide as specified in Section 01660 and supplemented by the conditions below.

2. Manufacturer shall instruct the Owner's personnel regarding the operation and maintenance of items supplied:
    a. Supply written handouts during the training period and these handouts shall be suitable for future reference after the training period is completed.
    b. Held at the Owner's facility.
    c. Contractor to record the entire training session in DVD format, and deliver the training disk to the Owner.
    d. Supply complete training documents for attendees, as determined by the Owner:
        1) Engineer reviewed and accepted training documents are to be supplied a minimum of 4 weeks before the training session, and to be used by the Owner as reference documents during the training period.
3. Held in a formal classroom environment that utilizes the actual equipment in the field:
    a. Training sessions that are conducted as part of start-up and commissioning will not be accepted as part of this requirement.
4. Training sessions consist of both operational and maintenance training.

3.11 PROTECTION

A. As specified in Section 16050.

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 16433

SERVICE ENTRANCE AUTOMATIC TRANSFER SWITCHGEAR

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Low voltage switchgear automatic transfer system.

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 16414 - Low Voltage Power Circuit Breakers.
      d. Section 16430 - Low Voltage Switchgear.
      e. Section 17710 - Control Systems - Panels, Enclosures, and Panel Components.
      f. Section 17720 - Control Systems - Programmable Logic Controllers Hardware.

1.02 REFERENCES

A. As specified in Section 16050.

1.03 DEFINITIONS

A. As specified in Section 16050.

1.04 SYSTEM DESCRIPTION

A. Provide an automatic transfer system as an integral part of the low voltage switchgear:
   1. The requirements of Section 16430 apply.

B. Automatic transfer system operation:
   1. Transfer and re-transfer schemes:
      a. Automatic mode:
         1) When the normal source voltage fails or if a single phase condition occurs, the control system shall:
            a) Initiate normal source failure (adjustable) timer.

b) Upon completion of the normal source failure timer:
(1) Open the commercial source breaker.
(2) Signal the engine to start via the engine control panel.

2) When the generator has reached normal operating voltage and frequency for an adjustable period of time, the control system shall:
a) Verify the normal source breaker is open.
b) Close the generator source breaker.

3) When the control system detects the return of normal source voltage for an adjustable period of time, the control system shall:
a) Open the generator source breaker.
b) Initiate a neutral position timer.
c) Upon completion of the timer, close the normal source breaker.
d) After the control system has opened the engine source breaker, the control system will continue to run the engine generator for an adjustable cool down period of time.

b. Test mode (Automatic mode only):

1) Provide a selector switch to test the automatic transfer system, including starting of the engine-generator:
a) Moving the selector switch to the test position will have the same effect as a normal power loss. The control system shall:
(1) Initiate normal failure timer.
(2) Open normal source breaker:
(a) Signal engine generator to start. Initiate a neutral position timer.
(b) Upon completion of the timer, verify normal source breaker open.
(c) Close generator source breaker.
b) The return to normal will have the same effect as restoration of the normal power. The control system shall:
(1) Open the generator source breaker.
(2) Initiate a neutral position timer.
(3) Upon completion of the timer, close the normal source breaker.
(4) After the control system has opened the generator source breaker, the control system will continue to run the engine generator for an adjustable cool down period of time.

c. Manual transfer operating mode:

1) Moving the transfer operation switch to manual will disengage the automatic transfer capability.

2) Manual transfer to standby power:
a) Open the normal source breaker via pushbutton on automatic transfer switchgear.
b) Start engine generator via engine control panel.
c) Close generator source breaker via selector switch on automatic transfer switchgear.

3) The generator source breaker will not be allowed to close until engine generator has reached normal operating voltage and frequency.

4) Manual transfer to normal source:
a) Open the generator source breaker via pushbutton on automatic transfer switchgear.

b) Close normal source breaker via selector switch on automatic transfer switchgear.
c) Stop engine generator via engine control panel after a cool down period of time.

2. If the normal source breaker has tripped due to any fault condition, the control system shall not signal the engine to start or initiate a transfer to the generator source, until the fault has been removed.

1.05 SUBMITTALS

A. Furnish submittals as specified in Sections 01330 and 16050.

B. Product data:
1. Include the following in the product data submittal for the low voltage switchgear:
   a. Description of the automatic transfer system.
   b. Catalog data for all automatic transfer system components.
   c. Product data describing the controller.
   d. Complete power requirements for the control and relaying system to be used in sizing the engine generator start battery.
2. Submit operator interface displays in full color as they will appear on the display screen:
   a. Uniquely title each display.
   b. Provide alarm and graphic displays.
   c. At a minimum, the submittal shall include the following screens:
      1) Provide a 1-line screen of all controllable breakers, their states, and a color-coded representation of which bus(es) are energized.
      2) Provide a timers screen showing selected value, default, and allowable range for each adjustable timer:
         a) Match timer designations to those specified in the automatic transfer system operation description.
      3) Provide an input/output screen showing all discrete and analog hardwired input/output points, with each point's current state:
         a) Indicate current state in color-coded form:
            (1) Discrete points: Active/not active.
            (2) Analog point: In engineering units.

C. Shop drawings:
1. Include the following in the shop drawing submittal for the low voltage switchgear:
   a. Complete interface and connection diagrams to the engine control panel.
   b. Schematic and interconnection diagrams for the controller.

D. Installation instructions:
1. The written instructions must detail the complete installation of the switchgear including rigging, moving, and setting into place.
2. Provide anchorage instructions and requirements for the switchgear based on the seismic requirements at the project site as indicated in Section 16050:
   a. Stamped by a professional engineer registered in the State where the Project is being constructed.

E. Operation and maintenance manuals:
   1. Include the following in the operation manuals submittal for the low voltage automatic transfer switchgear:
      a. Description of the sequence of operation that outlines the steps the controls follow during normal power failure and normal power return conditions.
      b. Detail the operational function of all controls and internal controller programming.
      c. Report listing the installed setting of all adjustable parameters for automatic transfer system.

1.06 QUALITY ASSURANCE

A. As specified in Section 16050.

B. The automatic transfer system and all components shall be UL listed and labeled.

1.07 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 16430.

1.08 PROJECT OR SITE CONDITIONS

A. As specified in Section 16050.

1.09 SEQUENCING

A. As specified in Section 16430.

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

A. As specified in Section 16430.

1.12 SYSTEM START-UP

A. As specified in Section 16430.

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 COMMISSIONING (NOT USED)

1.15 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. One of the following or equal:
   1. Relays:
      a. Negative sequence and under/overvoltage relay:
         1) Basler Electric.

b. Under/overvoltage relay:
   1) Basler Electric.
c. Under/over frequency relay:
   1) Basler Electric.
d. Battery under voltage relay:
   1) Basler Electric.

2. Selector switches:
   a. General Electric:
      1) Type SB.
3. Pushbuttons and pilot lights:
   a. As specified in Section 17710.
4. Control system:
   a. Programmable logic controller as specified in Section 17720.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS (NOT USED)

2.04 MANUFACTURED UNITS (NOT USED)

2.05 EQUIPMENT

A. As specified in Section 16430.

B. Automatic switchgear transfer system configuration:
   1. Utilizes circuit breakers as the transfer mechanisms.
   2. Provide equipment for operation, including but not limited to:
      a. Interface circuits.
      b. Relays.
      c. Interlocks.
      d. Control fuses.
      e. Fuse blocks.
   3. Provide controls on the front door of the automatic transfer system section as indicated on the Drawings.
   4. Provide power for pilot lights, protective relays, automatic transfer system control power, and shunt trip circuits from the 48v DC low voltage switchgear battery system.

2.06 COMPONENTS

A. Control system:
   1. As specified in Section 17720.
   2. Microprocessor based controller:
      a. Either a board level microprocessor controller that has been specifically designed for the control of automatic transfer systems, or a programmable logic controller programmed for the control of automatic transfer systems.
      b. Non-volatile logic memory:
         1) Controller power interruption shall not result in memory loss or improper operation, or require any manual operations to reprogram or restart the controller.
      c. Powered from the switchgear battery system:

d. Provide LED indicators on all inputs and outputs.
e. Provide the following status signals to the OWNER's control system:
1) Power failure.
2) Normal, Emergency, Test, and Auto status.

B. Pilot lights:
1. As specified in Section 17710.

C. Negative sequence and over/under voltage relay:
1. Connected to signal the automatic transfer control system to operate upon sensing abnormal conditions.
2. Mechanical trip indicator and target reset:
a. One target for 47N negative sequence device.
b. One target for 27/59 over/under voltage devices.
3. Provide contacts for connection to monitoring system.
4. Powered from the switchgear battery system.
5. Provide the following functions:
a. 47N device-negative sequence:
1) Adjustable definite time characteristic.
2) Capable of sensing a single-phase condition.
3) Relay shall be of the negative sequence design and not rely solely on voltage differences or imbalances.
b. Adjustable negative sequence level:
1) 27 device-undervoltage relay.
2) Adjustable definite time characteristic.
3) Adjustable pick up level.
c. 59 device-overvoltage relay:
1) Adjustable definite time characteristic.
2) Adjustable pick up level.

D. Over/under voltage device:
1. Connected to signal the automatic transfer control system to operate upon sensing abnormal conditions from the engine generator.
2. With mechanical trip indicator and target reset:
a. One target for 27 undervoltage device.
b. One target for 59 overvoltage device.
3. Provide contacts for connection to monitoring system.
4. Powered from the switchgear battery system.
5. Provide the following functions:
a. 27 device-undervoltage relay:
1) Adjustable definite time characteristic.
2) Adjustable pick up level.
b. 59 device-overvoltage relay:
1) Adjustable definite time characteristic.
2) Adjustable pick up level.

E. Over/under frequency device:
1. Connected to signal the automatic transfer control system to operate upon sensing abnormal conditions for the engine generator.
2. Mechanical trip indicator and target reset:
a. One target for 81O over frequency device.
b. One target for 81U under frequency device.

3. Provide contacts for connection to monitoring system.
4. Powered from the switchgear battery system.
5. Provide the following functions:
   a. 81O device-over frequency:
      1) Adjustable definite time characteristic.
      2) Relay shall be of the over frequency design single phase sensing.
      3) Adjustable pick up level.
   b. 81U device-under frequency:
      1) Adjustable definite time characteristic.
      2) Single phase sensing.

F. Battery monitor protective relay:
   1. Connect to alarm the automatic control system upon low voltage of switchgear battery system.

2.07 ACCESSORIES

A. Circuit breakers:
   1. As specified in Section 16414.
   2. Additional requirements for automatic transfer breakers:
      a. Provide each breaker with a motor operator or motor-charged operating spring.
   3. Normal and standby breaker electrical interlocks:
      a. Prevent both breakers from being closed at the same time, and prevent both breakers from closing at the same time (when either electrically or manually operated).
      b. Prevent one breaker from trying to close while the other breaker is closed, and shall prevent both breaker close coils (or motor operators) from operating at the same time.
         1) The interlock shall not prevent both breakers from being open at the same time.
      c. Opening and/or trip circuit voltage:
         1) 48v DC from the low voltage switchgear battery system.
      d. Closing circuit voltage:
         1) 120 VAC from the control power transformer circuits in the low voltage switchgear.

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL

A. As specified in Section 16430.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 16430.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 FIELD QUALITY CONTROL

A. As specified in Section 16430.

3.08 ADJUSTING

A. As specified in Section 16430.

3.09 CLEANING

A. As specified in Section 16430.

3.10 DEMONSTRATION AND TRAINING

A. Perform full functional test of operation and demonstration of automatic transfer system per written description as detailed in Article 1.05, Paragraph E of this specification.

3.11 PROTECTION

A. As specified in Section 16430.

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 16444

LOW VOLTAGE MOTOR CONTROL CENTERS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. 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.
   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 - Seismic Design Criteria
      c. Section 16050 - Common Work Results for Electrical
      d. Section 16075 - Electrical Identification.
      e. Section 16123 - 600 Volt or Less Wires and Cables.
      f. Section 16150 - Low Voltage Wire Connections.
      g. Section 16262 - Variable Frequency Drives 0.50 - 50 Horsepower.
      h. Section 16272 - Dry Type Transformers.
      i. Section 16285 - Surge Protective Devices.
      j. Section 16305 - Electrical System Studies.
      k. Section 16412 - Low Voltage Molded Case Circuit Breakers.
      l. Section 16422 - Motor Starters.
      m. Section 16445 - Panelboards.
      n. Section 16494 - Low Voltage Fuses.

1.02 REFERENCES

A. As specified in Section 16050.

B. National Electrical Manufacturer's Association (NEMA):
   1. ICS 18-2001 - Motor Control Centers.

C. Underwriters Laboratories (UL):
   1. 845 - Motor Control Centers.

1.03 DEFINITIONS

A. As specified in Section 16050.

1.04 SYSTEM DESCRIPTION

A. Factory assembled, factory wired and factory tested motor control centers:
   1. Motor control centers and major components to be products of a single manufacturer including, but not limited:
      a. Starters.
      b. VFD.
      c. Related equipment specified in the Contract Documents or indicated on the Drawings.

1.05 SUBMITTALS

A. Furnish submittals as specified in Sections 01330 and 16050.

B. Product data:
   1. Manufacturer of motor control center.
   2. Manufacturer of motor control center parts.
   3. Nameplate schedule.
   4. Bill of material.
   5. Enclosure:
      a. NEMA rating.
      b. Finish color.
   6. Ratings:
      a. Voltage.
      b. Phase.
      c. Current:
         1) Horizontal bus ampacity.
         2) Vertical bus ampacity.
         3) Ground bus ampacity.
      d. Short circuit withstand rating.
      e. Protective device interrupting rating.
   7. List of recommended spare parts.
   8. Catalog cut sheets:
      a. Submit complete manufacturer's catalog information:
         1) Clearly indicate the features of the equipment including any options necessary to meet the required functionality.
   9. Furnish circuit breaker submittals as specified in Section 16412.

C. Shop drawings:
   1. Layout drawings:
      a. Provide fully dimensioned and to scale layout drawings which include:
         1) Dimensions:
            a) Overall length.
            b) Overall width.
            c) Overall height.
            d) Overall weight and weight of individual shipping splits.
   2. Interfaces to other equipment.
   3. Shipping splits.
   4. Allowable top and bottom conduit windows.
   5. Complete component and unit layout drawings.

6. Indicate lug sizes, type, and manufacturer based on the cable size specified in the Contract Documents and as indicated on the Drawings.
7. Elementary schematics:
    a. Provide one custom schematic diagram for each compartment:
        1) Include all remote devices.
        2) Show wire numbers on the schematics:
            a) Provide wire numbering as specified in Section 16075.
8. External connection diagram showing the wiring to the external controls and devices associated with the motor control center.
9. One-line diagrams:
    a. Provide complete one-line diagrams for each motor control center, including but not limited to: protective devices, starters, drives, metering, and other equipment.
    b. Indicate electrical ratings of the equipment shown on the one-line diagrams.

D. Installation instructions:
1. Detail the complete installation of the motor control center including rigging, moving, and setting into place.
2. Provide anchorage instructions and requirements for the motor control center based on the seismic requirements at the Project Site as indicated in Section 16050 and Section 01612:
    a. Stamped by a professional engineer registered in the state where the Project is being constructed.

E. 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) Bus bracing and 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.
    c. Complete renewal parts list.

F. 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.

G. Calculations:
1. Detailed calculations or details of the actual physical testing performed on the motor control center to prove the motor control center is suitable for the seismic requirements at the Project Site.

1.06 QUALITY ASSURANCE

A. As specified in Section 16050.

B. All portions of the motor control center, vertical bays, and components shall be UL listed and labeled.

1.07 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 16050.

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.

1.08 PROJECT OR SITE CONDITIONS

A. As specified in Section 16050.

1.09 SEQUENCING

A. Conduct the initial fault current study as specified in Section 16305 and submit results for Engineer's review.

B. After successful review of the initial fault current study, as specified in Section 16305, submit complete equipment submittal as specified in the Submittals article of this Section for Engineer's review.

C. Conduct internal factory test to ensure that systems and equipment are functional and submit certified test results for Engineer's review.

D. Ship equipment to the Project Site after successful completion of factory acceptance test.

E. Assemble equipment in the field.

F. Conduct field acceptance test and submit results for Engineer's review.

G. Submit manufacturer's certification that the equipment has been properly installed and is fully functional for Engineer's review.

H. Formally energize, start-up, and commission equipment.

1.10 SCHEDULING

A. As specified in Section 16050.

1.11 WARRANTY

A. As specified in Section 16050.

1.12 SYSTEM START-UP

A. As specified in Section 16050.

1.13 OWNER'S INSTRUCTION (NOT USED)

1.14 COMMISSIONING (NOT USED)

1.15 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. One of the following or equal:
   1. Allen-Bradley:
      a. CENTERLINE.
   2. Eaton/Cutler-Hammer:
      a. Freedom 2100.
   3. General Electric:
      a. Evolution Series.
   4. Schneider Electric/Square D:
      a. Model 6 Industrial.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS (NOT USED)

2.04 MANUFACTURED UNITS (NOT USED)

2.05 EQUIPMENT

A. General:
   1. Furnish motor control centers as specified in the Contract Documents and indicated on the Drawings.
   2. Arrange the equipped sections side by side and/or back-to-back to form continuous motor control center lineups as indicated on the Drawings:
      a. Identify any deviations from the Drawings in writing and submit for approval.

3. Provide wire markers at each end of every wire as specified in Section 16075.
4. Provide complete and functional motor control centers.
5. Provide devices or accessories not specified in this Section but necessary for the proper installation and operation of the equipment.
6. Provide new components of the latest construction series available from the manufacturer.

B. Design and construct motor control center to operate at the voltage level and configuration indicated on the Drawings.

C. Bus system:
1. Material:
   a. Tin-plated copper.
   b. Short-circuit rating:
      1) As indicated on the Drawings.
   c. Bus bar supports:
      1) High impact strength, non-tracking glass-polyester material that is impervious to moisture and gases.
2. Horizontal power bus:
   a. Current-carrying capacity as indicated on the Drawings.
   b. Mounting:
      1) Mount horizontal bus bars edgewise, one above the other, and fully isolated from all wireways and units.
   c. Temperature rise:
      1) In accordance with UL 845.
      2) De-rate the temperature rating of the bus for the specified conditions of ambient temperature and altitude as specified in Section 16050.
3. Vertical power bus:
   a. Current-carrying capacity of not less than 300 amps.
   b. Mounting:
      1) Enclose the vertical bus in a polyester-glass cover with small openings to permit unit stabs to mate with the bus:
         a) Provide a shutter mechanism to cover the stab openings when plug-in units are removed.
      2) Provide top and bottom bus covers for insulation and isolation of the ends of the bus.
   c. Isolated from the unit compartments by a full height barrier.
   d. Horizontal ground bus:
      1) Current-carrying capacity of not less than 600 amps.
      2) Mounting:
         a) Full-width, firmly secured to each vertical section structure:
            (1) Located in the top or bottom wireway.
         b) Pre-drilled and furnished with lugs for connection to equipment ground wires:
            (1) Furnish a minimum of 10 lugs per vertical section of MCC.
   e. Vertical ground bus.
      1) Mounting:
         a) Furnish in each vertical section.
         b) Bolted to the horizontal ground bus.
         c) Install parallel to the vertical power bus.
         d) Mount vertical ground bus such that plug-in units engage the ground bus before any connection to the power bus is made.

Upon removal of plug-in units, ground stabs are disconnected from the ground bus after the power stabs have been disconnected.

4. Bus splice bars:
   a. Provided to join the bus at the splits.
   b. Connected to each horizontal bus bar with a minimum of two bolts.
   c. Employ conical or spring washers at connections, designed to maintain constant pressure against the splice joint.
   d. Same ampacity rating as the horizontal bus.
5. Provide bus system configured for back-to-back MCCs, where required.

D. Enclosures:
1. Each motor control center shall consist of 1 or more vertical sections bolted together:
   a. Freestanding.
   b. Totally enclosed.
   c. Dead-front assembly.
   d. Designed for modification and/or addition of future vertical sections.
   e. Form each vertical section of heavy gauge steel.
   f. Designed for back-to-back arrangement installation, where required and/or as indicated on the Drawings.
2. Enclosure rating:
   a. Indoor:
      1) NEMA Type 1 gasketed.
3. Standard section dimensions:
   a. Nominal height: 90 inches.
   b. Nominal depth: 20 inches.
   c. Vertical section width as indicated on the Drawings.
4. Wireways:
   a. Provide each vertical section with a horizontal wireway at the top and bottom of the section:
      1) Arranged to provide a full-width metal enclosed wiring trough across the entire motor control center assembly.
   b. Provide each vertical section with a full-height vertical wireway.
   c. Completely isolated from the vertical and horizontal bus bars.
   d. Provide a removable, hinged door.
5. Shipping splits:
   a. No more than 3 vertical sections and not more than 60 inches in width.
   b. Solid bussing between vertical sections in a shipping split is not acceptable.
6. Lifting angles:
   a. Furnish each vertical section and/or shipping split with a removable lifting angle mounted to the top of the enclosure:
      1) Extending the entire width of the shipping split.
7. Mounting channels:
   a. Mount each vertical section and/or shipping split on an external 1.5-inch by 3-inch mounting channel.

E. Units:
   1. A plug-in unit consists of:
      a. 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 3 padlocks.
      e. Mechanically interlocked so that the door cannot be opened with the handle in the “ON” position.
         1) Provide a means for qualified personnel to defeat this interlock.
      f. Interlocked so the unit cannot be inserted or withdrawn with the handle in the “ON” position.
      g. Lockable in the “ON” position:
         1) This shall not prevent the circuit breaker from operating and opening the contacts in the event of a 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. 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.

2.06 COMPONENTS

A. Provide components contained within the motor control center as specified in:
   1. Section 16075.
   2. Section 16123.
   3. Section 16150.
   4. Section 16262.

5. Section 16272.
6. Section 16285.
7. Section 16295.
8. Section 16412.
9. Section 16422.
10. Section 16445.
11. Section 16494.

2.07 ACCESSORIES

A. Wiring:
   1. Wire the motor control center in accordance with the following NEMA Class and Type as defined by NEMA ICS 18-2001:
      a. NEMA Class II-S:
         1) Furnish wiring diagrams for individual units consisting of drawings that identify electrical devices, electrical connections, and indicate terminal numbering designations.
         2) Furnish individual unit diagrams with each unit and include inter-wiring between units, i.e., electrical interlocking, etc., as specifically specified in the Contract Documents.
         3) Provide custom drawings with unique terminal numbering designations in lieu of standard manufacturer drawings.
      b. NEMA Type B wiring:
         1) Control wiring:
            a) Type B-T pull-apart terminal blocks.
         2) Power wiring:
            a) Type B-T for Size 1 starters.
            b) Type B-T or B-D for Size 2 and 3 starters.
            c) Type B for Size 4 and larger starters and feeder units.

B. Remote maintenance mode switch:
   1. Provide remote maintenance mode switch to override main incoming breakers MCC-E and MCC-F breaker trip settings for arc flash hazard reduction during maintenance procedures on MCC-C and MCC-D. Switch to come complete with contact for remote indication and status lamp. As specified in Section 16414.

C. Lugs and terminals:
   1. For all external connections of No. 6 AWG wire or larger:
      a. UL listed for copper or aluminum conductors.
   2. Compression type, requiring a hydraulic press and die for installation.
   3. Provide 20 percent spare control block terminals.

D. Nameplates:
   1. Provide nameplates as specified in Section 16075:
      a. Identifying the motor control center designation as indicated on the Drawings.
   2. Identifying each vertical section:
      a. Mounted and centered on the top horizontal wireway of the vertical section.
   3. Furnish individual nameplates for each unit indicated on the Drawings:
      a. 1 nameplate to identify the unit designation.

b. 1 nameplate to identify the load served.
c. Furnish space units with blank nameplates.

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 section.

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 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 ANSI 61 gray.

2.11 SOURCE QUALITY CONTROL (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 16050.

B. Install the motor control center per the manufacturer's guidelines and submitted installation instructions to meet the seismic requirements at the Project Site.

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. Assemble and install the motor control center in the locations and with the layouts as indicated on the Drawings.
   3. Make bus splice connections.
   4. Perform work in accordance with manufacturer's instruction and shop drawings.
   5. Furnish all components, and equipment necessary to complete the installation.

6. Replace hardware, lost or damaged during installation or handling, in order to provide a complete installation.
7. Install the MCC on a 3-1/2-inch raised concrete housekeeping pad:
   a. Provide structural leveling channels in accordance with the manufacturer's recommendations to provide proper alignment of the units.
      1) Remove the manufacturer's supplied mounting channels as required by the manufacturer's installation instructions.
   b. Weld and/or bolt the motor control center frame to leveling channels.

D. Provide openings in the top or bottom of the motor control center for conduit only.
   1. No additional openings will be accepted:
      a. Mis-cut holes will require that the entire vertical section or removable panel be replaced.
      b. No hole closers or patches will be accepted.

E. Bundle circuits together and terminate in each unit:
   1. Tie with nylon wire ties as specified in Section 16123.
   2. Label all wires at each end with wire markers as specified in Section 16075 as shown on the approved elementary schematics.

3.04 ERECTION, INSTALLATION, APPLICATION CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 FIELD QUALITY CONTROL

A. As specified in Section 16050.

B. Provide the services of a manufacturer's representative to:
   1. Inspect, verify, and certify that the motor control center installation meets the manufacturer's requirements.

3.08 ADJUSTING

A. Make all adjustments as necessary and recommended by the manufacturer, ENGINEER, or testing firm.

3.09 CLEANING

A. As specified in Section 16050.

3.10 DEMONSTRATION AND TRAINING

A. As specified in Section 16050.

B. Demonstrate the operation of the motor control center to the ENGINEER's and OWNER's satisfaction.

C. Training:
   1. Provide training for motor control center components as specified in the individual component specifications.

3.11 PROTECTION

A. As specified in Section 16050.

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 16445

PANELBOARDS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Panelboards serving facility feeder circuits, branch circuits or other utilization equipment at the voltage levels and configurations indicated on the Drawings.

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 16075 - Electrical Identification.
      d. Section 16285 - Surge Protective Devices.
      e. Section 16412 - Low Voltage Molded Case Circuit Breakers.

1.02 REFERENCES

A. As specified in Section 16050.

B. National Electrical Manufacturers Association (NEMA):
   1. 250 - Enclosures for Electrical Equipment (1,000 Volts Maximum).

C. Underwriter's Laboratories, Inc. (UL):
   1. 50 - Standard for Enclosures for Electrical Equipment.
   2. 67 - Standard for Panelboards.

1.03 DEFINITIONS

A. As specified in Section 16050.

1.04 SYSTEM DESCRIPTION

A. Circuit breaker panelboards as indicated in the panelboard schedules, one-lines, and where indicated on the Drawings:
   1. Service voltage and configuration as indicated on the panel schedules.

1.05 SUBMITTALS

A. Furnish submittals as specified in Sections 01330 and 16050.

B. Product data:
   1. Manufacturer of panelboard.
   2. Bill of material.
   3. Assembly ratings including:
      a. Voltage.
      b. Phase.
      c. Continuous current.
      d. Short circuit interrupting rating.
   4. NEMA enclosure type.
   5. Cable terminal sizes based upon actual feeder and sub-feeder conductors used.
   6. Furnish circuit breaker submittals as specified in Section 16412.

C. Shop drawings:
   1. Drawings to contain:
      a. Overall panelboard dimensions, interior panel dimensions, and wiring gutter dimensions:
         1) Height.
         2) Length.
         3) Width.
      b. Weight.
      c. Anchoring locations.
      d. Breaker layout drawing with dimensions:
         1) Location of the main, branches, solid neutral, and ground.
      e. Conduit entry/exit locations.
         1) Identify all conduit entry/exit locations and restrictions.
      f. Individual panel schedules identifying breaker locations, ratings, and nameplate designations within the panelboard, for every panelboard.

D. Installation instructions:
   1. Provide anchorage instructions and requirements for the panelboard based on the seismic requirements at the Project Site as specified in Section 16050:
      a. Stamped by a professional engineer registered in the state where the Project is being constructed.

E. Operations and maintenance manual:
   1. Provide a complete manual for the operation and maintenance of the panelboard, circuit breakers, devices, and accessories:
      a. Including but not limited to:
         1) Instruction narratives and bulletins.
         2) Renewal parts lists.
         3) Time-current curves for all devices.

F. Calculations:
   1. Detailed calculations or details of the actual physical testing performed on the panelboard to prove the panelboard is suitable for the seismic requirements at the Project Site.

1.06 QUALITY ASSURANCE

A. As specified in Section 16050.

B. Panelboards shall be UL listed and labeled.

1.07 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 16050.

1.08 PROJECT OR SITE CONDITIONS

A. As specified in Section 16050.

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

A. As specified in Section 16050.

1.12 SYSTEM START-UP

A. As specified in Section 16050.

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 COMMISSIONING (NOT USED)

1.15 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. One of the following or equal:
   1. Eaton/Cutler-Hammer.
   2. General Electric Company.
   3. Schneider Electric/Square D Company.

B. Circuit breakers:
   1. Same manufacturer as the panelboard.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS (NOT USED)

2.04 MANUFACTURED UNITS (NOT USED)

2.05 EQUIPMENT

A. Provide panelboards with:
   1. Molded-case circuit breakers with trip ratings as shown on the panel schedules.
   2. Spares and spaces for future circuit breakers in panels as shown on the panel schedules.

B. Short circuit rating:
   1. Provide panelboards with short-circuit ratings as indicated on the Drawings.
   2. Testing method per UL 67.
   3. Mark each panelboard with its maximum short circuit rating at the supply voltage.
   4. Panelboards shall be fully rated.

2.06 COMPONENTS

A. Enclosure:
   1. NEMA enclosure type as indicated on the Drawings.
      a. Where not indicated on the Drawings, as specified in Section 16050 for the installed location.
   2. Minimum width: 20 inches.
   3. Gutter space in accordance with the NEC:
      a. Minimum of 4 inches of gutter space.
   4. Dead-front, no live parts when the panelboard is in service.
   5. Enclose entire panelboard bus assembly in a corrosion resistant galvanized steel cabinet.
   6. 4-piece front to provide ease of wiring access.
   7. Lockable, hinged door over the protective devices with a flush, cylinder tumbler-type lock with catch and door pull.
      a. Minimum 2 keys per panelboard.
      b. Key all panelboard locks alike.
   8. Circuit directory frame and card on the inside of the door.
   9. Door-in-door construction consists of a one-piece front with 2 doors:
      a. The smaller door provides access to all device handles and rating labels and shall be lockable.
      b. The larger door provides access to all conductors and wiring terminals.
   10. Interior design such that replacement of circuit breakers does not require disturbing adjacent units or removal of the main bus connectors.
   11. Provide NEMA Type 4X enclosures with a NEMA Type 4X stainless steel outer enclosure (with a hinged door) and a NEMA Type 1 interior panelboard.

B. Bus:
   1. General:
      a. Tin-plated copper.
   2. Phase bus:
      a. Full size and height without reduction.
      b. Sized in accordance with UL standards to limit temperature rise on any current carrying part to a maximum of 50 degrees Celsius:
         1) Limit current density to less than 1,000 amps per square inch.
      c. Insulate all current carrying parts from ground and phase-to-phase with a high dielectric strength insulator.

3. Ground bus:
    a. Copper, solidly bonded.
4. Neutral bus:
    a. Provide where indicated on the Drawings.
    b. 100 percent rated.
    c. Provide lugs for each outgoing feeder requiring a neutral connection.
5. Provide insulation barriers over the vertical bus behind the dead front shield to provide increased safety during field service.

C. Lugs:
1. UL listed for copper and aluminum wire:
    a. Provide lugs rated for 75-degree Celsius terminations.
    b. Provide bolted or compression main lug terminations as required for the incoming cable size.

D. Circuit breakers: As specified in Section 16412 and as indicated on the Drawings:
1. Provide all circuit breakers with bolt-on connections:
    a. Plug-in circuit breakers are not allowed.

2.07 ACCESSORIES

A. Surge protective devices:
1. Furnish panelboards with surge protective devices as indicated on the Drawings.
2. As specified in Section 16285.

B. Nameplates:
1. As specified in Section 16075.
2. Install on outside of door.
3. Indicating:
    a. Panel designation.
    b. Voltage.
    c. Number of phases and configuration.
4. Panel designations in 1/4-inch high letters above service voltage and configuration; for example:

LP-1 208/120V -3PH -4W

C. Circuit identification labels:
1. Provide index cards behind heavy clear plastic in cardholders on the inside of the doors.
2. Type all information on the cards using designations in the panel schedules.
3. Laminated on both sides.

D. Pad locking mechanism:
1. Provide a pad locking attachment to allow circuit breakers to be locked in the off position.
2. At a minimum, provide one mechanism per panelboard:
    a. Provide multiple mechanisms if required to accommodate all circuit breaker frame sizes in the panelboard.

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES

A. Finish stand-alone panelboards with a primer, rust-resistant phosphate undercoat, and 2 coats of oven-baked enamel with finish color ANSI 61 gray.

B. Finish panelboards mounted in motor control centers to match the motor control center finish and color.

2.11 SOURCE QUALITY CONTROL

A. Perform standard factory tests on the panelboards:
   1. Test in accordance with the latest version of NEMA and UL standards.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 16050.

B. Install the equipment per the manufacturer's guidelines and submitted installed instruction to meet the seismic requirements at the project site.

C. General:
   1. Surface, flush or MCC mounted as indicated on the Drawings.
   2. Mount rigidly to structural members with exposed surfaces plumb and level to within 1/32 inch.
   3. Perform work in accordance with the manufacturer's instructions and shop drawings.
   4. Provide all brackets, hangers, supports, and hardware for mounting as required.
   5. In all NEMA Type 4 and NEMA Type 4X locations, mount panelboards on 7/8-inch deep stainless steel preformed channel, with channel running vertically from top to bottom of panelboard:
      a. Use only stainless steel mounting hardware.
   6. Mount panelboard so that top operating handle is not more than 6 feet-7 inches above the operating floor.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 FIELD QUALITY CONTROL

A. As specified in Section 16050.

3.08 ADJUSTING (NOT USED)

3.09 CLEANING

A. As specified in Section 16050.

3.10 DEMONSTRATION AND TRAINING (NOT USED)

3.11 PROTECTION

A. As specified in Section 16050.

3.12 SCHEDULES

A. Circuiting within the panelboard shall match the panel schedules as indicated on the Drawings.

B. Provide typewritten schedule in each panelboard.

END OF SECTION

SECTION 16452

BUSWAY

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Indoor and outdoor low voltage busway.

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 16070 - Hangers and Supports.
      d. Section 16075 - Electrical Identification.

1.02 REFERENCES

A. As specified in Section 16050.

B. Underwriter's Laboratory (UL):
   1. UL 857 - Busways.
   2. UL 1479 - Standard for Fire Tests of Through-Penetration Firestops.

C. International Electrotechnical Commission (IEC):
   1. IEC 439-1, 2 - IEC standards for 7 types of tests.
      a. Checking temperature rise limits.
      b. Checking Dielectric Properties.
      c. Checking short-circuit withstand
      d. Checking protective circuit effectiveness.
      e. Checking clearance and creepage distance.
      f. Checking mechanical operation.
      g. Checking degree of protection.
   2. IEC 529 - IEC standards for degree of protection.

1.03 DEFINITIONS

A. As specified in Section 16050.

1.04 SYSTEM DESCRIPTION

A. Low-voltage busway system as indicated on the Drawings for connection of external incoming utility service transformer to main switchgear located internally.

1.05 SUBMITTALS

A. Furnish submittals as specified in Sections 01330 and 16050.

B. Product data:
   1. Ratings:
      a. Voltage.
      b. Current.
      c. Short circuit.
   2. Housing:
      a. Material.
      b. Finish.
   3. Bus:
      a. Material.
   4. Accessories.

C. Shop drawings:
   1. Dimensioned busway assembly, including, but not limited to:
      a. Busway.
      b. Housing.
      c. Supports.
      d. Layouts.
      e. Expansion joints.
      f. Fire and weather barriers.
      g. Wall and floor penetrations.

D. Installation instructions:
   1. Provide support and hanger calculations for the busway for the seismic requirements at the Project Site as specified in Section 16050:
      a. Stamped by a professional engineer licensed in the state where the Project is being constructed.

E. Record Documents:
   1. As Built locations of busway routing.

F. Operation and maintenance manuals:
   1. Manufacturer's operating and maintenance instructions for the busway component parts.

G. Test reports:
   1. Factory test reports.

1.06 QUALITY ASSURANCE

A. As specified in Section 16050.

B. Manufacturer qualifications: Manufacturer of busway for minimum 5 years with satisfactory performance record.

C. Busway, components, and accessories shall be UL listed and labeled.

1.07 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 16050.

1.08 PROJECT OR SITE CONDITIONS

A. As specified in Section 16050.

1.09 SEQUENCING (NOT USED)

A. Sequence and coordinate installation with P.G and E entrance duct from main incoming transformer. Ref P.G and E Document 063929.

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

A. As specified in Section 16050.

1.12 SYSTEM START-UP

A. As specified in Section 16050.

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 COMMISSIONING (NOT USED)

1.15 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. One of the following or equal:
   1. Eaton/Cutler-Hammer, POW-R-Way.
   2. General Electric Company, Spectra.
   3. Schneider Electric/Square D.
   4. Siemens, Sentron Busway System.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS (NOT USED)

2.04 MANUFACTURED UNITS (NOT USED)

2.05 EQUIPMENT

A. Provide a complete busway system as indicated on the Drawings and specified:
   1. Busway consisting of rigidly supported insulated conductors enclosed by and supported by an outer housing.

B. Rating:
   1. Voltage: 600 VAC.
   2. Continuous current rating: As indicated on the Drawings.
   3. Short circuit rating: As indicated on the Drawings.

C. Temperature rise at hottest spot when carrying rated current:
   1. 55 degrees Celsius maximum above a 40-degree Celsius ambient.

2.06 COMPONENTS

A. Busway housing:
   1. Extruded aluminum.
   2. Completely enclosed.
   3. Suitable for indoor or outdoor installation.
   4. Provide EPDM or other non-corrosive material for all housing and flange gaskets, with gaskets completely concealed for protection against deterioration.

B. Conductors:
   1. Tin-plated copper bars.
   2. Epoxy insulation:
      a. NEMA Class B.
   3. Conductor joints:
      a. Single bolt design:
         1) Torque indicating bolts to provide visual indication of proper tightness.
      b. Within 1/2 inch adjustability.
      c. Provide joints that require no increase of enclosure size at splices between adjoining sections.
   4. Neutral bus:
      a. Provide where indicated on the Drawings, rated for 100 percent or more of phase bus rating.
      b. Provide the same material and insulation as the phase bus.
   5. Ground bus:
      a. Copper ground bus.
      b. Rated for 50 percent or more of the phase bus rating.

2.07 ACCESSORIES

A. Cable tap boxes:
   1. Provide where indicated on the Drawings or as specified in the Contract Documents for cable-to-busway transitions:
   2. Sheet steel fabricated, complete weatherproof housing.
   3. Galvanized and bonderized both inside and outside.

4. Cable lugs:
   a. Copper, sized to match number of cables and cable size as indicated on the Drawings, or as required to provide full ampacity of respective busway.

B. Busway supports:
   1. Provide outdoor column type with base for attaching to foundations supports as specified in Section 16070.

C. Joint covers:
   1. Provide weatherproof joint covers for all outside joints.

D. Nameplates:
   1. Provide as specified in Section 16075.

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES

A. Enamel or epoxy paint:
   1. ANSI-61 gray.

2.11 SOURCE QUALITY CONTROL (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION

A. Perform final measurements before busway fabrication to ensure coordination with other portions of the Work, equipment, and existing conditions.

B. Provide transpositions as required to maintain proper phase sequence and orientation.

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 16050.

B. Coordinate busway installation with electrical equipment, building construction, HVAC and other trades:
   1. Resolve any conflicts between trades before installation.

C. Assemble the busway sections and components into a rigid bus system.

D. Use busway sections and fittings of uniform size, and install to provide a neat and symmetrical appearance.

E. Use standard 8-foot or 10-foot lengths whenever possible:
   1. Furnish and install special sections and/or fittings to suit installation.

F. Supports:
   1. Furnish and install supports in accordance with manufacturer's requirements and seismic support calculations. As a minimum, furnish and install 1 hanger for every 4 feet of horizontally mounted duct. Furnish and install 1 adjustable vertical hanger for every 3 feet of vertically mounted duct.
   2. Support from ceiling unless floor or ground supports are indicated on the Drawings.

G. Install expansion fittings at intervals recommended by the manufacturer and at all structural expansion joints.

H. Install fire stop at fire-rated wall penetrations and where indicated on the Drawings.

I. Install wall flanges at all wall penetrations.

J. Connect to equipment following recommendations of busway duct and equipment manufacturers.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 FIELD QUALITY CONTROL

A. As specified in Section 16050.

3.08 ADJUSTING

A. Adjust all covers and operating mechanisms for free and proper operation.

3.09 CLEANING

A. As specified in Section 16050.

3.10 DEMONSTRATION AND TRAINING (NOT USED)

3.11 PROTECTION

A. As specified in Section 16050.

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 16494

LOW VOLTAGE FUSES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Fuses: 600 volt class and lower.

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. As specified in Section 16050.

1.03 DEFINITIONS

A. As specified in Section 16050.

1.04 SYSTEM DESCRIPTION

A. Fuses for overcurrent protection and/or current limiting applications as indicated on the Drawings.

1.05 SUBMITTALS

A. Furnish submittals as specified in Sections 01330 and 16050.

B. Product data:
   1. Catalog cut sheets.
   2. Complete fuse schedule.
   3. Manufacturer original 11-inch by 17-inch, time current curves for all fuses furnished.

C. Shop drawings:
   1. Include drawings of spare fuse cabinets.

1.06 QUALITY ASSURANCE

A. As specified in Section 16050.

B. All low voltage fuses shall be UL listed and labeled.

1.07 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 16050.

1.08 PROJECT OR SITE CONDITIONS

A. As specified in Section 16050.

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

A. As specified in Section 16050.

1.12 SYSTEM START-UP

A. As specified in Section 16050.

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 COMMISSIONING (NOT USED)

1.15 MAINTENANCE

A. Spare parts:
   1. Provide 3 spare fuses for each size and type used or supplied under any Section of the Contract Documents.
   2. Provide spare fuse cabinet(s):
      a. Metal cabinet with hinged door and shelves or fuse holders.
      b. Gray enamel finish.
      c. Mount near equipment and label "Spare Fuses" on face of cabinet.
      d. Suitable pocket inside door of each cabinet with typewritten spare fuse inventory in clear plastic protective insert.
      e. Provide as many cabinets as required to hold entire spare fuse inventory.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. One of the following or equal:
   1. Ferraz Shawmut.
   2. Littelfuse.
   3. Bussmann.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS (NOT USED)

2.04 MANUFACTURED UNITS

A. General:
   1. Provide durable, readily visible label inside each fuse enclosure, clearly indicating the correct type, size, and ratings of replacement fuse:
      a. Label shall not cover or interfere with equipment manufacturer's instructions.
   2. Affix a label indicating recommended torque for fuse mounting bolts or studs to the inside of fuse access doors.
   3. To ensure selective coordination of protective devices:
      a. Provide fuses for new facilities by the same manufacturer.
      b. Provide fuses for renovations of the same manufacturer as existing fuses.
   4. Provide fuses rated for the voltage and available short circuit current at which they are applied.

B. Fuses for services, switchboard mains, feeders, and branch circuits:
   1. 600 amperes and less:
      a. Provide UL listed RK1 dual-element, time-delay fuses with ampere ratings as indicated on the Drawings except as may be modified by the Contract Documents.
   2. 601 to 6,000 amperes:
      a. Provide UL listed Class L fuses.

C. Fuses for motor branch circuits:
   1. Ampere ratings shall not exceed motor controller manufacturer’s recommended values:
      a. If manufacturer does not have such standards, provide fuses as specified in this Section.
   2. Provide Class RK1 fuses or fuses as indicated on the Drawings and as specified in the Contract Documents, rated in accordance with the fuse manufacturer’s recommendations for backup running protection of motor circuits containing overload relays.
   3. Determine fuse ratings for overload protection of motor branch circuits by actual full-load currents of motors provided.
   4. Fuses in motor control centers may be time-delay Class J or Class CC fuses, if MCC manufacturer’s standard designs use these fuse types:
      a. Time-delay Class J fuse ratings shall not exceed 150 percent of motor full load current except as permitted.
      b. Follow fuse manufacturer’s recommendations for Class CC fuses.
      c. A motor having starting duty or other special characteristics requiring larger fuses than specified above, may have branch circuit fuse ratings increased as necessary to meet motor’s requirements, but no larger than maximum permitted by the NEC.
         1) Increased requirements for an individual motor shall not be cause for increasing size of all fuses.

5. Provide Class L fuses for motor branch circuits requiring fuses over 600 amperes, sized at 150 percent of motor full load current except as permitted below:
    a. A motor having starting duty or other special characteristics requiring larger fuses than specified above, may have branch circuit fuse ratings increased as necessary to meet motor's requirements, but no larger than maximum permitted by the NEC.
        1) Increased requirements for an individual motor shall not be cause for increasing size of all fuses.

D. Fusing of control circuits:
    1. Provide:
        a. RK1 fuses installed in UL listed Class CC fuse blocks as specified in the Contract Documents.
    2. Provide minimum protection for control circuits in accordance with the latest revision of UL Standard 508 for Industrial Control.
    3. Fuse both the primary and secondary circuit of control power transformers:
        a. Fuse ratings shall be in accordance with NEC requirements.

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS (NOT USED)

2.07 ACCESSORIES (NOT USED)

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 16050.

B. General:
    1. Install fuses properly aligned, electrically and mechanically secure.
    2. Evenly torque mounting bolts and nuts to ASTM recommendations for type and diameter of mounting bolts or studs provided.
    3. Paralleling of fuses is not permitted.
    4. Install fuses so that the fuse nameplate and rating are easily readable in the equipment.

C. Replace fuses, on all phases, for any fuses that opened during start-up and testing.

D. After completion of testing, deliver spare fuses in quantities specified:
   1. Fuses shall be new, in manufacturer's original packaging, and stored in a clean, dry location.

E. Install spare fuse cabinets where instructed by the OWNER.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 FIELD QUALITY CONTROL

A. As specified in Section 16050.

3.08 ADJUSTING (NOT USED)

3.09 CLEANING

A. As specified in Section 16050.

3.10 DEMONSTRATION AND TRAINING (NOT USED)

3.11 PROTECTION

A. As specified in Section 16050.

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 16500

LIGHTING

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Luminaires, lamps, ballasts, poles, and accessories.

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 - Seismic Design Criteria.
      c. Section 01660 - Testing, Training, and Commissioning.
      d. Section 16050 - Common Work Results for Electrical.
      e. Section 16422 - Motor Starters.

1.02 REFERENCES

A. As specified in Section 16050.

B. National Electrical Manufacturers Association (NEMA):
   1. C82.11 - High Frequency Fluorescent Lamp Ballast.

C. Underwriters Laboratories (UL):
   1. 1029 - High -Intensity Discharge Lamp Ballast.
   2. 1598- Luminaires

D. Illumination Society of North America (IESNA).

1.03 DEFINITIONS

A. As specified in Section 16050.

B. Specific definitions and abbreviations:
   1. BF: Ballast factor - Measure of light output from lamp operated by commercial ballast as compared to a laboratory standard reference ballast
   2. BEF: Ballast efficacy factor - Value used to evaluate various lighting systems based on light output and power input.
   3. CCT: Correlated color temperature - Scientific scale to describe how "warm" or how "cool" the light source is, measured in Kelvin.

4. Crest factor - ratio of peak lamp current to RMS or average lamp operating current.
5. Efficacy - Lumen output per unit of power supplied to ballast (lumens per watt).
6. EMI: Electromagnetic Interference - Electrical interference (noise) generated by electrical and electronic devices.
7. FC: Foot-Candles - Measure of light level on a surface being illuminated.
8. HID: High intensity discharge - A lamp containing a filled arc tube in which the active element becomes vaporized and is discharged into the arc stream to produce light.
9. Instant start - Lamp starting method in which lamps are started by high voltage input with no preheating of lamp filaments.
10. Luminaire - Lighting unit.
11. Programmed start - lamp starting method that utilizes an integrated circuit to preheat the lamp filament while not allowing the lamp to ignite and then applies the open circuit voltage to start the lamp.
12. Pulse start - An HID ballast with a high voltage igniter that provides high voltage pulses to ionize the gas within the lamp.
13. Rapid start - Lamp starting method in which lamp filaments are heated while open circuit voltage is applied to facilitate lamp ignition.
14. THD: Total harmonic distortion - The combined effect of harmonic Distortion on the AC waveform produced by a ballast or other device.
15. Driver - A power supply used to power LED fixtures.
16. LED - Light emitting diode to cover modules and arrays.

1.04 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.

1.05 SUBMITTALS

A. Furnish submittals as specified in Sections 01330 and 16050.

B. Product data:
   1. Luminaires:
      a. Catalog literature for each luminaire specified, cross-referenced to the luminaire type on the Luminaire Schedule in the Drawings.
      b. Provide for each luminaire type:
         1) Materials.
         2) Type of diffuser.
         3) Hardware.
         4) Gasketing.
         5) Reflector.
         6) Chassis.
         7) Finish and color.
         8) Ballast type and protection.
         9) Lamp:
            a) Type.
            b) Wattage.

c) Lumen output:
(1) Initial.
(2) Mean.
d) Correlated color temperature.
e) Lamp lumen depreciation.
f) Efficacy.
g) Base.
10) Picture of luminaire.
11) Dimensioned drawings:
a) 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.

c. Luminaire substitutions:
1) Provide complete literature for each luminaire substitution:
2) Submittals for substituted luminaires shall be sufficient for competent comparison of the proposed luminaire to the originally specified luminaire:
a) Photometric data:
(1) IES file in standard IES format.
(2) Coefficient of utilization tables based on the IES zonal cavity system by an approved testing laboratory.
(3) Candlepower distribution curves.
(4) Average luminaire brightness.
(5) Lumen output charts.
(6) Power requirements in watts and volt-amperes.
b) Calculations:
(1) Provide software generated calculations showing illuminance levels in foot-candles and power usage in watts per square foot for each of the areas in which substitutions are proposed:
(a) Use surface reflectance values and luminaire light loss factors approved by the Engineer to perform all calculations.
3) Substitutions for specified luminaires will be evaluated upon quality of construction, light distribution, energy use, appearance, and maintenance.
4) Substitutions shall comply with all applicable building codes.

2. Ballast:
a. Provide for each ballast type:
1) Type of ballast.
2) Lamp wattage.
3) Input voltage.

4) Input watts.
5) Starting line current.
6) Operating line current.
7) Sound rating.
8) Power factor.
9) Ballast factor.
10) Starting temperature.

3. Photocell:
   a. Provide for each photocell type:
      1) Switching capacity.
      2) The means of adjusting the lighting pickup level.
      3) Enclosure type.
      4) Mounting method.
4. Luminaire poles:
   a. Submit complete data for each pole type including but not limited to:
      1) Material.
      2) Finish and color.
      3) Handholes.
      4) Anchoring.
      5) Luminaire attachment methods and fittings.
      6) Pole height.
      7) Pole dimensions.
      8) Bolthole circle layout and hardware.
      9) Accessories.
      10) Provide the EPA wind load rating.
5. LED:
   a. Provide for each fixture type complete data for :
      1) Modules.
      2) Arrays.
      3) Half life of LED driver and half life of LED optics at rated ambient temperature. Testing to be per IEC LM 80.

C. Shop drawings:

D. Calculations:
   1. Provide complete design calculations and installation documents for pole mounting piers and poles mounted from structures:
      a. Include in the calculations the wind and seismic requirements at the project site.
      b. Calculations and design shall be performed by and signed by a Professional Engineer registered in the state where the project is being constructed:

E. Record documents:
   1. Update the Luminaire Schedule in the Drawings to reflect the acceptable substitutions, after the substitution has been reviewed and accepted by the Engineer.

1.06 QUALITY ASSURANCE

A. As specified in Section 16050.

1.07 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 16050.

1.08 PROJECT OR SITE CONDITIONS

A. As specified in Section 16050.

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING

A. Exterior and outdoor lighting system operation shall be demonstrated during the hours of darkness.

B. Lighting demonstration shall occur during the Testing Phase specified in Section 01660.

1.11 WARRANTY

A. As specified in Section 16050.

1.12 SYSTEM START-UP

A. As specified in Section 16050.

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 COMMISSIONING (NOT USED)

1.15 MAINTENANCE

A. Luminaires shall have ease of access of electrical components. LED drivers and illuminators will be field replaceable.

B. With the exception of LED lights, replace all lamps used during construction and return used lamps to OWNER for use as spares.

C. Furnish 5 percent of the quantity provided, but not less than 3 ballasts for every ballast type and size used.

D. Furnish 10 percent of the quantity provided, but not less than 12 new lamps for every lamp type and size used.

E. Furnish 5 percent spare drivers for each size and type provided.

F. Furnish 2 percent spare lenses for each size and type of luminaire.

G. Furnish 5 percent of LED illuminators and 5 percent of drivers.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Luminaires: One of the following or equal:
   1. As noted on the Luminaire Schedule.

B. Lamps: One of the following or equal:
   1. General Electric Company.
   2. Osram Sylvania.
   3. North American Philips Lighting Company.

C. Ballasts for fluorescent lamps: One of the following or equal:
   1. Advance.
   2. Universal.
   3. Osram Sylvania.
   4. General Electric Company.

D. Ballasts, HID lamps: One of the following or equal:
   1. Advance.
   2. Holophane.
   3. Osram Sylvania.
   4. General Electric Company.

E. Photo-electric cells: One of the following or equal:
   1. Intermatic.
   2. Tork.
   3. Paragon Electrical Products.

F. LEDs: One of the following or equal:
   1. Crete.
   2. Sylvania.

G. Substitutions:
   1. 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 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS (NOT USED)

2.04 MANUFACTURED UNITS (NOT USED)

2.05 EQUIPMENT

A. Luminaires:
   1. General:
      a. Standard 3 pole terminal block for connection of field wiring. Internal connections with lever lock connectors, no wire nuts. Provide the luminaires furnished per the Luminaire Schedule in the Drawings:
         1) The Specifications noted herein are an addition or supplement to the Luminaire Schedule.
   2. Exterior/outdoor luminaires:
      a. Luminaires in combination with their mounting pole and bracket shall be capable of withstanding:
         1) Wind levels at the project site without damage.
         2) Seismic levels at the project site. To have minimum 1.5g vibration rating.
      b. No dissimilar metals to be in contact with one another (stainless steel retaining screws to screw into stainless steel helicoils). All mounting hardware to be corrosion-resistant stainless steel.
      c. Hinged doors or lens retainer to come with corrosion-resistant retentive screws.
      d. Gaskets to be silicone rubber. Water shall not enter the compartment that houses wiring, wiring devices, or lamps under any condition of exposure other than submersion.
      e. Exterior lenses to be impact resistant borasilicate glass.
      f. All exposed metal to be either corrosion resistant or epoxy powder coat finish. Shall meet 1000 hour salt fog test.
   3. California Energy Code Light Pollution Reduction Compliance:
      a. Provide all exterior luminaires with cutoff photometrics so as to comply with California Green Buildings Standard Code 2010 (Calgreen) light pollution Section 5.106.8 as relates to backlight, uplight, and glare. Dark sky compliant..
      b. Provide DOE Lighting Facts Label.
   4. Luminaires in hazardous areas:
      a. In accordance with NEC Section 500 requirements.
      b. UL labeled and identified for hazardous area.
      c. Marking on Class I and II Division 1 and 2 areas shall identify the applicable material classification group.
      d. Marking shall include the temperature class (T code).

B. Lamps:
   1. General:
      a. Provide lamps as indicated on the Luminaire Schedule.
      b. Lamps selected to mate with luminaires selected.
      c. Suitable for operation in any burning position unless otherwise indicated in the Contract Documents.
   2. Fluorescent lamps:
      a. Type T8 unless otherwise indicated on the Luminaire Schedule.
   3. Compact fluorescent lamps:
      a. 4-pin biax lamps unless otherwise indicated on the Luminaire Schedule.
   4. Incandescent lamps:
      a. Frosted interior envelope, unless a specified lighting control system requires clear globe lamps.

b. Rated 130 Volts AC.
c. Lamp shape standard A or PS unless otherwise noted.
d. Lamps to utilize filaments recognized by dimming system manufacturer to reduce “ringing” and “chatter” of the lamp.

5. High intensity discharge lamps:
   a. Metal halide lamps:
      1) Pulse start.
   b. High pressure sodium lamps:
      1) Color corrected.

C. Photo-electric cells:
   1. Photoelectric cells for control of multiple luminaires:
      a. Self-contained.
      b. Weatherproof.
      c. Provided with time-delay features.
      d. Sized to meet switching capacity of the circuit:
         1) Based on ballast VA as indicated on the Drawings.
   2. Photoelectric cell for control of a single luminaire:
      a. Integral to the luminaire.

D. Luminaire control:
   1. Lighting control relays or contactors as specified in Section 16422.

E. Light Emitting Diodes (LED):
   1. General:
      a. No light out feature. Redundant power drivers, single driver fixtures not acceptable. If a single LED fails, the circuit will provide enough usable light to remaining LED’s. Driver to be field replaceable.
      b. Class 1 electronic driver with power factor greater than 90 percent and THD less than 20 percent. Driver to be internal with one piece die cast aluminum heat sink housing with driver in direct contact to ensure that driver does not exceed manufacturers temp rating across all specified ambient conditions. To be mounted with 3 “ separation from LED optics board.
      c. LED light source array testing complies with IEC LM 80 for published measure of LED light source lifetime. Minimum of 60,000 hours in 40 degrees C ambient.
      d. Minimum color rendering (CRI) 65.
      e. Correlated color temperature (CCT) 3000K-4500K.

F. Ballasts:
   1. General:
      a. Energy saving type suitable for use with energy saving lamps where available.
      b. Suitable for operation over the entire temperature range specified in Section 16050 for all luminaires not located in office areas or air conditioned spaces.
      c. Meet FCC standard, Class A for EMI/RFI (FCC 47FCR Part 18 Non-consumer equipment).
      d. Comply with applicable IEEE standards/guidelines for harmonic distortion and line voltage transient protection.

2. Ballasts for fluorescent lamps:
    a. Operate as a parallel circuit allowing remaining lamp(s) to maintain full light output if one or more lamps fail.
    b. Bear CBM and ETL labels.
    c. High frequency electronic type:
        1) Operate lamps above 20 kHz to avoid interference with infrared devices and to eliminate visible flicker.
    d. High output application:
        1) Utilize instant-start ballast.
    e. Dimming application:
        1) Utilize rapid-start ballast.
    f. Motion sensor controlled or frequent starting application:
        1) Utilize programmed-start ballast.
    g. Total harmonic distortion of the input current less than 20 percent.
    h. Sound rating: Class A or quieter.
    i. UL Class P, Type 1 thermally protected, or individually fused in accordance with manufacturer's recommendations.
    j. Auto restart circuitry to restart lamps without resetting power.
    k. Input power source:
        1) As indicated on the Drawings.
        2) Use universal voltage ballasts when available.
        3) With sustained variations of within 10 percent (voltage and frequency) with no change to the ballast.
    l. Power factor:
        1) Greater than 0.98 for primary lamp.
        2) Greater than 0.90 throughout the dimming range if applicable.
    m. Ballast factor:
        1) Low energy: 0.70 minimum.
        2) Instant start: 0.90 minimum.
        3) High output: 1.20 minimum.
    n. Lamp current crest factor:
        1) 1.7 or less for lamps operating in accordance with NEMA C82.11 parameters.
    o. Minimum starting temperature:
        1) Unless otherwise indicated on the Drawings, or on the Luminaire Schedule, or specified in Section 16050:
            a) For standard T8 lamps: -29 degrees Celsius (-20 degrees Fahrenheit).
            b) For T8/HO: 10 degrees Celsius (50 degrees Fahrenheit).
            c) For Slimline T8 lamps: 0 degrees Celsius (32 degrees Fahrenheit).
            d) For energy saving T8: 16 degrees Celsius (60 degrees Fahrenheit).
    p. Tolerate sustained open circuit and short circuit output conditions without damage.
    q. High efficiency and meet all US state and federal efficacy laws.
    r. Use dimming ballasts with dimmer controlled fluorescent fixtures where indicated on the Drawings.
    s. Rated for location of installation.

3. Ballast for compact fluorescent lamps:
    a. Type:
        1) Programmed start.
        2) Incorporate lamp shutdown circuitry for end of lamp life protection.
    b. High frequency electronic type:
        1) Operate lamps above 20 kHz to avoid interference with infrared devices and to eliminate visible flicker.
    c. Input power source:
        1) As indicated on the Drawings.
        2) With sustained variations of within 10 percent (voltage and frequency) with no damage to the ballast.
    d. Lamp current crest factor:
        1) 1.7 or less for lamps operating in accordance with NEMA C82.1 parameters.
    e. UL Class P, Type 1 thermally protected, or be individually fused in accordance with manufacturer's recommendations.
    f. Power factor:
        1) Greater than 0.98 for primary lamp.
        2) Greater than 0.90 throughout the dimming range for primary lamp.
    g. Ballast factor: 1.0 at maximum light output.
    h. Minimum starting temperature:
        1) Unless otherwise indicated on the Drawings, or on the Luminaire Schedule, or specified in Section 16050:
            a) For compact fluorescent lamps: 10 degrees Celsius (50 degrees Fahrenheit).
    i. Sound rating: Class A or quieter.
    j. Total harmonic distortion of the input current less than 10 percent.
    k. Tolerate sustained open circuit and short circuit output conditions without damage.
    l. High efficiency and meet all US state and federal efficacy laws.
    m. Use dimming ballasts with dimmer controlled fluorescent fixtures where indicated on the Drawings.
    n. Rated for location of installation.
4. Ballasts for high intensity discharge lamps:
    a. Meet requirements of UL 1029.
    b. Input power source:
        1) As indicated on the Drawings.
    c. With sustained variations of within 10 percent (voltage and frequency) with no change to the ballast.
    d. Minimum starting temperature:
        1) Unless otherwise indicated on the Drawings, or on the Luminaire Schedule, or specified in Section 16050.
            a) High pressure sodium: -40 degrees Celsius.
            b) Metal halide lamps: -30 degrees Celsius.
    e. Power factor: greater than 0.90.
    f. Provide pulse start ballasts with a minimum efficiency of 88 percent for metal halide lamps.

g. Core and coil ballast with class “H” (180 degree Celsius) or higher insulation system and vacuum-pressure impregnated with silica-filled polyester resin:
   1) Copper windings.
   2) Internally fused.
h. Ballast factor: 1.0.

2.06 COMPONENTS

A. Luminaire poles:
   1. As indicated on the Luminaire Schedule.
   2. Anchor bolts:
      a. Use anchor bolts, bolts, or welded studs for anchors for resisting seismic and wind forces.
         1) Standard hex bolt head.
         2) Do not use anchor bolts fabricated from rod stock with an L or J-shape.
      b. Complete with leveling shims.
   3. Anchor base:
      a. Fabricated from the same type of material as the pole shaft.
      b. Base plate to telescope the pole shaft.
      c. Welded top and bottom along the entire perimeter.
      d. With slotted boltholes on the bolt circles as submitted.
   4. Pole shaft:
      a. As indicated on the Luminaire Schedule.
   5. Handhole:
      a. Reinforced handhole located approximately 18 inches above the base.
      b. Complete with cover fabricated from the same material as the pole shaft and stainless steel attachment screws.
      c. With an integral ground connection nut, 1/2 inch by 13 inch UNC welded to the pole for connection to the grounding system.
   6. Shroud:
      a. Fabricated from the same type of material as the pole shaft.
      b. 1-piece formed channel section that shall conform to the pole shaft taper.
      c. Secured by a locking device with provisions for a padlock to prevent accidental lowering.
   7. Fastening hardware:
      a. All fasteners shall be stainless steel.
   8. Finish:
      a. As indicated on the Luminaire Schedule.

2.07 ACCESSORIES

A. Pole mounted convenience outlet:
   1. Where indicated, furnish a 120 Volt, GFCI protected receptacle:
      a. Integrally mounted in the pole shaft at 24 inches above the base.
   2. Complete with corrosion resistant and weatherproof cover.

B. Pole mounted toggle switch:
   1. Where indicated, furnish a 120 Volt 1-pole toggle switch:
      a. Integrally mounted in the pole shaft at 48 inches above the base.
      b. Complete with corrosion resistant and weatherproof cover.

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 16050.

B. Install luminaires per the manufacturer's guidelines and submitted installation calculations to meet seismic and wind requirements at the project site.

C. Special techniques:
   1. Support luminaires from structural elements capable of carrying the total weight.
   2. Install luminaires plumb and square with building and wall intersections:
      a. Suspend pendant-mounted luminaries that are mounted from sloping ceilings with ball hangers, unless otherwise indicated on the Drawings.
      b. Install luminaires in machinery rooms after machines have been installed, so as to ensure no conflict with machinery, piping, or duct work.
   3. In all cases, coordinate luminaire locations with work of other trades to prevent obstruction of light from the fixtures:
      a. Locate bottom of luminaire approximately at the bottom of ductwork, unless otherwise specified or indicated on the Drawings.
   4. Support luminaires weighing more than 25 pounds independently of the outlet box and the conduit.
   5. Provide ceiling or pendant mounted HID luminaires with a safety chain connecting the lens, reflector, ballast and other components to the building structure.
   6. Provide recessed luminaires with auxiliary safety supports attached directly to the building structure:
      a. The safety supports shall consist of number 12 AWG soft drawn galvanized wires.
   7. Install luminaires in accordance with the architectural reflected ceiling Drawings:
      a. Center luminaires on ceiling tiles unless otherwise indicated.
   8. Support luminaires installed in suspended grid ceilings, independently of the grid:
      a. Provide seismic restraint clips for all luminaires installed in suspended grid ceilings.

D. Luminaire poles:
   1. Set poles on anchor bolts and secured with double nuts on each bolt.

2. Dry-pack the pole base, after the luminaire and pole has been leveled and plumbed.
3. Bond metal poles to the plant grounding system, utilizing a ground lug connection within the pole:
    a. Route ground conductor through pier and pole base sleeve using Schedule 40 PVC conduit.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 FIELD QUALITY CONTROL

A. As specified in Section 16050.

3.08 ADJUSTING

A. Aim and verify all exterior and outdoor luminaires alignment, during dark evening hours, as directed by Owner or the Engineer.

3.09 CLEANING

A. As specified in Section 16050.

B. Clean all lenses, diffusers, and reflectors.

C. Refinish all luminaire's trim, poles, and support brackets, where finish has been damaged.

D. Clean and re-lamp all luminaires (new and old), used during construction for construction lighting, before substantial completion.

3.10 DEMONSTRATION AND TRAINING

A. As specified in Section 16050.
    1. Perform the lighting demonstration, in accordance with this Section, witnessed by the Owner and the Engineer. The entire lighting system shall be observed to verify luminaires are properly focused and aimed.
    2. Switching functions are in accordance with the Contract Documents and verify all:
        a. Photocell operation.
        b. Time clock operation.
        c. Programmable lighting control operations.
        d. Switching operations.
        e. Dimming operations.

3.11 PROTECTION

A. As specified in Section 16050.

3.12 SCHEDULES

A. Refer to the Luminaire Schedule in the Drawings.

END OF SECTION

SECTION 16670

LIGHTNING PROTECTION

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Design and installation of a complete lightning protection system.
   2. Materials and components for the lightning protection system.

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 01312 - Project Meetings.
      b. Section 01330 - Submittal Procedures.
      c. Section 01614 - Wind Design Criteria.
      d. Section 01770 - Closeout Procedures.
      e. Section 16050 - Common Work Results for Electrical.
      f. Section 16060 - Grounding and Bonding.

1.02 REFERENCES

A. As specified in Section 16050.

B. Lightning Protection Institute (LPI).

C. National Fire Protection Association (NFPA):
   1. 780 - Standard for the Installation of Lightning Protection Systems.

D. Underwriters Laboratories, Inc. (UL):
   1. 96 - Standard for Lightning Protection Components.
   2. 96A - Standard for Installation Requirements for Lightning Protection Systems.

1.03 DEFINITIONS

A. As specified in Section 16050.

B. Specific definitions:
   1. LPI: Lightning Protection Institute.

1.04 SYSTEM DESCRIPTION

A. Retain the services of a lightning protection contractor to design, furnish, and install a complete lightning protection system, connected to the facility grounding system for the below
   1. Electrical Building.
   2. Dewatering Building
   3. Admininstration Building.
   4. Maintenance Building,.

B. Lightning protection system: NFPA 780; Class **I** UL 96A; master labeled system(s) protecting roof-mounted mechanical equipment and penthouse roofs consisting of:
   1. Air terminals on roof(s).
   2. Bonding of structure and other metal objects.
   3. Grounding electrodes.
   4. Interconnecting conductors.

C. Connect the lightning protection system to the facility grounding electrode:

D. The installing contractor is responsible for all costs associated with UL inspection of the lightning protection system, including any costs associated with re-inspection necessary to obtain the UL 96A Master Label.

1.05 SUBMITTALS

A. Furnish submittals as specified in Sections 01330 and 16050.

B. Product data:
   1. Provide samples and pertinent catalog data for:
      a. Air terminals.
      b. Conductors.
      c. Connectors.
      d. Accessories.
      e. Include dimensions and materials of each component, and include indication of listing in accordance with UL 96.

C. Shop drawings:
   1. Including but not limited to:
      a. Layout of air terminals with the respective configuration of the zone of protection.
      b. Grounding electrodes, and bonding connections to structure and other metal objects.
      c. Type, size and locations for:
         1) Terminal.
         2) Electrode.
         3) Conductor.
      d. Conductor routing details.
      e. Connection details.
      f. Termination details.
      g. Applicable air terminal and other calculations.
   2. Details showing installation of air terminals, conductors, and connectors.

D. Certificates:
   1. Submit 2 notarized photocopies of the completed Application for UL Master Label for each lightning protection system.
   2. Submit written confirmation of having obtained UL Master Label and LPI certification for each lightning protection system.
   3. Photocopy of UL and LPI Installers' Certificate(s) for installation of lightning protection systems.
   4. Written confirmation regarding the system manufacturer's and the system installer's membership in the Lightning Protection Institute.
   5. Proof of the manufacturer and installer having been UL-listed and LPI-certified for at least 5 years.

E. Record Documents:
   1. Provide Record Documents as specified in Sections 01770 and 16050.
   2. Accurately record actual locations of air terminals, grounding electrodes, bonding connections, and routing of system conductors.
   3. Manufacturer's installation instructions.

1.06 QUALITY ASSURANCE

A. As specified in Section 16050.

B. Conform to the requirements of the UL and NFPA standards for lightning protection systems:
   1. Components shall be listed in accordance with UL 96.

C. Manufacturer’s qualifications:
   1. Company specializing in lightning protection equipment with minimum 5 years documented experience and a fully certified manufacturer member of the Lightning Protection Institute:
      a. Listed in section "Lightning Conductor, Air Terminals and Fittings" of the UL "Electrical Construction Materials Directory" for at least 5 years previous to this Contract's bid opening date.

D. Installers qualifications: Authorized installer for manufacturer with minimum 5 years documented experience and LPI-certified installer for installation of lightning protection systems for at least 5 years previous to this Contractor's bid opening date.

E. The lightning protection system shall meet the applicable requirements of NFPA 780.

F. Upon completion of installation the lightning protection contractor to have the building lightning system physically inspected by UL and furnish a UL Master Label for the building:
   1. Application for the UL Master Label without a physical inspection by UL is unacceptable.

1.07 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 16050.

1.08 PROJECT OR SITE CONDITIONS (NOT USED)

1.09 SEQUENCING

A. Pre-installation conference:
   1. Convene a pre-installation conference 1 week before commencing the Work of this Section, as specified in Sections 01312 and 16050.

B. Coordinate Work with other trades to ensure neat, correct, and unobtrusive installation.

C. Coordinate the Work of this Section with roofing and exterior and interior finish installations.

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

A. As specified in Section 16050.

1.12 SYSTEM START-UP

A. As specified in Section 16050.

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 COMMISSIONING (NOT USED)

1.15 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. One of the following or equal:
   1. Erico.
   2. Thompson Lightning Protection, Inc.
   3. Harger Lightning and Grounding.
   4. VFC, Inc**.**

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS

A. Air terminals:
   1. Material: Copper Size: 3/8-inch by 18-inch minimum extending a minimum of 12 inches above the object to be protected.
   2. Air terminal bases:
      a. Cast bronze with bolt pressure cable connections securely mounted with stainless steel screws and bolts.

B. Ground rods:
   1. As specified in Section 16060.

C. Ground plate: Copper.

D. Conductors:
   1. Perimeters:
      a. Copper
   2. Down conductors:
      a. Copper.
   3. UL listed for the application.
   4. Copper cable:
      a. Perimeters and down conductors:
         1) At least 32 strands of 17 gauge or larger copper wire weighing not less than 215 pounds per 1,000 feet.
         2) UL listed for the application.
   5. Cable fasteners:
      a. Electrolytically compatible with conductors and mounting surface:
         1) Spaced in accordance with LPI and NFPA requirements.

E. Connectors and splicers: Bronze
   1. Make connections between dissimilar metals with approved bimetallic connectors.

F. Miscellaneous materials:
   1. Copper of type and size recommended by the manufacturer of the lightning protection system.
   2. Stainless steel bolts, screws, and other threaded fasteners.

2.04 MANUFACTURED UNITS (NOT USED)

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS (NOT USED)

2.07 ACCESSORIES (NOT USED)

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION

A. It is the responsibility of the lightning protection subcontractor to review the electrical system design, and provide any and all additional equipment and materials needed in order to construct a master labeled UL lightning protection system.

B. Verify that surfaces are ready to receive work.

C. Verify that field measurements are as indicated on the Drawings.

D. Protect elements surrounding Work of this Section from damage or disfiguration.

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 16050.

B. Install systems in accordance with manufacturer's instructions unless otherwise specified in this Section.

C. Installation must be made under the supervision of an LPI certified master installer.
   1. Physically connect lightning protection equipment to structural roof framing members.
   2. Do not attach lightning protection equipment to rigid roof insulation.
   3. Coordinate sealing roofing penetrations to prevent leakage.

D. Conductor installations:
   1. Install the lightning protection roof system(s) grounding and bending conductors exposed on flat roof areas and concealed at ridge roof areas.
   2. Install main downleads completely concealed and sleeved.
   3. Other than for the purpose of protecting downlead conductors from damage up to 6 feet above grade level, do not use exposed conduits to conceal the downleads on the exterior of the buildings outside walls.
   4. Use minimum 1-inch PVC conduits to protect lightning system conductors from damage.

E. Clearances: Assure 6-foot minimum distance required by NEC:
   1. From lightning rod conductors to non-current-carrying metal parts of electrical equipment unless they are bonded to the rods.
   2. From lightning system conductors to open conductors of communication systems.
   3. From lightning protection grounding electrodes to electrodes of other grounding systems.

F. Extend air terminals a minimum of 12 inches above object to be protected.

G. Maintain horizontal or downward coursing of main conductor and ensure that bends have at least an 8-inch radius and that no bend of a conductor forms an included angle of less than 90 degrees.

H. Install ground electrodes not less than 1 foot below grade and not less than 2 feet from foundation walls.

I. Interconnection of metals:
   1. Bond all metal bodies within 6 feet of the conductor to the system with approved fittings and conductor.
   2. Connections between dissimilar metals shall be made with approved bimetallic connections.
   3. Bond metal bodies of inductance located within 6 feet of a conductor or object with secondary bonds.

J. Bond all isolated metallic bodies at or below the roof subject to inductance and within 6 feet of lightning protection system conductors.

K. Provide necessary common grounds between the lightning protections system and the electric and telephone service entrance wires, TV and radio antenna grounds.

L. Ensure that air terminals are installed to withstand calculated wind force due to 100 miles per hour winds or as specified in Section 01614, whichever is greater with a 1.3 gust factor without structural damage and without damage to integrity of the lightning protection system.

M. Protect down conductors entering corrosive soil against corrosion by a protective coating for not less than 3 feet above grade level and for the entire length below grade level until connection to the ground ring and rods.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 REINSTALLATION (NOT USED)

3.07 FIELD QUALITY CONTROL

A. As specified in Section 16050:

B. Provide the services of UL to physically inspect the entire lightning protection system and issue the UL Master Label:
   1. Furnish UL Master Label as evidence that the installation has met with UL 96A code requirements.

3.08 ADJUSTING (NOT USED)

3.09 CLEANING (NOT USED)

3.10 DEMONSTRATION AND TRAINING (NOT USED)

3.11 PROTECTION

A. As specified in Section 16050.

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 16710

FIRE SPRINKLER MONITORING AND ALARM SYSTEM

PART 1 GENERAL

1.01 SUMMARY

A. Section includes requirements for:
   1. Design, supply, and installation of a complete addressable type fire alarm system, including:
      a. Initiating devices.
      b. Notification appliances.
      c. Controls.
      d. Supervisory devices.

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 01782 - Operation and Maintenance Data.
      c. Section 16050 - Common Work Results for Electrical.
      d. Section 16123 - 600 Volt or Less Wires and Cables.

C. Utilize a single Fire Alarm System Supplier (FASS) to design, furnish, and install all materials, equipment, labor, and services required to achieve a fully integrated and operational fire alarm system, in complete compliance with the NFPA Class and Style specified.

D. Coordinate the fire alarm system with related equipment and materials furnished under other sections of these Specifications.

1.02 REFERENCES

A. As specified in Section 16050.

B. FM Global (FM).

C. National Fire Protection Association (NFPA):
   1. 70 - National Electric Code (NEC).
   2. 72 - National Fire Alarm Code.

D. Factory Mutual (FM).

E. Underwriters Laboratories, Inc. (UL):
   1. 268 - Standard for Smoke Detectors for Fire Alarm Systems.
   2. 268A - Standard for Smoke Detectors for Duct Application.
   3. 464 - Standard for Audible Signal Appliances.
   4. 1971 - Standard for Signaling Devices for the Hearing Impaired.

1.03 DEFINITIONS

A. As specified in Section 16050.

1.04 SYSTEM DESCRIPTION

A. Provide a complete, non-coded, addressable, microprocessor-based fire alarm system with initiating devices, notification appliances, and controls and supervisory devices as indicated for the facilities below
   1. Electrical Building.
   2. Dewatering Building.
   3. Administration Building.
   4. Maintenance Building.
   5. Chemical Facility.

B. As specified in this Section.
   1. System connections for initiating (signaling) circuits and notification appliance circuits shall be Class B Style 4.
   2. Circuit supervision: Circuit faults shall be indicated by a trouble signal at the FACP. Provide a distinctive audible tone and alphanumeric annunciation.

1.05 SUBMITTALS

A. Furnish submittals as specified in Sections 01330 and 16050.

B. Product data:
   1. Data sheets for system components highlighted to indicate the specific products, features, or functions required to meet this specification including electrical characteristics such as voltage and current ratings, connection requirements, software and firmware versions and operational details of all equipment.
   2. Alternate or as-equal products submitted under this contract must provide a detailed line-by-line comparison of how the submitted product meets, exceeds, or does not comply with this Specification.

C. Shop drawings:
   1. Fire detection system block diagram including interconnection with fire sprinkler flow switches and valves.
      a. Fire detection functions and control interconnections for each building as described in this Section, and as indicated on the Drawings.
      b. FACP layout, schematic, and wiring diagrams, panel displays, and LED arrangement.
      c. Detection device type, features, and setpoints.
      d. Number and size of wires, type of wire insulation required for devices specified, and conduit size for proposed circuits.

2. System power and battery charts with performance graphs and voltage drop calculations to assure that system will operate per the specified backup time periods and under all voltage conditions per UL and NFPA standards.
3. Test reports indicating satisfactory completion of required tests and inspections.
4. System layout on floor plan drawings, drawn to scale using AutoCAD software.
5. Fire alarm system input-output point list.
6. Spare parts list for extra materials being furnished.
7. Operating and Maintenance data as specified in Section 01782.

D. Manufacturer's installation instructions.

E. Designer, manufacturer, and installer qualifications.

F. Submit the equipment layout drawings and product data to the local authority having jurisdiction (AHJ), for review and approval of the proposed system.
   1. CONTRACTOR is responsible for paying plan check, permit, and inspection fees as necessary.
   2. Submit AHJ's approval to ENGINEER.

1.06 QUALITY ASSURANCE

A. As specified in Section 16050.

B. Designer qualifications:
   1. Designer of similar installations for a minimum of 5 years with a satisfactory performance record.

C. Manufacturer qualifications: Manufacturer of proposed system for a minimum of 10 years with satisfactory performance record.

D. Installer qualifications: Manufacturer approved installer of products similar to specified products on a minimum of 10 projects of similar scope as this project with a satisfactory performance record.

E. Installation to be supervised by NICET Level II Technician.

F. Fire alarm systems shall be UL approved.

1.07 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 16050.

1.08 PROJECT OR SITE CONDITIONS

A. As specified in Section 16050.

1.09 SEQUENCING

A. Design and submit plans to AHJ for approval.

B. Make submittals, including AHJ's approval to the ENGINEER.

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

A. As specified in Section 16050.

1.12 SYSTEM START-UP

A. As specified in Section 16050.

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 COMMISSIONING (NOT USED)

1.15 MAINTENANCE

A. Furnish service and maintenance of fire alarm system for 1 year from date of Substantial Completion.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Fire alarm and smoke detection systems: One of the following or equal:
   1. Siemens.
   2. Gamewell/FCI.
   3. Honeywell, Incorporated.
   4. Notifier.
   5. Edwards System Technologies (EST).

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS (NOT USED)

2.04 MANUFACTURED UNITS (NOT USED)

2.05 EQUIPMENT

A. Provide the fire alarm system with all necessary hardware and software to perform the following functions:
   1. Fire alarm and detection operations.
      a. Provide all required network interface modules, relay modules, and zone modules for interconnections as required and specified in this Section.
   2. Control and monitoring of fire sprinkler system, smoke detectors, and other equipment as indicated in the Specifications or as indicated on the Drawings.
   3. Annunciation:
      a. Operation of alarm and supervisory initiating devices shall be annunciated at the FACP indicating the location and type of device.
      b. Signal transmission:
         1) Alarms from the FACP shall be routed to:
            a) Central Station.

4. System general alarm sequence:
    a. Indication of alarm condition at the FACP.
    b. Identification of the device that is the source of the alarm at the FACP.
    c. Operation of audible and visible notification devices throughout the building until silenced at FACP.
    d. Notifying the local fire department.
5. Alarm silencing:
    a. When the “Alarm Silence” button is pressed, all audible alarm signals turn off.
6. System reset:
    a. Provide a system reset button that returns the system to its normal state.
    b. Display messages providing operator assurance of the sequential steps as they occur.
    c. The system shall verify all circuits or devices are restored before resetting the system to avoid the potential for re-alarming the system.
    d. Should an alarm condition continue, the system remains in an alarmed state.

2.06 COMPONENTS

A. FACP:
1. Power requirements:
    a. 120 VAC input power via a dedicated circuit.
    b. Battery system:
        1) Provided with sufficient battery capacity to operate the entire system upon loss of normal 120 VAC power in a normal supervisory mode for a period of 24 hours with 5 minutes of alarm operation at the end of this period.
        2) The system shall automatically transfer to battery standby upon power failure.
        3) Provide automatic battery charging and recharging operations.
        4) Supervise the system batteries so that a low battery condition or disconnection of the batteries indicates a trouble at the FACP.
    c. All circuits requiring system operating power shall be 24 VDC with individual fuses at the FACP.
    d. Supervise the incoming power to the system so that any power failure will be indicated at the control unit.
        1) A green "power on" LED shall be displayed continuously while incoming power is present.
        2) FACP shall sound a trouble signal at loss of primary power and to indicate when the system is operating on battery power.
2. Alphanumeric display and system controls:
    a. Include an LCD display to indicate alarm, supervisory, and component status messages and include a keypad for use in entering and executing control commands.
    b. Display battery voltage and amperage readouts on LCD display.
3. System supervision: Component or power supply failure places system in trouble mode.
4. Group actuating devices together in zones represented by zone light emitting diodes (LED):
    a. Provide provisions for supervised zone remote annunciator outputs.

b. Actuation of a UL approved alarm-initiating device shall cause the respective red alarm LED to flash.
   1) This LED should continue to flash until the alarm acknowledge switch is actuated.
   2) Once acknowledged, the LED or zone LED will be constantly illuminated until the actuating device is restored to normal and the system is reset.

5. FACP shall scan each addressable detector for its type identification to prevent inadvertent substitution of another sensor.
   a. Upon detection of a “wrong device,” the FACP shall operate with the installed device at the default alarm settings for that sensor; 2.5 percent ob.
6. Supply with an alarm silence/acknowledge switch to silence the audible alarms.
   a. Should a subsequent alarm actuation of a different zone occur, the alarm devices shall sound until silenced.
7. Cabinet:
   a. UL listed, lockable steel enclosure.
   b. Front access only.
   c. If more than a single unit is required to form a complete control unit, provide matching modular unit enclosures.

B. Software:
   1. Allows for loading and editing instructions and operating sequences as necessary.
   2. Capable of on-site programming to accommodate system expansion and facilitate changes in operation.
   3. Stored in a non-volatile programmable memory within the fire alarm control unit.
   4. Loss of primary and secondary power shall not erase the instructions stored in memory.
   5. Capable of full system operation during a new configuration download.

C. Manual pull stations:
   1. Description:
      a. Single action type.
      b. Red lexan or metal enclosure.
      c. Molded, raised-letter operating instructions of contrasting color.
      d. Mechanically latches upon operation and remain so until manually reset by opening with a key common with the FACPs.

D. Smoke detectors:
   1. In accordance with UL 268.
   2. Provide with the following features:
      a. Factory nameplate: Serial number and type identification.
      b. Operating voltage: 24 VDC, nominal.
      c. Plug-in arrangement: Detector and associated electronic components are mounted in a module that connects to a fixed base with a twist-locking plug connection.
         1) Base to provide break-off plastic tab that can be removed to engage the head/base locking mechanism.

2) No special tools required to remove head once it has been locked.
3) Removal of the detector head shall interrupt the supervisory circuit of the fire alarm detection loop and cause a trouble signal at the control unit.

d. LED that will flash each time it is scanned by the FACP (once every 4 seconds). In alarm condition, the detector head LED shall be on steady.

e. Magnetically actuated test switch to provide for easy alarm testing at the detector location.

3. Provide end-of-line resistors as required.

E. Standard alarm-notification appliances:

1. Horn: In accordance with UL 464.

a. Minimum sound pressure level of 83.

F. Addressable circuit interface modules:

1. Arrange to monitor one or more system components that are not otherwise equipped for addressable communication. Modules shall be used for monitoring of waterflow, valve tamper, non-addressable devices, and for control of evacuation indicating appliances and AHU systems.
2. Mounted in a standard electric outlet box.
3. Furnish with cover plates to allow surface or flush mounting.
4. Receive their operating power from the signaling line or a separate 2 wire pair running from an appropriate power supply as required.

G. Circuit interface modules:

1. Type 1: Monitor circuit interface module:

a. For conventional 2-wire smoke detector and/or contact device monitoring with Class B or Class A wiring supervision.

1) Supervision of the zone wiring will be Class B.
2) Module shall communicate status (normal, alarm, trouble) to the FACP.

b. For conventional 4-wire smoke detector with Class B wiring supervision.

1) Module shall provide detector reset capability
2) Fuse to provide over-current power protection for the 4-wire detector: 2 amp.
3) Module will communicate status (normal, alarm, trouble) to the FACP.

2. Type 2: Control circuit interface module:

a. Module for signals and other device control with Style 4 and Style 6 wiring supervision.

b. For non-supervised control.

c. Provide double pole double throw relay switching for 1 A at 28 VDC resistive, power limited and at 1/2 A at 120 VAC resistive, non-power limited.

d. The system shall be capable of energizing 100 percent of the relays connected to the signaling line circuit.

3. Type 3: Line powered monitor circuit interface module:

a. Power and its communications supplied by the 2 wire multiplexing signaling line circuit.

b. Provides location specific addressability to an initiating device by monitoring normally open dry contacts.

c. Module is required for monitoring waterflow and tamper switches.

4. The circuit interface module to be supervised and uniquely identified by the control unit.
    a. Identification to be transmitted to the control unit for processing according to the program instructions.
    b. On-board LED to provide an indication that the module is powered and communicating with the FACP.
    c. LEDs provide a troubleshooting aid since the LED blinks on poll whenever the peripheral is powered and communicating.

H. Wiring:
1. As specified in Section 16123.
2. Wire and cable shall be a type listed for its intended use by an approval agency acceptable to the AHJ.
3. SLC channel wiring shall be unshielded twisted pair.
    a. Capacitance rating of less than 60pf/ft
    b. Minimum 3 twists (turns) per foot.

2.07 ACCESSORIES(NOT USED)

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 16050.

B. Install system components and all associated devices in accordance with applicable NFPA Standards and manufacturer's recommendations.

C. Smoke detectors shall not be installed until after construction cleanup on all trades is complete and final in accordance with NFPA 72.

D. Locate FACP as indicated on the Drawings.

E. Water-flow and valve supervisory switches: Connect each sprinkler valve required to be supervised.

F. Device location-indicating lights: Locate in the public space immediately adjacent to the device.

G. Wiring:
   1. System wiring:
      a. Installed in accordance with the appropriate articles from the 2008 edition of NEC 70.
   2. Color coding:
      a. Color-code fire alarm conductors differently from the normal building power wiring.
      b. Use 1 color code for alarm initiating device circuits wiring and a different color code for supervisory circuits.
      c. Color-code notification appliance circuits differently from alarm-initiating circuits.
      d. Paint fire alarm system conduits, junction boxes, and covers red.
      e. Circuit that provides power to the FACP shall have a red marking and be identified as “FIRE ALARM CIRCUIT” in accordance with NFPA 72.
   3. Wiring to central station transmitter:
      a. 1-inch conduit between the FACP and the central station transmitter connection as indicated.
      b. Install number of conductors and electrical supervision for connecting wiring as required to suit central-station monitoring function.
      c. Final connections to terminals in central station transmitter are made under another contract.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 FIELD QUALITY CONTROL

A. As specified in Section 16050.

B. Manufacturer's field services: Provide services of a factory-authorized service representative to:
   1. Supervise the field assembly and connection of components and the pre-testing, testing, and adjustment of the system.
   2. Verify proper installation, correct deficiencies, and be present at the jobsite during final inspection by the ENGINEER.

C. Field tests:
   1. Notify the ENGINEER and the AHJ in writing a minimum of 2 weeks before the scheduled day for the field acceptance tests.
   2. Furnish the services of a field service engineer, and any special tools, equipment and labor to perform the tests.
   3. Each device and control function shall be individually witness tested and recorded:
      a. All acceptance tests shall be witnessed by and signed off by the ENGINEER, the FASS’s field engineer, the installing Subcontractor, and a representative of the AHJ.
   4. The approved Field Acceptance Test Binder shall form the basis of the documentation of the system acceptance tests:
      a. Furnish 2 certified copies of the tests.

3.08 ADJUSTING (NOT USED)

3.09 CLEANING

A. As specified in Section 16050.

3.10 DEMONSTRATION AND TRAINING

A. As specified in Section 16050.

B. Training:
   1. Provide the services of a factory-authorized service representative to demonstrate the system and train OWNER's maintenance personnel:
      a. Train OWNER's maintenance personnel in the procedures and schedules involved in operating, troubleshooting, servicing, and maintaining the system.

3.11 PROTECTION (NOT USED)

3.12 SCHEDULE (NOT USED)

END OF SECTION

SECTION 16950

FIELD ELECTRICAL COMPONENT ACCEPTANCE TESTS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Responsibilities for testing the electrical installation.
   2. Routine tests during installation.
   3. Adjusting and calibration.
   4. Acceptance tests.
   5. Demonstration of electrical equipment.
   6. Commissioning and plant start-up.

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 01660 - Testing, Training, and Commissioning.
      c. Section 16050 - Common Work Results for Electrical.
      d. Section 16060 - Grounding and Bonding.

C. Copyright information:
   1. Some portions of this Section are copyrighted by the InterNational Electrical Testing Association, Inc (NETA). See NETA publication ATS for details.

1.02 REFERENCES

A. As specified in Section 16050.

B. American National Standards Institute (ANSI).

C. ASTM International (ASTM):
   1. D 877 - Standard Test Method for Dielectric Breakdown Voltage of Insulating Liquids Using Disk Electrodes.
   2. D 923 - Standard Practices for Sampling Electrical Insulating Liquids.
   3. D 971 - Standard Test Method for Interfacial Tension of Oil Against Water by the Ring Method.
   4. D 1298 - Standard Test Method for Density, Relative Density, or API Gravity of Crude Petroleum and Liquid Petroleum Products by Hydrometer Method.
   5. D 1500 - Standard Test Method for ASTM Color of Petroleum Products (ASTM Color Scale).

6. D 1524 - Standard Test Method for Visual Examination of Used Electrical Insulating Oils of Petroleum Origin in the Field.
7. D 1816 - Standard Test Method for Dielectric Breakdown Voltage of Insulating Liquids Using VDE Electrodes.
8. D 3612 - Standard Test Method for Analysis of Gases Dissolved in Electrical Insulating Oil by Gas Chromatography.

D. Institute of Electrical and Electronics Engineers (IEEE):
1. 43 - IEEE Recommended Practice for Testing Insulation Resistance of Rotating Machinery.
2. 81 - IEEE Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Grounding System.
3. 95 - IEEE Recommended Practice for Insulation Testing of AC Electric Machinery (2300 V and Above) With High Direct Voltage.
4. 450 - IEEE Recommended Practice for Maintenance, Testing, and Replacement of Vented Lead-Acid Batteries for Stationary Applications.
5. C57.13 - IEEE Standard Requirements for Instrument Transformers.
6. C57.13.1 – IEEE Guide for Field Testing of Relaying Current Transformers.
7. C57.13.3 - IEEE Guide for Grounding of Instrument Transformer Secondary Circuits and Cases.
8. C57.104 - IEEE Guide for the Interpretation of Gases Generated in Oil-Immersed Transformers.

E. Insulated Cable Engineer's Association (ICEA).

F. InterNational Electrical Testing Association (NETA):
1. ATS-2009 Standard for Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems.

G. International Electrotechnical Commission (IEC).

H. Manufacturer's testing recommendations and instruction manuals.

I. National Fire Protection Association (NFPA):
1. 70 – National Electrical Code (NEC).
2. 110 – Standard for Emergency and Standby Power Systems.

J. National Institute of Standards and Technology (NIST).

K. Specification sections for the electrical equipment being tested.

L. Shop drawings.

1.03 DEFINITIONS

A. As specified in Section 16050.

B. Specific definitions:
1. Testing laboratory: The organization performing acceptance tests.

1.04 SYSTEM DESCRIPTION

A. Testing of all electrical equipment components 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:
   1. 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. The results of the tests shall determine the suitability for continued reliable operation.

D. Responsibilities:
   1. Contractor responsibilities:
      a. 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 as defined 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:
   1. The label shall indicate the date serviced and the company that performed the service.

1.05 SUBMITTALS

A. Furnish submittals as specified in Sections 01330 and 16050.

B. LAN cable test form:
   1. LAN cable test reports:
      a. Submit 3 copies of test reports showing the results of all tests specified in this Section:
         1) Test type.
         2) Test location.
         3) Test date.

4) Cable number.
5) Cable length.
6) Certification that the cable meets or exceeds the specified standard.

b. Furnish hard copy and electronic copy for all traces.

C. Test report:
1. Include the following:
a. Summary of Project.
b. Description of equipment tested.
c. Description of tests performed.
d. Test results.
e. Conclusions and recommendations.
f. Completed test forms.
g. List of test equipment used and calibration dates.
h. LAN cable test reports.

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:
1. Submit a list identifying who is responsible for performing each portion of the testing.

F. Manufacturers' testing procedures:
1. Submit manufacturers' recommended testing procedures and acceptable test results for review by the Engineer.

1.06 QUALITY ASSURANCE

A. As specified in Section 16050.

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 DELIVERY, STORAGE, AND PROTECTION (NOT USED)

1.08 PROJECT OR SITE CONDITIONS

A. As specified in Section 16050.

1.09 SEQUENCING

A. 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 start-up.

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

A. As specified in Section 16050.

1.12 SYSTEM START-UP (NOT USED)

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 COMMISSIONING

A. Start-Up and commissioning, as described in Section 01660, shall not begin until acceptance testing is complete, and operation has been demonstrated to the satisfaction of the Engineer.

B. Commissioning shall only be attempted as a function of normal plant operation in which plant process flows and levels are routine and equipment operates automatically in response to flow and level parameters or computer command, as applicable:
   1. Simulation of process parameters will be considered only upon receipt of a written request by the Contractor.

C. Record all motor currents during normal operation.

D. Record the indications of all power meters every half-hour during commissioning.

1.15 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS (NOT USED)

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS (NOT USED)

2.04 MANUFACTURED UNITS (NOT USED)

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS (NOT USED)

2.07 ACCESSORIES (NOT USED)

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL

A. General:
   1. Test instrument calibration:
      a. Utilize a testing laboratory with a calibration program, which maintains all applicable test instrumentation within rated accuracy.
      b. The accuracy shall be traceable to the NIST in an unbroken chain.
      c. Calibrate instruments in accordance with the following frequency schedule:
         1) Field instruments: 6 months maximum.
         2) Laboratory instruments: 12 months maximum.
         3) Leased specialty equipment where the accuracy is guaranteed by the lessor (such as Doble): 12 months maximum.
      d. Dated calibration labels shall be visible on all test equipment.
      e. Maintain an up-to-date instrument calibration record for each test instrument:
         1) The records shall show the date and results of each calibration or test.
      f. Maintain an up-to-date instrument calibration instruction and procedure for each test instrument.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION

A. 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.

3.03 INSTALLATION (NOT USED)

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 FIELD QUALITY CONTROL

A. Switchgear and switchboard:
   1. Visual and mechanical inspection:
      a. Compare equipment nameplate data with that indicated on the Drawings and specified in the Specifications.
      b. Inspect physical and mechanical condition.
      c. Inspect anchorage, alignment, grounding and required area clearances.
      d. Inspect equipment for cleanliness.
      e. Verify that circuit breaker/fuse sizes and types correspond to the approved submittals and the coordination study.
      f. Verify that current and voltage transformer ratios correspond to that indicated on the Drawings.
      g. Inspect bolted electrical connections for high resistance using one of the following methods:
         1) Use of low resistance ohmmeter.
         2) Verify tightness of accessible bolted electrical connections by the calibrated torque wrench method:
            a) Refer to manufacturer's instructions for proper foot-pound levels or NETA ATS tables.
         3) Thermographic survey.
      h. Mechanical and electrical interlocks:
         1) Attempt closure on locked-open devices.
         2) Attempt to open locked-closed devices.
         3) Make/attempt key-exchanges in all positions.
      i. Lubrication requirements:
         1) Verify appropriate lubrication on moving current-carrying parts.
         2) Verify appropriate lubrication on moving and sliding surfaces.
      j. Inspect insulators for evidence of physical damage or contaminated surfaces.
      k. Verify correct barrier and shutter installation and operation.
      l. Exercise all active components.
      m. Inspect all indicating devices for correct operation.
      n. Verify that filters are in place and/or vents are clear.
      o. Perform visual and mechanical inspection of instrument transformers as specified in this Section.
      p. Inspect control power transformers:
         1) Inspect for physical damage, cracked insulation, broken leads, tightness of connections, defective wiring, and overall general condition.
         2) Verify that primary and secondary fuse/circuit breaker ratings match the submittal drawings.
         3) Verify correct functioning of drawout disconnecting and grounding contacts and interlocks.
   2. Electrical tests:
      a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter if applicable.
      b. Perform insulation-resistance tests on each bus section, phase-to-phase and phase-to-ground for 1 minute.
         1) Perform test in accordance with NETA ATS tables.

c. Perform a dielectric withstand voltage test on each bus section, each phase to ground with phases not under test grounded, in accordance with manufacturer's published data or NETA ATS tables. Apply the test voltage for 1 minute.
d. Perform insulation-resistance tests on control wiring with respect to ground. Applied potential shall be 500 VDC for 300-volt rated cable and 1,000 VDC for 600-volt rated cable. Apply the test voltage for 1 minute:
    1) For solid-state devices that cannot tolerate the applied voltage, follow the manufacturer's recommendation.
e. Perform electrical tests on instrument transformers as specified in this Section.
f. Perform ground-resistance tests:
    1) Perform point-to-point tests to determine the resistance between the main grounding system and all major electrical equipment frames, system neutral and derived neutral points.
g. Determine the accuracy of all meters.
h. Control power transformers:
    1) Perform insulation resistance tests. Perform measurements from winding-to-winding and each winding-to-ground:
        a) Test voltages shall be in accordance with NETA ATS tables or as specified by the manufacturer.
    2) Perform secondary wiring integrity test:
        a) Disconnect transformer at secondary terminals and connect secondary wiring to a rated secondary voltage source:
            (1) Verify correct potential at all devices.
    3) Verify correct secondary voltage by energizing primary winding with system voltage:
        a) Measure secondary voltage with the secondary wiring disconnected.
    4) Verify correct function of control power transfer relays located in switchgear with multiple control power sources.
i. Voltage transformers:
    1) Perform secondary wiring integrity test:
        a) Verify correct potential at all devices.
    2) Verify correct secondary voltage by energizing primary winding with system voltage.
j. Perform current injection tests on the entire current circuit of each switchgear or switchboard:
    1) Perform current tests by secondary injection with magnitudes such that a minimum current of 1.0 ampere flows in the secondary circuit:
        a) Verify the correct magnitude of current at each device in the circuit.
    2) Perform current tests by primary injection with magnitudes such that a minimum current of 1.0 ampere flows in the secondary circuit:
        a) Verify the correct magnitude of current at each device in the circuit.
k. Perform system function tests.
l. Verify operation of space heaters.
m. Perform phasing check on double-ended or dual-source equipment to ensure correct bus phasing from each source.

3. Test values:
    a. Compare bolted connection resistance values to values of similar connections:
        1) Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.
    b. Bolt-torque levels shall be in accordance with manufacturer's published data:
        1) Refer to NETA ATS tables in the absence of manufacturer's published data.
    c. Results of the thermographic survey shall be in accordance with NETA ATS requirements.
    d. Compare bus connection resistances to values of similar connections.
        1) Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.
        2) Insulation-resistance values of bus insulation shall be in accordance with manufacturer's published data:
            a) Refer to NETA ATS tables in the absence of manufacturer's published data.
            b) Investigate insulation values less than the allowable minimum.
            c) Do not proceed with dielectric withstand voltage tests until insulation-resistance values are above minimum values.
    e. If no evidence of distress or insulation failure is observed by the end of the total time of voltage application during the dielectric withstand test, the test specimen is considered to have passed the test.
    f. Insulation-resistance values for control wiring shall not be less than 2 megohms.
    g. Instrument transformer test values as specified in this Section.
    h. Investigate grounding system resistance values that exceed 0.5 ohm.
    i. Meter accuracy shall be in accordance with manufacturer's published data.
    j. Control power transformers:
        1) Insulation resistance values of control power transformers shall be in accordance with manufacturer's published data:
            a) Refer to NETA ATS tables in the absence of manufacturer's published data.
            b) Investigate insulation values less than the allowable minimum.
            c) Do not proceed with dielectric withstand voltage tests until insulation-resistance values are above minimum values.
        2) Secondary wiring shall be as indicated on the Drawings and specified in the Specifications.
        3) Secondary voltage shall be as indicated on the Drawings.
        4) Control transfer relays shall perform as designed.
    k. Voltage transformers:
        1) Secondary wiring shall be as indicated on the Drawings and specified in the Specifications.
        2) Secondary voltage shall be as indicated on the Drawings.
    l. Current-injection tests shall prove current wiring is as indicated on the Drawings and specified in the Specifications.
    m. Results of system function tests shall match the Drawings and Specifications.
    n. Heaters shall be operational.
    o. Phasing checks shall prove the switchgear or switchboard phasing is correct and as indicated on the Drawings and specified in the Specifications.

B. Dry type transformers:
   1. Visual and mechanical inspection:
      a. Compare equipment nameplate data with that indicated on the Drawings and specified in the Specifications.
      b. Inspect physical and mechanical condition.
      c. Inspect anchorage, alignment, and grounding.
      d. Verify that resilient mounts are free and that any shipping brackets have been removed.
      e. Inspect equipment for cleanliness.
      f. Inspect bolted electrical connections for high resistance using one of the following methods:
         1) Use of low resistance ohmmeter.
         2) Verify tightness of accessible bolted electrical connections by the calibrated torque wrench method:
            a) Refer to manufacturer's instructions for proper foot-pound levels or NETA ATS tables.
         3) Thermographic survey.
      g. Verify that as-left tap connections are as specified.
   2. Electrical tests:
      a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter.
      b. Perform insulation-resistance tests winding-to-winding and each winding-to-ground:
         1) Apply voltage in accordance with manufacturer's published data.
            a) Refer to NETA ATS tables in the absence of manufacturer's published data.
      c. Calculate dielectric absorption ration or polarization index.
      d. Verify correct secondary voltage, phase-to-phase and phase-to-neutral after energization and before loading.
   3. Test values:
      a. Compare bolted connection resistance values to values of similar connections:
         1) Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.
      b. Bolt-torque levels shall be in accordance with manufacturer's published data:
         1) Refer to NETA ATS tables in the absence of manufacturer's published data.
      c. Results of the thermographic survey shall be in accordance with NETA ATS requirements.
      d. Tap connections are left as found unless otherwise specified.
      e. Minimum insulation resistance values of transformer insulation 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 insulation values less than the allowable minimum.
      f. The dielectric absorption ratio or polarization index shall not be less than 1.0.
      g. Turns-ratio results should not deviate more than 1/2 percent from either the adjacent coils or calculated ratio.
      h. Phase-to-phase and phase-to-neutral secondary voltages shall be in agreement with nameplate data.

C. Cables, 600 volts and less:
   1. Visual and mechanical inspection:
      a. Compare cable data with that indicated on the Drawings and specified in the Specifications.
      b. Inspect exposed sections of cables for physical damage and correct connection as indicated on the Drawings.
      c. Inspect bolted electrical connections for high resistance using one of the following methods:
         1) Use of low resistance ohmmeter.
         2) Verify tightness of accessible bolted electrical connections by the calibrated torque wrench method:
            a) Refer to manufacturer's instructions for proper foot-pound levels or NETA ATS tables.
         3) Thermographic survey.
      d. Inspect compression-applied connectors for correct cable match and indentation.
      e. Inspect for correct identification and arrangements.
      f. Inspect jacket insulation and condition.
   2. Electrical tests:
      a. Perform resistance measurements through bolted connections with low-resistance ohmmeter.
      b. Perform insulation-resistance tests on each conductor with respect to ground and adjacent conductors:
         1) Applied voltage shall be:
            a) 500 VDC for 300-volt rated cable.
            b) 1,000 VDC 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.
   3. Test values:
      a. Compare bolted connection resistance values to values of similar connections:
         1) Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.
      b. Bolt-torque levels shall be in accordance with manufacturer's published data:
         1) Refer to NETA ATS tables in the absence of manufacturer's published data.
      c. Results of the thermographic survey shall be in accordance with NETA ATS requirements.
      d. 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.
      e. Cables shall exhibit continuity.
      f. Investigate deviations in resistance between parallel conductors.

D. Metal enclosed bus duct:
   1. Visual and mechanical inspection:
      a. Compare equipment nameplate data with that indicated on the Drawings and specified in the Specifications.
      b. Inspected physical and mechanical condition.
      c. Inspect for proper bracing, suspension alignment, and grounding.
      d. Verify correct connection in accordance with the one-line diagrams.
      e. Inspect bolted electrical connections for high resistance using one of the following methods:
         1) Use of low-resistance ohmmeter.
         2) Verify tightness of bolted connections and bus joints by calibrated torque-wrench method:
            a) Refer to manufacturer's instructions for proper foot-pound levels or NETA ATS tables.
         3) Thermographic survey.
      f. Confirm physical orientation in accordance with the manufacturer's labels to ensure adequate cooling.
      g. Examine outdoor bus duct for removal of weep-hole plugs and the correct installation of the joint shield.
   2. Electrical tests:
      a. Perform resistance measurements through bolted connections and bus joints with a low-resistance ohmmeter.
      b. Measure insulation resistance of each busway, phase-to-phase and phase-to-ground for 1 minute, in accordance with NETA ATS tables.
      c. Perform a dielectric withstand voltage test on each busway, phase-to-ground with phases not under test grounded, in accordance with manufacturer's published data:
         1) Refer to NETA ATS tables in the absence of manufacturer's published data.
         2) Where no dc test value is shown in the NETA ATS tables, ac value shall be used.
         3) The test voltage shall be applied for 1 minute.
      d. Perform a contact-resistance test on each connection point of uninsulated busway. On insulated busway, measure resistance of assembled busway sections:
         1) Compare values with adjacent phases.
      e. Perform phasing test on each busway tie section energized by separate sources. Tests must be performed from their permanent sources.
      f. Verify operation of busway space heaters.
      g. Bolt-torque levels should be in accordance with manufacturer's published data:
         1) Refer to NETA ATS tables in the absence of manufacturer's published data.
      h. Results of the thermographic survey shall be in accordance with NETA ATS requirements.
   3. Test values:
      a. Compare bolted connection resistance values to values of similar connections:
         1) Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.

b. Insulation-resistance test voltages and resistance values shall be in accordance with manufacturer's published:
   1) Refer to NETA ATS tables in the absence of manufacturer's published data.
   2) Minimum resistance values are for a nominal 1,000-foot busway run. Use the following formula to convert the measured resistance value to the 1,000-foot nominal value:

$$R_{1000\,ft} = \text{Measured Resistance} \times \frac{\text{Length of run}}{1000}$$

      Converted values of insulation resistance less than those in NETA ATS tables or manufacturer's minimum should be investigated.
   3) Dielectric withstand voltage tests shall not proceed until insulation-resistance levels are raised above minimum values.
c. If no evidence of distress or insulation failure is observed by the end of the total time of voltage application during the dielectric withstand test, the test specimen is considered to have passed the test.
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:
   1) If manufacturer's published data is not available, investigate values that deviate from those of similar bus connections and sections by more than 50 percent of the lowest value.
e. Phasing test results shall indicate the phase relationships are in accordance with system design.
f. Heaters shall be operational.

E. Low voltage molded case circuit breakers:
   1. Visual and mechanical inspection:
      a. Compare equipment nameplate data with that indicated on the Drawings and specified in the Specifications.
      b. Inspect physical and mechanical condition.
      c. Inspect anchorage and alignment.
      d. Verify the unit is clean.
      e. Operate circuit breaker to ensure smooth operation.
      f. Inspect bolted electrical connections for high resistance by one of the following methods:
         1) Use of low resistance ohmmeter.
         2) Verify tightness of accessible bolted electrical connections by the calibrated torque wrench method:
            a) Refer to manufacturer's instructions for proper foot-pound levels or NETA ATS tables.
         3) Thermographic survey.
      g. Inspect operating mechanism, contacts, and arc chutes in unsealed units.
      h. Perform adjustments for final protective device settings in accordance with the coordination study.
   2. Electrical tests:
      a. Perform resistance measurements through bolted connections with a low resistance ohmmeter.

b. 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 500 VDC for 300-volt rated cable and 1,000 VDC for 600-volt rated cable. Apply the test voltage for 1 minute:
   1) 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:
   1) 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:
      1) Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.
   b. Bolt-torque levels shall be in accordance with manufacturer's published data:
      1) Refer to NETA ATS tables in the absence of manufacturer's published data.
   c. Results of the thermographic survey shall be in accordance with NETA ATS requirements.
   d. 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.
   e. Microhm or dc millivolt drop values shall not exceed the high levels of the normal range as indicated in the manufacturer's published data:
      1) If manufacturer's data is not available, investigate any values that deviate from adjacent poles or similar breakers by more than 50 percent of the lowest value.
   f. Insulation resistance values of control wiring shall not be less than 2 megohms.

g. 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:
   1) If manufacturer's curves are not available, trip times shall not exceed the value shown in NETA ATS tables.
h. Short-time pickup values shall be as specified, and the trip characteristic shall not exceed manufacturer's published time-current tolerance band.
i. Ground fault pickup values shall be as specified, and the trip characteristic shall not exceed manufacturer's published time-current tolerance band.
j. Instantaneous pickup values shall be as specified and within manufacturer's published tolerances:
   1) Refer to NETA ATS tables in the absence of manufacturer's published data.
k. Pickup values and trip characteristics shall be within manufacturer's published tolerances.
l. Minimum pickup voltage of the shunt trip and close coils shall conform to the manufacturer's published data:
   1) Refer to NETA ATS tables in the absence of manufacturer's published data.
m. Breaker open, close, trip, trip-free, antipump, and auxiliary features shall function as designed.
n. The charging mechanism shall operate in accordance with manufacturer's published data.

F. Low voltage air power circuit breakers - ANSI class breakers:
   1. Visual and mechanical inspection:
      a. Compare equipment nameplate data with that indicated on the Drawings and specified in the Specifications.
      b. Inspect physical and mechanical condition.
      c. Inspect anchorage, alignment, and grounding.
      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 manufacturer's published data.
      j. Inspect bolted electrical connections for high resistance by one of the following methods:
         1) Use of low resistance ohmmeter.
         2) Verify tightness of accessible bolted electrical connections by the calibrated torque wrench method:
            a) Refer to manufacturer's instructions for proper foot-pound levels or NETA ATS tables.
         3) Thermographic survey.
      k. Verify cell fit and element alignment.
      l. Verify racking mechanism operation.

m. Lubrication requirements:
    1) Verify appropriate lubrication on moving current-carrying parts.
    2) Verify appropriate lubrication on moving and sliding surfaces.
n. Perform adjustments for final protective device settings in accordance with the coordination study.
o. Record as-found and as-left operation counter readings.

2. Electrical tests:
    a. Perform resistance measurements through bolted connections with a low resistance ohmmeter.
    b. Perform insulation resistance tests for 1 minute on each pole, phase-to-phase and phase to ground with the circuit breaker closed, and across each open pole:
        1) Test voltage shall be in accordance with 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 500 VDC for 300-volt rated cable and 1,000 VDC for 600-volt rated cable. Apply the test voltage for 1 minute:
        1) 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:
        1) 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:
        1) Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.
    b. Bolt-torque levels shall be in accordance with manufacturer's published data:
        1) Refer to NETA ATS tables in the absence of manufacturer's published data.
    c. Results of the thermographic survey shall be in accordance with NETA ATS requirements.
    d. Settings shall comply with coordination study requirements.
    e. Operations counter shall advance one digit per close-open cycle.
    f. 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.

g. Microhm or dc millivolt drop values shall not exceed the high levels of the normal range as indicated in the manufacturer's published data:
   1) If manufacturer's data is not available, investigate any values that deviate from adjacent poles or similar breakers by more than 50 percent of the lowest value.
h. Insulation resistance values of control wiring shall not be less than 2 megohms.
i. 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:
   1) If manufacturer's curves are not available, trip times shall not exceed the value shown in NETA ATS tables.
j. Short-time pickup values shall be as specified, and the trip characteristic shall not exceed manufacturer's published time-current tolerance band.
k. Ground fault pickup values shall be as specified, and the trip characteristic shall not exceed manufacturer's published time-current tolerance band.
l. Instantaneous pickup values shall be as specified and within manufacturer's published tolerances:
   1) Refer to NETA ATS tables in the absence of manufacturer's published data.
m. Pickup values and trip characteristics shall be within manufacturer's published tolerances.
n. Minimum pickup voltage of the shunt trip and close coils shall conform to the manufacturer's published data:
   1) Refer to NETA ATS tables in the absence of manufacturer's published data.
o. Auxiliary features shall operate in accordance with manufacturer's published data.
p. The charging mechanism shall operate in accordance with manufacturer's published data.

G. Protective relays, microprocessor based:
1. Visual and mechanical inspection:
   a. Record model number, style number, serial number, firmware revision, software revision and rated control voltage.
   b. Verify operation of light-emitting diodes, display, and targets.
   c. Record passwords for all access levels.
   d. Clean the front panel and remove foreign material from the case.
   e. Check tightness of connections.
   f. Verify that the frame is grounded in accordance with manufacturer's instructions.
   g. Set the relay in accordance with the coordination study.
   h. Download settings from the relay. Print a copy of the settings for the report and compare the settings to those specified in the coordination study.
2. Electrical tests:
   a. Perform insulation resistance tests from each circuit to the grounded frame in accordance with the manufacturer's published data.
   b. Apply voltage or current to all analog inputs and verify correct registration of the relay meter functions.
   c. Functional operation:
      1) Check functional operation of each element used in the protection scheme.

2) 2/62 timing relay:
   a) Determine time delay.
   b) Verify operation of instantaneous contacts.
3) 21 distance relay:
   a) Determine maximum reach.
   b) Determine maximum torque angle.
   c) Determine offset.
   d) Plot impedance circle.
4) 24 volts/hertz relay:
   a) Determine pickup frequency at rated voltage.
   b) Determine pickup frequency at a second voltage level.
   c) Determine time delay.
5) 25 sync check relay:
   a) Determine closing zone at rated voltage.
   b) Determine maximum voltage differential that permits closing at zero degrees.
   c) Determine live line, live bus, dead line, and dead bus setpoints.
   d) Verify dead bus/live line, dead line/live bus, and dead bus/dead line control functions.
   e) Determine time delay.
6) 27 undervoltage relay:
   a) Determine dropout voltage.
   b) Determine time delay.
   c) Determine time delay at a second point on the timing curve for inverse time relays.
7) 32 directional power relay:
   a) Determine minimum pickup at maximum torque angle.
   b) Determine closing zone.
   c) Determine maximum torque angle.
   d) Determine time delay.
   e) Verify time delay at a second point on the timing curve for inverse time relays.
   f) Plot the operating characteristic.
8) 40 loss of field (impedance) relay:
   a) Determine maximum reach.
   b) Determine maximum torque angle.
   c) Determine offset.
   d) Plot impedance circle.
9) 46 current balance relay:
   a) Determine pickup of each unit.
   b) Determine percent slope.
   c) Determine time delay.
10) 46N negative sequence current relay:
   a) Determine negative sequence alarm level.
   b) Determine negative sequence minimum trip level.
   c) Determine maximum time delay.
   d) Verify 2 point on the $(I_2)^2t$ curve.
11) 47 phase sequence or phase balance voltage relay:
   a) Determine positive sequence voltage to close the normally open contact.
   b) Determine positive sequence voltage to open the normally closed contact (undervoltage trip).

c) Verify negative sequence trip.
d) Determine time delay to close the normally open contact with sudden application of 120 percent of pickup.
e) Determine time delay to close the normally closed contact upon removal of voltage when previously set to rated system voltage.

12) 49R thermal replica relay:
    a) Determine time delay at 300 percent of setting.
    b) Determine a second point on the operating curve.
    c) Determine pickup.
13) 49T temperature (RTD) relay:
    a) Determine trip resistance.
    b) Determine reset resistance.
14) 50 instantaneous overcurrent relay:
    a) Determine pickup.
    b) Determine dropout.
    c) Determine time delay.
15) 51 time overcurrent:
    a) Determine minimum pickup.
    b) Determine time delay at 2 points on the time current curve.
16) 55 power factor relay:
    a) Determine tripping angle.
    b) Determine time delay.
17) 59 overvoltage relay:
    a) Determine overvoltage pickup.
    b) Determine time delay to close the contact with sudden application of 120 percent of pickup.
18) 60 voltage balance relay:
    a) Determine voltage difference to close the contacts with one source at rated voltage.
    b) Plot the operating curve for the relay.
19) 63 transformer sudden pressure relay:
    a) Determine rate-of-rise or the pickup level of suddenly applied pressure in accordance with manufacturer's published data.
    b) Verify operation of the 63 FPX seal-in circuit.
    c) Verify trip circuit to remote operating device.
20) 64 ground detector relay:
    a) Determine maximum impedance to ground causing relay pickup.
21) 67 directional overcurrent relay:
    a) Determine directional unit minimum pickup at maximum torque angle.
    b) Determine closing zone.
    c) Determine maximum torque angle.
    d) Plot operating characteristics.
    e) Determine overcurrent unit pickup.
    f) Determine overcurrent unit time delay at 2 points on the time current curve.
22) 79 reclosing relay:
    a) Determine time delay for each programmed reclosing interval.
    b) Verify lockout for unsuccessful reclosing.
    c) Determine reset time.
    d) Determine close pulse duration.
    e) Verify instantaneous overcurrent lockout.

23) 81 frequency relay:
    a) Verify frequency setpoints.
    b) Determine time delay.
    c) Determine underfrequency cutoff.
24) 85 pilot wire monitor:
    a) Determine overcurrent pickup.
    b) Determine undercurrent pickup.
    c) Determine pilot wire ground pickup level.
25) 87 differential:
    a) Determine operating unit pickup.
    b) Determine the operation of each restraint unit.
    c) Determine slope.
    d) Determine harmonic restraint.
    e) Determine instantaneous pickup.
    f) Plot operating characteristics for each restraint.

d. Control verification:
    1) Functional tests:
        a) Check operation of all active digital inputs.
        b) Check all output contacts or SCRs preferably by operating the controlled device such as circuit breaker, auxiliary relay, or alarm.
        c) Check all internal logic functions used in the protection scheme.
        d) For pilot schemes, perform a loop-back test to check the receive and transmit communications circuits.
        e) For pilot schemes, perform satellite synchronized end-to-end tests.
        f) For pilot schemes with direct transfer trip (DTT) perform transmit and received DTT at each terminal.
        g) Upon completion of testing reset all min/max recorders, communications statistics, fault counters, sequence of events recorder and all event records.
    2) In-service monitoring:
        a) After the equipment is initially energized, measure magnitude and phase angle of all inputs and compare to expected values.

H. Instrument transformers:
    1. Visual and mechanical inspection:
        a. Compare equipment nameplate data with that indicated on the Drawings and specified in the Specifications.
        b. Inspect physical and mechanical condition.
        c. Verify correct connection of transformers with system requirements.
        d. Verify that adequate clearances exist between primary and secondary circuit wiring.
        e. Verify the unit is clean.
        f. Inspect bolted electrical connections for high resistance using one of the following methods:
            1) Use of low resistance ohmmeter.
            2) Verify tightness of accessible bolted electrical connections by calibrated torque wrench method:
                a) Refer to manufacturer’s instructions for proper foot-pound levels or NETA ATS tables.
                b) Thermographic survey.

g. Verify that all required grounding and shorting connections provide contact.
h. Verify correct operation of transformer withdrawal mechanism and grounding operation.
i. Verify correct primary and secondary fuse sizes for voltage transformers.
j. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.

2. Electrical tests - current transformers:
   a. Perform resistance measurements through bolted connections with a low resistance ohmmeter.
   b. Perform insulation resistance test of each current transformer and its secondary wiring with respect to ground at 1,000 VDC for 1 minute:
      1) For solid-state devices that cannot tolerate the applied voltage, follow the manufacturer's recommendation.
   c. Perform a polarity test of each current transformer in accordance with IEEE C57.13.1.
   d. Perform a ratio verification test using the voltage or current method in accordance with IEEE C57.13.1.
   e. Perform an excitation test on current transformers used for relaying applications in with accordance with IEEE C57.13.1.
   f. Measure current circuit burdens at transformer terminals in accordance with IEEE C57.13.1.
   g. When applicable perform insulation resistance tests on the primary winding with the secondary grounded:
      1) Test voltages shall be in accordance with NETA ATS tables.
   h. When applicable perform dielectric withstand tests on the primary winding with the secondary grounded:
      1) Test voltages shall be in accordance with NETA ATS tables.
   i. Perform power-factor or dissipation-factor tests in accordance with test equipment manufacturer's published data.
   j. Verify that current transformer secondary circuits are grounded and have only 1 grounding point in accordance with IEEE C57.13.3:
      1) That grounding point should be located as specified by the Engineer in the Contract Documents.

3. Electrical tests - voltage transformers:
   a. Perform resistance measurements through bolted connections with a low resistance ohmmeter.
   b. Perform insulation resistance tests winding-to-winding and winding-to-ground:
      1) Test voltage shall be applied for 1 minute in accordance with NETA ATS requirements.
      2) For solid-state devices that cannot tolerate the applied voltage, follow the manufacturer's recommendation.
   c. Perform a polarity test on each voltage transformer to verify the polarity marks on H_1- X_1 relationship as applicable.
   d. Perform a turns ratio test on all tap positions.
   e. Measure voltage circuit burdens at transformer terminals.
   f. Perform a dielectric withstand test on the primary windings with the secondary windings grounded:
      1) The dielectric voltage shall be in accordance with NETA ATS tables.
      2) Apply the test voltage for 1 minute.

g. Perform power-factor or dissipation-factor tests in accordance with test equipment manufacturers published data.
h. Verify that voltage transformer secondary circuits are grounded and have only 1 grounding point in accordance with IEEE C57.13.3:
1) That grounding point should be located as specified by the Engineer in the Contract Documents.

4. Test values:
a. Compare bolted connection resistance values to values of similar connections:
1) Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.
b. Bolt-torque levels shall be in accordance with manufacturer's published data:
1) Refer to NETA ATS tables in the absence of manufacturer's published data.
c. Results of the thermographic survey shall be in accordance with NETA ATS requirements.
d. Insulation resistance values of instrument transformers shall be in accordance with manufacturer's published data:
1) Refer to NETA ATS tables in the absence of manufacturer's published data.
e. Polarity results shall agree with transformer markings.
f. Ratio errors shall be in accordance with IEEE C57.13.
g. Excitation results for current transformers shall match the curve supplied by the manufacturer or be in accordance with IEEE C57.13.1.
h. Measured burdens shall be compared to instrument transformer ratings.
i. If no evidence of distress or insulation failure is observed by the end of the total time of voltage application during the dielectric withstand test, the current transformer primary winding is considered to have passed the test.
j. If no evidence of distress or insulation failure is observed by the end of the total time of voltage application during the dielectric withstand test, the voltage transformer primary windings are considered to have passed the test.
k. Power-factor or dissipation-factor values shall be in accordance with manufacturer's published data:
1) Refer to NETA ATS tables in the absence of manufacturer's published data.
l. Test results shall indicate that the circuits have only 1 grounding point.

I. Metering devices:
1. Visual and mechanical inspection:
a. Compare equipment nameplate data with that indicated on the Drawings and specified in the Specifications.
b. Inspect physical and mechanical condition.
c. Inspect bolted electrical connections for high resistance using one of the following methods:
1) Use of low resistance ohmmeter.
2) Verify tightness of accessible bolted electrical connections by calibrated torque wrench method:
a) Refer to manufacturer's instructions for proper foot-pound levels or NETA ATS tables.
d. Thermographic survey.

e. Inspect cover gasket, cover glass, condition of spiral spring, disk clearance, contacts, and case shorting contacts as applicable.
f. Verify the unit is clean.
g. Verify freedom of movement, endplay, and alignment of rotating disk(s).

2. Electrical tests:
   a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter.
   b. Verify accuracy of meter at all cardinal points.
   c. Calibrate meters in accordance with manufacturer's published data.
   d. Verify all instrument multipliers.
   e. Verify that current transformer, and voltage transformer secondary circuits are intact.
3. Test values:
   a. Compare bolted connection resistance values to values of similar connections:
      1) Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.
   b. Bolt-torque levels shall be in accordance with manufacturer's published data:
      1) Refer to NETA ATS tables in the absence of manufacturer's published data.
   c. Results of the thermographic survey shall be in accordance with NETA ATS requirements.
   d. Meter accuracy shall be in accordance with manufacturer's published data.
   e. Calibration results shall be within manufacturer's published tolerances.
   f. Instrument multipliers shall be in accordance with system design specifications.
   g. Test results shall confirm the integrity of the secondary circuits of current and voltage transformers.

J. 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 National Electrical Code.
   b. Inspect physical and mechanical condition.
   c. Inspect bolted electrical connections for high resistance using one of the following methods:
      1) Use of low resistance ohmmeter.
      2) Verify tightness of accessible bolted electrical connections by calibrated torque wrench method:
         a) Refer to 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:
        1) Investigate values that 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:
        1) 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. Investigate point-to-point resistance values that exceed 0.5 ohm.

K. Rotating machinery:
1. Visual and mechanical inspection:
    a. Compare equipment nameplate information with that indicated on the Drawings and specified in the Specifications.
    b. Inspect physical and mechanical condition.
    c. Inspect anchorage, alignment, and grounding.
    d. Inspect air baffles, filter media, cooling fans, slip rings, brushes, and brush rigging.
    e. Inspect bolted electrical connections for high resistance using one of the following methods:
        1) Use of low resistance ohmmeter.
        2) Verify tightness of accessible bolted electrical connections by calibrated torque wrench method:
            a) Refer to manufacturer's instructions for proper foot-pound levels or NETA ATS tables.
            b) Thermographic survey.
    f. Perform special tests such as gap spacing and machine alignment if applicable.
    g. Verify correct application of appropriate lubrication and lubrication systems.
    h. Verify that resistance temperature detector (RTD) circuits conform to that indicated on the Drawings.
2. Electrical tests:
    a. Perform resistance measurements through bolted connections with a low resistance ohmmeter.
    b. Perform insulation resistance test in accordance with IEEE 43:
        1) On motors 200 horsepower and smaller, test duration shall be 1 minute. Calculate dielectric absorption ratio.
        2) On motors larger than 200 horsepower, test duration shall be 10 minutes. Calculate polarization index.
    c. Perform dc dielectric withstand voltage tests on machines rated at 2,300 volts and greater in accordance with IEEE 95.
    d. Perform phase-to-phase stator resistance test on machines rated at 2,300 volts and greater.
    e. Perform insulation resistance test on insulated bearings in accordance with manufacturer's published data.
    f. Test surge protection devices as specified in this Section.

g. Test motor starter as specified in this Section.
h. Perform resistance tests on resistance temperature detector (RTD) circuits.
i. Verify operation of motor space heater.
j. Perform a rotation test to ensure correct shaft rotation.
k. Measure running current and evaluate relative to load conditions and nameplate full-load amperes.

3. Test values:
   a. Inspection:
      1) Air baffles shall be clean and installed in accordance with the manufacturer's published data.
      2) Filter media shall be clean and installed in accordance with the manufacturer's published data.
      3) Cooling fans shall operate.
      4) Slip ring alignment shall be within manufacturer's published tolerances.
      5) Brush alignment shall be within manufacturer's published tolerances.
      6) Brush rigging shall be within manufacturer's published tolerances.
   b. Compare bolted connection resistance values to values of similar connections:
      1) Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.
   c. Bolt-torque levels shall be in accordance with manufacturer's published data:
      1) Refer to NETA ATS tables in the absence of manufacturer's published data.
   d. Results of the thermographic survey shall be in accordance with NETA ATS requirements.
   e. Air-gap spacing and machine alignment shall be in accordance with manufacturer's published data.
   f. The dielectric absorption ratio or polarization index shall not be less than 1.0. The recommended minimum insulation ($IR_{1\ min}$) test results in megohms shall be corrected to 40 degrees Celsius and read as follows:
      1) IR1 min equals 100 megohms for dc armature and ac windings with form-wound coils above 1 kilovolt.
      2) IR1 min equals 5 megohms for machines and random-wound stator coils and form-wound coils rated below 1 kilovolt.
         a) Dielectric withstand voltage and surge comparison tests shall not be performed on machines having lower values than those indicated above.
   g. If no evidence of distress or insulation failure is observed by the end of the total time of voltage application during the dielectric withstand test, the test specimen is considered to have passed the test.
   h. Investigate phase-to-phase stator resistance values that deviate by more than 10 percent.
   i. Power factor or dissipation factor values shall be compared to manufacturer's published data:
      1) In the absence of manufacturer's published data compare values of similar machines.
   j. Tip-up values shall indicate no significant increase in power factor.
   k. If no evidence of distress, insulation failure, or waveform nesting is observed by the end of the total time of voltage application during the

surge comparison test, the test specimen is considered to have passed the test.

l. Bearing insulation resistance measurements shall be within manufacturer's published tolerances:
   1) In the absence of manufacturer's published data compare values of similar machines.

m. Test results of surge protection devices shall be as specified in this Section.

n. Test results of motor starter equipment shall be as specified in this Section.

o. RTD circuits shall conform to the design intent and machine protection device manufacturer's published data.

p. Heaters shall be operational.

q. Vibration amplitudes shall not exceed values in NETA ATS tables:
   1) If values exceed those in the NETA ATS tables, perform a complete vibration analysis.

r. Machine rotation should match required rotation of connected load.

s. Running phase-to-phase voltages should be within 1.0 percent. Running currents shall be balanced and proportional to load condition and nameplate data.

L. Motor starters, low voltage:

1. Visual and mechanical inspection:
   a. Compare equipment nameplate information with that indicated on the Drawings and specified in the Specifications.
   b. Inspect physical and mechanical condition.
   c. Inspect anchorage, alignment, and grounding.
   d. Verify the unit is clean.
   e. Inspect contactors:
      1) Verify mechanical operation.
      2) Verify contact gap, wipe, alignment, and pressure are in accordance with manufacturer's published data.
   f. Motor-running protection:
      1) Verify overload element rating is correct for its application.
      2) If motor running protection is provided by fuses, verify correct fuse rating.
   g. Inspect bolted electrical connections for high resistance using one of the following methods:
      1) Use of low resistance ohmmeter.
      2) Verify tightness of accessible bolted electrical connections by calibrated torque wrench method:
         a) Refer to manufacturer's instructions for proper foot-pound levels or NETA ATS tables.
      3) Thermographic survey.
   h. Lubrication requirements:
      1) Verify appropriate lubrication on moving current-carrying parts.
      2) Verify appropriate lubrication on moving and sliding surfaces.
2. Electrical tests:
   a. Perform resistance measurements through bolted connections with a low resistance ohmmeter.

b. Perform insulation resistance tests for 1 minute on each pole, phase-to-phase and phase to ground with the starter closed, and across each open pole for 1 minute:
   1) Test voltage shall be in accordance with manufacturer's published data.
   2) Refer to NETA ATS tables in the absence of manufacturer's published data.
c. Test motor protection devices in accordance with manufacturer's published data.
d. Test circuit breakers as specified in this Section.
e. Perform operational tests by initiating control devices.

3. Test values:
   a. Compare bolted connection resistance values to values of similar connections:
      1) Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.
   b. Bolt-torque levels shall be in accordance with manufacturer's published data:
      1) Refer to NETA ATS tables in the absence of manufacturer's published data.
   c. Results of the thermographic survey shall be in accordance with NETA ATS requirements.
   d. 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.
   e. Insulation resistance values of control wiring shall not be less than 2 megohms.
   f. Motor protection parameters shall be in accordance with manufacturer's published data.
   g. Circuit breaker test results shall as specified in this Section.
   h. Control devices shall perform in accordance with system design requirements.

M. Motor control centers, low voltage:
   1. Visual and mechanical inspection:
      a. Compare equipment nameplate data with that indicated on the Drawings and specified in the Specifications.
      b. Inspect physical and mechanical condition.
      c. Inspect anchorage, alignment, grounding and required clearances.
      d. Inspect equipment for cleanliness.
      e. Verify that circuit breaker/fuse sizes and types correspond to the approved submittals and coordination study.
      f. Verify that current and voltage transformer ratios correspond to that indicated on the Drawings.
      g. Inspect bolted electrical connections for high resistance using one of the following methods:
         1) Use of low resistance ohmmeter.

2) Verify tightness of accessible bolted electrical connections by the calibrated torque wrench method:
   a) Refer to manufacturer's instructions for proper foot-pound levels or NETA ATS tables.
3) Thermographic survey.

h. Mechanical and electrical interlocks:
   1) Attempt closure on locked-open devices.
   2) Attempt to open locked-closed devices.
   3) Make/attempt key-exchanges in all positions.

i. Lubrication requirements:
   1) Verify appropriate lubrication on moving current-carrying parts.
   2) Verify appropriate lubrication on moving and sliding surfaces.

j. Inspect insulators for evidence of physical damage or contaminated surfaces.

k. Verify correct barrier and shutter installation and operation.

l. Exercise all active components.

m. Inspect all indicating devices for correct operation.

n. Verify that filters are in place and/or vents are clear.

o. Perform visual and mechanical inspection of instrument transformers as specified in this Section.

p. Inspect control power transformers:
   1) Inspect for physical damage, cracked insulation, broken leads, tightness of connections, defective wiring, and overall general condition.
   2) Verify that primary and secondary fuse/circuit breaker ratings match the submittal drawings.

q. Perform visual and mechanical inspection of circuit breakers as specified in this Section.

r. Perform visual and mechanical inspection of starters as specified in this Section.

s. Perform visual and mechanical inspection of dry-type transformers as specified in this Section.

t. Perform visual and mechanical inspection of variable frequency drives as specified in this Section.

2. Electrical tests:
   a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter if applicable.
   b. Perform insulation-resistance tests on each bus section, phase-to-phase and phase-to-ground for 1 minute:
      1) Perform test in accordance with NETA ATS tables.
   c. Perform an dielectric withstand test on each bus section, each phase to ground with phases not under test grounded, in accordance with manufacturer's published data or NETA ATS tables. Apply the test voltage for 1 minute.
   d. Perform ground-resistance tests:
      1) Perform point-to-point tests to determine the resistance between the main grounding system and all major electrical equipment frames, system neutral and derived neutral points.
   e. Determine the accuracy of all meters.

f. Control power transformers:
   1) Perform insulation resistance tests, winding-to-winding and winding-to-ground:
      a) Test voltages shall be in accordance with NETA ATS tables or as specified by the manufacturer.
   2) Perform secondary wiring integrity test:
      a) Disconnect transformer at secondary terminals and connect secondary wiring to a rated secondary voltage source:
         (1) Verify correct potential at all devices.
   3) Verify correct secondary voltage by energizing primary winding with system voltage:
      a) Measure secondary voltage with the secondary wiring disconnected.
g. Verify operation of space heaters.
h. Perform electrical tests of circuit breakers as specified in this Section.
i. Perform electrical tests of starters as specified in this Section.
j. Perform electrical tests of dry-type transformers as specified in this Section.
k. Perform electrical tests of variable frequency drives as specified in this Section.

3. Test values:
   a. Compare bus connection resistances to values of similar connections:
      1) Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.
   b. Bolt-torque levels shall be in accordance with manufacturer's published data:
      1) Refer to NETA ATS tables in the absence of manufacturer's published data.
   c. Results of the thermographic survey shall be in accordance with NETA ATS requirements.
   d. Compare bus connection resistances to values of similar connections:
      1) Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.
      2) Insulation-resistance values for bus and control power transformers shall be in accordance with manufacturer's published data:
         a) Refer to NETA ATS tables in the absence of manufacturer's published data.
         b) Investigate insulation values less than the allowable minimum.
         c) Do not proceed with dielectric withstand voltage tests until insulation-resistance values are above minimum values.
   e. Bus insulation shall withstand the overpotential test voltage applied.
   f. Insulation-resistance values for control wiring shall not be less than 2.0 megohms.
   g. Instrument transformer test values shall be as specified in this Section.
   h. Investigate grounding system resistance values that exceed 0.5 ohm.
   i. Meter accuracy shall be in accordance with manufacturer's published data.
   j. Control power transformers:
      1) Insulation resistance values of control power transformers shall be in accordance with manufacturer's published data:
         a) Refer to NETA ATS tables in the absence of manufacturer's published data.

b) Investigate insulation values less than the allowable minimum.
c) Do not proceed with dielectric withstand voltage tests until insulation-resistance values are above minimum values.

2) Secondary wiring shall be in accordance with that indicated on the Drawings and specified in the Specifications.
3) Secondary voltage shall be in accordance with that indicated on the Drawings.

k. Heaters shall be operational.
l. Test values for circuit breakers shall be as specified in this Section.
m. Test values for starters shall be as specified in this Section.
n. Test values for dry-type transformers shall as specified in this Section.
o. Test values for variable frequency drives shall be as specified in this Section.

N. Variable frequency drive systems:
1. Visual and mechanical inspection:
a. Compare equipment nameplate data with that indicated on the Drawings and specified in the Specifications.
b. Inspect physical and mechanical condition.
c. Inspect anchorage, alignment, and grounding.
d. Verify the unit is clean.
e. Ensure vent path openings are free from debris and that heat transfer surfaces are clean.
f. Verify correct connections of circuit boards, wiring, disconnects, and ribbon cables.
g. Motor running protection:
1) Verify drive overcurrent setpoints are correct for their application.
2) If drive is used to operate multiple motors, verify individual overload element ratings are correct for their application.
3) Apply minimum and maximum speed setpoints. Verify setpoints are within limitations of the load coupled to the motor.
h. Inspect bolted electrical connections for high resistance using one of the following methods:
1) Use of low resistance ohmmeter.
2) Verify tightness of accessible bolted electrical connections by the calibrated torque wrench method:
a) Refer to manufacturer's instructions for proper foot-pound levels or NETA ATS tables.
3) Thermographic survey.
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. Perform insulation-resistance tests on control wiring with respect to ground. Applied potential shall be 500 VDC for 300-volt rated cable and 1,000 VDC for 600-volt rated cable. Apply the test voltage for 1 minute:
   1) For solid-state devices that cannot tolerate the applied voltage, follow the manufacturer's recommendation.
d. 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.
e. Perform continuity tests on bonding conductors as specified in this Section.
f. Perform start-up of drive in accordance with manufacturer's published data. Calibrate drive to the system's minimum and maximum speed control signals.
g. 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.
h. Perform electrical tests of input circuit breaker as specified in this Section.

3. Test values:
   a. Compare bolted connection resistances to values of similar connections:
      1) Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.
   b. Bolt-torque levels shall be in accordance with manufacturer's published data:
      1) Refer to NETA ATS tables in the absence of manufacturer's published data.
   c. Results of the thermographic survey shall be in accordance with NETA ATS requirements.
   d. Overload test trip times at 300 percent of overload element rating shall be in accordance with manufacturer's published time-current curve.
   e. Test values for input circuit breaker shall be as specified in this Section.
   f. Insulation-resistance values for control wiring shall not be less than 2.0 megohms.
   g. Relay calibration results shall be as specified in this Section.
   h. Continuity of bonding conductors shall be as specified in this Section.
   i. Control devices shall perform in accordance with system requirements.
   j. Operational tests shall conform to system design requirements.

O. Surge arresters, low-voltage:
   1. Visual and mechanical inspection:
      a. Compare equipment nameplate data with that indicated on the Drawings and specified in the Specifications.
      b. Inspect physical and mechanical condition.

c. Inspect anchorage, alignment, grounding, and clearances.
d. Verify the arresters are clean.
e. Inspect bolted electrical connections for high resistance using one of the following methods:
    1) Use of low resistance ohmmeter.
    2) Verify tightness of accessible bolted electrical connections by the calibrated torque wrench method:
        a) Refer to manufacturer's instructions for proper foot-pound levels or NETA ATS tables.
f. Verify that the ground lead on each device is individually attached to a ground bus or ground electrode.
g. Verify that stroke counter is correctly mounted and electrically connected, if applicable.
h. Record stroke counter reading.

2. Electrical tests:
    a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter.
    b. Perform an insulation-resistance test on each arrester, phase terminal-to-ground:
        1) Apply voltage in accordance with manufacturers published data.
        2) Refer to NETA ATS tables in the absence of manufacturer's published data.
    c. Test grounding connection as specified in this Section.
3. Test values:
    a. Compare bolted connection resistances to values of similar connections:
        1) Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.
    b. Bolt-torque levels shall be in accordance with manufacturer's published data:
        1) 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 insulation values less than the allowable minimum.
    d. Resistance between the arrester ground terminal and the ground system shall be less than 0.5 ohm.

P. Outdoor bus structures:
1. Visual and mechanical inspection:
    a. Compare bus arrangement with that indicated on the Drawings and specified in the Specifications.
    b. Inspect physical and mechanical condition.
    c. Inspect anchorage, alignment, and grounding.
    d. Verify the support insulators are clean.
    e. Inspect bolted electrical connections for high resistance using one of the following methods:
        1) Use of low-resistance ohmmeter.

2) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method:
a) Refer to manufacturer's instructions for proper foot-pound levels or NETA ATS tables.
3) Thermographic survey.

2. Electrical tests:
a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter.
b. Measure insulation resistance of each bus, phase-to-ground with other phases grounded:
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 dielectric withstand voltage test on each bus phase, phase-to-ground with other phases grounded. Potential application shall be for 1 minute.

3. Test values:
a. Compare bolted connection resistances to values of similar connections:
1) Investigate values that deviate from those of similar connections by more than 50 percent of the lowest value.
b. Bolt-torque levels shall be in accordance with manufacturer's published data:
1) Refer to NETA ATS tables in the absence of manufacturer's published data.
c. Results of the thermographic survey shall be in accordance with NETA ATS requirements.
d. 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.
e. If no evidence of distress or insulation failure is observed at the end of the total time of voltage application during the dielectric withstand test, the test specimen is considered to have passed the test.

Q. Uninterruptible power systems:
1. Visual and mechanical inspection:
a. Compare equipment nameplate data with that indicated on the Drawings and specified in the Specifications.
b. Inspect physical and mechanical condition.
c. Inspect anchorage, alignment, grounding, and required clearances.
d. Verify that fuse sizes and types correspond to that indicated on the Drawings.
e. Verify the unit is clean.
f. Test all electrical and mechanical interlock systems for correct operation and sequencing.
g. Inspect bolted electrical connections for high resistance using one of the following methods:
1) Use of low-resistance ohmmeter.
2) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method:
a) Refer to manufacturer's instructions for proper foot-pound levels or NETA ATS tables.
3) Thermographic survey.

h. Verify operation of forced ventilation.
i. Verify that filters are in place and/or vents are clear.

2. Electrical tests:
   a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter.
   b. Test static transfer from inverter to bypass and back. Use normal load, if possible.
   c. Set free running frequency of oscillator.
   d. Test dc undervoltage trip level on inverter input breaker. Set according to manufacturer's published data.
   e. Test alarm circuits.
   f. Verify synchronizing indicators for static switch and bypass switches.
   g. Perform electrical tests for UPS system breakers as specified in this Section.
   h. Perform electrical tests for UPS system automatic transfer switches as specified in this Section.
   i. Perform electrical tests for UPS system batteries as specified in this Section.
   j. Perform electrical tests for UPS rotating machinery as specified in this Section.
3. Test values:
   a. Electrical and mechanical interlock systems shall operate in accordance with system design requirements.
   b. Compare bolted connection resistance values to values of similar connections:
      1) Investigate values that 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:
      1) Refer to NETA ATS tables in the absence of manufacturer's published data.
   d. Results of the thermographic survey shall be in accordance with NETA ATS requirements.
   e. Static transfer shall function in accordance with manufacturer's published data.
   f. Oscillator free running frequency shall be within manufacturer's published tolerances.
   g. Direct current undervoltage shall trip inverter input breaker.
   h. Alarm circuits shall operate in accordance with design requirements.
   i. Synchronizing indicators shall operate in accordance with design requirements.
   j. Breaker performance shall be as specified in this Section.
   k. Automatic transfer switch performance shall be as specified in this Section.
   l. Battery test results shall be as specified in this Section.
   m. Rotating machinery performance shall be as specified in this Section.

R. Fiber-optic cables:
   1. Visual and mechanical inspection:
      a. Compare cable, connector, and splice data with that indicated on the Drawings and specified in the Specifications.

b. Inspect cable and connections for physical and mechanical damage.
c. Verify that all connectors and splices are correctly installed.

2. Electrical tests:
   a. Perform cable length measurement, fiber fracture inspection, and construction defect inspection using an optical time domain reflectometer (OTDR):
      1) OTDR test performed on fiber cables less than 100 meters shall be performed with the aid of a launch cable.
      2) Adjust OTDR pulse width settings to a maximum setting of 1/1000th of the cable length or 10 nanoseconds.
   b. Perform connector and splice integrity test using an optical time domain reflectometer.
   c. Perform cable attenuation loss measurement with an optical power loss test set:
      1) Perform attenuation tests with an Optical Loss Test Set capable and calibrated to show anomalies of 0.1 dB as a minimum.
      2) Test multimode fibers at 850 nanometers and 1,300 nanometers.
      3) Test single mode fibers at 1,310 nanometers and 1,550 nanometers.
   d. Perform connector and splice attenuation loss measurement from both ends of the optical cable with an optical power loss test set:
      1) At the conclusion of all outdoor splices at one location, and before they are enclosed and sealed, all splices shall be tested with OTDR at the optimal wavelengths (850 and 1,300 for multimode, 1,310 and 1,550 for single mode), in both directions. The splices shall be tested for integrity as well as attenuation.
   e. Perform fiber links integrity and attenuation tests using each link shall be an OTDR and an Optical Loss Test Set:
      1) OTDR traces shall be from both directions on each fiber at the 2 optimal wavelengths, 850 nanometers and 1,300 nanometers for multimode fibers.
      2) Optical loss testing shall be done with handheld test sets in 1 direction at the 2 optimal wavelengths for the appropriate fiber type. Test equipment shall equal or exceed the accuracy and resolution of Agilent/HP 8147 high performance OTDR.

3. Test values:
   a. Cable and connections shall not have been subjected to physical or mechanical damage.
   b. Connectors and splices shall be installed in accordance with industry standards.
   c. The optical time domain reflectometer signal should be analyzed for excessive connection, splice, or cable backscatter by viewing the reflected power/distance graph.
   d. Attenuation loss measurement shall be expressed in dB/km. Losses shall be within the manufacturer’s recommendations when no local site specifications are available.
   e. Individual fusion splice losses shall not exceed 0.1 dB. Measurement results shall be recorded, validated by trace, and filed with the records of the respective cable runs.

S. LAN cable testing:
   1. Visual and mechanical inspections:
      a. Compare cable type and connections with that indicated on the Drawings and specified in the Specifications.
      b. Inspect cable and connectors for physical and mechanical damage.
      c. Verify that all connectors are correctly installed.
   2. Pre-testing:
      a. Test individual cables before installation:
         1) Before physical placement of the cable, test each cable while on the spool with a LAN certification test device.
         2) Before the cable is installed, verify that the cable conforms to the manufacturer's attenuation specification and that no damage has been done to the cable during shipping or handling.
         3) The test shall be fully documented and the results submitted to the Engineer, including a hard copy of all traces, before placement of the cable.
         4) The Engineer shall be notified if a cable fails to meet specification and the cable shall not be installed unless otherwise directed by the Engineer.
   3. Electrical tests:
      a. Perform cable end-to-end testing on all installed cables after installation of connectors from both ends of the cable.
      b. Test shall include cable system performance tests and confirm the absence of wiring errors.
   4. Test results:
      a. Cables shall meet or exceed TIA standards for a CAT 6A installation.
   5. Test equipment:
      a. LAN certification equipment used for the testing shall be capable of testing Category 6 cable installation to TIA proposed Level III accuracy. Tests performed shall include:
         1) Near end cross talk.
         2) Attenuation.
         3) Equal level far end cross talk.
         4) Return loss.
         5) Ambient noise.
         6) Effective cable length.
         7) Propagation delay.
         8) Continuity/loop resistance.
      b. LAN certification test equipment shall be able to store and produce plots of the test results.
      c. Acceptable manufacturers: The following or equal:
         1) Agilent Technologies, WireScope 350.

T. Emergency Generator batteries, (flooded lead-acid):
   1. Visual and mechanical inspection:
      a. Verify that battery area ventilation system is operable.
      b. Verify existence of suitable eyewash equipment.
      c. Compare equipment nameplate data with that indicated on the Drawings and specified in the Specifications.
      d. Inspect physical and mechanical condition.
      e. Verify adequacy of battery support racks, mounting, anchorage, alignment, grounding, and clearances.

f. Verify electrolyte level. Measure electrolyte specific gravity and temperature levels.
g. Verify the units are clean.
h. Inspect spill containment installation.
i. Verify application of an oxide inhibitor on battery terminal connections.
j. Inspect bolted electrical connections for high resistance using one of the following methods:
    1) Use of low-resistance ohmmeter.
    2) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method
        a) Refer to manufacturer’s instructions for proper foot-pound levels NETA ATS tables.
    3) Perform thermographic survey.

2. Electrical tests:
    a. Perform resistance measurements through all bolted connections with a low-resistance ohmmeter if applicable.
    b. Measure charger float and equalizing voltage levels. Adjust to battery manufacturer's recommended settings.
    c. Verify all charger functions and alarms.
    d. Measure each cell voltage and total battery voltage with charger energized and in float mode of operation.
    e. Measure intercell connection resistances.
    f. Perform internal ohmic measurement tests.
    g. Perform a load test in accordance with manufacturer's published data or IEEE 450.
    h. Measure the battery system voltage from positive-to-ground and negative-to-ground.

3. Test values:
    a. Test values - visual and mechanical:
        1) Electrolyte level and specific gravity shall be within normal limits.
        2) Compare bolted connection resistance values to values of similar connections.
            a) Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.
        3) Bolt-torque levels shall be in accordance with manufacturer's published data.
            a) Refer to NETA ATS tables in the absence of manufacturer's published data.
        4) Results of the thermographic survey shall be in accordance with NETA ATS requirements.
    b. Test values - electrical:
        1) Compare bolted connection resistance values to values of similar connections.
            a) Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.
        2) Charger float and equalize voltage levels shall be in accordance with battery manufacturer's published data.
        3) The results of charger functions and alarms shall be in accordance with manufacturer's published data.
        4) Cell voltages shall be within 0.05 volt of each other or in accordance with manufacturer's published data.

5) Compare bolted connection resistance values to values of similar connections.
   a) Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.
6) Cell internal ohmic values (resistance, impedance, or conductance) shall not vary by more than 25 percent between identical cells in a fully charged state.
7) Results of load tests shall be in accordance with manufacturer's published data or IEEE 450.

3.08 ADJUSTING

A. Adjust limit switches and level switches to their operating points before testing.

B. Set pressure switches, flow switches, and timing relays to anticipated values before testing:
   1. Final settings shall be as dictated by operating results during testing.

3.09 CLEANING

A. As specified in Section 16050.

B. After the acceptance tests have been completed, dispose of all testing expendables, vacuum all cabinets, and sweep clean all surrounding areas.

3.10 DEMONSTRATION AND TRAINING

A. As specified in Section 16050.

B. Subsystem demonstration:
   1. Subsystem, as used in this Section, means individual and groups of pumps, conveyor systems, chemical feeders, air conditioning units, ventilation fans, air compressors, blowers, lighting control systems and other electrically operated or controlled equipment.
   2. Before demonstrating any subsystem:
      a. Demonstrate proper operation of all alarm and status contacts.
      b. Adjust and calibrate all process and control devices as accurately as possible.
   3. Operate each subsystem in its manual mode:
      a. Demonstrate compliance with all Contract requirements.
   4. After each subsystem has operated successfully in its manual mode, perform automatic and remote operation demonstrations:
      a. Verify that all features are fully operational and meet all Contract requirements.
      b. Demonstrate all operating modes and sequences, including proper start and stop sequence of pumps, proper operation of valves and proper speed control.

3.11 PROTECTION

A. As specified in Section 16050.

3.12 SCHEDULES

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.

END OF SECTION

SECTION 16970

LIGHTING ACCEPTANCE TESTING

PART 1 GENERAL

1.01 SUMMARY

A. A Certificate of Acceptance will be required to be filed (by the Contractor) with and approved by the enforcement agency prior to receiving a final occupancy permit for the Administration and Maintenance Buildings. The Certificate of Acceptance will indicate that the Contractor has demonstrated acceptance requirements of the plans and specifications, that current requirements for installation certificates are met, and that currently required operating and maintenance information (as well as the Certificate of Acceptance) were provided to the building Owner.

B. Section Includes:
   1. Testing, evaluation and calibration of lighting controls equipment provided, installed, and connected in DIVISION 16.
   2. Documentation of test results, completion of “Certificate of Acceptance” forms (included herein) and filing with the enforcement agency for approval.

C. Specific Jobsite Conditions as related to Administration and Maintenance Building:
   1. Acceptance testing must be tailored for each specific design, job site, and climactic conditions. While the steps for conducting each test remain consistent, the application of the tests to a particular site may vary. The Contractor shall review the construction documents and include all required time, material, testing equipment, etc. as required to complete the requirements of this Section.

D. 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 16500 - Lighting.

1.02 REFERENCES

A. Acceptance Testing Criteria: 2008 Building Energy Efficiency Standards Non-Residential Compliance Manual (October 2009).

1.03 SYSTEM DESCRIPTION

A. Performance Requirements:
   1. All material, equipment, labor and technical supervision to perform tests, calibrations, and documentation specified herein.

B. Scope of Testing, Evaluation, and Calibration (as applicable):
   1. Automatic (master) time switches.
   2. Occupancy sensors.
   3. Automatic daylighting controls.
   4. Photo electric sensors.
   5. Daylighting controls.
   6. Outdoor astronomical time switches.
   7. Area controls.

1.04 SUBMITTALS

A. Test Reports:
   1. Written record of all tests and completion of forms included in this Section.
   2. At completion of project, assemble a final test report. Submit report to the enforcement agency and the Owner prior to final occupancy to include:
      a. Summary of project.
      b. Description of systems and equipment tested.
      c. Visual inspection report.
      d. Description of tests.
      e. Test results.
      f. Conclusions and recommendations.
   3. Report shall be bound in booklet form, include on the Contractor's letterhead the title of the report and the systems tested.

B. Constructability Plan Review:
   1. The Contractor shall review the construction drawings and specifications to understand the scope of the acceptance tests and raise critical issues that might affect the success of the acceptance tests prior to starting construction. Any constructability issues associated with the lighting system should be forwarded to the design team for review/modifications prior to equipment procurement and installation. The Contractor shall submit on company letterhead, a letter confirming that the constructability review has been completed and their company has reviewed and is prepared to complete the lighting acceptance testing required by this Section, including the lighting control equipment required by Section 16500. The lighting acceptance testing shall be included in this letter at the time of equipment submittals.

PART 2 PRODUCTS

2.01 FORMS

A. Lighting acceptance testing forms and verification procedures for lighting systems that require acceptance testing are listed below and included as part of this Section and can be downloaded from the following website: http://www.energy.ca.gov/title24/2008standards/nonresidential_manual.html:
   1. Form LTG-2-A Certificate of Acceptance (1 of 3).

2. Form LTG-2-A Certificate of Acceptance (2 of 3).
3. Form LTG-2-A Certificate of Acceptance (3 of 3).
4. Form OLTG-2-A Certificate of Acceptance (1 of 3).
5. Form OLTG-2-A Certificate of Acceptance (2 of 3).
6. Form OLTG-3-A Certificate of Acceptance (3 of 3).

B. These completed forms will be the deliverable product to the enforcement agency and Owner as described in Article 1.04 of this Section.

PART 3 EXECUTION

3.01 FIELD QUALITY CONTROL

A. Tests:
1. Contractor's Responsibilities:
a. Perform all required tests required by this Section.
b. Schedule testing with building Owner.
c. Provide window/skylight masking material required to simulate dark conditions of test during evening hours.
d. Calibration of equipment such as light meters, photo electric controls, etc.
e. Programming of time switches (interior/exterior lighting) for operations as directed by the Owner.

3.02 ADJUSTING

A. Final Settings: The Contractor shall be responsible for implementing all final settings and adjustments on controls equipment as required for a complete and operating system.

CERTIFICATE OF ACCEPTANCE	LTG-2A
Lighting Control Acceptance Document	**(Page 1 of 3)**
Project Name/Address:	
System Name or Identification/Tag:	System Location or Area Served:

Enforcement Agency:	Permit Number:
Note: Submit one Certificate of Acceptance for each system that must demonstrate compliance.	Enforcement Agency Use: Checked by/Date

FIELD TECHNICIAN'S DECLARATION STATEMENT

- I certify under penalty of perjury, under the laws of the State of California, the information provided on this form is true and correct.
- I am the person who performed the acceptance requirements verification reported on this Certificate of Acceptance (Field Technician).
- I certify that the construction/installation identified on this form complies with the acceptance requirements indicated in the plans and specifications approved by the enforcement agency, and conforms to the applicable acceptance requirements and procedures specified in Reference Nonresidential Appendix NA7.
- I have confirmed that the Installation Certificate(s) for the construction/installation identified on this form has been completed and is posted or made available with the building permit(s) issued for the building.

Company Name:		
Field Technician's Name:		Field Technician's Signature:
	Date Signed:	Position With Company (Title):

RESPONSIBLE PERSON'S DECLARATION STATEMENT

- I certify under penalty of perjury, under the laws of the State of California, that I am the Field Technician, or the Field Technician is acting on my behalf as my employee or my agent and I have reviewed the information provided on this form.
- I am a licensed contractor, architect, or engineer, who is eligible under Division 3 of the Business and Professions Code, in the applicable classification, to take responsibility for the scope of work specified on this document and attest to the declarations in this statement (responsible person).
- I certify that the information provided on this form substantiates that the construction/installation identified on this form complies with the acceptance requirements indicated in the plans and specifications approved by the enforcement agency, and conforms to the applicable acceptance requirements and procedures specified in Reference Nonresidential Appendix NA7.
- I have confirmed that the Installation Certificate(s) for the construction/installation identified on this form has been completed and is posted or made available with the building permit(s) issued for the building.
- I will ensure that a completed, signed copy of this Certificate of Acceptance shall be posted, or made available with the building permit(s) issued for the building, and made available to the enforcement agency for all applicable inspections. I understand that a signed copy of this Certificate of Acceptance is required to be included with the documentation the builder provides to the building owner at occupancy.

Company Name:			Phone:
Responsible Person's Name:		Responsible Person's Signature:	
License:	Date Signed:	Position With Company (Title):	

Occupant Sensor, Manual Daylighting Control, and Automatic Time Switch Control		
Intent:	Lights are turned off when not needed per Section 119(d) & 131(d).	
Construction Inspection		
1	Instrumentation to perform test includes, but not limited to:	
	a.	Hand-held amperage and voltage meter
	b.	Power meter
		continued on next page

Project Name/Address:	
System Name or Identification/Tag:	System Location or Area Served:

2	Occupancy Sensor Construction Inspection		
	☐	Occupancy sensor has been located to minimize false signals	
	☐	Light meter	
	☐	Ultrasonic occupancy sensors do not emit audible sound (119a) 5 feet from source	
3	Manual Daylighting Controls Construction Inspection		
	☐	If dimming ballasts are specified for light fixtures within the daylit area, make sure they meet all the Standards requirements, including "reduced flicker operation" for manual dimming control systems	
4	Automatic Time Switch Controls Construction Inspection		
	a.	Automatic time switch control is programmed for (check all):	
		☐	Weekdays
		☐	Weekend
		☐	Holidays
	b.	Document for the owner automatic time switch programming (check all):	
		☐	Weekdays settings
		☐	Weekend settings
		☐	Holidays settings
		☐	Set-up settings
		☐	Preference program setting
	☐	Verify the correct time and date is properly set in the time switch	
	☐	Verify the battery is installed and energized	
	☐	Override time limit is no more than 2 hours	
	☐	Occupant Sensors and Automatic Time Switch Controls have been certified to the Energy Commission in accordance with the applicable provision in Section 119 of the Standards, and model numbers for all such controls are listed on the Commission database as Certified Appliance and Control Devices	

A.	**Select Acceptance Test** (Indicate lighting control systems Names/Designations by the applicable tests below)	
☐	1	Occupancy Sensor
☐	2	Manual Daylighting Controls
☐	3	Automatic Time Switch Controls

B.	**Equipment Testing Requirements** Check and verify those items applicable to selected system:	Applicable Lighting Control Systems		
Occupancy Sensor - Step 1: Simulate an unoccupied condition		1	2	3
a.	Lights controlled by occupancy sensors turn off within a maximum of 30 minutes from start of an unoccupied condition per Standard Section 119(d)	Y / N	Y / N	Y / N
b.	The occupant sensor does not trigger a false "on" from movement in an area adjacent to the controlled space or from HVAC operation	Y / N	Y / N	Y / N
c.	Signal sensitivity is adequate to achieve desired control	Y / N	Y / N	Y / N
Occupant Sensor - Step 2: Simulate an occupied condition				
a.	Status indicator or annunciator operates correctly	Y / N	Y / N	Y / N
b.	Lights controlled by occupancy sensors turn on when Immediately upon an occupied condition *OR* (this requirement is mutually exclusive with Step 2.c.)	Y / N	Y / N	Y / N
c.	Sensor indicates space is "occupied" and lights turn on manually	Y / N	Y / N	Y / N

continued on next page

CERTIFICATE OF ACCEPTANCE	LTG-2A
Lighting Control Acceptance Document	**(Page 3 of 3)**
Project Name/Address:	
System Name or Identification/Tag:	System Location or Area Served:

Occupant Sensor - Step 3: System returned to initial operating conditions		Y / N	Y / N	Y / N
Occupant Sensor - Step 4 - Sensor is also a multi-Level Occupant Sensor used to qualify for a Power Adjustment Factor in Section 146(a)2D of the Standards. If yes, then 'a,' 'b,' and 'c' must also be yes.		Y / N	Y / N	Y / N
a.	The first stage activates between 30 to 70% of the lighting either manually or automatically.	Y / N	Y / N	Y / N
b.	A reasonably uniform level of illuminance is achieved by dimming of all lamps or luminaires; or by switching alternate lamps in luminaires, alternate luminaires, or alternate rows of luminaires.	Y / N	Y / N	Y / N
c.	After the first stage occurs, manual switches have been provided to activate the alternate set of lights, activate 100% of the lighting power, and manually deactivate all of the lights.	Y / N	Y / N	Y / N
Manual Daylighting Controls - Step 1: Manual switching control				
a.	At least 50% of lighting power in daylit areas is separately controlled from other lights	Y / N	Y / N	Y / N
b.	The amount of light delivered to the space is uniformly reduced	Y / N	Y / N	Y / N
Manual Daylighting Controls - Step 2: System returned to initial operating conditions		Y / N	Y / N	Y / N
Automatic Time Switch Controls - Step 1: Simulate occupied condition				
a.	All lights can be turned on and off by their respective area control switch	Y / N	Y / N	Y / N
b.	Verify the switch only operates lighting in the ceiling-height partitioned area in which the switch is located	Y / N	Y / N	Y / N
Automatic Time Switch Controls - Step 2: Simulate unoccupied condition				
a.	All non-exempt lighting turn off per Section 131(d)1	Y / N	Y / N	Y / N
b.	Manual override switch allows only the lights in the selected ceiling height partitioned space where the override switch is located, to turn on or remain on until the next scheduled shut off occurs	Y / N	Y / N	Y / N
c.	All non-exempt lighting turns off	Y / N	Y / N	Y / N
Automatic Time Switch Controls - Step 3: System returned to initial operating conditions		Y / N	Y / N	Y / N
Note: Shaded areas do not apply for particular test procedure				
C.	**PASS / FAIL Evaluation (check one):**			
☐	PASS: All applicable **Construction Inspection** responses are complete and all applicable **Equipment Testing Requirements** responses are positive (Y - yes)			
☐	FAIL: Any applicable **Construction Inspection** responses are incomplete *OR* there is one or more negative (N - no) responses in any applicable **Equipment Testing Requirements** section. Provide explanation below. Use and attach additional pages if necessary.			

CERTIFICATE OF ACCEPTANCE	OLTG-2A
NA7.7 Outdoor Lighting Acceptance Tests	**(Page 1 of 3)**
Project Name/Address:	
System Name or Identification/Tag:	System Location or Area Served:

Enforcement Agency:	Permit Number:
Note: Submit one Certificate of Acceptance for each system that must demonstrate compliance.	Enforcement Agency Use: Checked by/Date

FIELD TECHNICIAN'S DECLARATION STATEMENT

- I certify under penalty of perjury, under the laws of the State of California, the information provided on this form is true and correct.
- I am the person who performed the acceptance requirements verification reported on this Certificate of Acceptance (Field Technician).
- I certify that the construction/installation identified on this form complies with the acceptance requirements indicated in the plans and specifications approved by the enforcement agency, and conforms to the applicable acceptance requirements and procedures specified in Reference Nonresidential Appendix NA7.
- I have confirmed that the Installation Certificate(s) for the construction/installation identified on this form has been completed and is posted or made available with the building permit(s) issued for the building.

Company Name:		
Field Technician's Name:		Field Technician's Signature:
	Date Signed:	Position With Company (Title):

RESPONSIBLE PERSON'S DECLARATION STATEMENT

- I certify under penalty of perjury, under the laws of the State of California, that I am the Field Technician, or the Field Technician is acting on my behalf as my employee or my agent and I have reviewed the information provided on this form.
- I am a licensed contractor, architect, or engineer, who is eligible under Division 3 of the Business and Professions Code, in the applicable classification, to take responsibility for the scope of work specified on this document and attest to the declarations in this statement (responsible person).
- I certify that the information provided on this form substantiates that the construction/installation identified on this form complies with the acceptance requirements indicated in the plans and specifications approved by the enforcement agency, and conforms to the applicable acceptance requirements and procedures specified in Reference Nonresidential Appendix NA7.
- I have confirmed that the Installation Certificate(s) for the construction/installation identified on this form has been completed and is posted or made available with the building permit(s) issued for the building.
- I will ensure that a completed, signed copy of this Certificate of Acceptance shall be posted, or made available with the building permit(s) issued for the building, and made available to the enforcement agency for all applicable inspections. I understand that a signed copy of this Certificate of Acceptance is required to be included with the documentation the builder provides to the building owner at occupancy.

Company Name:			Phone:
Responsible Person's Name:		Responsible Person's Signature:	
License:	Date Signed:	Position With Company (Title):	

Project Name/Address:	
System Name or Identification/Tag:	System Location or Area Served:

NA7.7.1 Outdoor Motion Sensor Acceptance

Intent: Lights are turned off when not needed per Section 119(d) & 132.

Construction Inspection

1.	Motion Sensor Construction Inspection	
	☐	Motion sensor has been located to minimize false signals
	☐	Sensor is not triggered by motion outside of adjacent area
	☐	Desired motion sensor coverage is not blocked by obstruction that could adversely affect performance

Functional testing

1.	Simulate motion in area under lights controlled by the motion sensor. Verify and document the following:	
	☐	Status indicator operates correctly.
	☐	Lights controlled by motion sensors turn on immediately upon entry into the area lit by the controlled lights near the motion sensor
	☐	Signal sensitivity is adequate to achieve desired control
2.	Simulate no motion in area with lighting controlled by the sensor but with motion adjacent to this area. Verify and document the following:	
	☐	Lights controlled by motion sensors turn off within a maximum of 30 minutes from the start of an unoccupied condition per Standard Section 119(d).
	☐	The occupant sensor does not trigger a false "on" from movement outside of the controlled area
	☐	Signal sensitivity is adequate to achieve desired control.

NA7.7.2 Outdoor Lighting Shut-off Controls

Construction Inspection

1.	Outdoor Lighting Shut-off Controls Construction Inspection	
	☐	Astronomical time switch controls and automatic time switch controls have been certified to the Energy Commission in accordance with the applicable provision in Standards Section 119. Verify that model numbers of all such controls are listed on the Energy Commission database as "Certified Appliances & Control Devices."
	☐	Controls to turn off lights during daytime hours are installed
	☐	Astronomical and standard time switch control is programmed with acceptable weekday, weekend, and holiday (if applicable) schedules
	☐	Demonstrate and document for the owner time switch programming including weekday, weekend, holiday schedules as well as all set-up and preference program settings
2.	Lighting systems that meet the criteria of Section 132(c)2 of the Standards shall have a scheduling control (time switch) installed which is able to schedule separately:	
	☐	A reduction in outdoor lighting power by 50 to 80%
	☐	Turning off all outdoor lighting covered by Section 132(c)2 of the Standards
	☐	Verify that the correct time and date is properly set in the standard and astronomical time switch.
	☐	Verify that the correct latitude, longitude and time zone are set in the astronomical time switch.
	☐	Verify the battery back-up (if applicable) is installed and energized in the standard and astronomical time switch.

Project Name/Address:	
System Name or Identification/Tag:	System Location or Area Served:

NA7.7.2.2 Outdoor Photocontrol Functional testing		
Note photocontrol must be used in conjunction with time switch or motion sensor to meet the requirements of Section 132(c)2 of the Standards.		
1.	Nighttime test. Simulate or provide conditions without daylight. Verify and document:	
	☐	Controlled lights turn on
2.	Sunrise test: Provide between 10 and 30 horizontal footcandles (fc) to photosensor. Verify and document the following	
	☐	Controlled lights turn off

NA7.7.2.3 Astronomical Time Switch Functional testing		
1.	Power off test. Program control with location information, local date and time, and schedules. Disconnect control from power source for at least 1 hour. Verify and document:	
	☐	Control retains all programmed settings and local date and time
2.	Night schedule ON test. Simulate or provide times when the sun has set and lights are scheduled to be ON. Verify and document:	
	☐	Controlled lights turn on
3.	Night schedule OFF test. Simulate or provide times when the sun has set and lights are scheduled to be OFF. Verify and document:	
	☐	Controlled lights turn off
4.	Sunrise test: Simulate or provide the programmed offset time after the time of local sunrise	
	☐	Controlled lights turn off

NA7.7.2.4 Standard (non-astronomical) Time Switch Functional Testing		
Note: this control must be used in conjunction with a photocontrol to meet requirements of Section 132(c) of the Standards.		
1.	Power off test. Program control with local date and time and schedules. Disconnect control from power source for at least 1 hour. Verify and document:	
	☐	Control retains all programmed schedules and local date and time
2.	On schedule test. Simulate or provide times when lights are scheduled to be ON. Verify and document:	
	☐	Controlled lights turn on
3.	Schedule test. Simulate or provide times when the sun has set and lights are scheduled to be OFF. Verify and document:	
	☐	Controlled lights turn off

END OF SECTION

SECTION 17050

COMMON WORK RESULTS FOR PROCESS CONTROL AND INSTRUMENTATION SYSTEMS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. General requirements applicable to all Process Control and Instrumentation Work.
   2. General requirements for process control and instrumentation 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. 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.
      a. Items involving electrical, control, and instrumentation construction may be indicated on the Drawings or specified in the Specifications that do not apply specifically to electrical, control and instrumentation systems.
   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 00700 - General Conditions.
      b. Section 01140 - Work Restrictions.
      c. Section 01330 - Submittal Procedures.
      d. Section 01410 - Regulatory Requirements.
      e. Section 01450 - Quality Control.
      f. Section 01610 - Project Design Criteria.
      g. Section 01612 - Seismic Design Criteria.
      h. Section 01614 - Wind Design Criteria.
      i. Section 01660 - Testing, Training, and Commissioning.
      j. Section 01740 - Warranties and Bonds
      k. Section 01770 - Closeout Procedures.
      l. Section 01782 - Operation and Maintenance Data.
      m. Section 16050 - Common Work Results for Electrical.
      n. Section 16075 - Electrical Identification.
      o. Section 16222 - Low Voltage Motors up to 500 Horsepower.
      p. Section 16950 - Field Electrical Acceptance Tests.
      q. Section 17100 - Control Strategies.
      r. Section 17101 - Specific Control Strategies.
      s. Section 17761 - PLC Programming Software.
      t. Section 17762 - Control Systems SCADA Software.
      u. Section 17950 - Testing, Calibration, and Commissioning.

C. Interfaces to equipment, instruments, and other components:
   1. The 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, include all costs to add any additional instruments, wiring, control system inputs/outputs, controls, interlocks, electrical hardware etc., 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 Document 00700.
   4. Review the complete set of Drawings and Specifications in order to ensure that all items related to the instrumentation and control systems are completely accounted for. Include any items that appear on Drawings or in 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 complete loop drawings for all systems, including packaged equipment furnished as part of a vendor furnished package, and for all pre-purchased equipment.
      b. The form, minimum level of detail, and format for the loop drawings must match that of the sample loop drawings included in the Contract Documents.
      c. The Owner and Engineer are not responsible for providing detailed loop diagrams for Contractor furnished equipment.

D. All instrumentation, and control equipment and systems for the entire project to comply with the requirements specified in the Instrumentation and Control Specifications, whether referenced in the individual Equipment Specifications or not:
   1. The requirements of the Instrumentation and Control Specifications apply to all Instrumentation and Control Work specified in other Specifications, including HVAC controls, packaged mechanical systems, LCPs, VCPs, etc.
   2. Inform all vendors supplying instrumentation, control systems, panels, and/or equipment of the requirements of the Instrumentation and Control 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 Instrumentation and Control Specifications' requirements.

E. Contract Documents:
   1. General:
      a. The Drawings and Specifications are complementary and are to be used together in order to fully describe the Work.
   2. Specifications:
      a. Section 00700 of the Contract Documents govern the Work.
      b. These requirements are in addition to all General Requirements.

3. Contract Drawings:
   a. The Instrumentation and Control Drawings show in a diagrammatic manner, the desired locations, and arrangements of the components of the Instrumentation Work. Follow the Drawings as closely as possible, use professional judgment and coordinate with the other trades to secure the best possible installation, use the entire Drawing set for construction purposes.
   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 indicated on the Drawings and elevations are approximate. Use the shop drawings to determine the proper layout, foundation, and pad requirements, etc. for final installation. Coordinate with all subcontractors to ensure that all instrumentation and control 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 Specifications; 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. It is the Contractor's responsibility to ensure that the equipment being furnished fits within the defined space.
   c. Installation details:
      1) The Contract Drawings include installation details showing means and methods for installing instrumentation and control equipment. For cases where typical details are not provided or compatible with an installed location, develop installation details that are necessary for completing the Work, and submit these details for review by the Engineer.
   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) Control schematics are to be used as a guide in conjunction with the descriptive operating sequences indicated on the Drawings or in the Specifications. Combine all information and furnish a coordinated and fully functional control system.

F. Alternates/Alternatives:
   1. Substitute item provisions as specified in Document 00700.

G. Changes and change orders:
   1. As specified in Document 00700.

1.02 REFERENCES

A. Code compliance:
   1. As specified in Section 01410:
      a. The publications are referred to in the text by basic designation only. The latest edition accepted by the Authority Having Jurisdiction of referenced publications in effect at the time of Bid governs.
   2. The following codes and standards are hereby incorporated into this Section:
      a. American National Standards Institute (ANSI):
         1) B16.5 - Pipe Flanges and Flanged Fittings.
      b. American Petroleum Institute (API):
         1) RP551 - Process Measurement Instrumentation.
         2) RP552 - Transmission Systems.
         3) RP553 - Refinery Control Valves.
         4) RP554 - Process Instrumentation and Control.
         5) RP555 - Process Analyzers.
         6) RP556 - Fired Heaters & Steam Generators.
         7) RP557 - Guide to Advanced Control Systems.
      c. ASTM International (ASTM):
         1) A269 - Seamless and Welded Austenitic Stainless Steel Tubing for General Service.
      d. FM Global (FM).
      e. Institute of Electrical and Electronics Engineers (IEEE).
      f. International Electrotechnical Commission (IEC).
      g. InterNational Electrical Testing Association (NETA).
      h. International Organization for Standardization (ISO):
         1) 9001 - Quality Systems - Model for Quality Assurance in Design/Development, Production, Installation, and Servicing.
      i. International Society of Automation (ISA):
         1) 5.1 - Instrumentation Symbols and Identification.
         2) 5.2 - Binary Logic Diagrams for Process Operations.
         3) 5.3 - Graphic Symbols for Distributed Control/Shared Display Instrumentation, Logic, and Computer Systems.
         4) 5.4 - Instrument Loop Diagrams.
         5) 5.5 - Graphic Symbols for Process Displays.
         6) 7.00.01 - Quality Standard for Instrument Air.
         7) RP - 12.4 - Pressurized Enclosures.
         8) 18.1 - Annunciator Sequences and Specifications.
         9) 20 - Specification Forms for Process Measurement and Control Instruments, Primary Elements, and Control Valves.
         10) TR20.00.01 - Specification Forms for Process Measurement and Control Instruments Part 1: General Considerations Updated with 27 New Specification Forms in 2004-2005.
         11) 50.00.01 - Compatibility of Analog Signals for Electric Industrial Process Instruments.
         12) 51.1 - Process Instrumentation Terminology.
         13) RP60.3 - Human Engineering for Control Centers.
         14) 71.01 - Environmental Conditions for Process Measurement and Control Systems: Temperature and Humidity.
         15) 71.02 - Environmental Conditions for Process Measurement and Control Systems: Power.

16) 71.03 - Environmental Conditions for Process Measurement and Control Systems: Mechanical Influences.
17) 71.04 - Environmental Conditions for Process Measurement and Control Systems: Airborne Contaminants.

j. National Electrical Manufacturers Association (NEMA):
1) 250 - Enclosures for Electrical Equipment (1000 V Maximum).

k. National Fire Protection Association (NFPA):
1) 70 - National Electric Code (NEC).
2) 496 - Purged and Pressurized Enclosures for Electrical Equipment, where applicable.
3) 820 - Standard for Fire Protection in Wastewater Treatment and Collection Facilities.

l. Underwriters Laboratories, Inc. (UL):
1) 508 - Industrial Control Equipment.

B. Compliance with Laws and Regulations:
1. As specified in Document 00700.

1.03 DEFINITIONS

A. Definitions of terms and other electrical and instrumentation considerations as set forth by:
1. FM.
2. IEC.
3. IEEE.
4. ISA.
5. ISO.
6. NEC.
7. NETA.
8. NFPA.
9. NIST.
10. UL.

B. Specific definitions:
1. Control circuit: Any circuit operating at 120 volts alternating current (VAC) or direct current (VDC) or less, whose principal purpose is the conveyance of information (including performing logic) and not the conveyance of energy for the operation of an electrically powered device.
2. Panel: An instrument support system that 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 is interpreted as a general term, which includes flat surfaces, enclosures, cabinets, and consoles.
3. Power circuit: Any circuit operating at 90 volts (AC or DC) or more, whose principal purpose is the conveyance of energy for the operation of an electrically powered device.
4. Signal circuit: Any circuit operating at less than 50 VAC or VDC, which conveys analog information or digital communications information.
5. Digital bus: A communication network, such as Profibus, Foundation Fieldbus, or DeviceNet, allowing instruments and devices to transmit data, control functions, and diagnostic information.

6. 2-Wire transmitter (loop powered): A transmitter that derives its operating power supply from the signal transmission circuit and requires no separate power supply connections. As used in this Section, two-wire transmitter refers to a transmitter that provides 4 to 20 milliamperes current regulation of a signal in a series circuit with an external 24 VDC driving potential:
   a. Fieldbus communications signal or both.
7. Powered transmitters: A transmitter that requires a separate power source (120 VAC, 240 VAC, etc.) in order for the transmitter to develop its signal. As used in this Section, the produced signal may be either a 4 to 20 milliampere current signal, a digital bus communications signal or both.
8. System supplier - As specified in ICSC Qualifications in the Quality Assurance article of this Section.
9. Modifications: Changing, extending, interfacing to, removing, or altering an existing circuit.

C. Acronym definitions:
1. CCS: The SCADA central computer system (CCS) consisting of personal computers and software. The personal computer-based hardware and software system that includes the operator interface, data storage, data retrieval, archiving, alarming, historian, reports, trending, and other higher level control system software and functions.
2. DPDT: Double-pole, double-throw.
3. ES: Enterprise system: Computer based communications or data sharing system utilized for non-process control functions such as E-mail, sharing files, creating documents, etc.
4. FAT: Factory acceptance test.
5. HART: Highway addressable remote transducer.
6. HOA: Hand-Off-Auto control function that is totally PLC based. In the Hand mode, equipment is started or stopped, valves are opened or closed through operator direction under the control of the PLC software. In the Auto mode, equipment is started or stopped and valves are opened or closed through a control algorithm within the PLC software. In the Off mode, the equipment is prohibited from responding from the PLC control.
7. HMI: Human machine interface: PLC based operator interface device consisting of an alphanumeric or graphic display with operator input functionality. The HMI is typically a flat panel type of display mounted on the front of a PLC enclosure with either a touch screen or tactile button interface.
8. ICSC: Instrumentation and control system contractor: Subcontractor who specializes in the design, construction, fabrication, software development, installation, testing, and commissioning of industrial instrumentation and control systems.
9. IJB: Instrument junction boxes: A panel designed with cord sets to easily remove, replace, or relocate instrument signals.
10. I/O: Input/Output.
11. IP: Internet protocol or ingress protection.
12. LCP: Local control panel: Operator interface panel that may contain an HMI, pilot type control devices, operator interface devices, control relays, etc. and does not contain a PLC or RIO.

13. LAN: Local area network: A control or communications network that is limited to the physical boundaries of the facility.
14. LOR: Local-Off-Remote control function. In the Remote mode, equipment is started or stopped, and valves are opened or closed through the PLC based upon the selection of the HOA. In the Local mode, equipment is started or stopped, valves are opened or closed based upon hardwired control circuits completely independent of the PLC with minimum interlocks and permissive conditions. In the Off mode, the equipment is prohibited from responding to any control commands.
15. NJB: Network junction box. An enclosure that contains multiple access points to various networks within the facility. Networks could be Ethernet, Ethernet/IP, Fieldbus, RIO etc.
16. OIT: Operator interface terminal: PC-based interface device used for operator interface with the SCADA system.
17. P&ID: Process and instrumentation diagram.
18. PC: Personal computer.
19. PCIS: Process control and instrumentation system: Includes the entire instrumentation system, the entire control system, and all of the Work specified in the Instrumentation and Control Specifications and depicted on the Instrumentation Drawings.
20. PCM: Process control module: An enclosure containing any of the following devices: PLC, RTU, or RIO.
21. PJB: Power junction box: An enclosure with terminal blocks that distribute power to multiple instruments.
22. PLC: Programmable logic controller.
23. RIO: Remote I/O device for the PLC consisting of remote I/O racks, or remote I/O blocks.
24. RTU: Remote telemetry unit: A controller typically consisting of a PLC, and a means for remote communications. The remote communications devices typically are radios, modems, etc.
25. SCADA: Supervisory control and data acquisition system: A general name for the computerized system that gathers and processes data from sensors and applies operational controls to the process equipment. It includes the PLCs and/or RTUs, HMI PLC-based operator interface units, related interconnecting communications systems, and the CCS operator interface and data management system.
26. SPDT: Single-pole, double-throw.
27. SPST: Single-pole, single-throw.
28. UPS: Uninterruptible power supply.
29. VCP: Vendor control panel: Control panels that are furnished with particular equipment by a vendor other than the ICSC. These panels may contain PLCs, RIO, OIT, HMI, etc.
30. WAN: Wide area network: A control or communications network that extends beyond the physical boundaries of the facility.

1.04 SYSTEM DESCRIPTION

A. General requirements:
   1. The Work includes everything necessary for and incidental to executing and completing the Instrumentation and Control System Work indicated on the

Drawings and specified in the Specifications and reasonably inferable there from including but not limited to:

a. Preparing hardware submittals for field instrumentation.
b. Design, develop, and draft loop drawings, control panel designs, and all other drawing submittals specified in the Instrumentation and Control Specifications.
c. Prepare the test plan, the training plan, and the spare parts submittals.
d. Procure all hardware.
e. Provide all PCIS system hardware and software.
f. Fabricate panels.
g. Perform factory tests on panels.
h. Perform bench calibration and verify calibration after installation.
i. Oversee and certify installation of the PCIS system.
j. Oversee, document, and certify loop testing.
k. Oversee, document, and certify system pre-commissioning.
l. Conduct the performance tests.
m. Prepare operation and maintenance manuals.
n. Conduct training classes.
o. Prepare Record Drawings.
p. Integrate the PCIS with instrumentation and control devices provided under other sections.
q. Develop all requisite loop drawings and Record Drawings associated with equipment provided under the Contract Documents and Owner furnished and existing equipment.
r. Resolve signal, power, or functional incompatibilities between the PCIS and interfacing devices.
s. Perform all required corrective and preventative maintenance.

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 all 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 the complete operating PCIS to perform the specified monitoring, communications, alarm, control, display, and reporting functions in accordance with the SCADA requirements.
4. 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 ICSC, the other subcontractors, or suppliers.
5. Furnish detailed, complete, and thorough operations and maintenance documentation, including but not limited to operations manuals, maintenance manuals, as-built wiring drawings, training manuals, as-built software documentation, and all other documentation required to operate, modify, and maintain all parts of the PCIS.

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 performing any Work.
    b. Provide and document interface with, modifications to, upgrade, or replacement of existing circuits, power systems, controls, and equipment.
7. Revise in a manner as directed by the Engineer all I/O and addressing that the Engineer determines to be unacceptable as a result of a lack of Contractor coordination between Contract Documents and all suppliers.
8. Defective Work:
    a. As specified in Document 00700.

B. New system:
1. Plant process PCM cabinet PCM-1.
2. Plant process PCM cabinet PCM-2.
3. Networking Panels NP-1 and NP-2.
4. SCADA Server and Cable Management Rack NR-MAIN and associated hardware.
5. Fiber optic infrastructure consisting of separate SCADA and process networks.
6. One SCADA development workstation located at the Administration Building.
7. Additional SCADA workstations utilizing terminal services located at the following areas:
    a. Administration Building.
    b. Electrical Building.
    c. Dewatering Building.
    d. Mid-Town Standby Power Building.
8. Field instruments throughout new facilities.
9. Programming and configuration of the entire PCIS system at Los Osos WRF.
10. Programming and configuration of the new operator workstation at the Mid-Town Standby Power Building.
11. SCADA programming of all facilities included in the Los Osos Wastewater Collection Systems Project. Refer to Appendices D and E for P&IDs and process control strategies of the Collection Systems Project.

1.05 SUBMITTALS

A. Furnish submittals as specified in Section 01330 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 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.

C. Submittal organization:
   1. First page:
      a. Specification section reference.
      b. Name and telephone number of individual who reviewed submittal before delivery to Engineer.
      c. Name and telephone number of individual 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 exactly the same order as the items are referenced, listed, and/or organized in the specification section. 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.

D. Submittal preparation:
   1. During the period of preparation of submittals, the Contractor shall authorize direct, informal liaison between the ICSC and the Engineer for exchange of technical information. As a result of this liaison, certain minor refinements and revisions may be authorized informally by the Engineer, which do not alter the scope of Work or cause increase or decrease in the Contract price or times. During this informal exchange, no oral statement by the Engineer shall be construed to give formal approval of any component or method, nor shall any statement be construed to grant exception to, or variation from, these Contract Documents.

2. In these Contract Documents, some items of Work are represented schematically, and are designated for the most part by numbers, as derived from criteria in ANSI/ISA S5.1:
   a. Employ the nomenclature and numbers designated in this Section and on the Drawings exclusively throughout shop drawings, data sheets, and similar submittals.
   b. Replace any other symbols, designations, and nomenclature unique to a manufacturer's, suppliers, or subcontractor's standard methods with those identified in this Section and on the Drawings.

E. Specific submittal requirements:
   1. Shop drawings:
      a. Required for materials and equipment listed in this and other sections.
      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. Shop drawings requirements:
         1) Front, side, and, rear elevations, and top and bottom views, showing all dimensions.
         2) Locations of conduit entrances and access plates.
         3) Component layout and identification.
         4) Schematic and wiring diagrams with wire numbers and terminal identification.
         5) Connection diagrams, terminal diagrams, internal wiring diagrams, conductor size, etc.
         6) Anchoring method and leveling criteria, including manufacturer's recommendations for the Project site seismic criteria.
         7) Weight.
         8) Finish.
         9) Nameplates:
            a) As specified in Section 16075.
         10) Temperature limitations, as applicable.
      d. Use equipment and instrument tags as depicted on the P&IDs for all submittals.
      e. Adhere to wiring numbering scheme outlined in Section 16075 throughout the Project:
         1) Uniquely number each wire per the Specifications.
      f. Wire numbers must appear on all equipment drawings.
      g. 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, 3-ring, D-ring, loose leaf, vinyl plastic, hard cover binders suitable for bookshelf storage.
         2) Binder ring size: 2 inches.
      h. 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 the drawing.
8) Date.

i. The work includes modifications to existing circuits:
1) Clearly show all modifications to existing circuits.
2) In addition, show all existing unmodified wiring to clearly depict the functionality and electrical characteristics of the complete modified circuits.

2. Product data:
a. Submitted for non-custom manufactured material listed in this and other sections and shown on shop drawings.
b. 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.
7) Neatly cross out options that do not apply or equipment not intended to be supplied.
8) Manufacturer's original time-current characteristic curves for all fuses, circuit breakers, and protective relays in 8-1/2 by 11-inch format.
c. Use equipment and instrument tags as depicted on the P&IDs for all submittals.
d. Adhere to wiring numbering scheme outlined in Section 16075 throughout the Project:
1) Uniquely number each wire per the Specifications.
e. Wire numbers must appear on all equipment drawings.

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

4. Completed Motor Data Sheet, as specified in Section 16222, for every motor furnished:
a. Submit one copy of the Motor Data Sheet to the Engineer for review as part of the associated equipment submittal.

5. Operation and maintenance manuals:
a. As specified in Section 01782.
b. Furnish the Engineer with a complete set of written operation and maintenance manuals 8 weeks before energization start-up and/or commissioning.
c. Submit preliminary sets of these manuals to the Engineer for review of format and content:
1) Engineer will return 1 set with comments.
2) Revise and/or amend as required and submit the requisite number of copies to the Engineer 15 days before Pre-commissioning of the systems.
d. Incorporate changes that occur during startup and submit as part of the final manuals.
e. Provide comprehensive information on all systems and components to enable operation, service, maintenance, and repair.

f. Include Record Documents and the approved shop drawing submittals, modified for conditions encountered in the field during the work.
g. Include signed results from Calibration, Loop Validation Tests, Pre-commissioning, and Performance Testing.
h. Provide installation, connection, operating, calibration, setpoints (e.g., pressure, pump control, time delays, etc.), adjustment, test, troubleshooting, maintenance, and overhaul instructions in complete detail.
i. Provide exploded or other detailed views of all instruments, assemblies, and accessory components together with complete parts lists and ordering instructions.
j. Operational Manual:
    1) Prepare and provide a simplified version of the standard manufacturer's HMI software and system operations manual that includes basic instructions in the application of the system as required for operators in day-to-day operations.
k. Spare parts list:
    1) Include a priced list of recommended spare parts for all the equipment furnished under this Contract:
        a) Include recommended quantities sufficient to maintain the furnished system for a period of 5 years.
    2) Annotate the list to indicate which items, if any and quantity are furnished as part of this Contract.
    3) Provide the name, address, and phone number of manufacturer and manufacturer's local service representative of these parts.
l. Control and SCADA System Software Record Documents:
    1) Include complete documentation of all the software programs provided for the entire control and SCADA systems, including:
        a) Listings of all application software on both hard copy and CD-ROM.
        b) Database, both hard copy and CD-ROM.
        c) Communication protocols.
        d) All documentation necessary to maintain, troubleshoot, modify, or update the software system.
m. Organize the operation and maintenance manuals for each process in the following manner:
    1) Section A - Process and Instrumentation Diagrams.
    2) Section B - Control Descriptions.
    3) Section C - Loop Drawings.
    4) Section D - Instrument Summary.
    5) Section E - Instrument Data Sheets and Brochures.
    6) Section F - Sizing Calculations.
    7) Section G - Instrumentation Installation Details.
    8) Section H - Test Results.
    9) Section I - Operational Manual.
    10) Section J - Spare Parts List.
    11) Section K - Control and SCADA System Software.

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

7. Itemized instrument summary:
    a. Submit a hard copy of the instrument summary.
    b. List all of the key attributes of each instrument including:
        1) Tag number.
        2) Manufacturer.
        3) Model number.
        4) Service.
        5) Area location.
        6) Calibrated range.
        7) Loop drawing number.
    c. Associated LCP, VCP, PCM, or PLC.
8. Instrument data sheets and cut sheets:
    a. 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. The data sheets provided with the instrument specifications are preliminary and are not complete. They are provided to assist with the completion of final instrument data sheets. Additional data sheets may be required. Include the following information on the data sheet:
        1) Component functional description specified in this Section and indicated on the Drawings.
        2) Manufacturers model number or other product designation.
        3) Tag number specified in this Section and indicated 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.
    b. 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 2 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.

c. Organization: Index the data sheets and brochures in the submittal by systems or loops.

9. Control panel hardware submittal:
   a. Submit the following in one submittal package.
   b. Complete and detailed bills of materials:
      1) Including quantity, description, manufacturer, and part number for each assembly or component for each control panel.
      2) Include all items within an enclosure.
   c. Complete grounding requirements for each system component including any requirements for PLCs, process LANs, and SCADA equipment.
   d. Requirements for physical separation between control system components and 120 VAC, 480 VAC, and medium voltage power cables.
   e. UPS and battery load calculations to show that the backup capacity and time meet the specified requirements.
   f. Provide a data sheet for each control system component together with a technical product brochure or bulletin, which include:
      1) The manufacturer's model number or other identifying product designation.
      2) Tag and loop number.
      3) System to which it belongs.
      4) Site to which it applies.
      5) Input and output characteristics.
      6) Requirements for electric power.
      7) Device ambient operating requirements.
      8) Materials of construction.
10. Schedule of values:
   a. In addition to completing all items referred to in the schedule of values, Section 01292, submit per unit instrument and labor costs used in developing the final bid for the PCIS system, for the express purpose of pricing and cost justification for any proposed change orders. It is the responsibility of the ICSC subcontractor to prove to the Engineer’s satisfaction that said per unit costs were used in the development of the final Bid amount.
11. Installation recommendations:
   a. Submit the manufacturer’s printed recommendations for installation of instrumentation equipment.
12. Training submittals:
   a. Develop and submit for review a general training plan. Include complete descriptions of all planned training classes, a preliminary training schedule, a list of all proposed instructors along with resumes, examples of proposed training manuals, and a description of any special training tools to be used (simulators, self-paced modules, personal computer-based training, etc.).
   b. The Engineer will review the general training plan. Special emphasis will be placed on review of the qualifications of the proposed instructors and the timing of the individual courses to maximize their effectiveness. If, in the opinion of the Engineer, the proposed instructors are not sufficiently qualified to conduct the specified training courses, or lack experience,

where required, on the specific configuration of the system, provide more qualified instructors.

c. Training course plan submittals:
   1) For each training course or other training activity, submit a detailed, complete outline and agenda for each lesson.
   2) Describe any student pre-requisites for the course or training activity.
   3) Provide an updated schedule for all sessions of the course, including dates, times, durations, and locations.
   4) Submit training materials.
d. Incorporate all submittal review comments into the course.
e. Do not conduct training courses before review and acceptance of the Course Plan submittal for the course.

13. Record documents:
   a. Furnish as specified in Section 01770.
   b. Provide record documents of all Instrumentation Drawings.
   c. Record Drawing requirements:
      1) Update Record Drawings weekly.
      2) Record Drawings must be fully updated as a condition of the monthly progress payments.
      3) Submit Record Drawings upon completion of the Work for final review.
      4) Clearly and neatly show all changes.
   d. Shop drawings:
      1) General:
         a) 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:
            (1) Clearly show every wire, circuit, and terminal provided under this contract on one or more submitted wiring diagrams.
         b) Show all interfaces between any of the following: instruments, vendor control panels, motor control centers, motor starters, variable speed drives, control valves, flowmeters, chemical feeders, and other equipment related to the PCIS.
         c) Generate all drawings developed for this project utilizing AutoCAD by Auto Desk Version 2004 or later:
            (1) Furnish on CD-ROM disks containing the following for each drawing:
               (a) Original CAD files
               (b) PDF version.
            (2) Provide hard copies on 11-inch by 17-inch plain bond paper.
         d) 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.

(3) Provide as-built shop drawings for all instrumentation equipment on 11-inch by 17-inch using Bond paper.
(4) Provide electronic copies of these documents on CD-ROM disks in.pdf. Size all drawings to be readable and legible on 11-inch by 17-inch media.

e) Submittal Documents:
(1) Provide an interim submittal of Record Documents after the PCIS system Pre-commissioning but prior to testing.
(2) Submit final Record Documents before Substantial Completion or earlier if so specified in Section 01770 or the General Requirements.

f) Review and Corrections:
(1) Correct any Record Documents or other documents found to be incomplete, not accurate, of poor quality, or containing errors.
(2) Promptly correct and re-submit Record Documents returned for correction.

2) Furnish written information prepared specifically for this Project using.pdf and printed on 8.5-inch by 11-inch plain bond paper:
a) Provide electronic copies of these documents on CD-ROM disks.

e. Review and corrections:
1) Correct any record documents or other documents found to be incomplete, not accurate, of poor quality, or containing errors.
2) Promptly correct and re-submit record documents returned for correction.

14. Loop Drawings:
a. Submit loop drawings for every analog, discrete, and fieldbus signal and control circuit:
1) Provide a loop drawing submittal that completely defines and documents the contents of each monitoring, alarming, interlock, and control loop on this Project.
2) This requirement applies to all signal and control circuits associated with equipment on this Project including vendor supplied equipment packages and control panels.

b. Show every instrument and I/O point on at least one loop diagram.

c. Provide a complete index in the front of each bound volume:
1) Index the loop drawings by systems or process areas.

d. Provide drawings showing definitive diagrams for every instrumentation loop system:
1) Show and identify each component of each loop or system using requirements and symbols from ANSI/ISA S5.4 - Instrument Loop Drawings as amended by the Contract Drawings, as defined by the most recent revision in ISA. Include all minimum and optional ISA S5.4 content and information.
2) Furnish a separate drawing sheet for each system or loop diagram.

e. In addition to the ISA S5.4 requirements, show the following details:
1) Functional name of each loop.
2) Reference name, drawing, and loop diagram numbers for any signal continuing off the loop diagram sheet.
3) Show all terminal numbers, regardless of the entity providing the equipment.

4) MCC panel, circuit, and breaker numbers for all power feeds to the loops and instrumentation.
5) Designation of and, if appropriate, terminal assignments associated with, every manhole, pull-box, junction box, conduit, and panel through which the loop circuits pass.
6) Show vendor control panel, instrument panel, conduit, junction box, equipment and PCIS terminations, termination identification, wire numbers and colors, power circuits, and ground identifications.
7) If a circuit is continued on another drawing, show the name and number of the continuation drawing on the loop drawing. Provide complete references to all continuation drawings whether vendor control panels, other loop drawings, existing drawings provided by the Owner, or other drawings.

f. In addition to the above requirements, provide loop diagrams in accordance with the example loop diagram as indicated on the Drawings.

15. Instrument Installation Drawings:
    a. Submit, instrument installation, mounting, and anchoring details for all components and assemblies, 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 pipefittings and valves.
        8) Routing of tubing and identification of supports.
        9) Mounting brackets, stands, anchoring devices, and sunshades.
        10) Conduit entry size, number, location, and delineation between power and signal.
        11) NEMA ratings of enclosures and 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.

16. 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.
17. Schematic Diagrams:
    a. Submit schematic diagrams for all electrical equipment in ladder diagram format.
    b. Include device and field connection terminal numbers on all schematic diagrams.
    c. Incorporate equipment manufacturer’s shop drawing information into the schematic diagrams in order to document the entire control system.
18. 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.

2) All cables required for communication requirements.
3) Show each component fully annotated with conduit size and number associated with the power source.

19. Process Control & SCADA Software Submittal:
    a. In accordance with Product Data and Shop Drawing general requirements.
    b. Submit a complete description of the standard application software programs, operating system and utility programs, including modifications and explanation of how the specific functional requirements are met:
        1) Provide a cross-reference between the Specification requirements and the software submittal, in order to provide the Engineer the ability to identify how each specified requirement or function is met.
    c. A complete listing of the PCIS system point I/O database:
        1) Include for each data point, relevant parameters such as range, contact orientation, limits, incremental limits, I/O card byte, I/O hardware address, and PLC assignment.
        2) Organize on a site-by-site basis, separate by point type.
        3) In addition to the active I/O points, list the implemented spare I/O points and the available I/O points remaining on each card, as well as other defined future points specified or shown.
    d. Detailed descriptions of procedures used to implement and modify control strategies and database construction.
    e. Preliminary overview, screens, station graphic displays, and preliminary reports.
    f. Refer to Section 17762 for additional requirements.
20. Instrumentation and Control System Contractor Statement of Qualifications:
    a. Submit statement of qualifications of the proposed ICSC in accordance with subsequent requirements of this Section.
21. Control Descriptions:
    a. For each control loop, provide a detailed functional description of the operation of the equipment, signals, and controls as shown on the P&IDs:
        1) Include all functions depicted or described in the Contract Documents.
        2) Include within the Control Description content:
            a) All specific requirements.
            b) All common requirements that pertain in general to all loops.
            c) Listing all ranges, setpoints, timers, values, counter values, etc.
22. Testing, Calibration, and Start-up Submittal:
    a. General testing submittal requirements are specified in this Section. Additional requirements are specified in Section 17950 and other Sections.
    b. Test Procedure Submittals:
        1) Submit the proposed procedures to be followed during tests of the PCIS and its components in two parts:
            a) Preliminary Submittal: Outline of the specific proposed tests and examples of proposed forms and checklists. Submit Preliminary Submittal for approval a minimum of six months prior to system testing described in Specification 01660.
            b) Detailed Submittal: After successful review of the Preliminary Submittal, submit the proposed detailed test procedures, forms, and checklists. Include a statement of test objectives with the test procedures. Submit Detailed Submittal for approval a

minimum of 30 days prior to system testing described in Specification 01660.

c. Provide certified and witnessed test and calibration checklists for each of the following tests:
   1) Calibration, adjustment, and test details for all components and systems.
   2) Factory Acceptance Tests.
   3) Loop Validation Tests:
      a) Loop Validation Certifications:
         (1) After the field device loop tests have been successfully completed for all individual instruments, all separate analog control networks, all valves, all VCPs, all motors, all local operator interface panels, all motor control centers, etc., submit a certified copy of all test forms signed by the Contractor, ICSC and the Owner's Representative, with test data entered, together with a clear and unequivocal statement that all instrumentation has been successfully calibrated, inspected, and tested.
   4) Pre-commissioning Test.
   5) Performance Test.

d. Factory Acceptance Test:
   1) Include complete test procedures and forms to be used during the test.

23. Test reports:
    a. As specified in Section 01330.
    b. Additional requirements for acceptance test reports are specified in Section 17950.
24. Calculations:
    a. Where required by specific Instrumentation Specifications:
       1) Because 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.
25. Factory acceptance test:
    a. As specified in Section 01330.
    b. Include complete test procedure and all forms to be used during test.

1.06 QUALITY ASSURANCE

A. Manufacture instruments at facilities certified to the quality standards of ISO 9001.

B. ICSC qualifications:
   1. General information on the proposing company:
      a. Document that the ICSC Company has been actively involved in the instrumentation, PLC based control systems, and SCADA systems business for a minimum of five years and has adequate facilities, organization structure, manpower and technical and managerial expertise to properly perform the Work as specified in these Specifications.
      b. Submit a financial prospectus indicative of the corporation's financial state. This prospectus shall also include:
         1) A letter from a financial institution indicating a current line of credit and bonding limit which can be applied to this Project.
         2) Latest annual report or reviewed financial statement.

2. Document that the ICSC has a qualified permanent service facility:
    a. Said facility shall be staffed with permanent employees and equipped with the tools and test equipment necessary to calibrate, test, and start-up all of the instrumentation, control, telemetry, and SCADA systems hardware and software furnished under this Contract, including remote diagnostic capability.
    b. Document in-house resource of permanent personnel experienced in the design and programming of equipment and systems as specified in these Specifications.
    c. Document the existence of a training program staffed by qualified instructors, to provide proper training in the operation and maintenance of equipment as specified in these Specifications.
    d. Document that the firm is a recognized or certified “system integrator partner” or similar designation for the SCADA software and PLC system being supplied for this Project.
3. Similar project experience of the company:
    a. Provide a list of at least 3 successfully completed projects for a water and/or wastewater system of similar scope and complexity in which the proposing firm used components the same as those intended for use on this Project. The proposing firm must have performed, for each listed project, system engineering, system fabrication and installation, documentation (including schematic, wiring, and panel assembly drawings), software configuration and documentation, field-testing, calibration and start-up, operator instruction and maintenance training. In addition, provide the following information for each project:
        1) Name of plant or system owner, contact name, and current telephone number. Design engineer’s name, address, and telephone number. Failure to provide current contact information may result in the listed project being disqualified for use in meeting the minimum requirements for prequalification.
        2) Manufacturer and model number(s) of the PLC based control system and the computer-based SCADA system used for both hardware and software.
        3) Brief description of the system.
        4) Approximate number of input and output signals: analog, digital, and fieldbus.
        5) Brief application software description.
        6) Contracted cost of the system, separate by base amount and any change orders for the completed projects.
        7) Duration of the project and date of completion.
4. Information on the proposed Project team members:
    a. Provide the name and resume of the individual persons who will be responsible for each of the following:
        1) Office engineering and management of this Project.
        2) Lead for software configuration/programming.
        3) Individual who will be responsible for the hardware and hardware interface design.

4) Individual who will be responsible for field-testing, calibration, start-up.
5) Individual who will be responsible for operator training.

b. All of these individuals must be permanent employees of the proposing firm.

5. Determination of the proposed ICSC qualifications is at the sole discretion of the Engineer.

C. Furnish all equipment listed by and bearing the label of UL or of an independent testing laboratory acceptable to the Engineer and the Authority Having Jurisdiction.

D. The ICSC must have their own operating UL listed panel fabrication facility. All panels must be fabricated at this facility and meet all UL 508/508A requirements.

E. ICSC:
1. The Contractor, through the use of a qualified ICSC, is responsible for the implementation of the PCIS and the integration of the PCIS with other required instrumentation and control devices.
2. The ICSC assumes full responsibility, through the Contractor, to perform all work to select, furnish, install, program, test, calibrate, and place into operation all instrumentation, controls, telemetry equipment, control panels, and SCADA system including application software, for a complete, integrated and functional PCIS system.
3. Due to the complexities associated with the interfacing of numerous control system devices, it is the intent of these Specifications that the ICSC be responsible for the integration of the PCIS with existing devices and devices provided under the Contract Documents with the objective of providing a completely integrated control system.

1.07 DELIVERY, STORAGE, AND HANDLING

A. 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. Shipping precautions:
1. After completion of shop assembly, successful FAT, pack all equipment, cabinets, panels, and consoles 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.

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

D. Tagging:
1. Tag each component and/or instrument to identify its location, instrument tag number, and function in the system.

2. Firmly attach a permanent tag indelibly machine marked with the instrument tag number, as given in the tabulation, on each piece of equipment constituting the PCIS.
3. Tag instruments immediately upon receipt in the field.
4. Prominently display identification on the outside of the package.
5. Utilize the Tag and Loop Number identifications shown on the P&IDs.

E. Delivery and inspection:
1. Deliver products in undamaged condition, in manufacturer's original container or packaging with identifying labels intact and legible. Include date of manufacture on label.

1.08 PROJECT OR SITE CONDITIONS

A. Site conditions:
1. Provide a PCIS, 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 classification:
   a. Provide all equipment and construction techniques suitable for the seismic requirements for the site, as specified in Section 01612.
3. Wind:
   a. Provide all equipment and construction techniques suitable for the site wind loading criteria, as specified in Section 01614.
4. Altitude, temperature and humidity:
   a. As specified in Section 01610.
   b. Provide all equipment and instrumentation fully rated for continuous operation at this altitude, temperature and humidity conditions with no additional derating factors applied.
   c. Provide additional temperature conditioning equipment to maintain all equipment and instrumentation in non-conditioned spaces or outdoors subject to these ambient temperatures 10 degrees Fahrenheit above the minimum operating temperature and 10 degrees Fahrenheit below maximum operating temperature as determined by the equipment manufacturer's guidelines:
      1) Provide all power wiring for these devices (e.g., heaters, fans, etc.), whether or not indicated on the Drawings.
5. Area classifications:
   a. Furnish enclosures that match the area classifications as specified in Section 16050.

1.09 SEQUENCING

A. General:
1. As specified in Section 01312.
2. Testing requirements are specified in Section 17950 and other sections.
3. Work restrictions and other scheduling requirements are specified in Section 01140.

B. Submit proposed ICSC statement of qualifications:
1. The ICSC must be approved by the Engineer before any other Work commences.

C. Pre-submittal conferences:
   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, and all manufacturers furnishing major pieces of equipment must attend, including but not limited to:
      a. Vendor control panels.
      b. Chemical feed systems.
      c. Motor control centers.
      d. Switchgear.
      e. Variable frequency drives.
      f. Lighting.
      g. Engine generators.

D. System configuration meetings:
   1. Review the system configuration, the system database, control schemes, displays, report formats, etc. with the Engineer and Owner on at least 3 occasions during development.
   2. Preliminary meeting: Before configuration work is begun. The ICSC must bring to this meeting examples of displays, display symbols, reports, etc. to show the capabilities of the system software.
   3. Intermediate review meeting: Held after the initial database is entered and typical screens and reports have been entered.
   4. Final review meeting: Held after initial completion of all configuration work. This final meeting may not be held in conjunction with the FAT. Make final format revisions after this review.
   5. Additional requirements as specified in Sections 17100, 17761 and 17762.

E. FAT:
   1. Before the delivery and installation of the PCIS system at the job site, but after the procurement, assembly, and configuration of all components, perform the FAT testing.
   2. Schedule the FAT after receiving approval of the FAT procedures submittal.
   3. Submit a copy of the test procedures including all forms at least 21 days before any scheduled test date.
   4. Notify the Engineer of scheduled tests a minimum of 15 days before the date of the test.

F. Loop validation test.
   1. Notify the Engineer of scheduled tests a minimum of 30 days before the estimated completion date of installation and wiring of the PCIS.
   2. Complete loop validation testing a minimum of 5 days before the pre-commissioning phase of the project.
   3. Loop validation certifications:
      a. After the field device loop tests have been successfully completed as specified in Section 17950 for all individual instruments, all separate analog control networks, all valves, all VCPs, all motors, all local operator interface panels, all motor control centers, etc., submit a certified copy of all test forms signed by the Contractor, ICSC, and the Owner's representative with test data entered, together with a clear and

unequivocal statement that all instrumentation, including all control and signal wiring, has been successfully calibrated, inspected, and tested.

G. Training:
   1. As specified in Section 01660.
   2. Complete all training before the pre-commissioning phase of the project may start.
   3. Schedule the training sessions a minimum of 15 days before the start date of the courses.
   4. Submit training manuals to the Engineer a minimum of 10 days before starting the training session.
   5. Within 10 days after the completion of each session, submit the following:
      a. A list of all Owner personnel that attended the session.
      b. A copy of the training materials utilized during the lesson with all notes, diagrams, and comments.

H. Pre-Start-Up test:
   1. Commence after acceptance of all training, wire test, calibration tests, and loop validation tests, and all inspections have demonstrated that the PCIS complies with all Contract requirements.
   2. Acceptance of the PCIS pre-Start-Up testing must be provided in writing by the Engineer before the performance testing may begin.

I. Provide all special tools and spare parts, as specified in the Maintenance paragraph of this Section, before performance testing commences, suitably wrapped and identified.

J. Performance testing:
   1. Complete pre-commissioning test a minimum of 5 days before the performance test.
   2. Conduct a 10-day performance test.

K. The following conditions be fulfilled before the PCIS is considered complete:
   1. All submittals have been completed and approved.
   2. The PCIS has been calibrated, loop tested and pre-commissioned.
   3. The Owner training has been performed.
   4. All required spare parts, expendable supplies, and test equipment have been delivered to the Owner.
   5. The performance test has been successfully completed.
   6. All debris associated with installation of instrumentation has been removed.
   7. All probes, elements, sample lines, transmitters, tubing, and enclosures have been cleaned, tagged, and are in like-new condition.

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

A. Warrant the PCIS as specified in Section 00700, 01740, and 01770:
   1. Provide additional warranty as specified in the individual Instrumentation and Control Specifications.

1.12 SYSTEM START-UP

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.

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 COMMISSIONING (NOT USED)

1.15 MAINTENANCE

A. Before Completion of Testing Phase specified in Section 01660, perform all maintenance activities required by the Contract Documents including any calibrations, final adjustments, component replacements or other routine service required before placing equipment or systems in service.

B. Furnish all spare parts as required by the Contract Documents.

C. Provide additional spare parts specified in other sections of the Instrumentation and Control Specifications.

D. Submit all special tools and spare parts, suitably wrapped and identified, before performance testing commences.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Provide similar items from a single manufacturer throughout the PCIS portion of the Project.

B. Allowable manufacturers are specified in individual instrument and equipment specifications in other sections of the Instrumentation and Control Specifications.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 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 devices and that bear all approvals and labels as required by the Specifications.

B. Provide materials complying with the applicable industrial standard as specified in the Contract Documents.

2.04 MANUFACTURED UNITS (NOT USED)

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS

A. Furnish all meters, instruments, and other components that are the most recent field proven models marketed by their manufacturers at the time of submittal of the shop drawings unless otherwise specified to match existing equipment.

B. Unless otherwise specified, furnish individual instruments that have a minimum accuracy of ±0.5 percent of full scale and a minimum repeatability of ±0.25 percent of full scale.

C. Signal transmission:
   1. Analog signals:
      a. Furnish analog measurements and control signals that vary in direct linear proportion to the measured variable, unless otherwise indicated.
      b. Furnish electrical analog signals outside control panels that are 4 to 20 milliamperes 24 VDC, except as indicated.
      c. Analog signals within enclosures may be 1 to 5 VDC.
      d. Electrically or optically isolate all analog signals from other signals.
      e. Furnish regulated analog signals that are not affected by changes in supply voltage or load resistance within the unit's rating.
      f. Maintain the total 4 to 20 milliamperes loop impedance to 10 percent below the published value at the loop operating voltage.
      g. Where necessary, reduce loop impedance by providing current-to-current (I/I) isolation amplifiers for signal re-transmission.
   2. All pneumatic signals: 3 to 15 pounds per square inch gauge.
   3. Discrete input signal as indicated in the controller hardware specification.
   4. Discrete output signals:
      a. Dry contacts or TRIAC outputs (with express written approval by the Engineer) as needed to coordinate with the field device.
      b. Provide external terminal block mounted fuse with blown fuse indication for all discrete outputs.
      c. Provide interposing relays for all discrete outputs for voltage and/or current compatibilities.
      d. Provide interposing relays as required for functionality of the control circuit.

D. Discrete circuit configuration:
   1. Configure discrete control circuits to fail safe, on loss of continuity or loss of power.
   2. Alarm contacts: Fail to the alarm condition.
   3. Control contacts fail to the inoperative condition unless otherwise indicated on the Drawings.

E. Grounding:
   1. Provide control panels with a signal ground bus, isolated from the power ground bus:
      a. Provide multiple panels in one location with a common point for signal ground bus connection to ground.

2. Ground single point ground shields and measurement loops at the source panel external terminals, unless otherwise noted, by bonding to the control panel signal ground bus.
3. Provide isolating amplifiers within control panels for field equipment possessing a grounded input or output, except when the panel circuit is galvanically isolated.

F. Instrument air:
1. Provide dry, filtered control air at 30 pounds per square inch gauge nominal pressure piped to all field instruments and instrument panels requiring air:
   a. Provide each field instrument with an integral, non-adjustable filter/regulator assembly to provide regulated air.
   b. Provide each instrument panel requiring air with an adjustable filter/regulator assembly with gauge and an air manifold to provide air to pneumatic instruments.
   c. Filter all air to 5-micron maximum particle size.
   d. Provide low-pressure switch to alarm on insufficient air supply.

2.07 ACCESSORIES

A. Provide flow conditioning devices or other required accessories if necessary to meet the accuracy requirements in the Contract Documents.

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 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 that bear all approvals and labels as required by the Specifications.

B. Arrange with all manufacturers of the equipment and fabricators of panels and cabinets, to allow the Owner and Engineer to inspect and witness the testing of the equipment at the site of fabrication:
1. Equipment includes the cabinets, special control systems, flow-measuring devices, and other pertinent systems and devices.

C. Factory testing is specified in Section 17950 and other sections of the Electrical, and the Instrumentation and Control Specifications.

PART 3 EXECUTION

3.01 EXAMINATION

A. The ICSC is encouraged to attend a pre-bid conference and examine the premises completely before bidding. It is the ICSC's responsibility to be fully familiar with the existing conditions and local requirements and regulations.

B. Review the existing 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.

C. Provide a complete instrumentation and control system:
   1. Install all extra conduits, cables, and interfaces as may be necessary to provide a complete and operating electrical, and process control and instrumentation system.

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. Equipment locations indicated on the 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:
      a. Actual field conditions govern all final installed locations, distances, and levels.
   2. Review all information indicated on the Drawings, including architectural, structural, mechanical, instrumentation, and the accepted electrical, instrumentation, and mechanical 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.

B. Perform all related Electrical Work in accordance with the applicable sections of the Electrical Specifications.

C. The PCIS configurations are diagrammatic:
   1. The locations of equipment are approximate unless dimensioned.
   2. Where Project conditions require, make reasonable changes in locations and arrangements.

D. Field instruments installation:
   1. Install field instruments as specified in the Contract Documents, ANSI/API 550 and 551, and the manufacturer's instructions.
   2. Mount field instruments so that they can be easily read, readily approached, and easily serviced, and so they do not restrict access to mechanical equipment:
      a. Mount field instruments on a pipe stand or local panel, if they are not directly mounted, unless otherwise indicated on the Drawings.
      b. Provide sun shields for all field electronic instruments exposed to direct sunlight.
   3. Make connections from rigid conduit systems to field instruments with PVC coated flexible conduit:
      a. Type of flexible conduit required for the area classification:
         1) Area classification as specified in Section 16050.
      b. Maximum length of 18 inches.
   4. Connect field instruments with cable as specified in the Electrical Specifications, except when the manufacturer requires the use of special cable, or otherwise specified in this Section:
      a. Special cable applications shall be in accordance with the NEC.

5. Verify the correctness of each installation:
    a. Polarity of electric power and signal connections.
    b. Ensure all process connections are free of leaks.
6. Provide a field local power disconnect switch for each 120 VAC powered instrument which does not have a built-in power disconnect:
    a. Disconnect enclosure suitable for the area classification:
        1) As specified in Section 16050.

E. Process sensing lines and air tubing:
1. Install individual tubes parallel and/or perpendicular to and near the surfaces from which they are supported.
2. Provide supports for rigid tubing at intervals of not more than 3 feet.
3. Slope horizontal runs of instrument tubing at a minimum of 1/16th inch per foot to allow for draining of any condensate.
4. Bends:
    a. Use proper tool.
    b. Make bends for parallel lines symmetrical.
    c. Make bends without deforming or thinning the walls of the tubing.
5. Square-cut and clean all ends of tubing before being inserted in the fittings.
6. Provide bulkhead fittings at all panels requiring pipe and/or tubing entries.
7. Use stainless steel tubing for all piping hard piped from the air header, unless otherwise indicated on the Drawings or not compatible with the fluids or atmosphere in the area:
    a. Use flexible connections only on moving equipment and under the constraint that the length shall be less than 1.5 times maximum travel of the equipment.

F. Conduit, cables, and field wiring:
1. Provide all PCIS equipment cables, and process LAN communication networks under the Instrumentation and Control Specifications.
2. Provide terminations and wire identification as specified in the Electrical Specifications.
3. Protect all wiring from sharp edges and corners.
4. Provide all conduits, fittings, boxes, etc. in accordance with all the requirements of the Electrical Specifications.

G. Equipment tie-downs:
1. Anchor all instruments, control panels, and equipment by methods that comply with seismic and wind bracing requirements, which apply to the Site.
2. All control panels, VCPs, LCPs, RTUs, PCMs, etc., shall be permanently mounted and tied down to structures.

H. Instrument tagging:
1. As specified in Section 16075.
2. Provide all field-mounted instruments with nameplates:
    a. Nameplates engraved with the instrument's full tag number as indicated on the Drawings:
        1) Affix tags with stainless steel wire fasteners.
3. Provide all back of panel instruments with nameplates:
    a. Engraved with the instrument's full tag number as indicated on the Drawings:

4. Provide all front of panel instruments with a nameplate:
    a. Engraving to include the instrument's full tag number and service description.
    b. Secure nameplates to the panel with stainless steel screws.
    c. Use an approved adhesive if screws would violate the NEMA or other ratings of the enclosure.

I. Cable and conductor termination:
1. Terminate all cables and conductors on terminal blocks.
2. Terminal block enclosures:
    a. Suitable for the area classification as specified in Section 16050.

J. Surge protection:
1. Provide outdoor field instrument loops with voltage surge protection units installed on the instruments.
2. Individually fuse each 4-20 milliamperes direct current loop with a 1/16 ampere fuse between power supplies and receiver surge protectors.
3. Provide voltage surge protection for 4 wire transmitters and analyzers:
    a. Protect both power source and signal loop.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 FIELD QUALITY CONTROL

A. Inspection:
1. Allow for inspection of PCIS installation as specified in Section 01450.
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 cable terminations.
    g. Inspect/witness instrument calibrations/verifications.
4. Inspection activities conducted during construction do not satisfy inspection requirements specified in Section 17950.

B. Field testing is specified in Section 17950. Additional general requirements are specified in Section 01660.

C. Installation supervision:
   1. Ensure that the entire PCIS is installed in a proper and satisfactory manner. At a minimum, the ICSC shall provide the following services:
      a. Installation resources:
         1) Coordinate with the Contractor regarding installation requirements of the Contract Documents.
      b. Provide technical assistance to installation personnel by telephone:
         1) Furnish installation personnel with at least one copy of the approved submittals, including all installation details.
      c. Periodic inspections during the construction period.
      d. A complete check of the completed installation to ensure that it is in conformance with the requirements of the equipment manufacturer and the Contract Documents.
      e. Field verify accuracy and calibration of all instruments.

3.08 ADJUSTING

A. Control valves:
   1. Stroke all control valves, cylinders, drives and connecting linkages from the control system as well as local control devices and adjust to verify proper control action, hand switch action, limit switch settings, torque settings, remote control actions, and remote feedback of valve status and position.
   2. Check control valve actions and positioner settings with the valves in place to ensure that no changes have occurred since the bench calibration.

B. Make all revisions necessary to the control system software, as directed by the Engineer. It is understood that the Contractor knows and agrees that changes will be required in the control system software during the factory acceptance tests, the pre-commissioning, performance testing, start-up and during the warranty period.

3.09 CLEANING

A. As specified in Section 01770.

B. Vacuum clean all control panels and enclosures before start-up and again after final completion of the project.

C. Clean all panel surfaces.

D. Return to new condition any scratches and/or defects.

E. Wipe all instrument faces and enclosures clean.

F. Leave wiring in panels, manholes, boxes, and other locations in a neat, clean, and organized manner:
   1. Neatly coil and label all spare wiring lengths.
   2. Shorten, re-terminate, and re-label excessive spare wire and cable lengths, as determined by the Engineer.

G. As specified in other sections of the Contract Documents.

3.10 DEMONSTRATION AND TRAINING

A. Furnish all personnel and equipment necessary to conduct the demonstration and training requirements as specified in the individual sections. Provide training in accordance with Section 01660.

B. Training:
   1. General:
      a. Provide system maintenance and operator training courses for all the instrumentation and control systems furnished.
      b. Conduct all training at the Project Site unless another location is approved by the Engineer and Owner:
         1) Include instruction on the use of all maintenance equipment and special tools provided under the Contract.
      c. Tailor training classes to the specific needs of the class participants:
         1) Develop separate courses for operators, maintenance staff, and supervisors:
            a) The specific categories and number of personnel in each category are identified below.
         2) Furnish training courses that are a combination of classroom and hands-on training:
            a) To the greatest extent possible, utilize components from the Owner's PCIS system.
            b) Limit classes that include extensive hands-on activities to a maximum of 5 students per class.
         3) Present the minimum number of sessions, specified in Table 17050-3.10-T1, for each course during the Testing Phase. Staff training shall be repeated during the Commissioning Phase as specified in Section 01660.
         4) Furnish additional sessions if required to accommodate the total number of personnel identified for each course.
      d. Temporarily install a test PLC and 2 user workstations in the training area for SCADA system training classes conducted on-site:
         1) Configure the workstations as full-function operator stations during the training classes.
         2) Connect these components with a LAN in order to fully simulate system operation.
      e. Schedule individual training classes with the Owner at least 3 weeks before the start of the class:
         1) Schedule all training classes Monday - Friday between 7:30 AM and 3:30 PM.
         2) Each individual daily training session, travel time excluded:
            a) Minimum duration of 4 hours.
            b) Maximum duration of 7 hours.
            c) Breaks scheduled at least every 90 minutes and 1 hour for lunch.
         3) Complete training for maintenance personnel 90 days before performance testing.

4) Complete operator training classes before start-up of the SCADA system, or any part of it:
   a) As specified in the Sequencing article of this Section.
5) Schedule follow-up training classes after SCADA start-up on a schedule determined by the Owner.

f. Furnish highly qualified training instructors for technical training with demonstrated expertise in not only control system functionality but also professional training techniques:
   1) Instructors are subject to the approval of the Engineer.
   2) Furnish training instructors thoroughly familiar with the PCIS system, who are members of the SCADA system implementation team.
   3) One of the individuals conducting the SCADA system training course must be the same individual responsible for the majority of the programming that was performed for the instrumentation and control system.

2. Training manuals and materials:
   a. Furnish training manuals and other materials for training courses.
   b. Manuals are to be professionally written to present the course material in a format that is easy to comprehend.
   c. The manuals are to serve as teaching aids during presentation of the training classes.
   d. Manuals are to serve as reference material after the training has been completed.

Table 17050-3.10-T1: Minimum Number of Sessions per Training Phase

Course Title	Minimum Course Length (days per session)	Personnel (Estimated Number of Students)	Minimum Number of Sessions
System Overview	1	10	1
Operator Training - Basic	3	10	2
Operator Training - Advanced	2	5	2
CIS (Computer) Equipment Maintenance	2	4	1
OIT Software	5	3	1
Historian System Training	3	5	1
Reports Training	1	5	2
PLC Hardware	2	4	1
PLC Software	4	6	1
HMI Hardware and Software	2	5	1
Network Equipment	2	4	1
Follow-up Training	1	5	5
Instrument Training	3	3	1
Analytical Instrument Training	1	3	5

1. Training course requirements:
   a. System overview training:
      1) Furnish training courses that give the Owner's supervisory level personnel an overview of all elements of the PCIS system that focus

on the overall functional aspect of elements of the control system and provide an understanding of the interaction of the various components.

b. Operator training:
   1) Furnish training courses that instruct system operators in the efficient operation of all aspects of the PCIS that include not only the general operation of the control system but also the operation of specific system features.
   2) Operator's training shall include:
      a) Control system overview: Architecture, equipment functions, software components, etc.
      b) Display navigation, overview, and types of displays.
      c) Process and equipment monitoring and control: Basic principles and operation.
      d) Logging ON and OFF the system and description of the security and access system.
      e) Alarm subsystem.
      f) Trending: Provide a thorough session on how to use all trending functions.
      g) Reports: How to access, print, and review content.
      h) Control strategies: Present an average 15-minute review of each control strategy, including a hands-on demonstration of screens and operator functions for each.
      i) Instruction on the use of all operational functionality alarm logging, trending, displays, database, reports, and control software developed for the Project and incorporated in the installed PCIS system.

c. CIS computer equipment maintenance training:
   1) Furnish training courses that will enable maintenance technicians to perform troubleshooting and repair of all system computer equipment. Include the theory of operation of the system as a whole, including related operating system and utility software.

d. OIT software training:
   1) Furnish training courses that will enable the Owner's staff to develop and maintain all aspects of the operator interface system applications.
   2) Include topics:
      a) Operating systems and utilities such as virus protection software.
      b) Point (tag) database development and modification.
      c) Graphic screen creation and editing.
      d) Scripting.
      e) I/O servers, drivers, etc.
      f) PLC interface functions and software.
      g) Displays, scripts conventions, and documentation.
      h) Trending.
      i) Alarms and events.
      j) System security, access levels, and areas of responsibility.
      k) General system maintenance, including backups, history data archive, version control, file naming and cataloging conventions, and system file housekeeping.

3) Address not only the procedures associated with the control system's standard software packages, but in addition include material explaining the specific conventions used in developing the Project's system applications (graphics, PLC/RTU interface, scripts, control strategies, trends, etc.). In addition, provide instruction in the use of techniques for developing and maintaining current, comprehensive documentation for all installed system applications.

e. Historian system training:
   1) Furnish the following training:
      a) Introduction to relational databases.
      b) Introductory training on the specific relational database program used for the historian server.
      c) How to set up points for historian logging.
      d) How to develop, edit, and print custom reports, in detail.
      e) Introduction to use of the query language.
      f) System maintenance.
      g) Interface to networks outside of the SCADA system.

f. Report training:
   1) Furnish training courses that will enable the Owner's staff to develop and maintain all aspects of reports.
   2) Include topics:
      a) Generation of a developed report.
      b) Generation of a new report.
      c) Modification and editing of reports.
      d) Formatting reports.
      e) Manual entry and automatic entry of data from a database.

g. PLC hardware training:
   1) Furnish training on PLC hardware and on related components, including battery backup equipment, UPSs, HMI hardware, control circuits, and analog circuits.
   2) Furnish training on PLC hardware principles, product features, proper installation, operation, troubleshooting, and maintenance.
   3) PLC training may be provided by manufacturer's certified trainers.

h. PLC software training:
   1) Furnish training on PLC software.
   2) Two types of training are required, basic and project-specific:
      a) Basic PLC software training covers the principles of PLC programming and the specific features and function of the PLC products used on this Project, provided by one of the PLC manufacturer's certified trainers.
      b) Project-specific PLC software training covers the programming conventions, new standardized software modules, specific control strategy programs, and documentation created for the Work performed under this Contract. This training includes the specific knowledge needed to modify, expand, duplicate, troubleshoot, and repair the PLC programs provided under this Contract, provided by a qualified member of the ICSC who is thoroughly familiar with the delivered system, and is one of the senior programmers who programmed the PLCs for this Project.

i. HMI hardware and software training:
   1) Provide the following:
      a) Overview of hardware and firmware, including starting, stopping, and PLC interface.
      b) Configuration of tag database.
      c) Creating, editing, and saving display screens.
      d) Troubleshooting.
j. Network equipment training:
   1) Furnish basic training on all network hardware, switch and router configuration and software, and network monitoring software.
   2) Include a detailed description and explanation of the installed network architecture, media, and functions.
   3) Furnish an overview of the function and operation of each piece of network equipment.
   4) Furnish training on network maintenance troubleshooting and repair.
   5) Furnish training on how to install spare or off-line backup equipment.
k. Follow-up training:
   1) Provide a series of on-site follow-up training classes beginning after start-up of the SCADA/PCIS system. The intent for these classes is to provide the Owner's personnel the opportunity for a review and "refresher" of the training topics and material after they have had some experience using the system.
   2) Mutually schedule and develop the content of these classes with the Owner no later than 1 month before the beginning of the first session:
      a) Schedule at the Owner's discretion on non-consecutive days spaced out over the start-up and warranty period.
l. Instrumentation training:
   1) Furnish training covering all instruments and control panels.
   2) Furnish the specified quantity of training, allocated to cover new instruments and hardwired controls as described in this Section and specifically determined in the approved training plan.
   3) Train maintenance staff in the use, cleaning, calibration, maintenance, and troubleshooting of all the instruments furnished within this Project.
   4) Furnish training on the operation of new hardwired controls.
m. Analytical instrument training:
   1) Furnish training covering all analytical instruments.
   2) Furnish the specified quantity of training, allocated to cover new analytical instruments as specified in this Section and specifically determined in the approved training plan.
   3) Train maintenance staff in the use, cleaning, calibration, maintenance, and troubleshooting of all the analytical instruments furnished within this Project.
   4) Provide training by manufacturer.

2. Recording training sessions:
   a. Record all training.
   b. Furnish digital video disk (DVD) format.
   c. These disks become the property of the Owner and cover, in detail, the training for the specific hardware and software of all the systems provided for the Project.
   d. Provide all the necessary cameras and recording equipment.

3.11 PROTECTION

A. Protect all Work from damage or degradation until date of Substantial Completion.

3.12 SCHEDULES-(NOT USED)

END OF SECTION

SECTION 17100

CONTROL STRATEGIES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Contractor-developed loop description submittal requirements.
   2. General programming requirements.
   3. Common control functions:
      a. General control and monitoring functions to be provided throughout the PCIS system.
         1) These requirements apply to all systems, and supplement the specific loop descriptions in Section 17101 and information indicated on the Drawings.

A. 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 17050 - Common Work Results for Process Control and Instrumentation Systems.
      b. Section 17101 - Specific Control Strategies.

1.02 REFERENCES

A. As specified in Section 17050.

1.03 DEFINITIONS

A. As specified in Section 17050.

B. Hardwired control: Control circuitry that does not utilize software to initiate functionality.

C. Hardwired interlocks: A safety or protective feature that will interrupt operation of the equipment in all operating modes with no required operator intervention.

D. Software interlocks: A safety or protective feature that will interrupt operation of the equipment when the PLC has control.

E. Slew rate: Rate of change in respect to time.

F. Clamp: Imposed upper and lower limits on setpoints to eliminate entries outside the allowable control parameters.

G. Watchdog timer: Timers imposed to test components such as discrete I/O to verify the health of the card.

1.04 SYSTEM DESCRIPTION (NOT USED)

1.05 SUBMITTALS

A. As specified in Section 17050.

1.06 QUALITY ASSURANCE (NOT USED)

1.07 DELIVERY, STORAGE, AND HANDLING (NOT USED)

1.08 PROJECT OR SITE CONDITIONS (NOT USED)

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

A. As specified in Section 17050.

1.12 SYSTEM START-UP (NOT USED)

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 COMMISSIONING (NOT USED)

1.15 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS (NOT USED)

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS (NOT USED)

2.04 MANUFACTURED UNITS (NOT USED)

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS (NOT USED)

2.07 ACCESSORIES (NOT USED)

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION (NOT USED)

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION

A. As specified in Section 17050.

B. General programming requirements:
   1. Use variable names or aliases derived from tag and loop identification on the P&IDs for all process values.
   2. Store all adjustable parameters in the PLC, and configure so that an operator with sufficient security access can change the parameters from the HMI or OIT. Update and display the current value at all locations, regardless of where the last change was made.
   3. Program slew rates for all setpoints to limit the effect of updated setpoints on the process:
      a. Provide for control setpoints and manual speed and position selections.
      b. Store new setpoints in one register, and gradually ramp the actual setpoint register at the slew rate until it reaches the new value.
      c. Provide operator access to change slew rates from the OIT.
   4. Saved setpoints:
      a. Provide an operator selection to save all setpoint values.
      b. Furnish one or more screens at the OIT that display the initial values for all setpoints defined during startup and the value for each setpoint the last time they were saved.
      c. Provide an operator selection to restore all setpoints to the initial startup value.
      d. Provide an operator selection to restore all setpoints to the last saved value.
   5. Store a copy of all adjustable parameters and accumulated and integrated totals in SCADA:
      a. Upon re-loading of the PLC program, re-load these values to the PLC from SCADA.
   6. Calculated values:
      a. Program calculations such that division by zero errors cannot occur.
      b. Prevent calculations from generating values that exceed the limits of the equipment or data type structures (integers) internal to the PLC.

c. Configure counting functions (start counts and operation counts) to allow a minimum of 10,000 counts, and to roll-over to zero at an even decimal interval (1 followed by 4 or more zeros).
d. Configure integrating functions to accurately accumulate the maximum rate from the instrument/equipment (totalizers, run time meters) for 30 years.

7. Timers:
   a. Provide programmable settling and proving timers in all control sequences for starting and stopping of equipment to allow the process to settle down before proceeding with any additional control functions.
   b. Embed the timers in the PLC logic, tune in the field, and list separately as part of the software submittal and O&M manual.
8. PCM status:
   a. Furnish a minimum of 1 screen that depicts the status of all enclosures containing PLCs or I/O in the control system, including but not limited to the following:
      1) PLC cabinet over-temperatures from high temperature switch.
      2) Intrusion status on all enclosures equipped with intrusion switches.
      3) AC power failure:
         a) Monitor ahead of UPS.
      4) DC power supply failure:
         a) For redundant power supplies, alarm when either power supply fails.
      5) UPS failure signal.
9. PLC system communication status:
   a. Furnish a minimum of 1 screen to display all communication errors and status within the PCIS:
      1) Communication between SCADA and PLCs, PLC to PLC.
      2) Display status of each node, and summary of failures over the past 60 minutes.
   b. Generate a communications alarm if any communication fault is detected or there is no response from a node for more than a user specified time.
   c. In the event of communications loss:
      1) Continue normal operation at each PLC.
      2) Where control parameters are received over a communications link:
         a) If a link fails where process elements use the remote value for closed-loop control, hold operating status, speed and position, of the process elements at their last state before the communication alarm, unless other I/O local to that PLC indicates shutdown or over-ride conditions:
            (1) Ensure that the operator can control the process using PCIS HAND mode at the local HMI.
         b) If a link fails where process elements use the remote value to determine setpoints, settings or control levels, continue to operate using the last value received:
            (1) Provide a manual over-ride entry at the local HMI to allow an operator to enter a different value for any such remote signal.
            (2) Generate an alarm whenever an over-ride value is in use.

C. Common control functions:
   1. Incorporate common control functions into all control loops and devices and into the control programming, whether or not specifically shown in the specific control descriptions or elsewhere in the Contract Documents.
   2. Alarms:
      a. Generate alarms within the PLC logic.
      b. Indicate alarms at the HMI and OIT. Enable acknowledgement from either the OIT or the HMI.
      c. Generate high, high-high, low, and low-low level alarms where indicated:
         1) Provide an alarm reset deadband for each analog value to prevent excessive repeated alarms.
         2) Provide logic and timers to inhibit analog alarms based on process events. For example, inhibit low flow alarms when a pump is stopped, or has not been running long enough to establish flow.
      d. Flash all alarm and fail conditions and their respective indicators on the PCIS graphic screens and local indicating lights until the condition is acknowledged by the operator, even if the alarm condition is no longer present.
      e. Once the alarm is acknowledged by an operator, display alarm conditions in a steady state (not flashing) while the alarm condition is still present:
         1) Flash with a cycle rate of 1/2 second on and 1/2 second off.
      f. Once the alarm has been cleared and the operator has acknowledged the alarm or fail condition, turn the graphic alarm indicator off.
      g. For all alarms that do not have inherent timers, provide an operator-adjustable proving timer to limit nuisance alarms, continuously adjustable from zero seconds to 100 minutes. The initial setting of proving timers shall be zero seconds:
         1) The PLC shall start the timer when it first detects an alarm condition, and shall only activate the alarm after the timer has expired.
         2) If the alarm condition clears while the timer is running, the timer shall reset, and the alarm shall not be activated.
      h. Use interlocks and proving timers to prevent alarms from operating due to power loss, except for loss of power alarms.
      i. Furnish an alarm silence pushbutton at each PCM, HMI, or LCP with an audible alarm to signal the PLC to turn off the audible alarm until the next alarm occurs.
      j. Any alarm that is not acknowledged after a setpoint period of time shall activate the auto dialer.
      k. Lamp test: Furnish lamp test pushbuttons at each control panel with more than 10 pilot lights, that illuminates all pilot lights on the panel:
         1) The lamp test may sequence through blocks of lights.
         2) Minimum on time for each lamp during lamp test 15 seconds.
   3. Where a reset is shown for counts, totals and times maintained in the PLC:
      a. Provide a reset selection on the OIT screen that displays the value.
      b. Provide a preset function on the OIT to allow an operator-entered value to become the current accumulated total.
      c. Limit access to the reset and preset functions to operators with suitable security level.
      d. Log the value before reset, operator, time, and date of reset in the SCADA archive.
      e. Log the value before preset, preset value, operator, time, and date of preset in the SCADA archive.

4. Where start counts are indicated on the Drawings, or required in this Section, count starts for each piece of equipment (off to on transitions of running status) in the PLC:
    a. Display total starts on PCIS screens, and provide a reset function.
    b. Where indicated, calculate number of starts for each day:
        1) Display current day and previous day starts on PCIS displays.
        2) Do not reset daily start count when overall count is reset.
        3) Archive starts for each day through SCADA.
5. Where run time accumulation is indicated on the Drawings, or required in this Section, integrate accumulated run time to the nearest 0.1 hour whenever the running status input indicates that the equipment is running:
    a. Display total run time in hours on PCIS screens.
    b. Where indicated, calculate total run time for each day:
        1) Display current day and previous day run time on the OIT to the nearest 0.1 hour.
        2) Do not reset daily run time when overall time is reset.
        3) Archive run time for each day through SCADA.
6. For all monitored analog values:
    a. Convert all values to engineering units within the PLC.
    b. Maintain trends in SCADA.
    c. Totalize flows in the PLC logic:
        1) Where totalized flows are input to a discrete input, count input pulses and multiply by the volume per pulse.
        2) Where no totalizer input is shown, integrate the analog input over time.
        3) Display totals on the OIT and HMI.
        4) Archive totals to the historical database through SCADA.
    d. Calculate hourly, daily, and monthly averages:
        1) Calculations may be performed by the PLC or SCADA.
        2) Display averages on the OIT, and archive through SCADA.
    e. Calculate minimum and maximum values for each hour, day, and month:
        1) Calculations may be performed by the PLC or SCADA.
        2) Display minima and maxima on the OIT, and archive through SCADA.
    f. Generate an alarm whenever an over-ride value is in use.
7. Analog data processing:
    a. Engineering units conversion:
        1) Use engineering units for all analog point values. Convert analog inputs to engineering units.
    b. Analog magnitude checking:
        1) Provide upper and lower limits to prevent operator-entered values (setpoints, etc.) from falling outside acceptable limits.
    c. Analog value quality:
        1) Monitor analog values received at each PLC from analog inputs or communications from another PLC or RIO, and generate alarms for the following conditions:
            a) Rate of change in excess of acceptable limit:
                (1) Provide a separate rate limit for each value.
            b) Stale value:
                (1) For analog signals that come from analog inputs or calculations using analog inputs, which are expected to have some variation each time the input is read, alarm

when there is no change in the value for 10 times the normal expected scan or communication update.

8. Analog device override (HMI and OIT):
    a. Provide the following functions from the OIT and the local HMI for each and every analog input:
        1) An over-ride value to be used in place of the analog input:
            a) Enter in engineering units:
                (1) Display the calibrated range in engineering units.
                (2) Only allow entries within the calibrated range of the instrument.
            b) When the analog input is enabled, track the analog input so that the over-ride matches the analog input value when the input is initially disabled.
            c) Maintain over-ride status and value in the PLC.
            d) Only allow access to over-ride selections and settings to operators with sufficient security.
        2) An enable/disable selection:
            a) When enabled, the value used by the PCIS system is equal to the analog input value.
            b) When disabled, the analog input is ignored, and the over-ride value is used for all control and display functions.
            c) Generate an alarm whenever an analog input is disabled.
            d) Enter a value for the analog input from the PCIS system to the PLC.
        3) Use the over-ride value for all display and control functions instead of the actual analog input value.
    b. Provide the following functions in the PLC, with selections and value entry from the OIT and/or HMI:
        1) An over-ride value to be used in place of the normal output value:
            a) Enter in percent of output span.
            b) When the analog output is enabled, track the analog input so that the over-ride matches the analog output value when the output is initially disabled.
        2) An enable/disable selection:
            a) When enabled, the value sent to the output is the value determined by the PLC based on the control logic or operator-entered value in PCIS HAND.
            b) When disabled, the calculated PCIS HAND values are ignored, and the over-ride value is sent to the output.
            c) Generate an alarm whenever an analog output is disabled.
9. Tank and vessel levels:
    a. Display all tank and vessel levels as both a level (typically in feet) and a volume (typically in gallons):
        1) Some individual displays may be only level or volume, when agreed to by the Owner and Engineer during screen meetings.
    b. Monitor rate of change of volume on all tanks and vessels:
        1) Establish the maximum withdraw rate at which the volume should decrease (all pumps or feeders operating at maximum output). Generate an alarm whenever the volume decreases faster than this rate.
        2) Establish the minimum fill rate at which the volume should increase when filling. Generate an alarm whenever the volume increases

faster than this rate. Verify tank and vessel level is fluctuating to verify the validity of the IO register. If it is determined the register is not active or failed in a manner that leaves a stagnant value generate an alarm.

10. I/O filtering and processing:
    a. Analog input filtering:
        1) For each analog input provide an adjustable first order filter, for the purpose of smoothing out spikes and other noise for analog transmitter input signals. By default, configure analog inputs with no filtering affect.
        2) Monitor analog input signal quality:
            a) Over range: The input value is above the normal range (typically over 21 mA).
            b) Under range: The input value is below the normal range (typically under 3 mA, indicating a probable broken connection).
            c) Generate alarms for over or under range inputs.
            d) Do not use over or under range values for control or calculation purposes:
                (1) Where a second instrument is provided to monitor the same condition (a redundant instrument, or additional instruments furnished for averaging or different operating modes), and has a valid signal, use that input for control.
                (2) Otherwise, hold all outputs affected by the signal at their last values before the signal went out of range.
        3) Digital input filtering (proving timer):
            a) Provide an adjustable time delay function (0-10 seconds) on discrete input for the purpose of de-bouncing.
            b) By default, discrete inputs shall be configured with de-bounce timers set to zero seconds.
11. Instrument scaling (OIT/HMI):
    a. Provide 1 or more maintenance screens to display ranges and trigger points for all field instruments:
        1) For analog instruments, use input scaling values in the PLC to determine minimum and maximum calibration points.
        2) For discrete instruments, display calibrated pick-up and drop-out values.
12. PCIS HAND-OFF-AUTO:
    a. Where indicated, provide HAND-OFF-AUTO and START-STOP selections in the PCIS, accessed from an HMI or OIT for operators with sufficient security, to provide the following operating modes:
        1) PCIS AUTO: The normal, automatic control mode of the strategy which allows full PLC control in response to process conditions and programmed sequences.
        2) PCIS HAND: Enables PCIS Manual control where control decisions are made by an operator through the PCIS START-STOP, OPEN/CLOSE, or other selections as indicated.
        3) PCIS OFF: Automated PCIS control is disabled and PLC calls for all associated equipment to stop and valves to close or go to their identified safe state.
        4) Program the PLC so that switching a strategy between AUTO and HAND (either direction) occurs with a smooth transition. Keep running or position status unchanged when control is switched to

HAND until a change is requested using the operator selections (START, STOP, OPEN, CLOSE). Keep running and position status unchanged when control is switched to AUTO until the control logic determines a change is required.

13. Display the current status of all operator selections (PCIS HAND/AUTO, PCIS START/STOP, etc.) on HMI and OIT.
14. Permissives:
    a. Implement software permissives where indicated to place equipment in a safe condition in response to impending hazardous process conditions. Apply software permissives when equipment is operating in PCIS AUTO or PCIS HAND:
    b. Use hard-wired permissives for equipment protection where indicated.
15. Process control algorithms:
    a. Jog and hold: Unless otherwise indicated, use jog and hold control algorithms where possible:
        1) When the error between process variable and setpoint is beyond a setpoint deadband:
            a) Jog valve or ramp speed in the required direction for a preset “Jog Time” or until the process variable reaches or passes the setpoint.
            b) Then hold speed or position through a setpoint “Hold Time.”
            c) Continue alternating jog and hold until the error is less than the deadband.
        2) Provide operator access to Jog Time and Hold Time setpoints from the OIT.
    b. PID algorithms: Use where indicated, or where necessary to provide fast response:
        1) Provide a PID faceplate with the following displays and functions for each PID control algorithm:
            a) Display Output, CV.
            b) Display Setpoint, SP.
            c) Display Process Variable, PV.
            d) Allow for operator selection of Automatic or Manual control of the output.
            e) Under Manual control of output allow the operator to enter the desired output value.
            f) Allow for input of the three Proportional, Integral and Derivative tuning parameters.
            g) Configure PID loops to prevent reset windup when controlled equipment is operating in Manual (local or PCIS), or when the equipment has reached a physical limit.
            h) When controlled equipment is being operated in remote PCIS HAND, configure the PID function to track the process variable to provide a smooth transfer between Manual and Automatic modes.
            i) Provide selectable slew rates with adjustable setpoints to allow the PID algorithm to slowly ramp to its final value to minimize system disturbance.
16. Equipment alternating and sequencing:
    a. Distribute number of starts and run time equally between identical equipment.

17. Motor control:
    a. Monitor the device's LOCAL-OFF-REMOTE (LOR) switch (the hard-wired switch at the MCC, drive or equipment) to determine when the PLC has control of the associated equipment:
        1) Display current REMOTE status on the PCIS screens.
    b. Monitor the device's running status from the starter auxiliary or run status input:
        1) Display the current status (running or stopped) on the PCIS screens.
        2) Use status to calculate total run time and daily run time, and to count total starts and daily starts.
        3) Provide time stamp for each start.
    c. When equipment control has been given to the PLC as reported by the LOCAL-OFF-REMOTE switch, allow selection of PCIS AUTO or PCIS HAND control modes based upon operator selection using the PCIS screens.
    d. Starting, stopping and running when the device LOR is in LOCAL:
        1) With the LOR switch in the LOCAL position, the motor is controlled by the START and STOP pushbuttons.
        2) With the LOR switch in the OFF position, the motor is prohibited from running.
        3) With the LOR switch in the REMOTE position, the motor is controlled remotely.
    e. Starting, stopping and running when the device LOR is in REMOTE:
        1) When the motor is expected to be running (PLC has issued a START or RUN due to process conditions or operator selection), LOR is in REMOTE, and the device is not reported to be running, start an operator adjustable "Control Activation" timer:
            a) Provide "Control Activation" timers for each piece of controlled equipment:
                (1) If the LOR and required running status do not change, and the PLC does not receive running status within the "Control Activation" time period:
                (a) De-activate the output.
                (b) Place the device in a "Failed" state.
                (c) Generate a "Failed to Respond" alarm.
        2) When the motor is not expected to be running (PLC has issued a STOP or removed the RUN output), LOR is in REMOTE, and the device is reported to be running, start the "Control Activation" timer:
            a) If the LOR and required stopped status do not change, and the PLC does not lose the running status within the "Control Activation" time period:
                (1) Keep the RUN output off or the STOP output on.
                (2) Place the device in a "Failed" state.
                (3) Generate a "Failed to Respond" alarm.
        3) Re-establish PLC control of a device in a "Failed" state only after the following:
            a) An operator turns the device's LOR switch out of REMOTE, and back to REMOTE (i.e., REMOTE input to the PLC cycles off and back on).
    f. Where motor winding high temperature switches or RTD temperature elements are shown, generate an alarm when high temperature is sensed

(contact opens or temperature above the high alarm setpoint), but do not stop the motor unless otherwise indicated.

g. Control two-speed motors similar to other motors, except as listed below:
   1) Motor states are RUN-FAST, RUN-SLOW, and STOP.
   2) Start all two-speed motors in the RUN-SLOW state. If or when the high speed is required (RUN-FAST operator selection or process conditions), transition to RUN-FAST after a designated time.
   3) When transitioning from RUN-FAST to RUN-SLOW, remove the RUN-FAST output or issue a STOP, then wait for a “Fast to Slow” time delay before energizing the RUN-SLOW or START-SLOW output.

h. Simultaneous starts:
   1) Prevent more than one motor-driven load 25 hp or larger in the same facility from starting concurrently:
      a) When starting one load, inhibit start logic for all other such equipment until the load being started is up to speed (RVSS or VFD), or after a setpoint time delay (full-voltage starters and miscellaneous equipment).
   2) Use the same logic to prevent multiple large devices from starting concurrently on restoration of power after a power outage, whether operating on generator or utility power.

i. Speed control:
   1) Modulate speed on VFD-driven motors using jog and hold, or PID control algorithms to maintain process conditions as described in the specific loop descriptions.
   2) Operate speed control within a pre-defined range:
      a) Minimum speed as determined by equipment manufacturer. The higher of:
         (1) Minimum motor speed to maintain adequate cooling for the type of load driven (constant or variable torque).
         (2) Minimum equipment speed, such as minimum speed to deliver flow or to deliver minimum flow for equipment cooling or lubrication.
      b) Maximum speed 100 percent (60 hertz) or as identified by equipment manufacturer.
   3) Where multiple equipment may operate together to maintain the same process condition:
      a) Provide an operator selection for starting sequence.
      b) Start the first equipment at a preset starting speed.
      c) When one or more equipment is running and the speed control algorithm reaches a preset “Start Next” speed value (initially 95 percent of speed range) through a preset time delay:
         (1) Start the next available equipment at the preset starting speed.
         (2) Ramp up the started equipment and ramp down the previously running equipment to the mid operating speed (adjustable in the PLC). Determine preset values for each condition based on equipment and system characteristics to provide approximately the same total flow or process condition with the new load running at the mid speed (for example if one pump is running and the second pump will be added, then the total flow of both pumps running at mid

operating speed should be approximately the same as flow of one pump at Start Next speed).

(3) Once both equipment reach the mid operating speed, resume the speed control algorithm for those equipment.

(4) Operate all equipment at the same speed following the output of the speed control algorithm.

d) When two or more pieces of equipment are running, monitor for a “Stop Next” condition:

(1) Where flow rate is monitored, use a preset “Stop Next” flow rate for each possible number and combination of equipment:

(a) Determine initial “Stop Next” speed based on the flow that can be provided with one fewer piece of equipment running at a speed slightly below the “Start Next” speed.

(2) When the “Stop Next” condition exists through a preset time delay:

(a) Ramp speed of running equipment except for the equipment to be stopped up to a preset value based on the number of items running. Determine preset values for each condition based on equipment and system characteristics to provide approximately the same total flow or process condition with one fewer load running (typically slightly below the preset “Start Next” speed) while ramping speed of equipment to be stopped down to the preset minimum speed.

(b) Stop the load once it reaches minimum speed.

(c) Operate all remaining equipment at the same speed following the output of the speed control algorithm.

18. Gate and valve control:

a. Monitor the device’s LOCAL-OFF-REMOTE (LOR) switch(es) (the integral switch in the actuator or hard-wired switch at the local control station):

1) Display current REMOTE status on PCIS screens.

b. Start an “Open Activation” timer whenever the device is expected to be open (PLC has issued an OPEN command in PCIS AUTO, or OPEN was selected in PCIS HAND):

1) Initially set “Open Activation” time to twice the normal opening time.

2) If the LOR position and open command do not change, and the PLC does not receive fully open status feedback within the “Open Activation” time period:

a) De-activate the open output.

b) Place the device in a “Failed” state.

c) Generate a “Failed to Open” alarm.

c. Start a “Close Activation” timer whenever the device is expected to be closed (PLC has issued a CLOSE command in PCIS AUTO, or CLOSE was selected in PCIS HAND):

1) Initially set “Close Activation” time to twice the normal closing time.

2) If the LOR position and close command do not change, and the PLC does not receive fully closed status feedback within the “Close Activation” time period:

a) De-activate the close output.

b) Place the device in a “Failed” state.
c) Generate a “Failed to Close” alarm.

d. For modulating valves (valves controlled from either a 4-20 mA signal or digital communications command) with position feedback, start a “Position Error” timer whenever the position feedback differs from the required position command by more than a setpoint error when the LOR is in REMOTE:
   1) For analog modulating devices, error is determined by position feedback differing from position command by more than the setpoint error.
   2) For discrete modulating devices, error is determined by feedback not changing in the correct direction, or changing at less than a setpoint rate, when the OPEN or CLOSE PLC output is active.
   3) Initially set the “Position Error” time to 60 seconds.
   4) If the LOR position does not change, and position error stays outside of the setpoint error through the “Position Error” time period:
      a) Hold position output.
      b) Place the device in a “Failed” state.
      c) Generate a “Position Fail” alarm.

e. Provide separate time delay settings for each function and for each device.

f. If the valve position inputs indicate an impossible state (i.e., valve open and closed at the same time), place the device in a “Failed” state and generate an “Illegal State” alarm.

g. Re-establish PLC control of a device in a “Failed” state only after one of the following:
   1) An operator turns the device’s LOR switch out of REMOTE and back to REMOTE (i.e., REMOTE input to the PLC cycles off and back on).

h. For all alarm conditions, control other devices (as stopping pumps, etc.) as stated in the individual loop descriptions to make the system safe.

i. For discrete modulating valves (valves positioned to intermediate positions to control process values through discrete OPEN and CLOSE outputs), count the number of actuations (OPEN or CLOSE commands) in the PLC:
   1) Display count on the OIT.
   2) Provide a reset function for the count.

19. Chemical systems (HMI/OIT):
   a. Provide the following chemical system screens:
      1) Where one HMI manages more than one chemical system, a main menu screen that will allow the operator to access the individual chemical system screens using software keys.
      2) One or more screens for each individual chemical system controlled at that location, containing:
         a) All status displays (running, failed, etc.).
         b) Selections (lead/lag, which process flow to pace to, etc.).
         c) Setpoint entry and display.
         d) Calculated feed requirement (result of flow pacing calculation) in engineering units (typically milligrams of chemical per minute).
         e) Output signal to feeder in percent of full span.

f) Actual chemical flow rate from flowmeter (where shown).
g) Process flow rate(s) used to pace each chemical on the individual chemical screens (PROC FLOW):
(1) Where different process flows can be selected for flow pacing, display and identify the selected source.

3) Chemical system calculations: Perform calculations as indicated in the individual loop descriptions. Use the following assumptions, unless otherwise noted.
4) Where chemical flow feedback is not used, assume feeder output is linear in response to control signal.
5) Zero signal (typically 4 milliamperes) produces zero flow.
6) Perform flow-pacing calculations using as described in the individual loop descriptions.

b. Provide the setpoints and selections indicated in the individual loop descriptions. Typical setpoints include:
1) QMAX: Maximum calibration value:
a) Chemical flow rate measured from calibration column at maximum feeder output (typically in gallons of solution per hour or milliliters of solution per minute).
2) CONC: Chemical concentration:
a) The concentration of the chemical in the solution to be fed, in engineering units (typically milligrams of chemical per liter of chemical solution).
3) DENSITY:
a) Density of the chemical solution to be fed in engineering units or as a specific gravity.
b) Used to calculate the concentration of the chemical in the solution.
4) DOSE: Desired dosage:
a) Desired chemical concentration in the process stream in engineering units (typically milligrams of chemical per liter of process fluid).

c. Virtual Day Tanks:
1) Most chemical systems will have their own “virtual” day tank, which will use either a pre-set volume (operator adjustable) or a calculated daily use rate based on the totalized flow (volume) of the chemical magnetic flowmeters over the virtual day tank cycle. The “virtual” day tank will start at the pre-set volume or the calculated volume (operator-selectable) and based on the storage tank level, the volume in the “virtual” day tank will decrease until the total “volume” in the virtual day tank is used. The virtual day tank will automatically compensate for any changes in the system due to the use of the dilution system (revised solution concentration). Once this occurs, the operator will be provided with a “pop-up” screen stating that the “virtual” day tank volume is used. Once this occurs, the operator will be provided with a “pop-up” screen stating that the virtual day tank needs to be refilled. The pop-up screen will contain the following information:
a) Time {hours and minutes} since the last day tank filling.
b) Volume utilized in the “virtual” day tank (based on the level transmitter measuring the chemical storage tank).

c) Dose {mg/L} based on the average flow rate over the “virtual” day tank cycle.
d) Target dose {mg/L} based on operator input.

2) Provide a double check using the actual flowmeter values to compare with the calculated dose. Compared the magnetic flowmeter value with the calculated dose. The magnetic flowmeter value will be based on an hourly average of chemical flow rate over the day tank cycle.
3) As an added level of control any chemical system that has an analyzer used for feedback will be tracked and alarmed if outside the operating parameters.
4) Alarm if any condition falls outside of the flow, or level parameters.

20. Breaker status:
    a. Display the following data to the extent it is available from the specified device:
        1) Open.
        2) Closed.
21. Plant shutdown:
22. Power failure:
    a. Retain all operating setpoints during power failure.
    b. Restore plant operation to the state it was before the power loss:
        1) Store the operating state of all major equipment and systems in the PLC, and retain the last state during a power loss.
        2) When transferring to generator power, Provide an operator adjustable a load sequence table on the OIT showing the major equipment and systems. The load sequence table shall be preset as specified in Section 16232.
            a) For each item, list the following:
                (1) Equipment name and tag.
                (2) Running kW and kVA.
                (3) Starting kW and kVA.
                (4) Identify whether it was running immediately before the power loss.
                (5) Show current running and available status.
                (6) Automatic re-start:
                    (a) Do not allow selection of loads that will cause the generator starting or running capacity to be exceeded.
                    (b) Insert a sequence number showing the order in which the load was selected. If a load is selected again, remove it from the queue, and update the sequence numbers for the remaining equipment.
            b) When operating on generator power, also display the following, updating as selections are made, and as load:
                (1) Generator(s) operating.
                (2) Generator(s) available.
                (3) Remaining running and starting kW and kVA:
                    (a) Calculate from measured generator output kW and kVA, and the maximum starting and running capacity required to start the selected loads.

c) Automatic Restart:
(1) Start the process loads in the order they were pre-selected.
(2) Use the logic described above for preventing concurrent starts to provide necessary delays between each step.
d) After the initial loads have been sequenced on, allow automatic operation to continue to stop and start loads within generator capabilities.

c. Operating on generator power:
1) Include running and starting kW and kVA requirements for each major equipment and system in registers in the PLC:
a) Where running load can vary due to speed, valve position, etc., use the normal starting value plus 25 percent of the difference between the maximum and minimum values.
2) Inhibit starting of loads from process control logic and from operator selection (in PCIS HAND) that will exceed generator capability.
3) Generate the following alarms:
a) Generator near capacity: When measured kW or kVA reaches 90 percent of the rating of the generator.
b) Generator at capacity: When measured kW or kVA reaches 95 percent of the rating of the generator.
c) Unable to start: When an operator selects a load that would exceed generator starting or running capacity.
d) Insufficient capacity: When the control system needs to start a load, but is inhibited due to generator capacity.
4) Whenever the Generator at Capacity alarm is active, inhibit starting of any loads, and inhibit increase in speed of all control loops, and other changes that would increase electrical load.
5) Display the following power system data on the OIT in numerical and graphical formats:
a) Available power.
b) Current power demand.
c) Capacity of the generator.
d) Current power demand load as a percentage of capacity.
e) Generator frequency.

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 FIELD QUALITY CONTROL (NOT USED)

3.08 ADJUSTING (NOT USED)

3.09 CLEANING (NOT USED)

3.10 DEMONSTRATION AND TRAINING

A. As specified in Section 17050.

3.11 PROTECTION (NOT USED)

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 17101-03A

SPECIFIC CONTROL STRATEGIES – REW STORAGE PONDS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Loop descriptions:
      a. Specific control requirements and functional descriptions for individual control loops.

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 - Common Work Results for Process Control and Instrumentation Systems.
      c. Section 17100 - Control Strategies.

1.02 REFERENCES

A. As specified in Section 17050.

1.03 DEFINITIONS

A. As specified in Section 17050.

1.04 SYSTEM DESCRIPTION (NOT USED)

1.05 SUBMITTALS

A. Develop detailed loop descriptions based on the information in the Contract Documents, and submit as specified in Sections 01330 and 17050.
   1. For each control loop, provide a detailed functional description of the operation of the equipment, signals, and controls shown on the P&IDs:
      a. Include all functions depicted or described in the Contract Documents.
      b. Include the following within each loop description:
         1) All requirements specific to that loop.
         2) Common control requirements applicable to that loop.
         3) List of all ranges, setpoints, timers, values, counters, etc.
   2. Where there are similar loops with identical control, such as multiple loops for individual raw water pumps, only 1 loop description need be developed and the remaining loops may reference that loop description.

B. Loop description format:
   1. Loop number and title.
   2. References:
      a. List P&IDs that are specifically referenced.
   3. Abstract:
      a. General description of how the loop works, what devices are involved, and how the process will be controlled.
      b. Process values, setpoints, and limits, including units and ranges:
         1) Show span and range values for analog inputs and outputs, and operating point and deadband for discrete inputs.
   4. Hardwired control:
      a. Detailed description of the control functions at the local level.
      b. Function of local operator interfaces.
      c. Operation of hardwired field pilot controls:
         1) Pushbuttons.
         2) Selector switches.
         3) Potentiometers.
         4) Pilot lights, indicators, and other displays.
   5. Hardwired interlocks:
      a. Explanation of the operation of system interlocks and hardwired permissive conditions.
   6. PLC control:
      a. Detailed description of the control functions that are under control of the PLC.
      b. Operator controls and automatic controls.
      c. Setpoints, alarms, etc.:
         1) Include units and ranges for analog values.
         2) Include span and range for analog inputs and outputs.
         3) Include operating point and deadband for discrete inputs, and identify conditions where contacts are open, and when they close.
      d. Control sequences.
   7. Software interlocks:
      a. Operation of system software interlocks.
   8. HMI control:
      a. Detailed description of the operator controls.
   9. SCADA control:
      a. Detailed description of the operator controls.
      b. Setpoints, alarms, etc.
   10. Indicators and alarms:
      a. List any indicators and alarms specific to the loop that are not covered in the common control strategies.
   11. Failure modes:
      a. List any failure modes specific to the loop that are not covered in the common control strategies.

1.06 QUALITY ASSURANCE (NOT USED)

1.07 DELIVERY, STORAGE, AND HANDLING (NOT USED)

1.08 PROJECT OR SITE CONDITIONS (NOT USED)

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY (NOT USED)

1.12 SYSTEM START-UP (NOT USED)

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 COMMISSIONING (NOT USED)

1.15 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS (NOT USED)

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS (NOT USED)

2.04 MANUFACTURED UNITS (NOT USED)

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS (NOT USED)

2.07 ACCESSORIES (NOT USED)

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION (NOT USED)

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION

A. Loop 320 – REW Storage Ponds
   1. References:
      a. 03N01.
      b. REW Pond 1 Inlet Gate: 03-EDR-321.
      c. REW Pond 1 Inlet Gate From Pond 3: 03-EDR-322 (Future).

d. REW Pond 1 Outlet Gate: 03-EDR-323.
e. REW Pond 2 Inlet Gate: 03-EDR-324.
f. REW Pond 2 Outlet Gate: 03-EDR-325.
g. REW Pond 1 Level Transmitter: 03-LIT-326.
h. REW Pond 2 Level Transmitter: 03-LIT-327.

2. Abstract:
   a. The REW Storage Ponds store raw effluent water from the UV Disinfection System REW Storage Channel. Pond levels are monitored via 03-LIT-326 and 03-LIT-327. The Ponds are equipped with inlet and outlet gate actuators that can be opened or closed to isolate the structures.
3. Hardwired Control:
   a. With the LOR switch in LOCAL position, the REW Pond Gates are controlled by the OPEN/STOP/CLOSE selector switches.
4. Hardwired Interlocks:
   a. No hardwired interlocks.
5. PLC Control:
   a. No PLC control.
6. Software Interlocks:
   a. No software interlocks.
7. HMI Control:
   a. No HMI control.
8. SCADA Control:
   a. As indicated on the Drawings and Section 17100.
9. Indicators and Alarms:
   a. As indicated on the Drawings and Section 17100.
10. Failure Modes:
    a. As indicated on the Drawings and Section 17100.

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 FIELD QUALITY CONTROL (NOT USED)

3.08 ADJUSTING (NOT USED)

3.09 CLEANING (NOT USED)

3.10 DEMONSTRATION AND TRAINING

A. As specified in Section 17050.

3.11 PROTECTION (NOT USED)

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 17101-04A

SPECIFIC CONTROL STRATEGIES – PLANT DRAIN PUMP STATION

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Loop descriptions:
      a. Specific control requirements and functional descriptions for individual control loops.

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 - Common Work Results for Process Control and Instrumentation Systems.
      c. Section 17100 - Control Strategies.

1.02 REFERENCES

A. As specified in Section 17050.

1.03 DEFINITIONS

A. As specified in Section 17050.

1.04 SYSTEM DESCRIPTION (NOT USED)

1.05 SUBMITTALS

A. Develop detailed loop descriptions based on the information in the Contract Documents, and submit as specified in Sections 01330 and 17050.
   1. For each control loop, provide a detailed functional description of the operation of the equipment, signals, and controls shown on the P&IDs:
      a. Include all functions depicted or described in the Contract Documents.
      b. Include the following within each loop description:
         1) All requirements specific to that loop.
         2) Common control requirements applicable to that loop.
         3) List of all ranges, setpoints, timers, values, counters, etc.
   2. Where there are similar loops with identical control, such as multiple loops for individual raw water pumps, only 1 loop description need be developed and the remaining loops may reference that loop description.

B. Loop description format:
   1. Loop number and title.
   2. References:
      a. List P&IDs that are specifically referenced.
   3. Abstract:
      a. General description of how the loop works, what devices are involved, and how the process will be controlled.
      b. Process values, setpoints, and limits, including units and ranges:
         1) Show span and range values for analog inputs and outputs, and operating point and deadband for discrete inputs.
   4. Hardwired control:
      a. Detailed description of the control functions at the local level.
      b. Function of local operator interfaces.
      c. Operation of hardwired field pilot controls:
         1) Pushbuttons.
         2) Selector switches.
         3) Potentiometers.
         4) Pilot lights, indicators, and other displays.
   5. Hardwired interlocks:
      a. Explanation of the operation of system interlocks and hardwired permissive conditions.
   6. PLC control:
      a. Detailed description of the control functions that are under control of the PLC.
      b. Operator controls and automatic controls.
      c. Setpoints, alarms, etc.:
         1) Include units and ranges for analog values.
         2) Include span and range for analog inputs and outputs.
         3) Include operating point and deadband for discrete inputs, and identify conditions where contacts are open, and when they close.
      d. Control sequences.
   7. Software interlocks:
      a. Operation of system software interlocks.
   8. HMI control:
      a. Detailed description of the operator controls.
   9. SCADA control:
      a. Detailed description of the operator controls.
      b. Setpoints, alarms, etc.
   10. Indicators and alarms:
      a. List any indicators and alarms specific to the loop that are not covered in the common control strategies.
   11. Failure modes:
      a. List any failure modes specific to the loop that are not covered in the common control strategies.

1.06 QUALITY ASSURANCE (NOT USED)

1.07 DELIVERY, STORAGE, AND HANDLING (NOT USED)

1.08 PROJECT OR SITE CONDITIONS (NOT USED)

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY (NOT USED)

1.12 SYSTEM START-UP (NOT USED)

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 COMMISSIONING (NOT USED)

1.15 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS (NOT USED)

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS (NOT USED)

2.04 MANUFACTURED UNITS (NOT USED)

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS (NOT USED)

2.07 ACCESSORIES (NOT USED)

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION (NOT USED)

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION

A. Loop 500 – Plant Drain Pump Station:
   1. References:
      a. 04N01.
      b. Plant Drain Pump No. 1: 04-PMP-501.
      c. Plant Drain Pump No. 2: 04-PMP-502.

d. Plant Drain Pump Station Level Transmitter: 04-LIT-504.
e. Plant Drain Pump Station Flow Meter: 04-FIT-503.
f. Plant Drain Pump Station Float Switches: 04-LSLL/LSH-500.

2. Abstract:
   a. The Plant Drain Pumps pump water from the pump station to headworks. The pumps function in a lead/lag operation. The pumps will operate based on the wetwell level as measured by the ultrasonic level transmitter. Monitoring of pump station flow is provided via the pump station flow meter.
3. Hardwired Control:
   a. With the LOR switch in LOCAL position, the pumps are controlled by the START and STOP pushbuttons.
4. Hardwired Interlocks:
   a. The Plant Drain Pumps are stopped and prohibited from starting if:
      1) Pump seal moisture sensor is activated.
      2) Pump temperature sensor is activated.
      3) Pump station low level switch is activated.
5. PLC Control:
   a. In PCIS AUTO, the Plant Drain Pumps are controlled via the PLC:
      1) Operator selects lead/lag pump configuration via the LEAD/LAG SCADA selector switch.
      2) Adjust the speed of the Plant Drain Pumps via a PID control algorithm to maintain a set-point level rate to the wetwell:
         a) SP = Wetwell level setpoint.
         b) PV = Wetwell level measured by the ultrasonic level transmitter.
         c) CV = Speed of the plant drain pumps.
      3) Operator enters the wetwell level setpoint.
         a) Lead pump shall sequence ON when the level of the wetwell reaches an operator adjustable START LEAD level setpoint (initially set at 10 feet). The lead pump shall ramp to its setpoint minimum speed. Upon reaching minimum speed, the PID shall adjust the pump speed to maintain the setpoint level.
         b) The lag pump shall be started if the level of the wetwell is greater than an operator adjustable START LAG level setpoint (initially set at 16 feet) than for a setpoint time. After reaching its minimum speed setpoint the lag pump speed shall be ramped at a setpoint rate. While the lag pump is being ramped up, the lead pump shall be controlled by the PID. When the speed of the lag pump equals the speed of the lead pump, the PID control algorithm shall control pump speed of both pumps. Both pumps under PID control shall be running at the same speed.
      4) Pumps shall be sequenced OFF in the following order:
         a) When the level of the wetwell reaches an operator adjustable STOP PUMPS level setpoint (initially set at 3 feet) the last pump to start shall be removed from PID control and ramped down until it reaches its minimum speed setpoint at which time it shall be sequenced OFF.
         b) Continue sequencing ON and OFF pumps according to the algorithms above until the level setpoint is maintained.
      5) Pump starting status shall be maintained in the following way:
         a) Alternate the priority position of the pumps after the lead and lag pumps are started and then stopped. At which point, each pump

that is in automatic mode should alternate position following the cycle:

(1) Lead → Lag → Lead

b) If any of pumps fail, the control system shall alarm the condition and re-assign the pump configuration. When the pump is proven ready for service, it should be entered back into the lag position.

6. Software Interlocks:
   a. No software interlocks.
7. HMI Control:
   a. No HMI control.
8. SCADA Control:
   a. As indicated on the Drawings and Section 17100.
9. Indicators and Alarms:
   a. As indicated on the Drawings and Section 17100.
10. Failure Modes:
    a. As indicated on the Drawings and Section 17100.

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 FIELD QUALITY CONTROL (NOT USED)

3.08 ADJUSTING (NOT USED)

3.09 CLEANING (NOT USED)

3.10 DEMONSTRATION AND TRAINING

A. As specified in Section 17050.

3.11 PROTECTION (NOT USED)

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 17101-04B

SPECIFIC CONTROL STRATEGIES – STORM WATER PUMP STATION

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Loop descriptions:
      a. Specific control requirements and functional descriptions for individual control loops.

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 - Common Work Results for Process Control and Instrumentation Systems.
      c. Section 17100 - Control Strategies.

1.02 REFERENCES

A. As specified in Section 17050.

1.03 DEFINITIONS

A. As specified in Section 17050.

1.04 SYSTEM DESCRIPTION (NOT USED)

1.05 SUBMITTALS

A. Develop detailed loop descriptions based on the information in the Contract Documents, and submit as specified in Sections 01330 and 17050.
   1. For each control loop, provide a detailed functional description of the operation of the equipment, signals, and controls shown on the P&IDs:
      a. Include all functions depicted or described in the Contract Documents.
      b. Include the following within each loop description:
         1) All requirements specific to that loop.
         2) Common control requirements applicable to that loop.
         3) List of all ranges, setpoints, timers, values, counters, etc.
   2. Where there are similar loops with identical control, such as multiple loops for individual raw water pumps, only 1 loop description need be developed and the remaining loops may reference that loop description.

B. Loop description format:
   1. Loop number and title.
   2. References:
      a. List P&IDs that are specifically referenced.
   3. Abstract:
      a. General description of how the loop works, what devices are involved, and how the process will be controlled.
      b. Process values, setpoints, and limits, including units and ranges:
         1) Show span and range values for analog inputs and outputs, and operating point and deadband for discrete inputs.
   4. Hardwired control:
      a. Detailed description of the control functions at the local level.
      b. Function of local operator interfaces.
      c. Operation of hardwired field pilot controls:
         1) Pushbuttons.
         2) Selector switches.
         3) Potentiometers.
         4) Pilot lights, indicators, and other displays.
   5. Hardwired interlocks:
      a. Explanation of the operation of system interlocks and hardwired permissive conditions.
   6. PLC control:
      a. Detailed description of the control functions that are under control of the PLC.
      b. Operator controls and automatic controls.
      c. Setpoints, alarms, etc.:
         1) Include units and ranges for analog values.
         2) Include span and range for analog inputs and outputs.
         3) Include operating point and deadband for discrete inputs, and identify conditions where contacts are open, and when they close.
      d. Control sequences.
   7. Software interlocks:
      a. Operation of system software interlocks.
   8. HMI control:
      a. Detailed description of the operator controls.
   9. SCADA control:
      a. Detailed description of the operator controls.
      b. Setpoints, alarms, etc.
   10. Indicators and alarms:
      a. List any indicators and alarms specific to the loop that are not covered in the common control strategies.
   11. Failure modes:
      a. List any failure modes specific to the loop that are not covered in the common control strategies.

1.06 QUALITY ASSURANCE (NOT USED)

1.07 DELIVERY, STORAGE, AND HANDLING (NOT USED)

1.08 PROJECT OR SITE CONDITIONS (NOT USED)

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY (NOT USED)

1.12 SYSTEM START-UP (NOT USED)

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 COMMISSIONING (NOT USED)

1.15 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS (NOT USED)

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS (NOT USED)

2.04 MANUFACTURED UNITS (NOT USED)

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS (NOT USED)

2.07 ACCESSORIES (NOT USED)

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION (NOT USED)

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION

A. Loop 500 – Storm Water Pump Station:
   1. References:
      a. 04N02.
      b. Storm Water Pump No. 1: 04-PMP-601.
      c. Storm Water Pump No. 2: 04-PMP-602.

d. Storm Water Pump Station Level Transmitter: 04-LIT-600.
e. Storm Water Pump Station Flow Meter: 04-FIT-603.
f. Storm Water Pump Station Float Switches: 04-LSLL/LSH-603.

2. Abstract:
   a. The Storm Water Pumps pump water from the pump station to headworks. The pumps function in a duty/standby operation. The pumps will operate based on operator initiation and the wetwell level as measured by the ultrasonic level transmitter. Monitoring of pump station flow is provided via the pump station flowmeter.
3. Hardwired Control:
   a. With the LOR switch in LOCAL position, the pumps are controlled by the START and STOP pushbuttons.
4. Hardwired Interlocks:
   a. The Storm Water Pumps are stopped and prohibited from starting if:
      1) Pump seal moisture sensor is activated.
      2) Pump temperature sensor is activated.
      3) Pump station low level switch is activated.
5. PLC Control:
   a. In PCIS AUTO, the Plant Drain Pumps are controlled via the PLC:
      1) Start the duty pump upon operator initiation.
      2) Stop the lead pump when the level in the wetwell reaches an operator adjustable STOP level setpoint.
      3) Pump starting status shall be maintained in the following way:
         a) Alternate duty/standby.
         b) If any of pumps fail, the control system shall alarm the condition and re-assign the pump configuration. When the pump is proven ready for service, it should be entered back into the standby position.
6. Software Interlocks:
   a. No software interlocks.
7. HMI Control:
   a. No HMI control.
8. SCADA Control:
   a. As indicated on the Drawings and Section 17100.
9. Indicators and Alarms:
   a. As indicated on the Drawings and Section 17100.
10. Failure Modes:
    a. As indicated on the Drawings and Section 17100.

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 FIELD QUALITY CONTROL (NOT USED)

3.08 ADJUSTING (NOT USED)

3.09 CLEANING (NOT USED)

3.10 DEMONSTRATION AND TRAINING

A. As specified in Section 17050.

3.11 PROTECTION (NOT USED)

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 17101-10

SPECIFIC CONTROL STRATEGIES – HEADWORKS/SEPTAGE RECEIVING

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Loop descriptions:
      a. Specific control requirements and functional descriptions for individual control loops.

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 11332 - Mechanical Fine Screens.
      c. Section 11333 - Screenings Compactors.
      d. Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
      e. Section 17100 - Control Strategies.

1.02 REFERENCES

A. As specified in Section 17050.

1.03 DEFINITIONS

A. As specified in Section 17050.

1.04 SYSTEM DESCRIPTION (NOT USED)

1.05 SUBMITTALS

A. Develop detailed loop descriptions based on the information in the Contract Documents, and submit as specified in Sections 01330 and 17050.
   1. For each control loop, provide a detailed functional description of the operation of the equipment, signals, and controls shown on the P&IDs:
      a. Include all functions depicted or described in the Contract Documents.
      b. Include the following within each loop description:
         1) All requirements specific to that loop.
         2) Common control requirements applicable to that loop.
         3) List of all ranges, setpoints, timers, values, counters, etc.
   2. Where there are similar loops with identical control, such as multiple loops for individual raw water pumps, only 1 loop description need be developed and the remaining loops may reference that loop description.

B. Loop description format:
   1. Loop number and title.
   2. References:
      a. List P&IDs that are specifically referenced.
   3. Abstract:
      a. General description of how the loop works, what devices are involved, and how the process will be controlled.
      b. Process values, setpoints, and limits, including units and ranges:
         1) Show span and range values for analog inputs and outputs, and operating point and deadband for discrete inputs.
   4. Hardwired control:
      a. Detailed description of the control functions at the local level.
      b. Function of local operator interfaces.
      c. Operation of hardwired field pilot controls:
         1) Pushbuttons.
         2) Selector switches.
         3) Potentiometers.
         4) Pilot lights, indicators, and other displays.
   5. Hardwired interlocks:
      a. Explanation of the operation of system interlocks and hardwired permissive conditions.
   6. PLC control:
      a. Detailed description of the control functions that are under control of the PLC.
      b. Operator controls and automatic controls.
      c. Setpoints, alarms, etc.:
         1) Include units and ranges for analog values.
         2) Include span and range for analog inputs and outputs.
         3) Include operating point and deadband for discrete inputs, and identify conditions where contacts are open, and when they close.
      d. Control sequences.
   7. Software interlocks:
      a. Operation of system software interlocks.
   8. HMI control:
      a. Detailed description of the operator controls.
   9. SCADA control:
      a. Detailed description of the operator controls.
      b. Setpoints, alarms, etc.
   10. Indicators and alarms:
      a. List any indicators and alarms specific to the loop that are not covered in the common control strategies.
   11. Failure modes:
      a. List any failure modes specific to the loop that are not covered in the common control strategies.

1.06 QUALITY ASSURANCE (NOT USED)

1.07 DELIVERY, STORAGE, AND HANDLING (NOT USED)

1.08 PROJECT OR SITE CONDITIONS (NOT USED)

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY (NOT USED)

1.12 SYSTEM START-UP (NOT USED)

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 COMMISSIONING (NOT USED)

1.15 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS (NOT USED)

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS (NOT USED)

2.04 MANUFACTURED UNITS (NOT USED)

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS (NOT USED)

2.07 ACCESSORIES (NOT USED)

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION (NOT USED)

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION

A. LOOPS 041, 042, 051, 052, 012 – Screen Channels:
   1. References:
      a. 10N01.
      b. 10N04.
      c. Screen Inlet Gate No. 1: 10-EDR-041.

d. Screen Outlet Gate No. 1: 10-EDR-042.
e. Screen Inlet Gate No. 2: 10-EDR-051.
f. Screen Outlet Gate No. 2: 10-EDR-052.
g. Channel No. 1 Inlet Level Transmitter: 10-LIT-041.
h. Channel No. 1 Outlet Level Transmitter: 10-LIT-042.
i. Channel No. 2 Inlet Level Transmitter: 10-LIT-051.
j. Channel No. 2 Outlet Level Transmitter: 10-LIT-052.
k. Main Inlet Chanel Level Transmitter: 10-LIT-012.

2. Abstract:
   a. Plant influent enters headworks via a main inlet channel, which diverts to two separate screening channels.
   b. The Screen Inlet and Outlet Gates control the flow split to Screening Channels No. 1 and No. 2.
   c. Level monitoring is provided at the inlet and outlet of each Screening Channel as well as the Main Inlet Channel.
   d. Differential level monitoring will be provided between four separate locations:
      1) Differential Level 1 (DL1): Between 10-LIT-041 and 10-LIT-042.
      2) Differential Level 2 (DL2): Between 10-LIT-051 and 10-LIT-052.
      3) Differential Level 3 (DL3): Between 10-LIT-012 and 10-LIT-042.
      4) Differential Level 4 (DL4): Between 10-LIT-012 and 10-LIT-052.
3. Hardwired Control:
   a. With the LOR switch in LOCAL position, the channel valves are controlled by OPEN/STOP/CLOSE selector switches.
4. Hardwired Interlocks:
   a. No hardwire interlocks.
5. PLC Control:
   a. In PCIS AUTO, the channel gates are controlled via the PLC:
      1) The operator shall select the LEAD Screen Channel from the Channel LEAD/LAG SCADA software selector switch.
      2) The operator selects ONLINE mode from the Channel ONLINE/OFFLINE SCADA selector switch, the PLC shall open the Lead Channel Inlet and Channel Outlet Gates.
      3) The PLC shall open the Lag Channel Inlet and Outlet Gates under the following conditions:
         a) Case 1: Channel No. 1-Lead, Channel No. 2-Lag:
            (1) Differential Level DL1 reaches an operator adjustable high-high level setpoint after a preset time delay.
            (2) Differential Level DL3 reaches an operator adjustable high-high level setpoint after a preset time delay.
            (3) Main Inlet Channel Level Transmitter Reaches an Operator adjustable high-level setpoint after a preset time delay.
         b) Case 2: Channel No. 2-Lead, Channel No. 1-Lag:
            (1) Differential Level DL2 reaches an operator adjustable high-high level setpoint after a preset time delay.
            (2) Differential Level DL4 reaches an operator adjustable high-high level setpoint after a preset time delay.
            (3) Main Inlet Channel Level Transmitter Reaches an Operator adjustable high-level setpoint after a preset time delay.
      4) The Channel Inlet and Outlet gates will close if the operator selects OFFLINE mode from the Channel ONLINE/OFFLINE SCADA selector switch.

6. Software Interlocks:
    a. No software interlocks.
7. HMI Control:
    a. No HMI control.
8. SCADA Control:
    a. As indicated on the Drawings and Section 17100.
9. Indicators and Alarms:
    a. As indicated on the Drawings and Section 17100.
10. Failure Modes:
    a. If the PLC receives any fail, E-STOP, or alarm signal from a Screenings System Control Panel, the PLC shall open the lag Channel Inlet and Outlet Gates if they are not already open. Only after the lag Channel Inlet and Outlet Gates are fully opened, the PLC shall close the Channel Inlet and Outlet Gates associated with the failed equipment. The gates will be prevented from opening until the fail status is removed.
    b. As indicated on the Drawings and Section 17100.

B. LOOPS 040, 043, 044, 050, 053, 054 – Screenings System:
1. References:
    a. 10N01.
    b. 10N02.
    c. 10N03.
    d. 10N04.
    e. Screen Inlet Gate No. 1: 10-EDR-041.
    f. Screen Outlet Gate No. 1: 10-EDR-042.
    g. Screen Inlet Gate No. 2: 10-EDR-051.
    h. Screen Outlet Gate No. 2: 10-EDR-052.
    i. Channel No. 1 Inlet Level Transmitter: 10-LIT-041.
    j. Channel No. 1 Outlet Level Transmitter: 10-LIT-042.
    k. Channel No. 2 Inlet Level Transmitter: 10-LIT-051.
    l. Channel No. 2 Outlet Level Transmitter: 10-LIT-052.
    m. Screenings Control Panel No. 1: 10-VCP-040.
    n. Screen No. 1: 10-MBS-043.
    o. Screenings Compactor No. 1: 10-CMP-044.
    p. Screenings Control Panel No. 2: 10-VCP-050.
    q. Screen No. 2: 10-MBS-053.
    r. Screenings Compactor No. 2: 10-CMP-054.
2. Abstract:
    a. Each Screenings System consists of a mechanical bar screen, washer compactor, and associated Screenings Control Panel.
    b. Channel No. 1 and Channel No. 2 Inlet and Outlet Level Monitoring Signals will be provided to their respective Screenings Control Panel for differential level calculations associated with the operation of the Screen and Washer Compactor.
3. Hardwired Control:
    a. As indicated on the Drawings and Sections 11332 and 11333.
4. Hardwired Interlocks:
    a. As indicated on the Drawings and Sections 11332 and 11333.

5. PLC Control:
    a. In PCIS AUTO, the Screenings Systems are controlled via the PLC:
        1) The PLC shall issue a run permissive to the Screenings Control Panel if both associated Channel Inlet and Outlet Gates are not fully closed.
        2) The PLC shall remove a run permissive to the Screenings Control Panel if either associated Channel Inlet and Outlet Gates are fully closed.
6. Software Interlocks:
    a. No software interlocks.
7. HMI Control:
    a. No HMI control.
8. SCADA Control:
    a. No SCADA control.
9. Indicators and Alarms:
    a. As indicated on the Drawings and Sections 11332, 11333, and 17100.
10. Failure Modes:
    a. As indicated on the Drawings and Sections 11332, 11333, and 17100.

C. LOOP 011 – Composite Sampler:
1. References:
    a. 10N01.
    b. Composite Sampler: 10-COS-011.
    c. Plant Influent Flowmeter: 10-FIT-010.
2. Abstract:
    a. The composite sampler draws water samples from the Headworks Main Inlet channel.
    b. The speed of the sampler is flow paced from the Plant Influent Flowmeter.
3. Hardwired Control:
    a. As described in Specification 11635.
4. Hardwired Interlocks:
    a. No hardwire interlocks.
5. PLC Control:
    a. In PCIS AUTO, the composite sampler is controlled via the PLC:
        1) The PLC shall adjust the speed of the sampler proportional to the plant influent flow rate measure by the Plant Inlfuent Flow Meter.
6. Software Interlocks:
    a. No software interlocks.
7. HMI Control:
    a. No HMI control.
8. SCADA Control:
    a. As indicated on the Drawings and Section 17100.
9. Indicators and Alarms:
    a. As indicated on the Drawings and Section 17100.
10. Failure Modes:
    a. As indicated on the Drawings and Section 17100.

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 FIELD QUALITY CONTROL (NOT USED)

3.08 ADJUSTING (NOT USED)

3.09 CLEANING (NOT USED)

3.10 DEMONSTRATION AND TRAINING

A. As specified in Section 17050.

3.11 PROTECTION (NOT USED)

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 17101-11

SPECIFIC CONTROL STRATEGIES – ODOR CONTROL FACILITY

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Loop descriptions:
      a. Specific control requirements and functional descriptions for individual control loops.

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 - Common Work Results for Process Control and Instrumentation Systems.
      c. Section 17100 - Control Strategies.

1.02 REFERENCES

A. As specified in Section 17050.

1.03 DEFINITIONS

A. As specified in Section 17050.

1.04 SYSTEM DESCRIPTION (NOT USED)

1.05 SUBMITTALS

A. Develop detailed loop descriptions based on the information in the Contract Documents, and submit as specified in Sections 01330 and 17050.
   1. For each control loop, provide a detailed functional description of the operation of the equipment, signals, and controls shown on the P&IDs:
      a. Include all functions depicted or described in the Contract Documents.
      b. Include the following within each loop description:
         1) All requirements specific to that loop.
         2) Common control requirements applicable to that loop.
         3) List of all ranges, setpoints, timers, values, counters, etc.

2. Where there are similar loops with identical control, such as multiple loops for individual raw water pumps, only 1 loop description need be developed and the remaining loops may reference that loop description.

B. Loop description format:
   1. Loop number and title.
   2. References:
      a. List P&IDs that are specifically referenced.
   3. Abstract:
      a. General description of how the loop works, what devices are involved, and how the process will be controlled.
      b. Process values, setpoints, and limits, including units and ranges:
         1) Show span and range values for analog inputs and outputs, and operating point and deadband for discrete inputs.
   4. Hardwired control:
      a. Detailed description of the control functions at the local level.
      b. Function of local operator interfaces.
      c. Operation of hardwired field pilot controls:
         1) Pushbuttons.
         2) Selector switches.
         3) Potentiometers.
         4) Pilot lights, indicators, and other displays.
   5. Hardwired interlocks:
      a. Explanation of the operation of system interlocks and hardwired permissive conditions.
   6. PLC control:
      a. Detailed description of the control functions that are under control of the PLC.
      b. Operator controls and automatic controls.
      c. Setpoints, alarms, etc.:
         1) Include units and ranges for analog values.
         2) Include span and range for analog inputs and outputs.
         3) Include operating point and deadband for discrete inputs, and identify conditions where contacts are open, and when they close.
      d. Control sequences.
   7. Software interlocks:
      a. Operation of system software interlocks.
   8. HMI control:
      a. Detailed description of the operator controls.
   9. SCADA control:
      a. Detailed description of the operator controls.
      b. Setpoints, alarms, etc.
   10. Indicators and alarms:
      a. List any indicators and alarms specific to the loop that are not covered in the common control strategies.
   11. Failure modes:
      a. List any failure modes specific to the loop that are not covered in the common control strategies.

1.06 QUALITY ASSURANCE (NOT USED)

1.07 DELIVERY, STORAGE, AND HANDLING (NOT USED)

1.08 PROJECT OR SITE CONDITIONS (NOT USED)

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY (NOT USED)

1.12 SYSTEM START-UP (NOT USED)

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 COMMISSIONING (NOT USED)

1.15 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS (NOT USED)

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS (NOT USED)

2.04 MANUFACTURED UNITS (NOT USED)

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS (NOT USED)

2.07 ACCESSORIES (NOT USED)

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION (NOT USED)

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION

A. Loop 070 - Odor Control Facility
   1. References:
      a. 11N01.
      b. Odor Control Fan No. 1: 11-FAN-071.
      c. Odor Control Fan No. 2: 11-FAN-072.
   2. Abstract:
      a. The Odor Control Facility treats foul air from the headworks channels, Dewatering Building, and Influent Splitter Structure. There are 2 fans, one in service and one standby, that exhaust foul air from the process facilities and convey them to the Biofilters. There are 2 biofilter vessels in service which treat the odorous air.
      b. The odor control system is provided with a vendor control panel that controls the irrigation and moisture system for the biofilters. The control logics for the system is resident in this control panel and designed by the vendor of the odor control system.
   3. Hardwired control:
      a. With the LOR switch in LOCAL position, the fans are controlled by the START and STOP pushbuttons.
   4. Hardwired interlocks:
      a. No hardwired interlocks.
   5. PLC control:
      a. In PCIS AUTO, the Odor Control Fans are controlled via the PLC:
         1) The PLC shall start the LEAD fan based on the position of the LEAD/STANDBY SCADA software selector switch.
         2) The LEAD fan shall run continuously until the LEAD/STANDBY configuration is changed.
         3) Upon fan failure, the control system shall alarm the condition and re-assign the fan configuration. When the fan is proven ready for service, it should be entered back into the STANDBY position.
   6. Software interlocks:
      a. No software interlocks.
   7. HMI control:
      a. No HMI control.
   8. SCADA control:
      a. As indicated on the Drawings and Section 17100.
   9. Indicators and alarms:
      a. As indicated on the Drawings and Section 17100.
   10. Failure modes:
      a. As indicated on the Drawings and Section 17100.

3.05 REPAIR/RESTORATION (NOT USED)

3.06 REINSTALLATION (NOT USED)

3.07 FIELD QUALITY CONTROL (NOT USED)

3.08 ADJUSTING (NOT USED)

3.09 CLEANING (NOT USED)

3.10 DEMONSTRATION AND TRAINING

A. As specified in Section 17050.

3.11 PROTECTION (NOT USED)

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 17101-20

SPECIFIC CONTROL STRATEGIES – OXIDATION DITCH

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Loop descriptions:
      a. Specific control requirements and functional descriptions for individual control loops.

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 - Common Work Results for Process Control and Instrumentation Systems.

1.02 REFERENCES

A. As specified in Section 17050.

1.03 DEFINITIONS

A. As specified in Section 17050.

1.04 SYSTEM DESCRIPTION (NOT USED)

1.05 SUBMITTALS

A. Develop detailed loop descriptions based on the information in the Contract Documents, and submit as specified in Sections 01330 and 17050.
   1. For each control loop, provide a detailed functional description of the operation of the equipment, signals, and controls shown on the P&IDs:
      a. Include all functions depicted or described in the Contract Documents.
      b. Include the following within each loop description:
         1) All requirements specific to that loop.
         2) Common control requirements applicable to that loop.
         3) List of all ranges, setpoints, timers, values, counters, etc.
   2. Where there are similar loops with identical control, such as multiple loops for individual raw water pumps, only 1 loop description need be developed and the remaining loops may reference that loop description.

B. Loop description format:
   1. Loop number and title.
   2. References:
      a. List P&IDs that are specifically referenced.
   3. Abstract:
      a. General description of how the loop works, what devices are involved, and how the process will be controlled.
      b. Process values, setpoints, and limits, including units and ranges:
         1) Show span and range values for analog inputs and outputs, and operating point and deadband for discrete inputs.
   4. Hardwired control:
      a. Detailed description of the control functions at the local level.
      b. Function of local operator interfaces.
      c. Operation of hardwired field pilot controls:
         1) Pushbuttons.
         2) Selector switches.
         3) Potentiometers.
         4) Pilot lights, indicators, and other displays.
   5. Hardwired interlocks:
      a. Explanation of the operation of system interlocks and hardwired permissive conditions.
   6. PLC control:
      a. Detailed description of the control functions that are under control of the PLC.
      b. Operator controls and automatic controls.
      c. Setpoints, alarms, etc.:
         1) Include units and ranges for analog values.
         2) Include span and range for analog inputs and outputs.
         3) Include operating point and deadband for discrete inputs, and identify conditions where contacts are open, and when they close.
      d. Control sequences.
   7. Software interlocks:
      a. Operation of system software interlocks.
   8. HMI control:
      a. Detailed description of the operator controls.
   9. SCADA control:
      a. Detailed description of the operator controls.
      b. Setpoints, alarms, etc.
   10. Indicators and alarms:
      a. List any indicators and alarms specific to the loop that are not covered in the common control strategies.
   11. Failure modes:
      a. List any failure modes specific to the loop that are not covered in the common control strategies.

1.06 QUALITY ASSURANCE (NOT USED)

1.07 DELIVERY, STORAGE, AND HANDLING (NOT USED)

1.08 PROJECT OR SITE CONDITIONS (NOT USED)

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY (NOT USED)

1.12 SYSTEM START-UP (NOT USED)

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 COMMISSIONING (NOT USED)

1.15 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS (NOT USED)

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS (NOT USED)

2.04 MANUFACTURED UNITS (NOT USED)

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS (NOT USED)

2.07 ACCESSORIES (NOT USED)

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION (NOT USED)

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION

A. Loops 090, 100 - Title: Oxidation Ditch No. 1 and 2.
   1. References:
      a. 20N01, 20N02, 20N03.
   2. Abstract:
      a. Wastewater flows from the headworks to the two oxidation ditches.

b. Influent flow is controlled by 4 weirs; 2 each for each ditch located in the influent splitter box. The weirs have manual gates that can be used to control the amount of influent to each ditch.
c. RAS is returned to the influent splitter box. RAS is controlled by 4 weirs, 2 each for each ditch. The weirs have manual gates that can be used control the amount of RAS to each ditch.
d. The combined flow (influent and RAS) flows into the anoxic zone.
e. Mixed liquor is returned from the aerated portion of the ditch to the anoxic zone through a manual gate.
f. The anoxic zone is mixed by mechanical mixers.
g. Mechanical aerators in the oxidation ditch, two per ditch, are used to aerate the wastewater and increase the dissolved oxygen concentration, which is consumed by the biological organisms that degrade the organics.
h. Dissolved oxygen is measure in each ditch using an online meter. The speed of the aerators are controlled by a DO setpoint.
i. The motorized effluent gate can be raised to 7 inches above the normal weir elevation to allow storage of plant flow during a low flow periods to the plant.

3. Hardwired control:
   a. Anoxic mixers:
      1) With the LOR switch in LOCAL, the mixer can be started and stopped by using the field START and STOP pushbuttons.
   b. Mechanical aerators:
      1) With the LOR switch in LOCAL, the aerator can be started and stopped by using the field START and STOP pushbuttons.
   c. Effluent gates:
      1) With the LOR switch in LOCAL, the gate can be opened and closed by using the field OPEN and CLOSE pushbuttons.
4. Hardwired interlocks:
   a. Anoxic mixers:
      1) Motor winding high temperature switch.
      2) Low gear reducer oil pressure.
   b. Mechanical aerators:
      1) Motor winding high temperature switch.
      2) Low gear reducer oil pressure.
   c. Effluent gates:
      1) Gate Fail.
5. PLC control:
   a. Aerator control:
      1) With the Aerators' LOR switch in REMOTE and the SCADA HOA in AUTOMATIC in aerators are controlled by the PLC.
      2) The operator will enter a setpoint DO for each oxidation ditch.
         a) The measured DO value shall be based on 12 equally spaced readings over a time span. Operator adjustable from 1 to 120 minutes, initially set at 2 minutes. This time average value shall be referred to "Actual DO."
         b) The PLC adjust the speed for each aerator as follows:
            (1) Aerators 20-AER-092 and 20AER-102: The speed signal shall be based on the Actual DO using a control algorithm.
            (2) Aerators 20-AER-091 and 20-AER-101: The speed signal shall be X times speed signal based on the Actual DO using the control algorithm. X is a ratio factor operator

adjustable from 0.75 to 2.0, initially set at 1.0. If the speed signal times the ratio factor equals 100-percent speed, the PLC shall hold the aerator at 100-percent speed.

b. Ditch Storage Mode:
   1) A software switch DITCH STORAGE-OFF-FIPS ADD WATER shall control the ditch effluent gates.
   2) The operator will enter the time of day to start ditch storage mode.
   3) The operator will enter the time of day to end the ditch storage mode.
   4) With the software switch in DITCH STORAGE mode and the ditch effluent gate LOR switch in REMOTE and the SCADA HOA in AUTOMATIC the effluent gate is controlled by the PLC.
      a) The PLC shall close the ditch effluent gate at the start of the ditch storage mode.
      b) The PLC shall open the ditch effluent gate in 6 steps over a period of 60 minutes at the end of the ditch storage mode.

6. Software interlocks:
   a. With the software switch in DITCH STORAGE mode and the ditch effluent gates are closed:
      1) Prevent from running the RAS pumps.
      2) Prevent from running the WAS system.
      3) Close the sodium hypochlorite feed valves to the secondary clarifiers weir chlorine system.
      4) Close the plant water feed solenoid valves to the secondary clarifiers weir chlorine system.
      5) Shut down the UV system.
   b. With the software switch in DITCH STORAGE mode and the ditch effluent gates are begin to open:
      1) Allow operation of the RAS system.
      2) Allow operation of the UV system.
   c. With the software switch in DITCH STORAGE mode and the ditch effluent gates are opened to step 4:
      1) Open the sodium hypochlorite feed valves to the secondary clarifiers weir chlorine system.
      2) Open the plant water feed solenoid valves to the secondary clarifiers weir chlorine system.
   d. With the software switch in DITCH STORAGE mode and the ditch effluent gates are opened to step 6 (gate is at normal weir elevation):
      1) Allow operation of the WAS system.
7. HMI control:
   a. None.
8. SCADA control:
   a. As indicated on the Drawings and Section 17100.
9. Indicators and alarms:
   a. As indicated on the Drawings and Section 17100.
10. Failure modes:
   a. As indicated on the Drawings and Section 17100.

3.05 REPAIR/RESTORATION (NOT USED)

3.06 REINSTALLATION (NOT USED)

3.07 FIELD QUALITY CONTROL (NOT USED)

3.08 ADJUSTING (NOT USED)

3.09 CLEANING (NOT USED)

3.10 DEMONSTRATION AND TRAINING

A. As specified in Section 17050.

3.11 PROTECTION (NOT USED)

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 17101-21

SPECIFIC CONTROL STRATEGIES – SECONDARY CLARIFIERS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Loop descriptions:
      a. Specific control requirements and functional descriptions for individual control loops.

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 - Common Work Results for Process Control and Instrumentation Systems.

1.02 REFERENCES

A. As specified in Section 17050.

1.03 DEFINITIONS

A. As specified in Section 17050.

1.04 SYSTEM DESCRIPTION (NOT USED)

1.05 SUBMITTALS

A. Develop detailed loop descriptions based on the information in the Contract Documents, and submit as specified in Sections 01330 and 17050.
   1. For each control loop, provide a detailed functional description of the operation of the equipment, signals, and controls shown on the P&IDs:
      a. Include all functions depicted or described in the Contract Documents.
      b. Include the following within each loop description:
         1) All requirements specific to that loop.
         2) Common control requirements applicable to that loop.
         3) List of all ranges, setpoints, timers, values, counters, etc.
   2. Where there are similar loops with identical control, such as multiple loops for individual raw water pumps, only 1 loop description need be developed and the remaining loops may reference that loop description.

B. Loop description format:
   1. Loop number and title.
   2. References:
      a. List P&IDs that are specifically referenced.
   3. Abstract:
      a. General description of how the loop works, what devices are involved, and how the process will be controlled.
      b. Process values, setpoints, and limits, including units and ranges:
         1) Show span and range values for analog inputs and outputs, and operating point and deadband for discrete inputs.
   4. Hardwired control:
      a. Detailed description of the control functions at the local level.
      b. Function of local operator interfaces.
      c. Operation of hardwired field pilot controls:
         1) Pushbuttons.
         2) Selector switches.
         3) Potentiometers.
         4) Pilot lights, indicators, and other displays.
   5. Hardwired interlocks:
      a. Explanation of the operation of system interlocks and hardwired permissive conditions.
   6. PLC control:
      a. Detailed description of the control functions that are under control of the PLC.
      b. Operator controls and automatic controls.
      c. Setpoints, alarms, etc.:
         1) Include units and ranges for analog values.
         2) Include span and range for analog inputs and outputs.
         3) Include operating point and deadband for discrete inputs, and identify conditions where contacts are open, and when they close.
      d. Control sequences.
   7. Software interlocks:
      a. Operation of system software interlocks.
   8. HMI control:
      a. Detailed description of the operator controls.
   9. SCADA control:
      a. Detailed description of the operator controls.
      b. Setpoints, alarms, etc.
   10. Indicators and alarms:
      a. List any indicators and alarms specific to the loop that are not covered in the common control strategies.
   11. Failure modes:
      a. List any failure modes specific to the loop that are not covered in the common control strategies.

1.06 QUALITY ASSURANCE (NOT USED)

1.07 DELIVERY, STORAGE, AND HANDLING (NOT USED)

1.08 PROJECT OR SITE CONDITIONS (NOT USED)

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY (NOT USED)

1.12 SYSTEM START-UP (NOT USED)

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 COMMISSIONING (NOT USED)

1.15 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS (NOT USED)

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS (NOT USED)

2.04 MANUFACTURED UNITS (NOT USED)

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS (NOT USED)

2.07 ACCESSORIES (NOT USED)

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION (NOT USED)

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION

A. Loops 110, 111 - Secondary Clarifiers:
   1. References:
      a. 21N01.
      b. 21N02.
      c. Secondary Clarifier No. 1 Drive: 21-CLR-111.

d. Secondary Clarifier No. 2 Drive: 21-CLR-112.
e. Secondary Clarifier No. 1 Scum Spray Solenoid Valve: 21-SV-111.
f. Secondary Clarifier No. 2 Scum Spray Solenoid Valve: 21-SV-112.
g. Secondary Clarifier No. 1 Skimmer Arm Limit Switch: 21-ZS-111.
h. Secondary Clarifier No. 2 Skimmer Arm Limit Switch: 21-ZS-112.
i. Secondary Clarifier No.1 Plant Water Feed Solenoid Valve : 21-SV-752A.
j. Secondary Clarifier No. 2 Plant Water Feed Solenoid Valve : 21-SV-752B.

2. Abstract:
   a. The secondary clarifiers operate continuously to remove secondary sludge and secondary scum from the mixed liquor to produce clarified effluent.
   b. Settled solids are removed as RAS from each secondary clarifier by rotating spiral scrapers, which are driven by the associated secondary clarifier drive.
   c. Scum is removed in the clarifier is discharged to the secondary scum pit.
   d. Spray water is used to control foam through spray nozzles.
   e. Chlorinated water is used to control algae at the effluent launders.
3. Hardwired control:
   a. With the LOR switch in LOCAL position, the Clarifier Drives are controlled by the START and STOP pushbuttons.
4. Hardwired interlocks:
   a. The Clarifier Drives are stopped and prohibited from starting if:
      1) Shear pin switch is activated.
      2) High-high torque switch is activated.
5. PLC control:
   a. In PCIS AUTO, the Clarifier Drives are controlled via the PLC:
      1) The PLC shall operate the Clarifier Drives continuously.
      2) The PLC shall open the Scum Spray Solenoid Valve for an operator adjustable time period of (0 to 120 seconds; default 30 seconds) each time the skimming arm activates the Skimmer Arm Limit Switch.
6. Software interlocks:
   a. The Weir Chlorine System and Plant Water Feed Solenoid Valves shall be interlocked with the DITCH STORAGE mode, refer to Section 17101-20.
7. HMI control:
   a. None.
8. SCADA control:
   a. As indicated on the Drawings and in Section 17100.
9. Indicators and alarms:
   a. As indicated on the Drawings and in Section 17100.
10. Failure modes:
    a. As indicated on the Drawings and in Section 17100.

3.05 REPAIR/RESTORATION (NOT USED)

3.06 REINSTALLATION (NOT USED)

3.07 FIELD QUALITY CONTROL (NOT USED)

3.08 ADJUSTING (NOT USED)

3.09 CLEANING (NOT USED)

3.10 DEMONSTRATION AND TRAINING

A. As specified in Section 17050.

3.11 PROTECTION (NOT USED)

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 17101-23

SPECIFIC CONTROL STRATEGIES – SCUM PUMP STATION

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Loop descriptions:
      a. Specific control requirements and functional descriptions for individual control loops.

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 - Common Work Results for Process Control and Instrumentation Systems.

1.02 REFERENCES

A. As specified in Section 17050.

1.03 DEFINITIONS

A. As specified in Section 17050.

1.04 SYSTEM DESCRIPTION (NOT USED)

1.05 SUBMITTALS

A. Develop detailed loop descriptions based on the information in the Contract Documents, and submit as specified in Sections 01330 and 17050.
   1. For each control loop, provide a detailed functional description of the operation of the equipment, signals, and controls shown on the P&IDs:
      a. Include all functions depicted or described in the Contract Documents.
      b. Include the following within each loop description:
         1) All requirements specific to that loop.
         2) Common control requirements applicable to that loop.
         3) List of all ranges, setpoints, timers, values, counters, etc.
   2. Where there are similar loops with identical control, such as multiple loops for individual raw water pumps, only 1 loop description need be developed and the remaining loops may reference that loop description.

B. Loop description format:
   1. Loop number and title.
   2. References:
      a. List P&IDs that are specifically referenced.
   3. Abstract:
      a. General description of how the loop works, what devices are involved, and how the process will be controlled.
      b. Process values, setpoints, and limits, including units and ranges:
         1) Show span and range values for analog inputs and outputs, and operating point and deadband for discrete inputs.
   4. Hardwired control:
      a. Detailed description of the control functions at the local level.
      b. Function of local operator interfaces.
      c. Operation of hardwired field pilot controls:
         1) Pushbuttons.
         2) Selector switches.
         3) Potentiometers.
         4) Pilot lights, indicators, and other displays.
   5. Hardwired interlocks:
      a. Explanation of the operation of system interlocks and hardwired permissive conditions.
   6. PLC control:
      a. Detailed description of the control functions that are under control of the PLC.
      b. Operator controls and automatic controls.
      c. Setpoints, alarms, etc.:
         1) Include units and ranges for analog values.
         2) Include span and range for analog inputs and outputs.
         3) Include operating point and deadband for discrete inputs, and identify conditions where contacts are open, and when they close.
      d. Control sequences.
   7. Software interlocks:
      a. Operation of system software interlocks.
   8. HMI control:
      a. Detailed description of the operator controls.
   9. SCADA control:
      a. Detailed description of the operator controls.
      b. Setpoints, alarms, etc.
   10. Indicators and alarms:
      a. List any indicators and alarms specific to the loop that are not covered in the common control strategies.
   11. Failure modes:
      a. List any failure modes specific to the loop that are not covered in the common control strategies.

1.06 QUALITY ASSURANCE (NOT USED)

1.07 DELIVERY, STORAGE, AND HANDLING (NOT USED)

1.08 PROJECT OR SITE CONDITIONS (NOT USED)

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY (NOT USED)

1.12 SYSTEM START-UP (NOT USED)

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 COMMISSIONING (NOT USED)

1.15 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS (NOT USED)

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS (NOT USED)

2.04 MANUFACTURED UNITS (NOT USED)

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS (NOT USED)

2.07 ACCESSORIES (NOT USED)

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION (NOT USED)

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION

A. Loop 130 - Title: Secondary Scum Pump Station:
   1. References:
      a. 23N01.
      b. Secondary Scum Pump No. 1: 23-PMP131.
      c. Secondary Scum Pump No. 2: 23-PMP-132.

d. Secondary Scum Pit Radar Level Transmitter: 23-LIT-130.
e. Scum Mixing Valve: 23-EDR-130.

2. Abstract:
   a. Secondary scum is drawn off the oxidation ditch and secondary clarifiers.
   b. Scum flows to the scum pump station.
   c. There are two submersible scum pumps. In the AUTOMATIC mode the operator will set the DUTY/STANDBY status of the pumps.
   d. The pumps and three-way mixing valve is controlled by the PLC.
   e. There are manual valves that the operator will open/close to pump the scum to the oxidation ditch or to the sludge storage tank.
3. Hardwired control:
   a. Scum pit mixing valve:
      1) With LOR switch in LOCAL, the mixing valve position can be changed from TRANSFER to MIX positions at the valve.
   b. Scum Pumps:
      1) With the LOR switch in LOCAL position, the Scum Pumps are controlled by the START and STOP pushbuttons.
4. Hardwired interlocks:
   a. The Scum Pumps are stopped and prohibited from starting if:
      1) Pump seal moisture sensor is activated.
      2) Pump temperature sensor is activated.
5. PLC control:
   a. In PCIS AUTO, the Scum Pumps are controlled via the PLC:
   b. When the Scum Pit level measured by the Scum Pit Radar Level Transmitter reaches an operator adjustable START level setpoint the PLC shall:
      1) Verify mixing valve is in MIX position.
      2) Start the duty pump.
      3) When the pump starts the system shall mix the wet well for an operator adjustable time period (0-600 seconds; default value 300 seconds).
      4) When the mixing timer times out the PLC shall change the mixing valve position to TRANSFER.
   c. When the Scum Pit level measured by the Scum Pit Radar Level Transmitter reaches an operator adjustable STOP level setpoint the PLC shall:
      1) Stop the duty pump.
      2) Change the mixing valve position to MIX.
6. Software interlocks:
   a. The Scum Pumps are stopped and prohibited from starting if:
      1) Scum pit level measured by the Scum Pit Radar Level Transmitter is reaches the operator adjustable STOP level setpoint.
7. HMI control:
   a. None.
8. SCADA control:
   a. As indicated on the Drawings and in Section 17100.
9. Indicators and alarms:
   a. As indicated on the Drawings and in Section 17100.
10. Failure modes:
   a. If the DUTY pump fails the PLC shall replace the duty pump with the STANDBY pump.

3.05 REPAIR/RESTORATION (NOT USED)

3.06 REINSTALLATION (NOT USED)

3.07 FIELD QUALITY CONTROL (NOT USED)

3.08 ADJUSTING (NOT USED)

3.09 CLEANING (NOT USED)

3.10 DEMONSTRATION AND TRAINING

A. As specified in Section 17050.

3.11 PROTECTION (NOT USED)

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 17101-28

SPECIFIC CONTROL STRATEGIES – FILTER INFLUENT PUMP STATION

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Loop descriptions:
      a. Specific control requirements and functional descriptions for individual control loops.

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 - Common Work Results for Process Control and Instrumentation Systems.

1.02 REFERENCES

A. As specified in Section 17050.

1.03 DEFINITIONS

A. As specified in Section 17050.

1.04 SYSTEM DESCRIPTION (NOT USED)

1.05 SUBMITTALS

A. Develop detailed loop descriptions based on the information in the Contract Documents, and submit as specified in Sections 01330 and 17050.
   1. For each control loop, provide a detailed functional description of the operation of the equipment, signals, and controls shown on the P&IDs:
      a. Include all functions depicted or described in the Contract Documents.
      b. Include the following within each loop description:
         1) All requirements specific to that loop.
         2) Common control requirements applicable to that loop.
         3) List of all ranges, setpoints, timers, values, counters, etc.
   2. Where there are similar loops with identical control, such as multiple loops for individual raw water pumps, only 1 loop description need be developed and the remaining loops may reference that loop description.

B. Loop description format:
   1. Loop number and title.
   2. References:
      a. List P&IDs that are specifically referenced.
   3. Abstract:
      a. General description of how the loop works, what devices are involved, and how the process will be controlled.
      b. Process values, setpoints, and limits, including units and ranges:
         1) Show span and range values for analog inputs and outputs, and operating point and deadband for discrete inputs.
   4. Hardwired control:
      a. Detailed description of the control functions at the local level.
      b. Function of local operator interfaces.
      c. Operation of hardwired field pilot controls:
         1) Pushbuttons.
         2) Selector switches.
         3) Potentiometers.
         4) Pilot lights, indicators, and other displays.
   5. Hardwired interlocks:
      a. Explanation of the operation of system interlocks and hardwired permissive conditions.
   6. PLC control:
      a. Detailed description of the control functions that are under control of the PLC.
      b. Operator controls and automatic controls.
      c. Setpoints, alarms, etc.:
         1) Include units and ranges for analog values.
         2) Include span and range for analog inputs and outputs.
         3) Include operating point and deadband for discrete inputs, and identify conditions where contacts are open, and when they close.
      d. Control sequences.
   7. Software interlocks:
      a. Operation of system software interlocks.
   8. HMI control:
      a. Detailed description of the operator controls.
   9. SCADA control:
      a. Detailed description of the operator controls.
      b. Setpoints, alarms, etc.
   10. Indicators and alarms:
      a. List any indicators and alarms specific to the loop that are not covered in the common control strategies.
   11. Failure modes:
      a. List any failure modes specific to the loop that are not covered in the common control strategies.

1.06 QUALITY ASSURANCE (NOT USED)

1.07 DELIVERY, STORAGE, AND HANDLING (NOT USED)

1.08 PROJECT OR SITE CONDITIONS (NOT USED)

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY (NOT USED)

1.12 SYSTEM START-UP (NOT USED)

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 COMMISSIONING (NOT USED)

1.15 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS (NOT USED)

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS (NOT USED)

2.04 MANUFACTURED UNITS (NOT USED)

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS (NOT USED)

2.07 ACCESSORIES (NOT USED)

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION (NOT USED)

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION

A. Loops 181, 182, 183, 184, 188 - Filter Influent Pump Station:
   1. References:
      a. 28N01.
      b. 28N02.
      c. 28N03.

d. Filter Influent Pump No. 1: 28-PMP-181.
e. Filter Influent Pump No. 2: 28-PMP-182.
f. Filter Influent Pump No. 3: 28-PMP-183.
g. Filter Influent Pump No. 4: 28-PMP-184.

2. Abstract:
   a. The secondary effluent flows from the secondary clarifiers to the Filter Influent Pump Station.
   b. There are four VFD-controlled pumps. Two of the pumps, 28-PMP-181 and 28-PMP-183, are low-flow pumps, and pumps 28-PMP-182 and 28-PMP-184 are high-flow pumps.
   c. Three of the pumps, two low flow and one high flow, operate in a lead/lag/lag/lag-lag sequence.
   d. One of the high-flow pumps will be a standby pump.
   e. There is a overflow weir in the pump station. If the water level rises to the overflow level, the secondary effluent will flow to the stormwater pond.
   f. Plant water can be added manually to the pump pit by the operator.
   g. There are two flash-mix pumps located at the pump station. Control of these pumps is described in another control strategy.
3. Hardwired control:
   a. With the LOR switch in LOCAL, the pumps can be started and stopped by using the field START and STOP pushbuttons.
4. Hardwired interlocks:
   a. Low-low level float shall stop all pumps.
   b. The high-high level float shall alarm only.
   c. Integral moisture detection and motor winding temperature switches for each pump shall stop the pump.
5. PLC control:
   a. Normal Mode:
      1) With the LOR switch in REMOTE and the SCADA HOA switch in AUTOMATIC, the pumps are controlled by the PLC as follows:
      2) When the level in the wet well reaches LEVEL 1 (L1= elevation 78.00), the PLC shall start the lead low-flow pump at minimum speed.
      3) The PLC shall hold the lead pump at minimum speed until the level in the wet well reaches LEVEL 2 (L2 = elevation 74.75).
      4) The PLC shall vary the speed of the lead pump until the SET POINT LEVEL (SPL = elevation 80.00) is reached.
      5) When the SPL is reached, the PLC shall start the lag pump and ramp both pumps up in speed to maintain the water level.
      6) If the level continues to rise above the SPL, the PLC shall start the lag-lag pump and adjust the speed of all three pumps to maintain the water level.
      7) If the flow rate from the system reaches a setpoint flow rate set at 2,777 gpm (4.0 mgd), the PLC shall hold the pump speed and allow the water level to rise in the wet well.
      8) If the level begins to fall below the SPL and all three pumps are operating at minimum speed, the PLC shall stop the lag-lag pump and adjust the speed of the two remaining pumps.
      9) If the level continues to fall and the duty and lag pumps are operating at minimum speed, the PLC shall stop the lag pump and adjust the speed of the lead pump.

10) If the level continues to fall and the lead pump is operating at minimum speed, the PLC shall hold the pump at minimum speed until the level in the wet well reaches LEVEL 3 (L3=elevation 74.00).
11) The PLC shall stop the lead pump at L3.

b. FIPS ADD WATER mode
1) A software switch DITCH STORAGE-OFF-FIPS ADD WATER shall control the pump operation in the FIPS ADD WATER mode.
2) With the software switch in the FIPS ADD WATER mode, LOR switch in REMOTE and the SCADA HOA switch in AUTOMATIC, the pumps are controlled by the PLC as follows:
a) When the level in the wet well reaches L1, the PLC shall start the lead low-flow pump at minimum speed.
b) The PLC shall hold the lead pump at minimum speed until the level in the wet well reaches L2.
c) The PLC shall vary the speed of the lead pump until the SPL is reached.
d) When the SPL is reached, the PLC shall start the lag pump and ramp both pumps up in speed to maintain the water level.
e) If the level continues to rise above the SPL, the PLC shall start the lag-lag pump and adjust the speed of all 3 pumps to maintain the water level.
f) If the flow rate from the system reaches a setpoint flow rate set at 2,800 gpm , the PLC shall hold the pump speed and allow the water level to rise in the wet well.
g) If the level begins to fall below the SPL and all 3 pumps are operating at minimum speed, the PLC shall stop the lag-lag pump and adjust the speed of the 2 remaining pumps.
h) If the level continues to fall and the duty and lag pumps are operating at minimum speed, the PLC shall stop the lag pump and adjust the speed of the lead pump.
i) If the level continues to fall and the lead pump is operating at minimum speed, the PLC shall hold the pump at minimum speed.
j) The PLC shall modulate valve 28-EAM-188 to keep the water level in the wet well above L1.
k) If the water level in the wet well rises to L2 the PLC shall close valve 28-EAM-188.

6. Software interlocks:
a. The UV system shall generate a run signal for each UV channel operating.
b. If only one UV channel is operating the PLC shall limit the flow rate to 1,380 gpm (2 mgd) by only allowing two low flow pumps to operate or one high flow pump. The PLC shall control the pumps based on flow rate and allow the water to rise in the wet well.
c. If two UV channels are operating the lead, lag and lag-lag pumps shall be allowed to operate.

7. HMI control:
a. None.

8. SCADA control:
    a. With the LOR switch in REMOTE and the SCADA HOA switch in HAND, the Filter Influent pumps can be started and stopped from SCADA.
    b. Operator enters lead/lag/lag-lag pump sequence. One of the low-flow pumps shall be lead. The remaining high flow pump shall be the standby pump.
9. Indicators and alarms:
    a. As indicated on the Drawings and in Section 17100.
10. Failure modes:
    a. If the lead low-flow pump fails, the PLC shall replace the failed pump with the next low-flow pump and replace the next low-flow pump with the standby pump in the pump sequence.

B. Loop AE181 – Filter Influent Turbidity:
1. References:
    a. 28N01.
2. Abstract:
    a. Filter influent turbidity is continuously monitored immediately downstream of the filter influent pumps.
    b. The turbidity analyzer ensures the water quality remains in compliance with the current criteria set forth by California Department of Public Health (CDPH) for tertiary disinfected recycled water without continuous coagulant addition: Influent turbidity does not exceed 5 NTU for more than 15 minutes without coagulant addition and never exceeds 10 NTU.
3. Hardwired control:
    a. None.
4. Hardwired interlocks:
    a. None.
5. PLC control:
    a. With the SCADA HOA switch in AUTOMATIC, the PLC shall control the system as follows:
        1) Triggering the high-turbidity setpoint (operator adjustable 0 to 5 NTU in 0.1 increments) for 15 continuous minutes will trigger “HIGH FILTER INFLUENT TURBIDITY” alarm at SCADA and simultaneously start the flash mix pumps and coagulant addition as described in Sections 17101-28 and 17101-32, respectively.
        2) Triggering the high-high turbidity setpoint (operator adjustable 0 to 10 NTU in 0.1 increments) will trigger “HIGH-HIGH FILTER INFLUENT TURBIDITY” and immediately simultaneously start the flash mix pumps and coagulant addition.
6. Software interlocks:
    a. Start Flash Mix Pump.
    b. Start coagulant addition, refer to Section 17101-32.
7. HMI control:
    a. None.
8. SCADA control:
    a. With the SCADA HOA switch in HAND mode:
        1) The turbidity analyzer will trigger an operator notification alarm at SCADA at the high and high-high turbidity setpoints only.

b. Power failure recovery:
    1) The plant SCADA system will detect an interruption of utility power. The SCADA will inhibit all alarms that would affect the programmed operation of the system.
    2) Following power supply interruption, the plant SCADA will clear all alarms and automatically restart operation of the turbidimeter.

9. Indicators and alarms:
    1) As indicated on the Drawings and in Section 17100.

10. Failure modes:
    a. If communication with the turbidity analyzer fails, alarm at SCADA and the coagulant addition and dispersion system shall automatically activate.

C. Loops 185, 186 – Flash Mix Pumps:

1. References:
    a. 28N03.
    b. 30N01.
    c. 31N01.
    d. 32N02.
    e. 32N03.
    f. Alum Pump No. 1: 32-PMP-271.
    g. Alum Pump No. 2: 32-PMP-272.
    h. Flash Mix Pump No. 1: 28-PMP-185.
    i. Flash Mix Pump No. 2: 28-PMP-186.
2. Abstract:
    a. Filter influent turbidity is continuously monitored immediately downstream of the filter influent pumps.
    b. A high turbidity alarm shall start the flash mix pumps and the coagulant addition.
3. Hardwired control:
    a. With the LOR switch in LOCAL position, the pumps are controlled by the START and STOP pushbuttons.
4. Hardwired interlocks
    a. The Flash Mix Pumps are stopped and prohibited from starting if:
        1) Pump temperature sensor is activated.
        2) Pump high pressure switch is activated.
5. PLC control:
    a. In PCIS AUTO, the Flash Mix Pumps are controlled via the PLC as described in the Filter Influent Turbidity Section of 17101-28 and Filter Effluent Turbidity Section of 17101-31:
        1) Pump starting status shall be maintained in the following way:
            a) Alternate the priority position of the pumps after the lead pump is started and then stopped. At which point, each pump that is in automatic mode should alternate position following the cycle:
                (1) Lead → Standby → Lead.
            b) If any of pumps fail, the control system shall alarm the condition and re-assign the pump configuration. When the pump is proven ready for service it should be entered back into the standby position.
6. Software interlocks:
    a. Prohibit the flash mix pumps from running if all Filter Influent Pumps are off.

7. HMI control:
    a. No HMI control.
8. SCADA control:
    a. With the LOR switch in REMOTE and the SCADA HOA switch in HAND, the Flash Mix pumps can be started and stopped from SCADA.
    b. Operator enters Duty/Standby sequence.
9. Indicators and alarms:
    a. As indicated on the Drawings and in Section 17100.
10. Failure modes:
    a. If the Duty pump fails, the PLC shall replace the failed pump with the Standby pump.

3.05 REPAIR/RESTORATION (NOT USED)

3.06 REINSTALLATION (NOT USED)

3.07 FIELD QUALITY CONTROL (NOT USED)

3.08 ADJUSTING (NOT USED)

3.09 CLEANING (NOT USED)

3.10 DEMONSTRATION AND TRAINING

A. As specified in Section 17050.

3.11 PROTECTION (NOT USED)

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 17101-30

SPECIFIC CONTROL STRATEGIES – TERTIARY FILTERS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Loop descriptions:
      a. Specific control requirements and functional descriptions for individual control loops.

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 11366A - Cloth Disk Filters.
      c. Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
      d. Section 17100 - Control Strategies.

1.02 REFERENCES

A. As specified in Section 17050.

1.03 DEFINITIONS

A. As specified in Section 17050.

1.04 SYSTEM DESCRIPTION (NOT USED)

1.05 SUBMITTALS

A. Develop detailed loop descriptions based on the information in the Contract Documents, and submit as specified in Sections 01330 and 17050.
   1. For each control loop, provide a detailed functional description of the operation of the equipment, signals, and controls shown on the P&IDs:
      a. Include all functions depicted or described in the Contract Documents.
      b. Include the following within each loop description:
         1) All requirements specific to that loop.
         2) Common control requirements applicable to that loop.
         3) List of all ranges, setpoints, timers, values, counters, etc.

2. Where there are similar loops with identical control, such as multiple loops for individual raw water pumps, only 1 loop description need be developed and the remaining loops may reference that loop description.

B. Loop description format:
   1. Loop number and title.
   2. References:
      a. List P&IDs that are specifically referenced.
   3. Abstract:
      a. General description of how the loop works, what devices are involved, and how the process will be controlled.
      b. Process values, setpoints, and limits, including units and ranges:
         1) Show span and range values for analog inputs and outputs, and operating point and deadband for discrete inputs.
   4. Hardwired control:
      a. Detailed description of the control functions at the local level.
      b. Function of local operator interfaces.
      c. Operation of hardwired field pilot controls:
         1) Pushbuttons.
         2) Selector switches.
         3) Potentiometers.
         4) Pilot lights, indicators, and other displays.
   5. Hardwired interlocks:
      a. Explanation of the operation of system interlocks and hardwired permissive conditions.
   6. PLC control:
      a. Detailed description of the control functions that are under control of the PLC.
      b. Operator controls and automatic controls.
      c. Setpoints, alarms, etc.:
         1) Include units and ranges for analog values.
         2) Include span and range for analog inputs and outputs.
         3) Include operating point and deadband for discrete inputs, and identify conditions where contacts are open, and when they close.
      d. Control sequences.
   7. Software interlocks:
      a. Operation of system software interlocks.
   8. HMI control:
      a. Detailed description of the operator controls.
   9. SCADA control:
      a. Detailed description of the operator controls.
      b. Setpoints, alarms, etc.
   10. Indicators and alarms:
      a. List any indicators and alarms specific to the loop that are not covered in the common control strategies.
   11. Failure modes:
      a. List any failure modes specific to the loop that are not covered in the common control strategies.

1.06 QUALITY ASSURANCE (NOT USED)

1.07 DELIVERY, STORAGE, AND HANDLING (NOT USED)

1.08 PROJECT OR SITE CONDITIONS (NOT USED)

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY (NOT USED)

1.12 SYSTEM START-UP (NOT USED)

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 COMMISSIONING (NOT USED)

1.15 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS (NOT USED)

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS (NOT USED)

2.04 MANUFACTURED UNITS (NOT USED)

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS (NOT USED)

2.07 ACCESSORIES (NOT USED)

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION (NOT USED)

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION

A. Loop 211, 221 – Tertiary Filter Inlet Valves:
   1. References:
      a. 30N02.
      b. 30N03.
      c. Tertiary Filter No. 1 VCP: 30-VCP-210.
      d. Tertiary Filter No. 2 VCP: 30-VCP-220.
      e. Tertiary Filter No. 1 Inlet Valve: 30-EDR-211.
      f. Tertiary Filter No. 2 Inlet Valve: 30-EDR-221.
   2. Abstract:
      a. The Tertiary Filter Influent Valves control secondary effluent flow to the Tertiary Filters.
   3. Hardwired control:
      a. With the LOR switch in LOCAL position, the Tertiary Filter Inlet Valves are controlled by OPEN/STOP/CLOSE selector switches.
   4. Hardwired interlocks
      a. No hardwire interlocks.
   5. PLC control:
      a. In PCIS AUTO, the channel gates are controlled via the PLC:
         1) The PLC shall open the Tertiary Filter Inlet Valves based on the position of the Filter ONLINE/OFFLINE SCADA software selector switch.
            a) The PLC shall open the Tertiary Filter Inlet Valve if Filter ONLINE is selected.
            b) The PLC shall close the Tertiary Filter Inlet Valve if Filter OFFLINE is selected.
   6. Software interlocks:
      a. None.
   7. HMI control:
      a. As indicated on the Drawings and in Section 17100.
   8. SCADA control:
      a. As indicated on the Drawings and in Section 17100.
   9. Indicators and alarms:
         1) As indicated on the Drawings and in Section 17100.
   10. Failure modes:
      a. If two both Tertiary Filters are ONLINE:
         1) If a COMMON FAIL signal is received by an ONLINE Filter VCP, the PLC shall close the Tertiary Filter Inlet Valve and place it OFFLINE.
      b. If one Tertiary Filter is ONLINE:
         1) If a COMMON FAIL signal is received by the ONLINE Filter VCP, the PLC shall open the Tertiary Filter Inlet Valve for the OFFLINE filter and place the filter ONLINE. The PLC shall then close the Tertiary Filter Inlet Valve for the failed filter and place it OFFLINE.

B. Loops 210, 220 – Tertiary Cloth Filters:
   1. References:
      a. 30N01.
      b. 30N02.
      c. 30N03.
      d. Tertiary Filter No. 1 VCP: 30-VCP-210.
      e. Tertiary Filter No. 2 VCP: 30-VCP-220.

f. Tertiary Filter No. 1 Inlet Valve: 30-EDR-211.
g. Tertiary Filter No. 2 Inlet Valve: 30-EDR-221.

2. Abstract:
   a. Each filter system consists of, 2 backwash pumps, 5 motorized backwash valves, a motorized sludge valve, a vendor control panel with an integral PLC, and other instrumentation and controls.
3. Hardwired control:
   a. As Indicated in Section 11366A.
4. Hardwired interlocks:
   a. As Indicated in Section 11366A.
5. PLC control:
   a. As Indicated in Section 11366A.
   b. In PCIS AUTO, the Tertiary Filters are controlled via the Plant PLC:
      1) Upon receiving a BACKWASH READY signal from a Filter VCP, The Plant PLC shall issue a FILTER HIGH FLOW signal to the UV PLC as described in specification 17101-31. The signal shall remain while BACKWASH status is received from the Filter VCP and will cease once a FILTERING status is received from the Filter VCP.
      2) Following notification to the UV VCP of FILTER HIGH FLOW, the Plant PLC shall issue a backwash permissive to the Filter VCP following an operator adjustable setpoint time delay.
      3) The Plant PLC shall not issue permissives to allow for simultaneous backwashing of both filters at any time.
6. Software interlocks:
   a. As Indicated in Section 11366A.
7. HMI control:
   a. As Indicated in Section 11366A.
8. Indicators and alarms:
   a. As indicated on the Drawings and in Section 11366A.
9. Failure modes:
   a. As indicated on the Drawings and in Section 11366A.

3.05 REPAIR/RESTORATION (NOT USED)

3.06 REINSTALLATION (NOT USED)

3.07 FIELD QUALITY CONTROL (NOT USED)

3.08 ADJUSTING (NOT USED)

3.09 CLEANING (NOT USED)

3.10 DEMONSTRATION AND TRAINING

A. As specified in Section 17050.

3.11 PROTECTION (NOT USED)

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 17101-31

SPECIFIC CONTROL STRATEGIES – UV FACILITY

PART 1 GENERAL

1.01 SUMMARY

A. This section is provided for requirements as a minimum. CONTRACTOR shall also refer to Section 11287 and coordinate with SUPPLIER to provide the programming requirements for a fully operational ultraviolet (UV) disinfection system.

B. Section includes:
   1. Loop descriptions:
      a. Specific control requirements and functional descriptions for individual control loops.

C. 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 - Common Work Results for Process Control and Instrumentation Systems.

1.02 REFERENCES

A. As specified in Section 17050.

1.03 DEFINITIONS

A. As specified in Section 17050.

1.04 SYSTEM DESCRIPTION (NOT USED)

1.05 SUBMITTALS

A. Develop detailed loop descriptions based on the information in the Contract Documents, and submit as specified in Sections 01330 and 17050.
   1. For each control loop, provide a detailed functional description of the operation of the equipment, signals, and controls shown on the P&IDs:
      a. Include all functions depicted or described in the Contract Documents.
      b. Include the following within each loop description:
         1) All requirements specific to that loop.

        2) Common control requirements applicable to that loop.
        3) List of all ranges, setpoints, timers, values, counters, etc.
    2. Where there are similar loops with identical control, such as multiple loops for individual raw water pumps, only 1 loop description need be developed and the remaining loops may reference that loop description.

B. Loop description format:
    1. Loop number and title.
    2. References:
        a. List P&IDs that are specifically referenced.
    3. Abstract:
        a. General description of how the loop works, what devices are involved, and how the process will be controlled.
        b. Process values, setpoints, and limits, including units and ranges:
            1) Show span and range values for analog inputs and outputs, and operating point and deadband for discrete inputs.
    4. Hardwired control:
        a. Detailed description of the control functions at the local level.
        b. Function of local operator interfaces.
        c. Operation of hardwired field pilot controls:
            1) Pushbuttons.
            2) Selector switches.
            3) Potentiometers.
            4) Pilot lights, indicators, and other displays.
    5. Hardwired interlocks:
        a. Explanation of the operation of system interlocks and hardwired permissive conditions.
    6. PLC control:
        a. Detailed description of the control functions that are under control of the PLC.
        b. Operator controls and automatic controls.
        c. Setpoints, alarms, etc.:
            1) Include units and ranges for analog values.
            2) Include span and range for analog inputs and outputs.
            3) Include operating point and deadband for discrete inputs, and identify conditions where contacts are open, and when they close.
        d. Control sequences.
    7. Software interlocks:
        a. Operation of system software interlocks.
    8. HMI control:
        a. Detailed description of the operator controls.
    9. SCADA control:
        a. Detailed description of the operator controls.
        b. Setpoints, alarms, etc.
    10. Indicators and alarms:
        a. List any indicators and alarms specific to the loop that are not covered in the common control strategies.
    11. Failure modes:
        a. List any failure modes specific to the loop that are not covered in the common control strategies.

1.06 QUALITY ASSURANCE (NOT USED)

1.07 DELIVERY, STORAGE, AND HANDLING (NOT USED)

1.08 PROJECT OR SITE CONDITIONS (NOT USED)

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY (NOT USED)

1.12 SYSTEM START-UP (NOT USED)

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 COMMISSIONING (NOT USED)

1.15 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS (NOT USED)

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS (NOT USED)

2.04 MANUFACTURED UNITS (NOT USED)

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS (NOT USED)

2.07 ACCESSORIES (NOT USED)

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION (NOT USED)

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION

A. Loop 230 – Tertiary Effluent Turbidity:
   1. References:
      a. 28N03.
      b. 30N01.
      c. 31N01.
      d. 32N02.
      e. 32N03.
      f. Alum Pump No. 1: 32-PMP-271.
      g. Alum Pump No. 2: 32-PMP-272.
      h. Flash Mix Pump No. 1: 28-PMP-185.
      i. Flash Mix Pump No. 2: 28-PMP-186.
   2. Abstract:
      a. Filter effluent turbidity is continuously monitored immediately upstream of the UV Disinfection structure.
      b. The turbidity analyzer ensures the water quality remains in compliance with the current criteria set forth by California Department of Public Health (CDPH) for tertiary disinfected recycled water: Effluent turbidity shall not exceed 2 NTU within a 24-hour period, 5 NTU for more than 5-percent of the time within a 24-hour period, and never exceeds 10 NTU.
   3. Hardwired control:
      a. None.
   4. Hardwired interlocks:
      a. None.
   5. PLC control:
      a. With the ENABLE/DISABLE SCADA software selector switch in ENABLE:
         1) Exceeding a turbidity trend over the past 24 hour period for either 2 NTU or 5 NTU for more than 5-percent of the time will trigger the “HIGH FILTER EFFLUENT TURBIDITY” alarm and simultaneously start the flash mix pumps and coagulant addition as described in Sections 17101-28 and 17101-32, respectively.
         2) Exceeding an instantaneous turbidity value of 10 NTU for an operator adjustable duration (0 – 15 minutes) will trigger the “HIGH-HIGH FILTER EFFLUENT TURBIDITY” alarm and:
            a) Simultaneously start the flash mix pumps and Aluminum Sulfate Pump as described in Sections 17101-28 and 17101-32, respectively.
            b) Open tertiary filter-to-waste valve, 31-EDR-240.
            c) Send NOT READY permissive to Plant PLC to close all UV inlet valves and turn off UV banks.
      b. With the HOA toggle switch in HAND mode:
         1) The turbidity analyzer will trigger an operator notification alarm at SCADA at the high and high-high turbidity setpoints only.
   6. Software interlocks:
      a. None.
   7. HMI control:
      a. As indicated on the Drawings and in Section 17100.
   8. SCADA control:
      a. As indicated on the Drawings and in Section 17100.

9. Indicators and alarms:
    a. As indicated on the Drawings and in Section 17100.
10. Failure modes:
    a. If communication with the turbidity analyzer fails, alarm at SCADA and the coagulant addition and dispersion system shall automatically activate.

B. Loop 240 – UV System:
1. References:
    a. 31N01.
    b. 31N02.
    c. 31N03.
2. Abstract:
    a. Filter effluent exiting the Tertiary Filters is send to the UV System for final disinfection.
3. Hardwired control:
    a. As indicated in Section 11287.
4. Hardwired interlocks:
    a. No hardwired interlocks:
5. PLC control:
    a. In PCIS AUTO, the Plant PLC communicates with the UV PLC via Ethernet:
        1) UV System Startup: Refers to startup of the complete UV system.
            a) The Plant PLC shall issue the RUN permissive to the UV PLC as described in Section 17101-28. UV PLC will initiate the startup sequence for the same number of channels as required during previous operation.
            b) Prior to initiating the startup sequence, the UV PLC confirms the water level in the channel(s) being called to run:
                (1) Operating preference is given to channel(s) with normal operating water level.
                (2) If water in channel(s) being called to run is above the low operating level, the UV PLC will initiate the startup sequence for the channel(s) per normal Vendor requirements as described in Section 11287.
                (3) If water in channel(s) being called to run is lower than the low operating level:
                    (a) UV PLC shall request the Plant Water UV Channel Fill valve opens for the channel that is being put into service to the fully open position. If the inlet valve for the channel that is being put into service fails to open, then a fail status shall be generated at Plant PLC and the UV PLC. Start-up of the channel shall not resume until the inlet valve is opened.
                    (b) UV PLC sends “Channel # Filling” signal to Plant PLC. Plant PLC opens the plant water fill valve at the tertiary filter effluent weir.
                    (c) UV PLC monitors and closes the Plant Water UV Channel Fill valve when water has reached low water level.
            c) UV PLC shall initiate and execute the startup sequence for the channel(s) per normal Vendor requirements as described in Section 11287.

d) Upon successful startup completion, the UV PLC will communicate a “UV Channel 1 Running,” “UV Channel 2 Running”, and/or “UV Channel 3 Running” to the Plant PLC. The Plant PLC will begin operation of the Filter Influent Pump Station described in Section 17101-28.

2) System Shutdown:
   a) The Plant PLC shall clear the RUN permissive to the UV PLC as described in Section 17101-28.
   b) The UV PLC will clear the “UV Channel 1 Running,” “UV Channel 2 Running”, and/or “UV Channel 3 Running” signal to the Plant PLC. UV system will shutdown as described in Section 11287.

3) Filter Backwash:
   a) Upon receiving a BACKWASH READY Signal from a FILTER VCP, the Plant PLC will send a FILTER HIGH FLOW signal to the UV PLC to turn ON all duty banks currently operating in the channel(s) to 100-percent power. The signal shall remain while BACKWASH status is received from the Filter VCP and will cease once a FILTERING status is received from the Filter VCP. The UV PLC will then return to normal operating mode.

4) Power Failure:
   a) Upon loss of utility power/use of generator power or restoration to utility power, the UV PLC will retain and attempt to restore the last channel operational settings.
   b) Generator power restrictions: Plant PLC will send “Generator Power” signal to UV PLC while plant is operating on generator power. The signal will interlock the UV PLC from allowing no more than 2 channels to be energized at any given time.
      (1) The UV PLC shall suspend normal UV channel rotation due to run time.
      (2) If one channel is in operation and an alarm is triggered, the UV PLC shall operate as described in Section 11287.
      (3) If two channels are simultaneously in operation and a major alarm is triggered, the UV PLC shall power down the alarming channel and clear the “Channel # Running” signal to the Plant PLC prior to energizing the standby channel.
      (4) Upon restoration of utility power, the Generator Power signal will be cleared.

6. Software interlocks:
   a. As indicated on the Drawings.
7. HMI control:
   a. As indicated on the Drawings and in Section 17100.
8. SCADA control:
   a. As indicated on the Drawings and in Section 17100.
9. Indicators and alarms:
   a. As indicated on the Drawings and in Section 17100.
10. Failure modes:
   a. As indicated on the Drawings and in Section 17100.

C. LOOP 011 – Composite Sampler:
1. References:
   a. 31N02.

b. Composite Sampler: 10-COS-011.
c. UV Channel No. 1 Flowmeter: 31-FIT-241.
d. UV Channel No. 2 Flowmeter: 31-FIT-242.
e. UV Channel No. 3 Flowmeter: 31-FIT-243.
f.

2. Abstract:
   a. The composite sampler draws water samples from the REW Storage Channel.
   b. Flow into each UV channel is monitored by the UV master PLC and transmitted to PLC-1 and SCADA.
   c. The speed of the sampler is flow paced from the total flow entering the UV system.
3. Hardwired Control:
   a. As described in Specification 11635.
4. Hardwired Interlocks:
   a. No hardwire interlocks.
5. PLC Control:
   a. In PCIS AUTO, the composite sampler is controlled via the Plant PLC:
      1) The PLC shall adjust the speed of the sampler proportional to the summation of UV Channel No.'s 1, 2, and 3 flowmeters.
6. Software Interlocks:
   a. No software interlocks.
7. HMI Control:
   a. No HMI control.
8. SCADA Control:
   a. As indicated on the Drawings and Section 17100.
9. Indicators and Alarms:
   a. As indicated on the Drawings and Section 17100.
10. Failure Modes:
    a. As indicated on the Drawings and Section 17100.
    b.

3.05 REPAIR/RESTORATION (NOT USED)

3.06 REINSTALLATION (NOT USED)

3.07 FIELD QUALITY CONTROL (NOT USED)

3.08 ADJUSTING (NOT USED)

3.09 CLEANING (NOT USED)

3.10 DEMONSTRATION AND TRAINING

A. As specified in Section 17050.

3.11 PROTECTION (NOT USED)

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 17101-32

SPECIFIC CONTROL STRATEGIES – CHEMICAL FACILITY

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Loop descriptions:
      a. Specific control requirements and functional descriptions for individual control loops.

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 11242 - Diaphragm-Type Metering Pumps.
      c. Section 11245 - Peristaltic Tube Metering Pumps.
      d. Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
      e. Section 17100 - Control Strategies.
      f. Section 17101-20 - Specific Control Strategies - Oxidation Ditch.
      g. Section 17101-28 - Specific Control Strategies - Filter Influent Pump Station.
      h. Section 17101-31 - Specific Control Strategies - UV Facility.

1.02 REFERENCES

A. As specified in Section 17050.

1.03 DEFINITIONS

A. As specified in Section 17050.

1.04 SYSTEM DESCRIPTION (NOT USED)

1.05 SUBMITTALS

A. Develop detailed loop descriptions based on the information in the Contract Documents, and submit as specified in Sections 01330 and 17050.
   1. For each control loop, provide a detailed functional description of the operation of the equipment, signals, and controls shown on the P&IDs:
      a. Include all functions depicted or described in the Contract Documents.

b. Include the following within each loop description:
    1) All requirements specific to that loop.
    2) Common control requirements applicable to that loop.
    3) List of all ranges, setpoints, timers, values, counters, etc.

2. Where there are similar loops with identical control, such as multiple loops for individual raw water pumps, only 1 loop description need be developed and the remaining loops may reference that loop description.

B. Loop description format:
1. Loop number and title.
2. References:
    a. List P&IDs that are specifically referenced.
3. Abstract:
    a. General description of how the loop works, what devices are involved, and how the process will be controlled.
    b. Process values, setpoints, and limits, including units and ranges:
        1) Show span and range values for analog inputs and outputs, and operating point and deadband for discrete inputs.
4. Hardwired control:
    a. Detailed description of the control functions at the local level.
    b. Function of local operator interfaces.
    c. Operation of hardwired field pilot controls:
        1) Pushbuttons.
        2) Selector switches.
        3) Potentiometers.
        4) Pilot lights, indicators, and other displays.
5. Hardwired interlocks:
    a. Explanation of the operation of system interlocks and hardwired permissive conditions.
6. PLC control:
    a. Detailed description of the control functions that are under control of the PLC.
    b. Operator controls and automatic controls.
    c. Setpoints, alarms, etc.:
        1) Include units and ranges for analog values.
        2) Include span and range for analog inputs and outputs.
        3) Include operating point and deadband for discrete inputs, and identify conditions where contacts are open, and when they close.
    d. Control sequences.
7. Software interlocks:
    a. Operation of system software interlocks.
8. HMI control:
    a. Detailed description of the operator controls.
9. SCADA control:
    a. Detailed description of the operator controls.
    b. Setpoints, alarms, etc.
10. Indicators and alarms:
    a. List any indicators and alarms specific to the loop that are not covered in the common control strategies.
11. Failure modes:
    a. List any failure modes specific to the loop that are not covered in the common control strategies.

1.06 QUALITY ASSURANCE (NOT USED)

1.07 DELIVERY, STORAGE, AND HANDLING (NOT USED)

1.08 PROJECT OR SITE CONDITIONS (NOT USED)

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY (NOT USED)

1.12 SYSTEM START-UP (NOT USED)

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 COMMISSIONING (NOT USED)

1.15 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS (NOT USED)

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS (NOT USED)

2.04 MANUFACTURED UNITS (NOT USED)

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS (NOT USED)

2.07 ACCESSORIES (NOT USED)

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION (NOT USED)

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION

A. Loops 271, 272 - Aluminum Sulfate (ALUM):
   1. References:
      a. 32N01.
      b. 32N02.
      c. 32N03.
      d. 28N01.
      e. 28N03.
      f. Alum Pump No. 1: 32-PMP-271.
      g. Alum Pump No. 2: 32-PMP-272.
      h. Filter Influent Turbidimeter: 28-AE-181.
      i. Filter Effluent Turbidimeter: 31-AE-181.
      j. Filter Influent Pump Station Flowmeter: 28-FIT-186.
   2. Abstract:
      a. The ALUM system consists of one bulk storage tote and two feed pumps.
      b. ALUM will be added upstream of the tertiary filters, right after the filter influent pumps.
      c. Feed pumps (32-PMP-271 and 32-PMP-272) function as lead and standby and are flow paced based on Filter Influent Pump Station flow. Lead/standby selection is made by operator.
      d. Based on operator selection, the dosing of ALUM can be achieved by:
         1) Direct feed control where the operator sets the feed rate by entering the pump speed manually.
         2) Flow paced control where the operator selects a desired dose and the control system adjusts the chemical feed rate to dose based on process flow, chemical concentration, and specific gravity.
   3. Hardwired control:
      a. As indicated in Section 11245.
   4. Hardwired interlocks:
      a. As indicated in Section 11245.
   5. PLC control:
      a. In PCIS AUTO, the Alum Pumps are controlled via the PLC:
         1) The PLC shall start and stop the Alum Pumps based on Filter Influent and Effluent Turbidity as described in Sections 17101-28 and 17101-31.
         2) Upon Start, the PLC shall use a flow pace control algorithm as described below.
            a) Operator Adjustable Inputs:
               (1) SG = Specific gravity of Aluminum Sulfate solution in lbs per gallon (Initial Setting: 1.335).
               (2) D = Dosage Setpoint as Solution in mg/L (Range 1 to 25, Initial Setting: 3.5 mg/L).
               (3) C = Concentration of Aluminum Sulfate solution in percent (Initial Setting: 48.5%).
            b) Calculated Values:
               (1) FR= Q x D /(C x SG x 24).
               Where FR = volumetric feed rate in gallons per hour and Q = total filter influent pump station flow rate.
         3) The PLC shall adjust the speed of the chemical feeder through a speed control signal to match the feed rate to a flow rate setpoint.

This flow rate setpoint shall be derived from the process flow and operator setpoints for dosage, specific gravity, and concentration.

6. Software interlocks:
   a. No software interlocks.
7. HMI Control:
8. No HMI control. SCADA control:
   a. As indicated on the Drawings and in Section 17100.
9. Indicators and alarms:
   a. As indicated on the Drawings and in Section 17100.
10. Failure modes:
    a. As indicated on the Drawings and in Section 17100.

B. Loops 281, 282, 283, 284, 285 – Sodium Hypochlorite (SHS):
   1. References:
      a. 32N04.
      b. 32N05.
      c. 32N06.
      d. 32N07.
      e. 32N08.
      f. 32N09.
      g. 60N03.
      h. 03N01.
      i. 31N01.
      j. 23N01.
      k. 20N03.
      l. 21N01.
      m. 21N02.
      n. Sodium Hypochlorite Pump No. 1: 32-PMP-281.
      o. Sodium Hypochlorite Pump No. 2: 32-PMP-282.
      p. Sodium Hypochlorite Pump No. 3: 32-PMP-283.
      q. Sodium Hypochlorite Pump No. 4: 32-PMP-284.
      r. Sodium Hypochlorite Pump No. 5: 32-PMP-285.
      s. Potable Water System Sodium Hypochlorite Feed Valve: 32-EDR-281B.
      t. Clarifier No. 1 Sodium Hypochlorite Feed Valve: 32-EDR-281C.
      u. Clarifier No. 2 Sodium Hypochlorite Feed Valve: 32-EDR-281D.
      v. Plant Influent Flowmeter: 10-FIT-010.
      w. Plant Effluent Flowmeter: 40-FIT-307.
   2. Abstract:
      a. The SHS system consists of one bulk storage tank, a chemical fill station, two peristaltic feed pumps, and three diaphragm feed pumps.
      b. SHS will be added:
         1) Upstream of the Hydropneumatic Tank 60-TNK-735.
         2) Directly into the water storage tank 60-TNK-715.
         3) Directly into the Fe-Mn Pressure Filter 60-FLT-716 system chemical feed line.
         4) Directly into Secondary Clarifier No. 1 21-CLR-111 and Secondary Clarifier No. 2 21-CLR-112.
         5) At the Effluent Pump Station.
         6) Directly into REW Pond 1 and REW Pond 2.
         7) Directly into REW Storage Channel, downstream of UV Disinfection.
         8) Upstream of Oxidation Ditch No. 1 and Oxidation Ditch No. 2.
         9) At the Scum Pump Station.

c. Based on operator selection, the dosing of SHS can be achieved by:
   1) Direct feed control where the operator sets the feed rate by entering the pump speed manually.
   2) Flow paced control where the operator selects a desired dose and the control system adjusts the chemical feed rate to dose based on process flow, chemical concentration, and specific gravity.
d. Feed pumps 32-PMP-281 and 32-PMP-282 function as LEAD/STANDBY and operate by using manual feed rate setpoints for each system:
   1) Secondary Clarifier No. 1.
   2) Secondary Clarifier No. 2.
   3) Potable Water System.
e. Feed pumps 32-PMP-283 and 32-PMP-284 function as LEAD/STANDBY, and are flow paced based on Plant Effluent flow. Through manual valve adjustment, pump 32-PMP-284 can also serve as backup to 32-PMP-285.
f. Feed pump 32-PMP-285 is flow paced based on the running average of Plant Influent Flow.

3. Hardwired control:
   a. As indicated in Sections 11245 and 11242.
4. Hardwired interlocks:
   a. As indicated in Sections 11245 and 11242.
5. PLC control:
   a. 32-PMP-281, 32-PMP-282:
      1) In PCIS AUTO, the Sodium Hypochlorite Pumps are controlled via the PLC:
         a) The operator shall enter SHS feed rate for the following locations:
            (1) QF1-Secondary Clarifier No. 1:
                (a) Range: .2GPH to .6GPH, initial setting .4GPH.
            (2) QF2-Secondary Clarifier No. 2:
                (a) Range: .2GPH to .6GPH, initial setting .4GPH.
            (3) QF3-Potable Water System:
                (a) Range: .01GPH to .06GPH, initial setting .03GPH.
         b) The PLC will control the feed rate of the pump based on the sum of the operator entered feed rates and the quantity of Sodium Hypochlorite Feed Valves open as indicated by the valve position switches:
            (1) FR=(QF1+QF2+QF3)/(# of feed valves open).
   b. 32-PMP-283 and 32-PMP-284:
      1) In PCIS AUTO, the Sodium Hypochlorite Pumps are controlled via the PLC:
         a) The PLC shall use a flow pace control algorithm as described below.
            (1) Operator Adjustable Inputs:
                (a) SG = Specific gravity of SHS solution in lbs per gallon (Initial Setting: 1.198).
                (b) D = Dosage Setpoint as Solution in mg/L (Range 2 to 10 mg/L, Initial Setting: 4 mg/L).
                (c) C = Concentration of SHS solution in percent (Initial Setting: 12.5%).

(2) Calculated Values:
(a) FR= Q x D /(C x SG x 24).
Where FR = volumetric feed rate in gallons per hour and Q = total plant effluent flow rate.

b) The PLC shall adjust the speed of the chemical feeder through a speed control signal to match the feed rate to a flow rate setpoint. This flow rate setpoint shall be derived from the process flow and operator setpoints for dosage, specific gravity, and concentration.

c. 32-PMP-285:

1) In PCIS AUTO, the Sodium Hypochlorite Pumps are controlled via the PLC:

a) The PLC shall use a flow pace control algorithm as described below.

(1) Operator Adjustable Inputs:
(a) SG = Specific gravity of SHS solution in lbs per gallon (Initial Setting: 1.198).
(b) D = Dosage Setpoint as Solution in mg/L (Range 9 to 45 mg/L, Initial Setting: 18 mg/L).

(2) Calculated Values:
(a) FR= Q x D /(SG x 24).
Where FR = volumetric feed rate in gallons per hour and Q = total running average plant influent flow rate over a 1-hour period.

b) The PLC shall adjust the speed of the chemical feeder through a speed control signal to match the feed rate to a flow rate setpoint. This flow rate setpoint shall be derived from the process flow and operator setpoints for dosage and specific gravity.

6. Software interlocks:
   a. No software interlocks.
7. HMI Control:
   a. No HMI control.
8. SCADA control:
   a. As indicated on the Drawings and in Section 17100.
9. Indicators and alarms:
   a. As indicated on the Drawings and in Section 17100.
10. Failure modes:
   a. As indicated on the Drawings and in Section 17100.

C. Loops 281B, 281C, 281D – Sodium Hypochlorite Feed Valves

1. References:
   a. 32N05.
   b. 21N01.
   c. 21N02.
   d. 60N01.
   e. 60N02.
   f. 60N03.
   g. 60N05.
   h. Potable Water System Sodium Hypochlorite Feed Valve: 32-EDR-281B.
   i. Clarifier No. 1 Sodium Hypochlorite Feed Valve: 32-EDR-281C.
   j. Clarifier No. 2 Sodium Hypochlorite Feed Valve: 32-EDR-281D.

k. Groundwater Well Pump No. 1: 60-PMP-711.
l. Groundwater Well Pump No. 2: 60-PMP-712.

2. Abstract:
   a. The Sodium Hypochlorite Feed Valves isolate the SHS system from Secondary Clarifiers, and the Potable water system.
   b. The Clarifier Sodium Hypochlorite Feed Valves are normally open unless a DITCH STORAGE mode is initiated.
      1) Refer to Section 17101-20.
   c. The Potable Water System Sodium Hypochlorite Feed Valve can be automatically controlled to open and close based on Groundwater Well Pump operation if manual valves are adjusted in the field to allow dosing into the FE/MN Filter. This operation is operator selectable at SCADA.
3. Hardwired Control:
   a. No hardwired control.
4. Hardwired Interlocks:
   a. No hardwired interlocks.
5. PLC Control:
   a. In PCIS AUTO, the Potable Water System Sodium Hypochlorite Feed Valve is controlled via the PLC:
      1) If the valve ENABLE/DISABLE SCADA software selector switch is in ENABLE:
         a) The PLC shall open the valve upon start of the Groundwater Well Pump.
         b) The PLC shall close the valve upon stop of the Groundwater Well Pump.
      2) If the valve ENABLE/DISABLE SCADA software selector switch is in DISABLE:
         a) The PLC shall open the valve. The valve shall remain open at all times.
6. Software Interlocks:
   a. If a DITCH STORAGE mode is initiated, the Clarifier Sodium Hypochlorite Feed Valves shall operate as described in Section 17101-20.
7. HMI Control:
   a. No HMI control.
8. SCADA Control:
   a. As indicated on the Drawings and Section 17100.
9. Indicators and Alarms:
   a. As indicated on the Drawings and Section 17100.
10. Failure Modes:
    a. As indicated on the Drawings and Section 17100.

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 FIELD QUALITY CONTROL (NOT USED)

3.08 ADJUSTING (NOT USED)

3.09 CLEANING (NOT USED)

3.10 DEMONSTRATION AND TRAINING

A. As specified in Section 17050.

3.11 PROTECTION (NOT USED)

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 17101-40

SPECIFIC CONTROL STRATEGIES – EFFLUENT PUMP STATION

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Loop descriptions:
      a. Specific control requirements and functional descriptions for individual control loops.

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 - Common Work Results for Process Control and Instrumentation Systems.
      c. Section 17100 - Control Strategies.

1.02 REFERENCES

A. As specified in Section 17050.

1.03 DEFINITIONS

A. As specified in Section 17050.

1.04 SYSTEM DESCRIPTION (NOT USED)

1.05 SUBMITTALS

A. Develop detailed loop descriptions based on the information in the Contract Documents, and submit as specified in Sections 01330 and 17050.
   1. For each control loop, provide a detailed functional description of the operation of the equipment, signals, and controls shown on the P&IDs:
      a. Include all functions depicted or described in the Contract Documents.
      b. Include the following within each loop description:
         1) All requirements specific to that loop.
         2) Common control requirements applicable to that loop.
         3) List of all ranges, setpoints, timers, values, counters, etc.

2. Where there are similar loops with identical control, such as multiple loops for individual raw water pumps, only 1 loop description need be developed and the remaining loops may reference that loop description.

B. Loop description format:
   1. Loop number and title.
   2. References:
      a. List P&IDs that are specifically referenced.
   3. Abstract:
      a. General description of how the loop works, what devices are involved, and how the process will be controlled.
      b. Process values, setpoints, and limits, including units and ranges:
         1) Show span and range values for analog inputs and outputs, and operating point and deadband for discrete inputs.
   4. Hardwired control:
      a. Detailed description of the control functions at the local level.
      b. Function of local operator interfaces.
      c. Operation of hardwired field pilot controls:
         1) Pushbuttons.
         2) Selector switches.
         3) Potentiometers.
         4) Pilot lights, indicators, and other displays.
   5. Hardwired interlocks:
      a. Explanation of the operation of system interlocks and hardwired permissive conditions.
   6. PLC control:
      a. Detailed description of the control functions that are under control of the PLC.
      b. Operator controls and automatic controls.
      c. Setpoints, alarms, etc.:
         1) Include units and ranges for analog values.
         2) Include span and range for analog inputs and outputs.
         3) Include operating point and deadband for discrete inputs, and identify conditions where contacts are open, and when they close.
      d. Control sequences.
   7. Software interlocks:
      a. Operation of system software interlocks.
   8. HMI control:
      a. Detailed description of the operator controls.
   9. SCADA control:
      a. Detailed description of the operator controls.
      b. Setpoints, alarms, etc.
   10. Indicators and alarms:
      a. List any indicators and alarms specific to the loop that are not covered in the common control strategies.
   11. Failure modes:
      a. List any failure modes specific to the loop that are not covered in the common control strategies.

1.06 QUALITY ASSURANCE (NOT USED)

1.07 DELIVERY, STORAGE, AND HANDLING (NOT USED)

1.08 PROJECT OR SITE CONDITIONS (NOT USED)

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY (NOT USED)

1.12 SYSTEM START-UP (NOT USED)

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 COMMISSIONING (NOT USED)

1.15 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS (NOT USED)

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS (NOT USED)

2.04 MANUFACTURED UNITS (NOT USED)

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS (NOT USED)

2.07 ACCESSORIES (NOT USED)

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION (NOT USED)

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION

A. Loops 301, 302, 303, 304 - Effluent Pumps:
   1. References:
      a. 40N01.
      b. 40N02.
      c. 40N03.
      d. Effluent Pump No. 1: 40-PMP-301.
      e. Effluent Pump No. 2: 40-PMP-302.
      f. Effluent Pump No. 3: 40-PMP-303.
      g. Effluent Pump No. 4: 40-PMP-304.
      h. Effluent Pump Discharge Header Pressure Transmitter: 40-PIT-306.
      i. 03N01:
         1) REW Pond 1 Outlet Gate: 03-EDR-323.
         2) REW Pond 2 Outlet Gate: 03-EDR-325.
         3) REW Pond 1 Level Transmitter: 03-LIT-326.
         4) REW Pond 2 Level Transmitter: 03-LIT-327.
   2. Abstract:
      a. The effluent pump station delivers recycled water to the plant water system as well as the off-site effluent distribution system including the leach field and various irrigation clients.
      b. The pressure in the effluent distribution system is maintained by a hydropneumatic tank. The effluent pumps are operated based on the pressure in the hydropneumatic tank as measured by Pressure Indicating Transmitter 40-PIT-306.
      c. Four effluent pumps are included, all the same size, 3 duty and 1 standby.
      d. The effluent pump station draws water from REW Storage Ponds 1 and 2.
   3. Hardwired control:
      a. With the LOR switch in LOCAL position, the pumps are controlled by the START and STOP pushbuttons.
   4. Hardwired interlocks:
      a. The Effluent Pumps are stopped and prohibited from starting if:
         1) High discharge pressure switch is activated.
         2) Motor temperature switch is activated.
   5. PLC control:
      a. In PCIS AUTO, the Effluent Pumps are controlled via the PLC:
         1) The PLC will control pump operation based on the pressure in the hydropneumatic tank, which varies between 130 psig and 110 psig.
         2) Decreasing pressure operation:
            a) The LEAD pump shall start when the pressure of the hydropneumatic tank reaches an operator adjustable START LEAD pressure setpoint, preset at 115 PSIG, for an operator adjustable PUMP START setpoint proving time.
            b) Following start of the LEAD pump, the LAG 1 pump shall start upon decreasing pressure in the hydropneumatic tank at an operator adjustable START LAG 1 pressure setpoint preset at 112 psig, for an operator adjustable PUMP START setpoint proving time.
            c) Following start of the LAG 1 pump, the LAG 2 pump shall start upon decreasing pressure in the hydropneumatic tank at an operator adjustable START LAG 2 pressure setpoint preset at

110 psig, for an operator adjustable PUMP START setpoint proving time.

d) Following start of the LAG 2 pump, the LAG 3 pump shall start upon decreasing pressure in the hydropneumatic tank at an operator adjustable START LAG 3 pressure setpoint preset at 106 psig, for an operator adjustable PUMP START setpoint proving time.

3) Increasing pressure operation:

a) The LAG 3 Pump will stop when hydropneumatic tank reaches an operator adjustable STOP LAG 3 pressure setpoint preset at 118 psig, for an operator adjustable PUMP STOP setpoint proving time. If the LAG 3 pump is not operational, the PLC will proceed to the next step.

b) The LAG 2 Pump will stop when hydropneumatic tank reaches an operator adjustable STOP LAG 2 pressure setpoint preset at 120 psig, for an operator adjustable PUMP STOP setpoint proving time. If the LAG 2 pump is not operational, the PLC will proceed to the next step.

c) The LAG 1 Pump will stop when hydropneumatic tank reaches an operator adjustable STOP LAG 1 pressure setpoint preset at 125 psig, for an operator adjustable PUMP STOP setpoint proving time. If the LAG 2 pump is not operational, the PLC will proceed to the next step.

d) The LEAD Pump will stop when hydropneumatic tank reaches an operator adjustable STOP LEAD pressure setpoint preset at 130 psig, for an operator adjustable PUMP STOP setpoint proving time.

4) Pump starting status shall be maintained in the following way:

a) Alternate the priority position of the pumps after the lead and lag pumps are started and then stopped. At which point, each pump that is in automatic mode should alternate position following the cycle:

(1) LEAD → LAG 1 → LAG 2 → LAG 3 → LEAD

b) If any of pumps fail, the control system shall alarm the condition and re-assign the pump configuration. When the pump is proven ready for service, it should be entered back into the lag position.

6. Software interlocks:

a. The Effluent Pumps are stopped and prohibited from starting if:

1) In PCIS AUTO Both REW Pond 1 and 2 Outlet Gates are closed.

2) In PCIS AUTO Both REW Pond Level Indicating Transmitters reach an operator adjustable STOP level setpoint.

7. HMI control:

a. No HMI control.

8. SCADA control:

a. As indicated on the Drawings and in Section 17100.

9. Indicators and alarms:

a. As indicated on the Drawings and in Section 17100.

10. Failure modes:

a. As indicated on the Drawings and in Section 17100.

3.05 REPAIR/RESTORATION (NOT USED)

3.06 REINSTALLATION (NOT USED)

3.07 FIELD QUALITY CONTROL (NOT USED)

3.08 ADJUSTING (NOT USED)

3.09 CLEANING (NOT USED)

3.10 DEMONSTRATION AND TRAINING

A. As specified in Section 17050.

3.11 PROTECTION (NOT USED)

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 17101-50

SPECIFIC CONTROL STRATEGIES – SOLIDS STORAGE TANKS, RAS/WAS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Loop descriptions:
      a. Specific control requirements and functional descriptions for individual control loops.

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 - Common Work Results for Process Control and Instrumentation Systems.

1.02 REFERENCES

A. As specified in Section 17050.

1.03 DEFINITIONS

A. As specified in Section 17050.

1.04 SYSTEM DESCRIPTION (NOT USED)

1.05 SUBMITTALS

A. Develop detailed loop descriptions based on the information in the Contract Documents, and submit as specified in Sections 01330 and 17050.
   1. For each control loop, provide a detailed functional description of the operation of the equipment, signals, and controls shown on the P&IDs:
      a. Include all functions depicted or described in the Contract Documents.
      b. Include the following within each loop description:
         1) All requirements specific to that loop.
         2) Common control requirements applicable to that loop.
         3) List of all ranges, setpoints, timers, values, counters, etc.
   2. Where there are similar loops with identical control, such as multiple loops for individual raw water pumps, only 1 loop description need be developed and the remaining loops may reference that loop description.

B. Loop description format:
   1. Loop number and title.
   2. References:
      a. List P&IDs that are specifically referenced.
   3. Abstract:
      a. General description of how the loop works, what devices are involved, and how the process will be controlled.
      b. Process values, setpoints, and limits, including units and ranges:
         1) Show span and range values for analog inputs and outputs, and operating point and deadband for discrete inputs.
   4. Hardwired control:
      a. Detailed description of the control functions at the local level.
      b. Function of local operator interfaces.
      c. Operation of hardwired field pilot controls:
         1) Pushbuttons.
         2) Selector switches.
         3) Potentiometers.
         4) Pilot lights, indicators, and other displays.
   5. Hardwired interlocks:
      a. Explanation of the operation of system interlocks and hardwired permissive conditions.
   6. PLC control:
      a. Detailed description of the control functions that are under control of the PLC.
      b. Operator controls and automatic controls.
      c. Setpoints, alarms, etc.:
         1) Include units and ranges for analog values.
         2) Include span and range for analog inputs and outputs.
         3) Include operating point and deadband for discrete inputs, and identify conditions where contacts are open, and when they close.
      d. Control sequences.
   7. Software interlocks:
      a. Operation of system software interlocks.
   8. HMI control:
      a. Detailed description of the operator controls.
   9. SCADA control:
      a. Detailed description of the operator controls.
      b. Setpoints, alarms, etc.
   10. Indicators and alarms:
      a. List any indicators and alarms specific to the loop that are not covered in the common control strategies.
   11. Failure modes:
      a. List any failure modes specific to the loop that are not covered in the common control strategies.

1.06 QUALITY ASSURANCE (NOT USED)

1.07 DELIVERY, STORAGE, AND HANDLING (NOT USED)

1.08 PROJECT OR SITE CONDITIONS (NOT USED)

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY (NOT USED)

1.12 SYSTEM START-UP (NOT USED)

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 COMMISSIONING (NOT USED)

1.15 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS (NOT USED)

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS (NOT USED)

2.04 MANUFACTURED UNITS (NOT USED)

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS (NOT USED)

2.07 ACCESSORIES (NOT USED)

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION (NOT USED)

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION

A. Loops 401, 402, 403, 404, 405, 406, 407, 408 – Blower System:
   1. References:
      a. 50N04.
      b. 50N05.
      c. 50N06.

d. 50N07.
e. Sludge Aeration Blower No. 1: 50-BLO-401.
f. Sludge Aeration Blower No. 2: 50-BLO-402.
g. Sludge Aeration Blower No. 3: 50-BLO-403.
h. Blower No. 1 Discharge Valve: 50-EDR-404.
i. Blower No. 2 Discharge Valve: 50-EDR-405.
j. Blower No. 3 Discharge Valve: 50-EDR-406.
k. Blower Cross-tie Valve No. 1: 50-EDR-407.
l. Blower Cross-tie Valve No. 2: 50-EDR-408.
m. Sludge Storage Tank No. 1 Differential Pressure Transmitter: 50-PDIT-411.
n. Sludge Storage Tank No. 2 Differential Pressure Transmitter: 50-PDIT-412.

2. Abstract:
   a. The Sludge Aeration Blowers provide air to the Sludge Storage Tanks for sludge mixing.
   b. There are 3 blowers. Two of the blowers are LEAD and the third blower is STANDBY.
   c. Each bower has a motorized Discharge Valve that opens prior to starting the blower.
   d. There are two motorized Cross-tie valves that are operated .
   e. Blower No. 1 is dedicated to provide air to Solid Storage Tank No. 1.
   f. Blower No. 3 is dedicated to provide air to Solid Storage Tank No. 2.
   g. Blower No. 2 and the associated motorized Cross-tie Valves can be selected to provide air to either Sludge Storage Tank No. 1 or Sludge Tank No. 2.
   h. All Blower Valves are normally closed unless a Blower is called to operate.
3. Hardwired control:
   a. With the LOR switch in LOCAL position, the Blowers are controlled by the START and STOP pushbuttons.
   b. With the LOR switch in LOCAL position, the Blower Valves are controlled by the OPEN/STOP/CLOSE selector switches.
4. Hardwired interlocks:
   a. The Blowers are stopped and prohibited from starting if:
      1) Blower high discharge pressure switch is activated.
      2) Pump motor high temperature switch is activated.
      3) Blower vacuum pressure switch is activated.
5. PLC control:
   a. In PCIS AUTO, the Blowers are controlled via the PLC:
      1) The PLC shall control the Blowers System based on the position of the Blower LEAD/STANDBY SCADA software switches for each blower:
         a) Only one blower shall be permitted to serve as lead for each tank.
         b) If any of the blowers or valve fail, the control system shall alarm the condition and re-assign the system configuration. When the blower or valve is proven ready for service it should be entered back into the standby position

2) **Blower 1:** If LEAD is selected via the LEAD/STANDBY SCADA software selector switch, the PLC shall perform the following operations.
   a) The PLC shall open the Blower No. 1 Discharge Valve when the level in Sludge Storage Tank No. 1 reaches an operator adjustable START BLOWER setpoint. When the Blower No. 1 Discharge Valve is proven open by the position switches, the PLC shall start the blower.
   b) The PLC shall stop the Blower when the level in Sludge Storage Tank No. 1 reaches an operator adjustable STOP BLOWER setpoint. When the Blower run status is no longer present, the PLC shall close the Blower No. 1 Discharge Valve.
3) **Blower 2:** If LEAD is selected via the LEAD/STANDBY SCADA software selector switch, the PLC shall perform the following operations.
   a) If TANK1 is selected via the TANK1/TANK2 SCADA software selector switch:
      (1) The PLC shall open the Blower No. 2 Discharge Valve and Blower Cross-tie Valve No. 1 when the level in Sludge Storage Tank No. 1 reaches an operator adjustable START BLOWER setpoint. When the Blower No. 2 Discharge Valve and Blower Cross-tie Valve No. 1 is proven open by the position switches, the PLC shall start the Blower.
      (2) The PLC shall stop the Blower when the level in Sludge Storage Tank No. 1 reaches an operator adjustable STOP BLOWER setpoint. When the Blower run status is no longer present, the PLC shall close the Blower No. 1 Discharge Valve and Blower Cross-tie Valve No. 1.
   b) If TANK2 is selected via the TANK1/TANK2 SCADA software selector switch:
      (1) The PLC shall open the Blower No. 2 Discharge Valve and Blower Cross-tie Valve No. 2 when the level in Sludge Storage Tank No. 2 reaches an operator adjustable START BLOWER setpoint. When the Blower No. 2 Discharge Valve and Blower Cross-tie Valve No. 2 is proven open by the position switches, the PLC shall start the Blower.
      (2) The PLC shall stop the Blower when the level in Sludge Storage Tank No. 2 reaches an operator adjustable STOP BLOWER setpoint. When the Blower run status is no longer present, the PLC shall close the Blower No. 2 Discharge Valve and Blower Cross-tie Valve No. 2.
4) **Blower 3:** If LEAD is selected via the LEAD/STANDBY SCADA software selector switch, the PLC shall perform the following operations.
   a) The PLC shall open the Blower No. 3 Discharge Valve when the level in Sludge Storage Tank No. 2 reaches an operator adjustable START BLOWER setpoint. When the Blower No. 3 Discharge Valve is proven open by the position switches the PLC shall start the blower.
   b) The PLC shall stop the Blower when the level in Sludge Storage Tank No. 2 reaches an operator adjustable STOP BLOWER

setpoint. When the blower run status is no longer present, the PLC shall close the Blower No. 3 Discharge Valve.

6. Software interlocks:
   a. The PLC shall stop the blower and prohibit it from starting if:
      1) Any valve associated with the blower is proven closed by the position switches.
7. HMI control:
   a. No HMI control.
8. SCADA control:
   a. As indicated on the Drawings and Section 17100.
9. Indicators and alarms:
   a. As indicated on the Drawings and Section 17100.
10. Failure modes:
    a. As indicated on the Drawings and Section 17100.

B. Loops 417, 418 – Sludge Storage Tank Dewatering Feed Valves
1. References:
   a. 50N08.
   b. 50N09.
   c. Sludge Storage Tank No. 1 Dewatering Feed Valve: 50-EDR-417.
   d. Sludge Storage Tank No. 2 Dewatering Feed Valve: 50-EDR-418.
2. Abstract:
   a. Sludge Storage Tank Dewatering Feed Valves isolate sludge from the dewatering trains.
3. Hardwired Control:
   a. With the LOR switch in LOCAL position, the Sludge Storage Tank Dewatering Feed Valves are controlled by the OPEN/STOP/CLOSE selector switches.
4. Hardwired Interlocks:
   a. No hardwired interlocks.
5. PLC Control:
   a. The Sludge Storage Tank Dewatering Feed Valves are normally closed unless a dewatering cycle is in progress as described in Specification Section 17101-51.
   b. In PCIS AUTO, the Sludge Storage Tank Dewatering Feed Valves are controlled via the PLC as described in the Dewatering System section of Specification Section 17101-51.
6. Software Interlocks:
   a. No software interlocks.
7. HMI Control:
   a. No HMI control.
8. SCADA Control:
   a. As indicated on the Drawings and Section 17100.
9. Indicators and Alarms:
   a. As indicated on the Drawings and Section 17100.
10. Failure Modes:
    a. As indicated on the Drawings and Section 17100.

C. Loops 417, 418 – Sludge Storage Tank Dewatering Feed Valves:
1. References:
   a. 50N08.
   b. 50N09.

c. Sludge Storage Tank No. 1 Dewatering Feed Valve: 50-EDR-417.
d. Sludge Storage Tank No. 2 Dewatering Feed Valve: 50-EDR-418.

2. Abstract:
   a. Sludge Storage Tank Dewatering Feed Valves isolate sludge from the dewatering trains.
3. Hardwired Control:
   a. With the LOR switch in LOCAL position, the Sludge Storage Tank Dewatering Feed Valves are controlled by the OPEN/STOP/CLOSE selector switches.
4. Hardwired Interlocks:
   a. No hardwired interlocks.
5. PLC Control:
   a. The Sludge Storage Tank Dewatering Feed Valves are normally closed unless a dewatering cycle is in progress as described in Specification Section 17101-51.
   b. In PCIS AUTO, the Sludge Storage Tank Dewatering Feed Valves are controlled via the PLC as described in the Dewatering System section of Specification Section 17101-51.
6. Software Interlocks:
   a. No software interlocks.
7. HMI Control:
   a. No HMI control.
8. SCADA Control:
   a. As indicated on the Drawings and Section 17100.
9. Indicators and Alarms:
   a. As indicated on the Drawings and Section 17100.
10. Failure Modes:
    a. As indicated on the Drawings and Section 17100.

D. Loops 423, 427 – Dewatering Feed Pumps:
1. References:
   a. 50N10.
   b. 50N11.
   c. Dewatering Feed Pump No. 1: 50-PMP-423.
   d. Dewatering Feed Pump No. 2: 50-PMP-427.
   e. Dewatering Feed Pump No. 1 Flowmeter: 50-FIT-425.
   f. Dewatering Feed Pump No. 2 Flowmeter: 50-FIT-429.
2. Abstract:
   a. Dewatering Feed Pumps transfer sludge from the sludge storage tanks to the dewatering process. Each of the two pumps is dedicated to a dewatering train. Sludge piping and manual valves connecting the two trains enable each pump to feed the second dewatering train when necessary.
   b. The Dewatering Feed Pumps will only operate if their associated Dewatering Feed Grinders are in operation.
3. Hardwired Control:
   a. With the LOR switch in LOCAL position, the Dewatering Feed Pumps are controlled by the START and STOP pushbuttons.
   b. The Dewatering Feed Pumps seal water solenoids are energized during the following periods:
      1) During pump operation.

2) For an adjustable period of time prior to pump start.
3) For an adjustable period of time following pump stop.

4. Hardwired Interlocks:
   a. The Dewatering Feed Pumps are stopped and prohibited from starting if:
      1) Pump discharge pressure switch is activated.
      2) Pump motor high temperature switch is activated.
      3) Pump stator high temperature switch is activated.
      4) Seal water low-flow switch is activated.
      5) Dewatering Feed Grinder is not running.
5. PLC Control:
   a. In PCIS AUTO, the Dewatering Feed Pumps are controlled via the PLC as described in the Dewatering System section of Specification 17101-51.
      1) Adjust the speed of the Dewatering Feed Pumps via a PID control algorithm to maintain a set-point feed rate to the Screw Press:
         a) SP = Operator entered sludge flow rate:
         b) PV = Sludge flow rate measured by the associated Dewatering Feed Pump Flowmeter.
         c) CV = Dewatering Feed Pump:
6. Software Interlocks:
   a. No software interlocks.
7. HMI Control:
   a. No HMI control.
8. SCADA Control:
   a. As indicated on the Drawings and Section 17100.
9. Indicators and Alarms:
   a. As indicated on the Drawings and Section 17100.
10. Failure Modes:
    a. As indicated on the Drawings and Section 17100.

E. Loops 422, 426 – Dewatering Feed Grinders:
1. References:
   a. 50N10.
   b. 50N11.
   c. Dewatering Feed Grinder No. 1: 50-GDR-422.
   d. Dewatering Feed Grinder No. 2: 50- GDR -426.
2. Abstract:
   a. The Dewatering Feed Grinders prepare incoming sludge from the sludge storage tanks prior to entering the Dewatering feed pumps. Each Grinder is dedicated to its Dewatering Feed Pump.
   b. The Dewatering Feed Grinders are started whenever the associated Dewatering Feed Pump is called to run.
3. Hardwired Control:
   a. As specified in Section 11334.
   b. The Dewatering Feed Grinders are started whenever the associated Dewatering Feed Pump is called to run.
4. Hardwired Interlocks:
   a. No hardwired interlocks:
5. PLC Control:
   a. No PLC control.
6. Software Interlocks:
   a. No software interlocks.

7. HMI Control:
    a. No HMI control.
8. SCADA Control:
    a. As indicated on the Drawings and Section 17100.
9. Indicators and Alarms:
    a. As indicated on the Drawings and Section 17100.
10. Failure Modes:
    a. As indicated on the Drawings and Section 17100.

A. Loops 120 through 129 - Title: RAS/WAS Pump Station:
1. References:
    a. 50N01.
    b. 50N02.
    c. 50N02A.
    d. 50N03.
    e. RAS/WAS Pump No. 1: 50-PMP-121.
    f. RAS/WAS Pump No. 2: 50-PMP-122.
    g. RAS/WAS Pump No. 3: 50-PMP-123.
    h. RAS Discharge Flow meter: 50-FIT-126.
    i. WAS Discharge Flow meter: 50-FIT-127.
    j. WAS Isolation Valve No. 1: 50-EDR-128.
    k. WAS Isolation Valve No. 2: 50-EDR-129.
    l. WAS Discharge valve No. 1: 50-EAM-127.
    m. RAS Suction Valve No. 1: 50-EAM-124.
    n. RAS Suction Valve No. 2: 50-EAM-125.
2. Abstract:
    a. RAS/WAS is drawn off the secondary clarifiers.
        1) RAS is pumped to the oxidation ditches.
        2) WAS is pumped to the sludge storage tank.
    b. Flow is measured on the suction side of the pumps from each clarifier and the flow is balanced between the clarifiers.
    c. The RAS flow rate is measured on the discharge side of the pumps and the pump speed is controlled to meet an operator setpoint flow rate.
    d. The WAS flow rate is measured on the discharge side of the pumps and a throttle valve position is controlled to meet an operator setpoint flow rate.
3. Hardwired control:
    a. With the LOR switch in LOCAL position, the RAS/WAS Pumps are controlled by the START and STOP pushbuttons.
        1) The RAS/WAS Pumps seal water solenoids are energized during the following periods:
            a) During pump operation.
            b) For an adjustable period of time prior to pump start.
            c) For an adjustable period of time(set at 5 seconds) following pump stop.
    b. With the LOR switch in LOCAL position, the WAS Isolation Valves are controlled by the OPEN/STOP/CLOSE selector switches.
    c. With the LOR switch in LOCAL position, the WAS Discharge Valve is controlled by the OPEN/STOP/CLOSE selector switches.
    d. With the LOR switch in LOCAL position, the RAS Suction Valves are controlled by the OPEN/STOP/CLOSE selector switches.

4. Hardwired interlocks:
    a. The RAS/WAS Pumps are stopped and prohibited from starting if:
        1) Pump discharge pressure switch is activated.
        2) Pump motor high temperature switch is activated.
        3) Seal water low-flow switch is activated.
5. PLC control:
    a. Pump suction valve:
        1) When the Secondary Clarifier is in AUTO, it shall be considered to be "in service."
        2) Adjust the RAS Suction Valve to maintain an even flow rate split between the "in service" Secondary Clarifiers.
        3) The flow rate shall be calculated as the sum of RAS flow meter (50-FE-126) and the WAS flow meter (50-FE-127).
        4) Adjust RAS Suction Valve for one clarifier at a time with a 120-second delay between clarifiers, to allow the system to stabilize between adjustment.
    b. RAS:
        1) The operator will enter a setpoint flow rate for each hour of the day, adjustable set point 275 gpm to 1,100 gpm.
        2) The PLC shall vary the speed of the pumps to meet the setpoint flow as measured by the RAS flow meter (50-FE-126).
    c. WAS:
        1) The operator will enter the time of day to begin the sludge wasting period (WAS).
        2) The operator will enter the total volume of sludge wasted in gallons.
        3) The operator will enter the WAS flow rate, adjustable set point 275 gpm to 550 gpm.
        4) The PLC shall open control valve 50-EAM-127 on the WAS discharge line.
        5) The PLC shall start pump and ramp the pump up to 100 percent speed.
        6) The PLC shall throttle control valve 50-EAM-127 on the WAS discharge line to maintain the sludge wasting set point as measured by meter 50-FE-127 on the WAS discharge line.
        7) When the totalized WAS flow equals the total WAS volume setpoint, the PLC shall shut down pump and close valve 50-EAM-127 on the WAS discharge line.
6. Software interlocks:
    a. The WAS valve shall not open unless one of the sludge storage tank valves is open.
    b. The RAS pumps shall be interlocked with the DITCH STORAGE mode, refer to Section 17101-20.
    c. The WAS pumping system shall be interlocked with the DITCH STORAGE mode, refer to Section 17101-20.
7. HMI control:
    a. No HMI control.
8. SCADA control:
    a. As indicated on the Drawings and in Section 17100.
9. Indicators and alarms:
    a. As indicated on the Drawings and in Section 17100.

10. Failure modes:
    a. RAS/WAS pumps 2 and 3:
        1) Low seal water flow: Fail pump and start next available pump.
        2) High pump motor temperature: Fail pump and start next available pump.
    b. RAS/WAS pump 1:
        1) Low seal water flow: Fail pump and start next available pump.
        2) High pump motor temperature: Fail pump and start next available pump
        3) If RAS/WAS pump 1 fails during the wasting period the PLC shall open WAS Isolation Valve 50-VAL-128 and close 50-VAL-129 and replace pump 1 with pump 2. If pump 2 is required for the RAS flow set point, the PLC shall replace pump 1 and continue speed control of pump 3, in an attempt to meet the set point flow.
    c. If pump 3 fails and pump 2 is in WAS pumping mode, the PLC shall continue the WAS pumping mode.
    d. If pump 3 fails and pump 2 is not in WAS pumping mode the PLC shall replace the failed pump 3 and continue RAS pumping.
    e. As indicated on the Drawings and in Section 17100.

B. LOOP 126 – Composite Sampler:
1. References:
    a. 50N03.
    b. Composite Sampler: 50-COS-126.
    c. RAS Discharge Flow meter: 50-FIT-126.
2. Abstract:
    a. The composite sampler draws water samples from the RAS discharge header.
    b. The duration and quantity of the sample taken is flow paced from the RAS Discharge Flowmeter.
3. Hardwired Control:
    a. As described in Specification 11635.
4. Hardwired Interlocks:
    a. No hardwire interlocks.
5. PLC Control:
    a. In PCIS AUTO, the composite sampler is controlled via the PLC:
        1) The PLC shall adjust the speed of the sampler proportional to the RAS Discharge Flow Meter.
6. Software Interlocks:
    a. No software interlocks.
7. HMI Control:
    a. No HMI control.
8. SCADA Control:
    a. As indicated on the Drawings and Section 17100.
9. Indicators and Alarms:
    a. As indicated on the Drawings and Section 17100.
10. Failure Modes:
    a. As indicated on the Drawings and Section 17100.

3.05 REPAIR/RESTORATION (NOT USED)

3.06 REINSTALLATION (NOT USED)

3.07 FIELD QUALITY CONTROL (NOT USED)

3.08 ADJUSTING (NOT USED)

3.09 CLEANING (NOT USED)

3.10 DEMONSTRATION AND TRAINING

A. As specified in Section 17050.

3.11 PROTECTION (NOT USED)

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 17101-51

SPECIFIC CONTROL STRATEGIES – DEWATERING

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Loop descriptions:
      a. Specific control requirements and functional descriptions for individual control loops.

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 - Common Work Results for Process Control and Instrumentation Systems.

1.02 REFERENCES

A. As specified in Section 17050.

1.03 DEFINITIONS

A. As specified in Section 17050.

1.04 SYSTEM DESCRIPTION (NOT USED)

1.05 SUBMITTALS

A. Develop detailed loop descriptions based on the information in the Contract Documents, and submit as specified in Sections 01330 and 17050.
   1. For each control loop, provide a detailed functional description of the operation of the equipment, signals, and controls shown on the P&IDs:
      a. Include all functions depicted or described in the Contract Documents.
      b. Include the following within each loop description:
         1) All requirements specific to that loop.
         2) Common control requirements applicable to that loop.
         3) List of all ranges, setpoints, timers, values, counters, etc.
   2. Where there are similar loops with identical control, such as multiple loops for individual raw water pumps, only 1 loop description need be developed and the remaining loops may reference that loop description.

B. Loop description format:
   1. Loop number and title.
   2. References:
      a. List P&IDs that are specifically referenced.
   3. Abstract:
      a. General description of how the loop works, what devices are involved, and how the process will be controlled.
      b. Process values, setpoints, and limits, including units and ranges:
         1) Show span and range values for analog inputs and outputs, and operating point and deadband for discrete inputs.
   4. Hardwired control:
      a. Detailed description of the control functions at the local level.
      b. Function of local operator interfaces.
      c. Operation of hardwired field pilot controls:
         1) Pushbuttons.
         2) Selector switches.
         3) Potentiometers.
         4) Pilot lights, indicators, and other displays.
   5. Hardwired interlocks:
      a. Explanation of the operation of system interlocks and hardwired permissive conditions.
   6. PLC control:
      a. Detailed description of the control functions that are under control of the PLC.
      b. Operator controls and automatic controls.
      c. Setpoints, alarms, etc.:
         1) Include units and ranges for analog values.
         2) Include span and range for analog inputs and outputs.
         3) Include operating point and deadband for discrete inputs, and identify conditions where contacts are open, and when they close.
      d. Control sequences.
   7. Software interlocks:
      a. Operation of system software interlocks.
   8. HMI control:
      a. Detailed description of the operator controls.
   9. SCADA control:
      a. Detailed description of the operator controls.
      b. Setpoints, alarms, etc.
   10. Indicators and alarms:
      a. List any indicators and alarms specific to the loop that are not covered in the common control strategies.
   11. Failure modes:
      a. List any failure modes specific to the loop that are not covered in the common control strategies.

1.06 QUALITY ASSURANCE (NOT USED)

1.07 DELIVERY, STORAGE, AND HANDLING (NOT USED)

1.08 PROJECT OR SITE CONDITIONS (NOT USED)

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY (NOT USED)

1.12 SYSTEM START-UP (NOT USED)

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 COMMISSIONING (NOT USED)

1.15 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS (NOT USED)

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS (NOT USED)

2.04 MANUFACTURED UNITS (NOT USED)

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS (NOT USED)

2.07 ACCESSORIES (NOT USED)

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION (NOT USED)

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION

A. Loop 460 – Dewatering System:
   1. References:
      a. 50N08.
      b. 50N09.
      c. 50N10

d. 51N01.
e. 51N02.
f. 51N03.
g. 51N04.
h. 51N05.
i. Dewatering Feed Pump No. 1: 50-PMP-423.
j. Dewatering Feed Pump No. 2: 50-PMP-427.
k. Dewatering Feed Grinder No. 1: 50-GDR-422.
l. Dewatering Feed Grinder No. 2: 50- GDR -426.
m. Dewatering Train No. 1 Flowmeter: 50-FIT-425.
n. Dewatering Train No. 2 Flowmeter: 50-FIT-429.
o. Dewatering Screw Press No. 1: 51-PRE-431.
p. Dewatering Screw Press No. 2: 51-PRE-432.
q. Dewatering Screw Press No. 1 VCP: 51-VCP-431.
r. Dewatering Screw Press No. 2 VCP: 51-VCP-432.
s. Cake Conveyor No. 1: 51-CNV-433.
t. Cake Conveyor No. 2: 51-CNV-433.
u. Dewatering Inlet Valve No. 1: 50-EDR-421.
v. Dewatering Outlet Valve No. 1: 50-EDR-424.
w. Dewatering Inlet Valve No. 2: 50-EDR-425.
x. Dewatering Outlet Valve No. 2: 50-EDR-428.
y. Sludge Storage Tank No. 1 Dewatering Feed Valve: 50-EDR-417.
z. Sludge Storage Tank No. 2 Dewatering Feed Valve: 50-EDR-418.
aa. Sludge Storage Tank No. 1 Differential Pressure Transmitter: 50-PDIT-411.
bb. Sludge Storage Tank No. 2 Differential Pressure Transmitter: 50-PDIT-412.

2. Abstract:
   a. The dewatering system includes two dewatering trains from the sludge storage tanks, each consisting of a dewatering feed pump, grinder, screw press, polymer injection system, and cake conveyor. Sludge is pumped from the sludge storage tanks to the dewatering screw presses via the dewatering feed pumps. Polymer is injected into the influent sludge pipe via a polymer injection ring upstream of a polymer mixing valve and mixed to condition the sludge for dewatering. The conditioned sludge flows into the inlet of the screw press where it is augured and dewatered. The dewatered cake from the Screw Press is conveyed into a cake hauling truck via a shaftless screw conveyor for final hauling and disposal.
3. Hardwired control:
   a. No hardwired control.
4. Hardwired interlocks:
   a. No hardwired interlocks.
5. PLC control:
   a. In PCIS AUTO, the Dewatering System is controlled via the PLC:
      1) The PLC shall permit START of the Dewatering System based on the position of the Solid Storage Tanks TANK1/TANK2/BOTH SCADA Software selector switch.
         a) If TANK1 is selected, permit START of the Dewatering System if level in Tank 1 is above an operator adjustable START level setpoint.

b) If TANK2 is selected, permit START of the Dewatering System if level in Tank 2 is above an operator adjustable START level setpoint.
c) If BOTH is selected, permit START of the Dewatering System if levels in both tanks are above an operator adjustable START level setpoint.

2) The PLC shall permit START of the Dewatering System only if a DEWATERING MODE READY signal is received from the Dewatering Screw Press VCP press associated with the Train.

3) The PLC shall START the Dewatering System for the respective Dewatering Train based on the position of the TRAIN 1-AUTO/MANUAL and TRAIN 2-AUTO/MANUAL SCADA Software selector switches.
   a) In MANUAL, the train(s) shall be started by START/STOP SCADA Software pushbuttons.
   b) In AUTO, the train(s) shall be started and stopped based on operator adjustable start time and duration setpoints.
      (1) The PLC shall START the Dewatering System at the Operator Adjustable Dewatering Train Start Time (Hour:Minute).
      (2) Once Started, the PLC shall reset and start the Dewatering System Duration Timer.
      (3) The PLC Shall STOP the Dewatering system once the Dewatering System Train Duration Timer reaches the operator adjustable Dewatering System Train Duration Setpoint.
      (4) Following START of the Dewatering System, if the PLC receives a WASH CYCLE READY signal from the Dewatering Screw Press VCP, the PLC will pause the Dewatering System Train Duration Timer and initiate a WASH CYCLE.
      (5) Following completion of the WASH CYCLE the PLC shall resume the Dewatering System Train Duration Timer. The system will continue until subsequent WASH CYCLES are performed or until the timer expires.
      (6) If the selected Solid Storage Tank Reaches an operator adjustable STOP level setpoint, the Dewatering System shall STOP, the Dewatering System Train Duration Timer shall reset, and the Dewatering System shall remain inactive until the next call to run.

4) The steps associated with **Dewatering System START** are as follows:
   a) **Step 1:** The PLC shall open Sludge Storage Tank Dewatering Feed Valves based on the position of the TANK1/TANK2/BOTH SCADA Software selector switch:
      (1) If TANK1 is selected, the PLC shall open Sludge Storage Tank No. 1 Dewatering Feed Valve.
      (2) If TANK2 is selected, the PLC shall open Sludge Storage Tank No. 2 Dewatering Feed Valve.
      (3) If BOTH is selected the PLC shall open both Sludge Storage Tank Dewatering Feed Valves.

Once the Sludge Storage Tank Dewatering Feed Valve(s) are proven open the PLC will proceed to the next step.

b) **Step 2:** The PLC shall open the Dewatering Inlet and Outlet Valves associated with the Dewatering Train. Once the Dewatering Inlet and Outlet Valves are proven open the PLC will proceed to the next step.

c) **Step 3:** The PLC shall issue a remote start command to the Dewatering Screw Press VCP. Once a DEWATERING MODE ACTIVE status signal is received from the Screw Press VCP, a Dewatering Polymer Blending Unit Start Delay Timer Shall reset and start. The PLC will proceed to the next step once the Dewatering Polymer Blending Unit Start Delay Timer expires.

d) **Step 4:** The PLC shall start the Dewatering Polymer Blending Unit. Once a running status signal is received from the Polymer Blending Unit, a Dewatering Feed Pump Start Delay Timer Shall reset and start. The PLC will proceed to the next step once the Dewatering Feed Pump Start Delay Timer expires.

e) **Step 5:** The PLC shall start the Dewatering Feed Pump. Once a running status signal is received from the Dewatering Feed Pump, a Cake Conveyor Start Delay Timer Shall reset and start. The PLC will proceed to the next step once the Cake Conveyor Start Delay Timer expires.

f) **Step 6:** The PLC shall start the Cake Conveyor.

5) The steps associated with **Dewatering System WASH CYCLE** are as follows:

a) **Step 1:** The PLC shall stop the Dewatering Feed Pump. Once the running status signal is no longer present from the Dewatering Feed Pump The PLC shall close the Dewatering Inlet and Outlet Valves associated with the Dewatering Train. Once the Dewatering Inlet and Outlet Valves are proven closed, a Dewatering Polymer Blending Unit Stop Delay Timer Shall reset and start. The PLC will proceed to the next step once the Dewatering Polymer Blending Unit Stop Delay Timer expires.

b) **Step 2:** The PLC shall stop the Dewatering Polymer Blending Unit associated with the Dewatering Train. Once running status signals are no longer present, a Dewatering Screw Press Stop Delay Timer Shall reset and start. The PLC will proceed to the next step once the Dewatering Screw Press Stop Delay Timer expires.

c) **Step 3:** The PLC shall issue a remote stop command to the Dewatering Screw Press VCP. Once the DEWATERING MODE ACTIVE status signal is no longer present from the Screw Press VCP, a Cake Conveyor Stop Delay Timer Shall reset and start. The PLC will proceed to the next step once the Cake Conveyor Stop Delay Timer expires.

d) **Step 4:** The PLC shall stop the Cake Conveyor.

e) **Step 5:** The PLC shall issue a wash cycle start command to the Dewatering Screw Press VCP. The Dewatering Screw Press will enter into a washing sequence and issue a WASH CYCLE ACTIVE STATUS signal to the PLC. When the Dewatering Screw Press VCP removes the WASH CYCLE ACTIVE Status

and Issues a DEWATERING MODE READY Status, the PLC will proceed to the next step.

f) **Step 6:** The PLC shall open the Dewatering Inlet and Outlet Valves associated with the Dewatering Train. Once the Dewatering Inlet and Outlet Valves are proven open the PLC will proceed to the next step.

g) **Step 7:** The PLC shall issue a remote start command to the Dewatering Screw Press VCP. Once a DEWATERING MODE ACTIVE status signal is received from the Screw Press VCP, a Dewatering Polymer Blending Unit Start Delay Timer Shall reset and start. The PLC will proceed to the next step once the Dewatering Polymer Blending Unit Start Delay Timer expires.

h) **Step 8:** The PLC shall start the Dewatering Polymer Blending Unit. Once a running status signal is received from the Polymer Blending Unit, a Dewatering Feed Pump Start Delay Timer Shall reset and start. The PLC will proceed to the next step once the Dewatering Feed Pump Start Delay Timer expires.

i) **Step 9:** The PLC shall start the Dewatering Feed Pump. Once a running status signal is received from the Dewatering Feed Pump, a Cake Conveyor Start Delay Timer Shall reset and start. The PLC will proceed to the next step once the Cake Conveyor Start Delay Timer expires.

j) **Step 10:** The PLC shall start the Cake Conveyor.

6) The steps associated with **Dewatering System STOP** are as follows:

a) **Step 1:** The PLC shall stop the Dewatering Feed Pump. Once the running status signal is no longer present from the Dewatering Feed Pump The PLC shall close the Dewatering Inlet and Outlet Valves associated with the Dewatering Train. Once the Dewatering Inlet and Outlet Valves are proven closed, a Dewatering Polymer Blending Unit Stop Delay Timer Shall reset and start. The PLC will proceed to the next step once the Dewatering Polymer Blending Unit Stop Delay Timer expires.

b) **Step 2:** The PLC shall stop the Dewatering Polymer Blending Unit associated with the Dewatering Train. Once running status signals are no longer present, a Dewatering Screw Press Stop Delay Timer Shall reset and start. The PLC will proceed to the next step once the Dewatering Screw Press Stop Delay Timer expires.

c) **Step 3:** The PLC shall issue a remote stop command to the Dewatering Screw Press VCP. Once the DEWATERING MODE ACTIVE status signal is no longer present from the Screw Press VCP, a Cake Conveyor Stop Delay Timer Shall reset and start. The PLC will proceed to the next step once the Cake Conveyor Stop Delay Timer expires.

d) **Step 4:** The PLC shall stop the Cake Conveyor.

e) **Step 5:** The PLC shall close the Sludge Storage Tank Dewatering Feed Valves based on the position of the TANK1/TANK2/BOTH SCADA Software selector switch:

(1) If TANK1 is selected, the PLC shall close Sludge Storage Tank No. 1 Dewatering Feed Valve.

(2) If TANK2 is selected, the PLC shall close Sludge Storage Tank No. 2 Dewatering Feed Valve.
(3) If BOTH is selected the PLC shall close both Sludge Storage Tank Dewatering Feed Valves.

6. Software interlocks:
   a. The PLC shall STOP the Dewatering System and prohibit it from starting if:
      1) Based on the position of the TANK1/TANK2/BOTH SCADA software selector switch, the Sludge Storage Tank Level associated with the selected tank(s) falls below an operator adjustable STOP LEVEL setpoint.
         a) If TANK1 is selected, STOP the Dewatering System if level in Tank 1 is below an operator adjustable STOP level setpoint.
         b) If TANK2 is selected, STOP the Dewatering System if level in Tank 2 is below an operator adjustable STOP level setpoint.
         c) If BOTH is selected, STOP the Dewatering System if level in either tank is below an operator adjustable STOP level setpoint.
      2) After an operator adjustable time delay, the Dewatering Sludge Flowmeter associated with the operating Dewatering Train Reaches an operator adjustable LOW FLOW ALARM setpoint.
      3) Any failure condition of equipment comprising a Dewatering Train.
      4) Sludge Storage Dewatering Feed Valve associated with the selected Tank(s) is proven closed as indicated by the position switches.
      5) Dewatering Inlet Valve associated with the operating Dewatering Train is proven closed as indicated by the position switches.
      6) Dewatering Outlet Valve associated with the operating Dewatering Train is proven closed as indicated by the position switches.
      7) Running status of any equipment comprising the operating Dewatering Train is no longer present.
7. HMI control:
   a. None.
8. SCADA control:
   a. As indicated on the Drawings and Section 17100.
9. Indicators and alarms:
   a. As indicated on the Drawings and Section 17100.
10. Failure modes:
   a. As indicated on the Drawings and Section 17100.

B. Loops 451, 452 – Dewatering Screw Press:
1. References:
   a. 51N01.
   b. 51N02.
   c. Dewatering Screw Press No. 1: 51-PRE-431.
   d. Dewatering Screw Press No. 2: 51-PRE-432.
   e. Dewatering Screw Press No. 1 VCP: 51-VCP-431.
   f. Dewatering Screw Press No. 2 VCP: 51-VCP-432.
2. Abstract:
   a. The Screw Presses dewater thickened waste activated sludge which is then transported to the screw conveyor.
   b. Each screw press has a VCP, which has a PLC and HMI.
3. Hardwired Control:
   a. As indicated in Section 11380.

4. Hardwired Interlocks:
    a. As indicated in Section 11380.
5. PLC Control:
    a. In PCIS AUTO, the Dewatering Screw Presses are controlled via the PLC as described in the Dewatering System section of the control strategy.
6. Software Interlocks:
    a. No software interlocks.
7. HMI Control:
    a. As indicated in Section 11380.
8. SCADA Control:
    a. As indicated on the Drawings and Section 17100.
9. Indicators and Alarms:
    a. As indicated on the Drawings and Section 17100.
10. Failure Modes:
    a. As indicated on the Drawings and Section 17100.

C. Loops 451, 452 – Dewatering Polymer Blending Units:
1. References:
    a. 51N05.
    b. 50N10.
    c. 50N11.
    d. Dewatering Polymer Blending Unit No. 1: 51-PBU-451.
    e. Dewatering Polymer Blending Unit No. 2: 51-PBU-452.
    f. Dewatering Feed Pump No. 1 Flowmeter: 50-FIT-425.
    g. Dewatering Feed Pump No. 2 Flowmeter: 50-FIT-429.
2. Abstract:
    a. The dewatering polymer blending units (PBUs) are used to inject polymer into the polymer injection ring at the influent sludge pipe upstream of each screw press unit. There are two dewatering PBUs each normally dedicated to a screw press. The polymer piping and manual valves allow for any of the two PBUs to provide polymer to either of the two screw presses. Sludge and polymer are mixed in the pipe via a mixing valve to condition the feed solids before being dewatered in the screw press system.
    b. The polymer is metered from polymer tote bin containers with the polymer metering pump included on the skid-mounted PBU. The polymer dosage is manually adjusted at the PBU control panel or remotely controlled from the plant PLC. The neat polymer pumped from the tote is “activated” by mixing/dilution with potable water (W) or reclaimed plant water (PW) at the PBU before it is delivered to the sludge injection point.
    c. Each PBU will be dedicated to a dewatering unit. The unit will be active when the dewatering train is online and will perform the remote control functions. Manual valves will enable each PBU to feed the second dewatering unit when necessary.
    d. Speed (percent maximum) is automatically adjusted to maintain a setpoint percentage of the feed sludge flow rate.
    e. Polymer blender local control panels are described in Specification Section 11246.
3. Hardwired Control:
    a. As indicated in Section 11246.
4. Hardwired Interlocks:
    a. As indicated in Section 11246.

5. PLC Control:
    a. In PCIS AUTO, the Dewatering Treatment Polymer Blending Unit is controlled via the PLC:
        1) Adjust the speed of the Polymer Blending Unit via a PID control algorithm to maintain a set-point feed rate to the Screw Press:
            a) SP=Operator entered parameters:
                (1) Q_1=Polymer dosage in lbs of active polymer per dry ton of solids.
                (2) Q_2= Percent solids concentration.
                (3) Q_3= Percent polymer active solution.
                (4) Q_4=Density of polymer solution (lbs/gallon).
                (5) Q_5=Maximum output of the Polymer Blending Unit (gallons/hour).
            b) PV = Sludge flow rate measured by the associated Dewatering Feed Pump Flowmeter (F, gallon/min).
            c) CV = Speed of the Dewatering Polymer Blending Unit, calculated as follows:
                (1) Speed= $(F_r \times 100)/Q_5$
                (2) F_r=Feed rate (F_r, gallons/hour) of the Dewatering Polymer Blending Unit, calculated as follows:
                (a) $F_r=(60 \times .0005 \times Q_1 \times F \times 8.34 \times Q_2)/(Q_3 \times Q_4)$.
6. Software Interlocks:
    a. No software interlocks.
7. HMI Control:
    a. No HMI control.
8. SCADA Control:
    a. As indicated on the Drawings and Section 17100.
9. Indicators and Alarms:
    a. As indicated on the Drawings and Section 17100.
10. Failure Modes:
    a. As indicated on the Drawings and Section 17100.

D. Loops 433, 434 – Cake Conveyors:
1. References:
    a. 51N03.
    b. Cake Conveyor No. 1: 51-CNV-433.
    c. Cake Conveyor No. 2: 51-CNV-433.
2. Abstract:
    a. The Cake Conveyors convey dewatered cake discharged by the screw presses to a cake hauling truck outside the dewatering building.
    b. Each Cake Conveyor is dedicated to its own Screw Press.
3. Hardwired Control:
    a. With the LOR switch in LOCAL position, the Cake Conveyors are controlled by the START and STOP pushbuttons.
4. Hardwired Interlocks:
    a. The Cake Conveyors are stopped and prohibited from starting if:
        1) Conveyor zero speed sensor is activated.
        2) Motor temperature sensor is activated.
        3) Emergency stop pull cord is activated.
5. PLC Control:
    a. In PCIS AUTO, the Cake Conveyors are controlled via the PLC as described in the Dewatering System section of the control strategy.

6. Software Interlocks:
   a. No software interlocks.
7. HMI Control:
   a. No HMI control.
8. SCADA Control:
   a. As indicated on the Drawings and Section 17100.
9. Indicators and Alarms:
   a. As indicated on the Drawings and Section 17100.
10. Failure Modes:
    a. As indicated on the Drawings and Section 17100.

E. Loops 453 – Secondary Treatment Polymer Blending Unit:
1. References:
   a. 51N06.
   b. 10N01.
   c. Secondary Treatment Polymer Blending Unit: 51-PBU-453.
   d. Plant Influent Flowmeter: 10-FIT-010.
2. Abstract:
   a. The Secondary Treatment Polymer Blending Unit is used to inject polymer into the Oxidation Ditch Mixed Liquor Splitter Box before flow proceeds to the secondary clarifiers.
   b. Speed (percent maximum) is automatically adjusted to maintain a setpoint percentage of the running average plant influent flow rate.
   c. Polymer blender local control panels are described in Specification Section 11246.
3. Hardwired Control:
   a. As indicated in Section 11246.
4. Hardwired Interlocks:
   a. As indicated in Section 11246.
5. PLC Control:
   a. In PCIS AUTO, the Secondary Treatment Polymer Blending Unit is controlled via the PLC:
      1) Adjust the speed of the Secondary Treatment Polymer Blending Unit via a PID control algorithm to maintain a setpoint feed rate to the Secondary Clarifiers:
         a) SP=Operator entered parameters:
            (1) Q_1=Polymer dosage in mg/L.
            (2) Q_2= Percent polymer active solution.
            (3) Q_3=Density of polymer solution (lbs/gallon).
            (4) Q_4=Maximum output of the Polymer Blending Unit (gallons/hour).
         b) PV = Running average plant influent flow rate measured by the Plant Influent Flowmeter (F, mgd).
         c) CV = Speed of the Polymer Blending Unit, calculated as follows:
            (1) Speed= $(F_r \times 100)/Q_4$.
            (2) F_r=Feed rate (F_r, gallons/hour) of the Polymer Blending Unit, calculated as follows:
               (a) $F_r = F \times Q_1 \times 8.34/(Q_2 \times Q_3 \times 24)$.
6. Software Interlocks:
   a. No software interlocks.
7. HMI Control:
   a. No HMI control.

8. SCADA Control:
    a. As indicated on the Drawings and Section 17100.
9. Indicators and Alarms:
    a. As indicated on the Drawings and Section 17100.
10. Failure Modes:
    a. As indicated on the Drawings and Section 17100.

F. Loops 421, 424, 425, 428 – Dewatering Inlet/Outlet Valves:
1. References:
    a. 50N10.
    b. 50N11.
    c. Dewatering Inlet Valve No. 1: 50-EDR-421.
    d. Dewatering Outlet Valve No. 1: 50-EDR-424.
    e. Dewatering Inlet Valve No. 2: 50-EDR-425.
    f. Dewatering Outlet Valve No. 2: 50-EDR-428.
2. Abstract:
    a. Dewatering Inlet/Outlet Valves isolate sludge from the Dewatering Feed Pumps trains.
3. Hardwired Control:
    a. With the LOR switch in LOCAL position, the Dewatering Inlet/Outlet Valves are controlled by the OPEN/STOP/CLOSE selector switches.
4. Hardwired Interlocks:
    a. No hardwired interlocks.
5. PLC Control:
    a. The Dewatering Inlet/Outlet Valves are normally closed unless a dewatering cycle is in progress as described in the Dewatering System section of the control strategy
    b. In PCIS AUTO, the Dewatering Inlet/Outlet Valves are controlled via the PLC as described in the Dewatering System section of Specification.
6. Software Interlocks:
    a. No software interlocks.
7. HMI Control:
    a. No HMI control.
8. SCADA Control:
    a. As indicated on the Drawings and Section 17100.
9. Indicators and Alarms:
    a. As indicated on the Drawings and Section 17100.
10. Failure Modes:
    a. As indicated on the Drawings and Section 17100.

3.05 REPAIR/RESTORATION (NOT USED)

3.06 REINSTALLATION (NOT USED)

3.07 FIELD QUALITY CONTROL (NOT USED)

3.08 ADJUSTING (NOT USED)

3.09 CLEANING (NOT USED)

3.10 DEMONSTRATION AND TRAINING

A. As specified in Section 17050.

3.11 PROTECTION (NOT USED)

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 17101-60

SPECIFIC CONTROL STRATEGIES – POTABLE WATER

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Loop descriptions:
      a. Specific control requirements and functional descriptions for individual control loops.

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 - Common Work Results for Process Control and Instrumentation Systems.

1.02 REFERENCES

A. As specified in Section 17050.

1.03 DEFINITIONS

A. As specified in Section 17050.

1.04 SYSTEM DESCRIPTION (NOT USED)

1.05 SUBMITTALS

A. Develop detailed loop descriptions based on the information in the Contract Documents, and submit as specified in Sections 01330 and 17050.
   1. For each control loop, provide a detailed functional description of the operation of the equipment, signals, and controls shown on the P&IDs:
      a. Include all functions depicted or described in the Contract Documents.
      b. Include the following within each loop description:
         1) All requirements specific to that loop.
         2) Common control requirements applicable to that loop.
         3) List of all ranges, setpoints, timers, values, counters, etc.
   2. Where there are similar loops with identical control, such as multiple loops for individual raw water pumps, only 1 loop description need be developed and the remaining loops may reference that loop description.

B. Loop description format:
   1. Loop number and title.
   2. References:
      a. List P&IDs that are specifically referenced.
   3. Abstract:
      a. General description of how the loop works, what devices are involved, and how the process will be controlled.
      b. Process values, setpoints, and limits, including units and ranges:
         1) Show span and range values for analog inputs and outputs, and operating point and deadband for discrete inputs.
   4. Hardwired control:
      a. Detailed description of the control functions at the local level.
      b. Function of local operator interfaces.
      c. Operation of hardwired field pilot controls:
         1) Pushbuttons.
         2) Selector switches.
         3) Potentiometers.
         4) Pilot lights, indicators, and other displays.
   5. Hardwired interlocks:
      a. Explanation of the operation of system interlocks and hardwired permissive conditions.
   6. PLC control:
      a. Detailed description of the control functions that are under control of the PLC.
      b. Operator controls and automatic controls.
      c. Setpoints, alarms, etc.:
         1) Include units and ranges for analog values.
         2) Include span and range for analog inputs and outputs.
         3) Include operating point and deadband for discrete inputs, and identify conditions where contacts are open, and when they close.
      d. Control sequences.
   7. Software interlocks:
      a. Operation of system software interlocks.
   8. HMI control:
      a. Detailed description of the operator controls.
   9. SCADA control:
      a. Detailed description of the operator controls.
      b. Setpoints, alarms, etc.
   10. Indicators and alarms:
      a. List any indicators and alarms specific to the loop that are not covered in the common control strategies.
   11. Failure modes:
      a. List any failure modes specific to the loop that are not covered in the common control strategies.

1.06 QUALITY ASSURANCE (NOT USED)

1.07 DELIVERY, STORAGE, AND HANDLING (NOT USED)

1.08 PROJECT OR SITE CONDITIONS (NOT USED)

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY (NOT USED)

1.12 SYSTEM START-UP (NOT USED)

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 COMMISSIONING (NOT USED)

1.15 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS (NOT USED)

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS (NOT USED)

2.04 MANUFACTURED UNITS (NOT USED)

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS (NOT USED)

2.07 ACCESSORIES (NOT USED)

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION (NOT USED)

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION

A. LOOPS 711, 712 - Groundwater Well Pumps:
   1. References:
      a. 60N01, 60N02.
      b. Groundwater Well No. 1 Level Transmitter: 60-LIT-711.

c. Groundwater Well No. 2 Level Transmitter: 60-LIT-712.
d. Potable/Fire Water Storage Tank Level Transmitter 60-LIT-715.

2. Abstract:
   a. The Ground Water Well Pumps supply raw water to the Potable/Fire Water Storage Tank via the FE/MN Filter.
3. Hardwired control:
   a. With the LOR switch in LOCAL position, the Well Pumps are controlled by the START and STOP pushbuttons.
4. Hardwired interlocks:
   a. No hardwired interlocks.
5. PLC control:
   a. In PCIS AUTO, the Well Pumps are controlled via the PLC:
      1) The Well Pumps will be automatically controlled by the Plant PLC based on level in the Potable/Fire Water Storage Tank, as measured by an ultrasonic level transmitter 60-LIT-715.
      2) The operator shall select the LEAD Well Pump from the Channel LEAD/STANDBY SCADA software selector switch.
         a) The lead Well pump will start when the level of the Potable/Fire Water Storage Tank reaches an operator adjustable low level setpoint.
         b) The lead Well pump will stop when the level of the Potable/Fire Water Storage Tank reaches an operator adjustable high level setpoint.
      3) Pump starting status shall be maintained in the following way:
         a) Alternate the priority position of the pumps after a pump is started then stopped. At which point, the pump that is in automatic mode should alternate position following the cycle:
            (1) Lead → Standby → Lead
         b) If any of pumps fail, the control system shall alarm the condition and re-assign the pump configuration. When the pump is proven ready for service it should be entered back into the standby position.
6. Software interlocks:
   a. Prohibit the well pumps from running when the level of the well reaches an operator adjustable low level setpoint.
7. HMI control:
   a. No HMI control.
8. SCADA control:
   a. As indicated on the Drawings and Section 17100.
9. Indicators and alarms:
   a. As indicated on the Drawings and Section 17100.
10. Failure modes:
    a. As indicated on the Drawings and Section 17100.

B. LOOPS 731, 732, 733 – Non-Potable Water Pressurization Pumps:
   1. References:
      a. 60N04, 60N05.
      b. Non-Potable Water Header Pressure Indicating Transmitter 60-PIT-734.
   2. Abstract:
      a. The non-potable water pressurization pumps supply potable water to the plant.

b. The non-potable water pressurization pumps operate in a rotating LEAD/LAG/STANDBY configuration.

3. Hardwired control:
   a. With the LOR switch in LOCAL position, the Well Pumps are controlled by the START and STOP pushbuttons.
4. Hardwired interlocks:
   a. The non-potable water pressurization pump is stopped and prohibited from starting if:
      1) Pump discharge pressure switch is activated.
5. PLC control:
   a. In PCIS AUTO, the Non-Potable Water Pressurization Pumps are controlled via the PLC:
      1) The Non-Potable Water Pressurization Pumps will be automatically controlled by the Plant PLC based on pressure in the Non-Potable Water Header, as measured by Pressure Indicating Transmitter 60-PIT-734.
      2) The operator shall select LEAD, LAG, and STANDBY pumps from the LEAD/LAG/STANDBY SCADA software selector switch.
         a) The lead pump will start when the pressure of the Non-Potable Water Header reaches an operator adjustable START LEAD pressure setpoint, preset at 63 PSIG.
            (1) Following start of the lead pump, the lag pump will start when the pressure of the Non-Potable Water Header drops to an operator adjustable START LAG pressure setpoint, preset at 60 PSIG.
         b) Both lead and lag pumps will stop when the pressure of the Non-Potable Water Header reaches an operator adjustable STOP pressure setpoint, preset at 80 PSIG.
      3) Pump starting status shall be maintained in the following way:
         a) Alternate the priority position of the pumps after a pump is started then stopped. At which point, the pump that is in automatic mode should alternate position following the cycle:
            (1) Lead → Lag → Standby → Lead
         b) If any of pumps fail, the control system shall alarm the condition and re-assign the pump configuration. When the pump is proven ready for service it should be entered back into the standby position.
6. Software interlocks:
   a. No software interlocks.
7. HMI control:
   a. No HMI control.
8. SCADA control:
   a. As indicated on the Drawings and Section 17100.
9. Indicators and alarms:
   a. As indicated on the Drawings and Section 17100.
10. Failure modes:
   a. As indicated on the Drawings and Section 17100.

C. LOOPS 761, 762, 763 –Potable Water Pressurization Pumps:
   1. References:
      a. 60N07, 60N08.
      b. Potable Water Header Pressure Indicating Transmitter 60-PIT-764.

2. Abstract:
   a. The potable water pressurization pumps supply potable water to the plant.
   b. The potable water pressurization pumps operate in a rotating LEAD/LAG/STANDBY configuration.
3. Hardwired control:
   a. With the LOR switch in LOCAL position, the Well Pumps are controlled by the START and STOP pushbuttons.
4. Hardwired interlocks:
   a. The potable water pressurization pump is stopped and prohibited from starting if:
      1) Pump discharge pressure switch is activated.
5. PLC control:
   a. In PCIS AUTO, the Potable Water Pressurization Pumps are controlled via the PLC:
      1) The Potable Water Pressurization Pumps will be automatically controlled by the Plant PLC based on pressure in the Potable Water Header, as measured by Pressure Indicating Transmitter 60-PIT-734.
      2) The operator shall select LEAD, LAG, and STANDBY pumps from the LEAD/LAG/STANDBY SCADA software selector switch.
         a) The lead pump will start when the pressure of the Potable Water Header reaches an operator adjustable START LEAD pressure setpoint, preset at 63 PSIG.
            (1) Following start of the lead pump, the lag pump will start when the pressure of the Potable Water Header drops to an operator adjustable START LAG pressure setpoint, preset at 60 PSIG.
         b) Both lead and lag pumps will stop when the pressure of the Potable Water Header reaches an operator adjustable STOP pressure setpoint, preset at 80 PSIG.
      3) Pump starting status shall be maintained in the following way:
         a) Alternate the priority position of the pumps after a pump is started then stopped. At which point, the pump that is in automatic mode should alternate position following the cycle:
            (1) Lead → Lag → Standby → Lead
         b) If any of pumps fail, the control system shall alarm the condition and re-assign the pump configuration. When the pump is proven ready for service it should be entered back into the standby position.
6. Software interlocks:
   a. No software interlocks.
7. HMI control:
   a. No HMI control.
8. SCADA control:
   a. As indicated on the Drawings and Section 17100.
9. Indicators and alarms:
   a. As indicated on the Drawings and Section 17100.
10. Failure modes:
    a. As indicated on the Drawings and Section 17100.

D. LOOPS 715, 760 – Potable/Non-Potable Water Storage Tanks:
   1. References:
      a. 60N03.

b. Potable water Storage Inlet Valve 60-EDR-760
c. Potable Water Storage Tank 60-TNK-760.
d. Potable Water Storage Tank Level Transmitter 60-LIT-760.
e. Non-Potable Water Storage Tank 60-TNK-715.
f. Non-Potable Water Storage Tank Level Transmitter 60-LIT-715.
g. Non-Potable Water Storage Tank Mixer 60-MIX-714.
h. Non-Potable water Storage Inlet Valve 60-EDR-713.
i. FE/MN Filter System FLT-716

2. Abstract:
   a. The Non-Potable water Storage Inlet Valve is normally Open.
   b. The Potable water Storage Inlet Valve is normally Closed.
   c. The Water Storage Tank Mixer operates continuously.
   d. Mixer motor current is monitored by the PLC for proper operation.
3. Hardwired control:
   a. Hardwired control is performed locally at the Mixer VCP.
4. Hardwired interlocks:
   a. No hardwired interlocks.
5. PLC control:
   a. Potable/Non-Potable Water Tank Inlet Valves
      1) In PCIS AUTO, the Potable/Non-Potable Water Tank Inlet Valves are controlled via the PLC:
      2) If the water level in the Potable Water Storage Tank reaches a low level operator adjustable SCADA setpoint the PLC shall:
      3) Open the Potable Water Tank Inlet Valve. Once the inlet valve is proven open by its limit switch position the PLC shall close the Non-Potable Water Tank Inlet Valve.
   b. Non-Potable Water Tank Mixer:
      1) No PLC AUTO Control. The Mixer is controlled manually via START/STOP software pushbuttons at SCADA.
6. Software interlocks:
   a. Prohibit the Mixer from running when the level of the Water Storage Tank reaches an operator adjustable low level setpoint.
   b. The Potable Water Tank Inlet Valve shall be prohibited from opening if the FE/MN Filter System is currently in backwash mode.
7. HMI control:
   a. No HMI control.
8. SCADA control:
   a. As indicated on the Drawings and Section 17100.
9. Indicators and alarms:
   a. As indicated on the Drawings and Section 17100.
10. Failure modes:
    a. As indicated on the Drawings and Section 17100.

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 FIELD QUALITY CONTROL (NOT USED)

3.08 ADJUSTING (NOT USED)

3.09 CLEANING (NOT USED)

3.10 DEMONSTRATION AND TRAINING

A. As specified in Section 17050.

3.11 PROTECTION (NOT USED)

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 17201

LEVEL MEASUREMENT - SWITCHES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Ball float level switch.
   2. Displacement float level switch.

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 - Common Work Results for Process Control and Instrumentation Systems.

C. Provide all instruments identified in the Contract Documents.

1.02 REFERENCES

A. As specified in Section 17050.

1.03 DEFINITIONS

A. As specified in Section 17050.

1.04 SUBMITTALS

A. Furnish submittals as specified in Sections 01330 and 17050.

1.05 QUALITY ASSURANCE

A. As specified in Section 17050.

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.

1.07 PROJECT OR SITE CONDITIONS

A. As specified in Section 17050.

1.08 WARRANTY

A. As specified in Section 17050.

1.09 MAINTENANCE

A. As specified in Section 17050.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. One of the following or equal:
1. Ball float level switch:
   a. Siemens Water Technologies Corp 9G-EF.
   b. ITT Flygt Model ENM-10.
   c. Anchor Scientific Incorporated Ecofloat/Solofloat.
2. Displacement float level switch:
   a. Gems Sensors and Controls Series LS-3.
   b. B/W Unifloat.

2.02 MANUFACTURED UNITS

A. Ball float level switch:
1. General:
   a. Free hanging, encapsulated body with a switch to determine position of float.
2. Element:
   a. Mechanical switch encapsulated in waterproof floating polypropylene ball of nominal diameter, supported by flexible PVC cable and jacket or heavy neoprene.
   b. The length of the PVC cable shall be, at a minimum, equal to sump depth plus 5 feet.
   c. Float: Provide Type 316 SS, minimum 3 inches in diameter. The float shall provide a minimum of 2 pounds of buoyancy in solutions with specific gravity of 1 and shall have an operating temperature rating of -30 degrees Fahrenheit to +150 degrees Fahrenheit.

d. Mercury switches are not acceptable.
e. Lead wires: Mounted in flexible waterproof PVC cable from switch to junction box terminals without splices.

3. Switch:
a. Single pole double throw contacts rated 10 amps resistive at 120 VAC.
b. Provide the number of floats per level system as indicated on the Drawings.
c. Suspend ball float and adjust for level setpoint as required.

4. Components:
a. Floats shall include Type 316 stainless steel clamp and brackets and 1/4 inch cable to allow testing of the float without entering the basin or wet well.
b. Provide strain relief at both ends of the float cable.

B. Displacement float level switch:
1. General: Float with a permanent magnet encircles a stationary stem. A hermetically sealed magnetically operated latching reed switch(es) mounted in the stem:
a. Mercury switches are not acceptable.
2. Lead wires: Mounted in flexible waterproof PVC cable from switch to junction box terminals without splices.
3. Switch:
a. Single pole single throw (SPST).
4. Compatible for the chemical service application indicated on the Drawings.
5. The number of floats per level system shall be as indicated on the Drawings.

2.03 ACCESSORIES

A. Provide sun shield for outdoor installations that use tuning fork or capacitance probe level switches.

2.04 SOURCE QUALITY CONTROL

A. As specified in Section 17050.

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 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 17050.

B. Coordinate the installation with all trades to ensure that the mechanical system has all necessary appurtenances for proper installation of instruments.

3.04 FIELD QUALITY CONTROL

A. As specified in Section 17050.

3.05 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.

3.06 CLEANING

A. As specified in Section 17050.

3.07 DEMONSTRATION AND TRAINING

A. As specified in Section 17050.

B. Demonstrate performance of all instruments to the ENGINEER before commissioning.

3.08 PROTECTION

A. As specified in Section 17050.

3.09 SCHEDULES

A. The provided information does not necessarily include all required instruments. Provide all instruments identified in the Contract Documents:
   1. Instruments may be as indicated on the Drawings, as specified in the Specifications or both.

END OF SECTION

A/E:	**Carollo Engineers**	**LEVEL SWITCHES**							
						Spec. No.		**Rev.**	
Contractor:		**No**	**By**	**Date**	**Revision**	17201			
Project:	8930A11					**Contract**		**Date**	
Customer:	San Luis Obispo County								
Plant:	Los Osos					**Req.**		**P.O.**	
Location:	San Luis Obispo County, CA								
BOM No.:						**By**		**Chk**	**App**
File:									

	1	**Type**	Conductance:	Capacitance:	Tuning Fork:	Ball Float **X**	Displacement **X**	
	2	**Setting**	Field Set:	Factory Set: **X**				
G	**3**	**Dead Band**	Fixed: **X**	Adj:	Other:			
E	**4**	**Material**						
N	**5**	**Dimensions**	Field Set					
E	**6**	**Mounting**	Flange:	Threaded:	Other: Suspended **X**			
R	**7**	**Operating Pressure /Temperature**						
A	**8**	**Connection**	MFR STD: **X**	Other:				
L	**9**	**Manufacturer**						
	10	**Other**						
	11	**Other**						
S	**12**	**Type**	Mechanical: **X**	Reed:	Other:			
W	**13**	**Quantity**	Single: **X**	Dual:	Other:			
I	**14**	**Form**	SPST:	SPDT: **X**	DPDT:	Other:		
T	**15**	**Rating: Amps Volts Hertz**	10	120	60			
C	**16**	**Load**	Inductive:	Non-Inductive: **X**				
H	**17**	**Other**						
	18	**Other**						

Rev.	**Tag Number**	**Model No.**	**Setpoint**	**P&ID**	**Service**	**Notes**
	04-LSH-500		19.5 FT	04 N01	Plant Drain P.S.	Ball Float
	04-LSLL-500		2 FT	04 N01	Plant Drain P.S.	Ball Float
	04-LSH-603		12 FT	04 N02	Storm Water P.S.	Ball Float
	04-LSLL-603		2 FT	04 N02	Storm Water P.S.	Ball Float
	28-LSH-189		ELEV 84 ft	28 N01	Filter Influent P.S.	Ball Float
	28-LSLL-189		ELEV 73.5 ft	28 N01	Filter Influent P.S.	Ball Float
	32-LSH-273		1 ft	32 N03	Al. Sulfate Floor Sump	Displacement
	32-LSH-280		1 ft	32 N04	Hypo Floor Sump	Displacement
	51-LSH-440		0.5 ft	51 N04	Polymer Floor Sump	Displacement

Notes: (1) Refer to Section 17201 for additional level switch requirements.
(2) Setpoint reference is the floor level.
(3) Provide level switches meeting Specification 16050 area classification requirements.

SECTION 17206

LEVEL MEASUREMENT - ULTRASONIC

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Ultrasonic level instruments.

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 01660 - Testing, Training, and Commissioning.
      c. Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

C. Provide all instruments identified in the Contract Documents.

1.02 REFERENCES

A. As specified in Section 17050.

1.03 DEFINITIONS

A. As specified in Section 17050.

B. Specific definitions:
   1. FDT: Field Device Tool.
   2. DTM: Device Type Manager.

1.04 SUBMITTALS

A. Furnish submittals as specified in Sections 01330 and 17050.

B. Provide complete documentation covering the traceability of all calibration instruments.

1.05 QUALITY ASSURANCE

A. As specified in Section 17050.

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. As specified in Section 17050.

1.07 PROJECT OR SITE CONDITIONS

A. Project environmental conditions as specified in Section 17050.
   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.

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 completion of Testing Phase, specified in Section 01660.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Manufacturers: One of the following or equal:
   1. Ultrasonic Level sensor with 4-wire remote transmitter:
      a. Endress+Hauser: Prosonic S FDU Series Sensor with FMU Series Transmitter.
      b. Ametek Drexelbrook: USonic-R Series.
      c. Siemens: Echomax Series sensor with HydroRanger 200 Series Transmitter.

2.02 MANUFACTURED UNITS

A. Ultrasonic level measurement with 4-wire remote transmitter:
   1. General:
      a. Continuous non-contact level measurement device with remote transmitter using ultrasonic echo sensing. The transducer generates an ultrasonic pulse in the range of 12 to 50 kHz and measures the time required for the

pulse to travel to the process surface and return. The distance is calculated from the send and receive times. Each 4-wire level transmitter system includes, but is not limited to:

1) Ultrasonic Transducer.
2) Signal cable.
3) Transmitter.

2. Performance requirements:
   a. Accuracy:
      1) 0.25 percent of range.
   b. Repeatability:
      1) 0.1 percent of range.
3. Ultrasonic transducer:
   a. Encapsulated in chemical and corrosion-resistant material as indicated on the Instrument Data Sheet or Instrument index.
   b. Class I, Division 1 for transducer only.
   c. Operating temperature range: -5 to 122 degrees Fahrenheit (-20 to 50 degrees Celsius).
   d. Operating relative humidity range: 5 to 95 percent.
   e. Functions:
      1) Temperature compensation.
   f. Mounting: As indicated in the Contract Documents.
4. Transmitter:
   a. Level indicating transmitter:
      1) Indicator: Liquid crystal display with approximately 0.50-inch display scaled to read in engineering units.
      2) Sensitivity: Able to ignore momentary level spikes or momentary loss of echo and indicate loss of echo condition on indicating transmitter unit.
      3) Ability to allow for signal profiles and echo mapping:
         a) Provide manufacturers software for re-mapping the signal.
   b. Functions:
      1) Level measurement.
      2) Tank volume.
      3) Flow measurement.
   c. Power supply:
      1) 120 VAC.
      2) Power consumption: 36 VA maximum.
   d. Outputs:
      1) Isolated 4 to 20 milliamperes DC with HART communication protocol.
      2) Relay outputs:
         a) 3 Form A or Form C contacts.
         b) Rated 5 amps at 250 VAC.
         c) Programmable.
      3) Enclosure: NEMA Type 4X
      4) Mounting: As indicated in the Contract Documents.
      5) Operating temperature range from -5 to 122 degrees Fahrenheit (-20 to 50 degrees Celsius), relative humidity of 10 to 100 percent.

2.03 ACCESSORIES

A. Mounting brackets: As indicated on the Drawings.

B. Provide sunshades for outdoor installations.

C. Provide handheld programmers for all transmitters.

2.04 SOURCE QUALITY CONTROL

A. As specified in Section 17050.

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.
   1. 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 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 17050.

B. Coordinate the installation with all trades to ensure that the mechanical system has all necessary appurtenances including weld-o-lets, valves, etc. for proper installation of instruments.

3.04 FIELD QUALITY CONTROL

A. As specified in Section 17050.

3.05 ADJUSTING

A. As specified in Section 17950.

3.06 CLEANING

A. As specified in Section 17050.

3.07 DEMONSTRATION AND TRAINING

A. As specified in Section 17050.

3.08 PROTECTION

A. As specified in Section 17050.

3.09 SCHEDULES

A. The provided information does not necessarily include all required instruments. Provide all instruments identified in the Contract Documents:
   1. Instruments may be as indicated on the Drawings, specified in the Specifications, or both.

END OF SECTION

A/E:	Carollo Engineers		ULTRASONIC LEVEL INSTRUMENTS						
							Spec. No.		Rev.
Contractor:			No	By	Date	Revision	17206		
Project:	8930A11						Contract		Date
Customer:	San Luis Obispo County								
Plant:	Los Osos						Req.		P.O.
Location:	San Luis Obispo County, CA								
BOM No.:							By	Chk	App
File:									

GEN	1	Instrument Tag Number	03-LE/LIT-326	03-LE/LIT-327	04-LE/LIT-504
	2	Service	Rew Pond No. 1	Rew Pond No. 2	Plant Drain PS
	3	P&ID	03N01	03N01	04N01
	4	Other			
PROBE	5	Type	Ultrasonic	Ultrasonic	Ultrasonic
	6	Housing Material	Mfr. Standard for Intended Service	Mfr. Standard for Intended Service	Mfr. Standard for Intended Service
	7	Measurement Range	0-16 ft	0-16 ft	0-23 ft
	8	Op. Temp. Range	-5 to 122 deg. F	-5 to 122 deg. F	-5 to 122 deg. F
	9	Manufacturer			
	10	Model			
	11	Model Number			
CABLE	12	Style	Mfg. Std	Mfg. Std	Mfg. Std
	13	Length			
	14	Other			
	15	Other			
	16	Other			
TRANSMITTER	17	Type	4-wire	4-wire	4-wire
	18	Operating Mode	Continuous	Continuous	Continuous
	19	Enclosure	NEMA 4X	NEMA 4X	NEMA 4X
	20	Mounting	Remote	Remote	Remote
	21	Temperature Range	-5 to 122 deg. F	-5 to 122 deg. F	-5 to 122 deg. F
	22	Voltage Requirements	115 VAC, 60 Hz	115 VAC, 60 Hz	115 VAC, 60 Hz
	23	Power			
	24	Accuracy	0.25% of Range	0.25% of Range	0.25% of Range
	25	Display	LCD	LCD	LCD
	26	Output	4-20 mA	4-20 mA	4-20 mA
	27	Calibration			
	28	Status Relay	2 Form C Contacts	2 Form C Contacts	2 Form C Contacts
	29	Manufacturer			
	30	Model No.			
	31	Elect. Entry			
	32	Other			
OPTS	33				
	34				
	35				
	36				

Notes:

A/E:		Carollo Engineers		ULTRASONIC LEVEL INSTRUMENTS						
								Spec. No.		Rev.
Contractor:				No	By	Date	Revision	17206		
Project:		8930A11						Contract		Date
Customer:		San Luis Obispo County								
Plant:		Los Osos						Req.		P.O.
Location:		San Luis Obispo County, CA								
BOM No.:								By	Chk	App
File:										
G	1	Instrument Tag Number	04-LE/LIT-600	10-LE/LIT-012				10-LE/LIT-041		
E	2	Service	Storm Water PS	Headworks Main Inlet Channel				Headworks Channel No. 1 Inlet		
N	3	P&ID	04N02	10N01				10N01		
	4	Other								
	5	Type	Ultrasonic	Ultrasonic				Ultrasonic		
P	6	Housing Material	Mfr. Standard for Intended Service	Mfr. Standard for Intended Service				Mfr. Standard for Intended Service		
R	7	Measurement Range		0-6 ft				0-6 ft		
O	8	Op. Temp. Range	-5 to 122 deg. F	-5 to 122 deg. F				-5 to 122 deg. F		
B	9	Manufacturer								
E	10	Model								
	11	Model Number								
C	12	Style	Mfg. Std	Mfg. Std				Mfg. Std		
A	13	Length								
B	14	Other								
L	15	Other								
E	16	Other								
	17	Type	4-wire	4-wire				4-wire		
T	18	Operating Mode	Continuous	Continuous				Continuous		
R	19	Enclosure	NEMA 4X	NEMA 4X				NEMA 4X		
A	20	Mounting	Remote	Remote				Remote		
N	21	Temperature Range	-5 to 122 deg. F	-5 to 122 deg. F				-5 to 122 deg. F		
S	22	Voltage Requirements	115 VAC, 60 Hz	115 VAC, 60 Hz				115 VAC, 60 Hz		
M	23	Power								
I	24	Accuracy	0.25% of Range	0.25% of Range				0.25% of Range		
T	25	Display	LCD	LCD				LCD		
T	26	Output	4-20 mA	4-20 mA				4-20 mA		
E	27	Calibration								
R	28	Status Relay	2 Form C Contacts	2 Form C Contacts				2 Form C Contacts		
	29	Manufacturer								
	30	Model No.								
	31	Elect. Entry								
	32	Other								
O	33									
P	34									
T	35									
S	36									

Notes:

A/E:	Carollo Engineers		ULTRASONIC LEVEL INSTRUMENTS						
							Spec. No.		Rev.
Contractor:			No	By	Date	Revision	17206		
Project:	8930A11						Contract		Date
Customer:	San Luis Obispo County								
Plant:	Los Osos						Req.		P.O.
Location:	San Luis Obispo County, CA								
BOM No.:							By	Chk	App
File:									

GEN	1	Instrument Tag Number	10-LE/LIT-051	10-LE/LIT-042	10-LE/LIT-052
	2	Service	Headworks Channel No. 2 Inlet	Headworks Channel No. 1 Outlet	Headworks Channel No. 2 Outlet
	3	P&ID	10N01	10N04	10N04
	4	Other			
PROBE	5	Type	Ultrasonic	Ultrasonic	Ultrasonic
	6	Housing Material	Mfr. Standard for Intended Service	Mfr. Standard for Intended Service	Mfr. Standard for Intended Service
	7	Measurement Range	0-6 ft	0-6 ft	0-6 ft
	8	Op. Temp. Range	-5 to 122 deg. F	-5 to 122 deg. F	-5 to 122 deg. F
	9	Manufacturer			
	10	Model			
	11	Model Number			
CABLE	12	Style	Mfg. Std	Mfg. Std	Mfg. Std
	13	Length			
	14	Other			
	15	Other			
	16	Other			
TRANSMITTER	17	Type	4-wire	4-wire	4-wire
	18	Operating Mode	Continuous	Continuous	Continuous
	19	Enclosure	NEMA 4X	NEMA 4X	NEMA 4X
	20	Mounting	Remote	Remote	Remote
	21	Temperature Range	-5 to 122 deg. F	-5 to 122 deg. F	-5 to 122 deg. F
	22	Voltage Requirements	115 VAC, 60 Hz	115 VAC, 60 Hz	115 VAC, 60 Hz
	23	Power			
	24	Accuracy	0.25% of Range	0.25% of Range	0.25% of Range
	25	Display	LCD	LCD	LCD
	26	Output	4-20 mA	4-20 mA	4-20 mA
	27	Calibration			
	28	Status Relay	2 Form C Contacts	2 Form C Contacts	2 Form C Contacts
	29	Manufacturer			
	30	Model No.			
	31	Elect. Entry			
	32	Other			
OPTS	33				
	34				
	35				
	36				

Notes:

A/E:		Carollo Engineers	ULTRASONIC LEVEL INSTRUMENTS							
								Spec. No.		Rev.
Contractor:			No	By	Date	Revision		17206		
Project:		8930A11						Contract		Date
Customer:		San Luis Obispo County								
Plant:		Los Osos						Req.		P.O.
Location:		San Luis Obispo County, CA								
BOM No.:								By	Chk	App
File:										
G	1	Instrument Tag Number	28-LE/LIT-180	31-LE/LIT-241	31-LE/LIT-242					
E	2	Service	Filter Influent PS	UV Channel No. 1	UV Channel No. 2					
N	3	P&ID	28N01	31N01	31N02					
	4	Other								
	5	Type	Ultrasonic	Ultrasonic	Ultrasonic					
P	6	Housing Material	Mfr. Standard for Intended Service	Mfr. Standard for Intended Service	Mfr. Standard for Intended Service					
R	7	Measurement Range		0-6 ft	0-6 ft					
O	8	Op. Temp. Range	-5 to 122 deg. F	-5 to 122 deg. F	-5 to 122 deg. F					
B	9	Manufacturer								
E	10	Model								
	11	Model Number								
C	12	Style	Mfg. Std	Mfg. Std	Mfg. Std					
A	13	Length								
B	14	Other								
L	15	Other								
E	16	Other								
	17	Type	4-wire	4-wire	4-wire					
T	18	Operating Mode	Continuous	Continuous	Continuous					
R	19	Enclosure	NEMA 4X	NEMA 4X	NEMA 4X					
A	20	Mounting	Remote	Remote	Remote					
N	21	Temperature Range	-5 to 122 deg. F	-5 to 122 deg. F	-5 to 122 deg. F					
S	22	Voltage Requirements	115 VAC, 60 Hz	115 VAC, 60 Hz	115 VAC, 60 Hz					
M	23	Power								
I	24	Accuracy	0.25% of Range	0.25% of Range	0.25% of Range					
T	25	Display	LCD	LCD	LCD					
T	26	Output	4-20 mA	4-20 mA	4-20 mA					
E	27	Calibration								
R	28	Status Relay	2 Form C Contacts	2 Form C Contacts	2 Form C Contacts					
	29	Manufacturer								
	30	Model No.								
	31	Elect. Entry								
	32	Other								
O	33									
P	34									
T	35									
S	36									

Notes:

A/E:	Carollo Engineers	ULTRASONIC LEVEL INSTRUMENTS							
						Spec. No.		Rev.	
Contractor:		No	By	Date	Revision	17206			
Project:	8930A11					Contract		Date	
Customer:	San Luis Obispo County								
Plant:	Los Osos					Req.		P.O.	
Location:	San Luis Obispo County, CA								
BOM No.:						By	Chk	App	
File:									

GEN	1	Instrument Tag Number	31-LE/LIT-243	32-LE/LIT-280	60-LE/LIT-715
	2	Service	UV Channel No. 3	Sodium Hypo Tank	Non-Potable Water Storage Tank
	3	P&ID	31N03	32N04	60N03
	4	Other			
PROBE	5	Type	Ultrasonic	Ultrasonic	Ultrasonic
	6	Housing Material	Mfr. Standard for Intended Service	Mfr. Standard for Intended Service	Mfr. Standard for Intended Service
	7	Measurement Range	0-6 ft	0-12 ft	0-35 ft
	8	Op. Temp. Range	-5 to 122 deg. F	-5 to 122 deg. F	-5 to 122 deg. F
	9	Manufacturer			
	10	Model			
	11	Model Number			
CABLE	12	Style	Mfg. Std	Mfg. Std	Mfg. Std
	13	Length			
	14	Other			
	15	Other			
	16	Other			
TRANSMITTER	17	Type	4-wire	4-wire	4-wire
	18	Operating Mode	Continuous	Continuous	Continuous
	19	Enclosure	NEMA 4X	NEMA 4X	NEMA 4X
	20	Mounting	Remote	Remote	Remote
	21	Temperature Range	-5 to 122 deg. F	-5 to 122 deg. F	-5 to 122 deg. F
	22	Voltage Requirements	115 VAC, 60 Hz	115 VAC, 60 Hz	115 VAC, 60 Hz
	23	Power			
	24	Accuracy	0.25% of Range	0.25% of Range	0.25% of Range
	25	Display	LCD	LCD	LCD
	26	Output	4-20 mA	4-20 mA	4-20 mA
	27	Calibration			
	28	Status Relay	2 Form C Contacts	2 Form C Contacts	2 Form C Contacts
	29	Manufacturer			
	30	Model No.			
	31	Elect. Entry			
	32	Other			
OPTS	33				
	34				
	35				
	36				

Notes:

A/E:		Carollo Engineers		ULTRASONIC LEVEL INSTRUMENTS						
								Spec. No.		Rev.
Contractor:				No	By	Date	Revision	17206		
Project:		8930A11						Contract		Date
Customer:		San Luis Obispo County								
Plant:		Los Osos						Req.		P.O.
Location:		San Luis Obispo County, CA								
BOM No.:								By	Chk	App
File:										
G	1	Instrument Tag Number						60-LE/LIT-760		
E	2	Service						Potable/Fire Water Storage Tank		
N	3	P&ID						60N06		
	4	Other								
	5	Type						Ultrasonic		
P	6	Housing Material						Mfr. Standard for Intended Service		
R	7	Measurement Range						0-6 ft		
O	8	Op. Temp. Range						-5 to 122 deg. F		
B	9	Manufacturer								
E	10	Model								
	11	Model Number								
C	12	Style						Mfg. Std		
A	13	Length								
B	14	Other								
L	15	Other								
E	16	Other								
	17	Type						4-wire		
T	18	Operating Mode						Continuous		
R	19	Enclosure						NEMA 4X		
A	20	Mounting						Remote		
N	21	Temperature Range						-5 to 122 deg. F		
S	22	Voltage Requirements						115 VAC, 60 Hz		
M	23	Power								
I	24	Accuracy						0.25% of Range		
T	25	Display						LCD		
T	26	Output						4-20 mA		
E	27	Calibration								
R	28	Status Relay						2 Form C Contacts		
	29	Manufacturer								
	30	Model No.								
	31	Elect. Entry								
	32	Other								
O	33									
P	34									
T	35									
S	36									

Notes:

SECTION 17208

LEVEL MEASUREMENT - RADAR PULSE TIME OF FLIGHT (PTOF)

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Non-contact radar (PTOF) level instruments.

A. 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 - Common Work Results for Process Control and Instrumentation Systems.

B. Provide all instruments identified in the Contract Documents.

1.02 REFERENCES

A. As specified in Section 17050.

1.03 DEFINITIONS

A. As specified in Section 17050.

B. Specific definitions:
   1. PTOF: Pulse Time of Flight.

1.04 SUBMITTALS

A. Furnish submittals as specified in Sections 01330 and 17050.

1.05 QUALITY ASSURANCE

A. As specified in Section 17050.

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. As specified in Section 17050.

1.07 PROJECT OR SITE CONDITIONS

A. As specified in Section 17050.

1.08 WARRANTY

A. As specified in Section 17050.

1.09 MAINTENANCE

A. As specified in Section 17050.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. One of the following or equal:
1. Rosemount 5400.
2. Endress+Hauser, Micropilot M.
3. Siemens/Milltronics, LR250.
4. Ohmart Vega, VegaPuls.
5. Ametek Drexelbrook, DR7000 Series.

2.02 MANUFACTURED UNITS

A. Pulse Time of Flight :
1. General:
a. Instrument emits radar pulses via a transmitter, with a frequency range of 6.3 GHz to 26 GHz.
b. The pulses reflect from the surface being measured and are received back at the instrument via a sensor.
c. The instrument measures the pulse travel time between the transmitter, surface, and receiver to calculate the level.
d. Safety:
1) Shall not generate frequency waves with power levels hazardous to humans.
2. Performance requirements:
a. Accuracy: Level:
1) 0.25 inch.

3. Element:
   a. Level element must conform to the process material compatibility as indicated on the Instrument Data Sheets or the Instrument Index.
   b. Connections:
      1) Process: The antenna design shall be suitable for mounting in a nozzle as indicated on the Instrument Data Sheets or the Instrument Index:
      2) The design shall be such that product condensation on the antenna shall not affect the performance of the gauge. It shall be possible to choose between either parabolic-, cone-, rod-shaped antennas.
4. Transmitter:
   a. Microprocessor-based signal converter/transmitter.
   b. Power supply:
      1) 24 VDC - 2 wire loop powered.
      2) Power consumption: 15 VA maximum.
   c. Outputs:
      1) Isolated 4-20 mA DC with HART communication protocol.
   d. Backlit digital display for level or volume.
   e. Self-diagnostics and automatic data checking.
   f. Signal integrity:
      1) Immune to radio frequency and electromagnetic interference with field strength of 15 volts/meter or less over a frequency range of 50 Hz to 460 MHz.
      2) Able to ignore momentary level spikes or momentary loss of echo and indicate loss of echo condition on indicating transmitter unit.
   g. Protected terminals and fuses in a separate compartment, which isolates field connection from electronics.
      1) Indication: Local - 5-digit display.
   h. Enclosure rating: NEMA Type 4X.
   i. Instruments located within hazardous classified areas shall be explosion proof:
      1) Class 1, Division 1 and 2, Group A, B, C, and D.
   j. Electrical connection: 1/2 inch male NPT.

2.03 ACCESSORIES

A. Software: Provide Windows based PC software for configuration and echo mapping.

B. Provide sun shield for outdoor installations.

2.04 SOURCE QUALITY CONTROL

A. As specified in Section 17050.

B. Factory calibrate each level transmitter at a facility that is traceable to NIST (National Institute of Standards and Technology).

C. Provide complete documentation covering the traceability of all calibration instruments.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 17050.

B. Coordinate the installation with all trades to ensure that the mechanical system has all necessary appurtenances including weld-o-lets, valves, etc. for proper installation of instruments.

3.04 FIELD QUALITY CONTROL

A. As specified in Section 17050.

B. Provide manufacturer's services to perform start-up and calibration or verification.

3.05 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.

3.06 CLEANING

A. As specified in Section 17050.

3.07 DEMONSTRATION AND TRAINING

A. As specified in Section 17050.

B. Demonstrate performance of all instruments to the Engineer before commissioning.

3.08 PROTECTION

A. As specified in Section 17050.

3.09 SCHEDULES

A. The provided information does not necessarily include all required instruments. Provide all instruments identified in the Contract Documents:
   1. Instruments may be indicated on the Drawings, specified in the Specifications or both.

END OF SECTION

A/E:		**Carollo Engineers**		**RADAR PTOF LEVEL INSTRUMENTS**						
								Spec. No.		**Rev.**
Contractor:				**No**	**By**	**Date**	**Revision**	17208		
Project:		8930A11						**Contract**		**Date**
Customer:		San Luis Obispo County								
Plant:		Los Osos						**Req.**		**P.O.**
Location:		San Luis Obispo County, CA								
BOM No.:								**By**	**Chk**	**App**
File:										
G	**1**	**Instrument Tag Number**	**23-LE/LIT-130**							
E	**2**	**Service**	Scum Pump Station							
N	**3**	**P&ID**	23 N01							
	4	**Other**								
	5	**Type**	Pulse Time of Flight (PTOF)							
P	**6**	**Housing Material**								
R	**7**	**Measurement Range**	0-10 ft							
O	**8**	**Op. Temp. Range**								
B	**9**	**Manufacturer**								
E	**10**	**Model**								
	11	**Model Number**								
	12	**Antenna Style**	Probe							
	13	**Other**								
	14	**Other**								
	15	**Other**								
	16	**Other**								
	17	**Type**	Pulse Time of Flight (PTOF)							
T	**18**	**Operating Mode**								
R	**19**	**Enclosure**	NEMA 7							
A	**20**	**Mounting**								
N	**21**	**Temperature Range**	-40 to 300 deg. F							
S	**22**	**Voltage Requirements**								
M	**23**	**Power**	Loop Powered (24 VDC)							
I	**24**	**Accuracy**	± 0.25 inches							
T	**25**	**Calibrated Range**	0-10 ft							
T	**26**	**Display**	Multi Character LCD							
E	**27**	**Output**	4-20 mA							
R	**28**	**Calibration**								
	29	**Status Relay**								
	30	**Manufacturer**								
	31	**Model No.**								
	32	**Damping**								
	33	**Elect. Entry**								
	34	**Other**								
O	**35**									
P	**36**									
T	**37**									
S	**38**									

Notes:

SECTION 17301

FLOW MEASUREMENT - SWITCHES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Shuttle flow 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.
      a. Items involving electrical, control, and instrumentation construction may be indicated on the Drawings or specified in the Specifications that do not apply specifically to electrical, control and instrumentation systems.
   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 01660 - Testing, Training, and Commissioning.
      c. Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

C. Provide all instruments identified in the Contract Drawings.

1.02 REFERENCES

A. As specified in Section 17050.

B. National Institute of Standards and Technology (NIST).

1.03 DEFINITIONS

A. As specified in Section 17050.

1.04 SUBMITTALS

A. Furnish submittals as specified in Sections 01330 and 17050.

B. Provide complete documentation covering the traceability of all calibration instruments.

1.05 QUALITY ASSURANCE

A. As specified in Section 17050.

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.

1.07 PROJECT OR SITE CONDITIONS

A. As specified in Section 17050.
   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.

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 the completion of the Testing Phase specified in Section 01660.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. One of the following or equal.
   1. Shuttle:
      a. Magnetrol Model F50.
      b. Flotect Series V6.

2.02 MANUFACTURED UNITS

A. Shuttle type:
   1. General:
      a. Fluid pushes against a disk or shuttle and moves the element to close contact by means of a magnetic pick up point.
   2. Performance requirements:
      a. Accuracy: Within 20 percent full scale.

3. Switch characteristics:
   a. Material:
      1) Body: Stainless steel.
      2) Magnetic sleeve: Stainless steel.
   b. Inline installation for pipes ranging between 1/2-inch to 2-inch diameter.
   c. Contacts: Single pole, double throw (SPDT), rated 5 amperes at 120 volts.
   d. Maximum operating temperature range: 140 degrees Fahrenheit.
   e. Enclosure: NEMA Type 7.

2.03 ACCESSORIES

A. Provide sunshades for outdoor installations.

2.04 SOURCE QUALITY CONTROL

A. As specified in Section 17050.

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 National Institute of Standards and Technology.
   1. 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 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 17050.

3.04 FIELD QUALITY CONTROL

A. As specified in Section 17050.

B. Manufacturer's field services.

3.05 ADJUSTING

A. As specified in Section 17950.

3.06 CLEANING

A. As specified in Section 17050.

3.07 DEMONSTRATION AND TRAINING

A. As specified in Section 17050.

3.08 PROTECTION

A. As specified in Section 17050.

3.09 SCHEDULES

A. The provided information does not necessarily include all required instruments. Provide all instruments identified in the Contract Documents:
   1. Instruments may be indicated on the Drawings, specified in the Specifications or both.

END OF SECTION

A/E:	**Carollo Engineers**	**FLOW SWITCHES**							
						Spec. No.		**Rev.**	
Contractor:		**No**	**By**	**Date**	**Revision**	17301			
Project:	8930A11					**Contract**		**Date**	
Customer:	San Luis Obispo County								
Plant:	Los Osos					**Req.**		**P.O.**	
Location:	San Luis Obispo County, CA								
BOM No.:						**By**	**Chk**	**App**	
File:									

D	**1**	**Type**			Thermal: Rotary Vane: Shuttle: **X** Other		
E	**2**	**Setting**			Set in Field: Factory Set: X Internal: External: Dial:		
V	**3**	**Dead Band**			**Fixed: X Adj.: Min.: Other:**		
I	**4**	**Material**			Bronze: SS:X Alloy St.: Other		
C	**5**	**Connection**			1/2-Inch NPT: 3/4-Inch NPT: **X** Other:		
	6	**Mounting**			Local: **X** Surface: Flush:		
	7	**Accuracy**					
	8	**Other**					
	9	**Type**			Mercury: Snap: Other X		
S	**10**	**Quantity**			Single: **X** Dual: Other		
W	**11**	**Form**			SPST: SPDT: **X** DPDT: Other		
I	**12**	**Rating:**	**Amps**	**Volts**	**Hertz**	10	120	60
T	**13**	**Other**					
C	**14**	**Load**			Inductive: Non-Inductive: X		
H	**15**	**Enclosure**			General Purpose: Weatherproof: **X** None: Explosion proof:X		
	16	**Enclosure Class**			NEMA 7		
	17	**Conduit Connection**			MFR STD:X Other		
	18	**Other**					
	19	**Manufacturer**					
	20	**Model No.**					

Rev	Tag Number	Adj. Range	SP Process	Signal SP	Op. Temp.	P&ID	Service	Notes
	50-FSL-121		Flow/No Flow	N/A	Ambient	50N02	RAS/WAS Pump No.1 Seal	**1**
	50-FSL-122		Flow/No Flow	N/A	Ambient	50N02	RAS/WAS Pump No.2 Seal	**1**
	50-FSL-123		Flow/No Flow	N/A	Ambient	50N02A	RAS/WAS Pump No.3 Seal	**1**
	50-FSL-423		Flow/No Flow	N/A	Ambient	50N12	Dewatering Feed Pump No. 1 Seal	**1**
	50-FSL-427		Flow/No Flow	N/A	Ambient	50N12	Dewatering Feed Pump No. 2 Seal	**1**

Notes:

1. Coordinate Flow Ranges With Pump Seal Manufacturers.

SECTION 17302

FLOW MEASUREMENT - MAGNETIC FLOWMETERS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Full-body magnetic flowmeters.

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 - Common Work Results for Process Control and Instrumentation Systems.

C. Provide all instruments identified in the Contract Drawings.

1.02 REFERENCES

A. As specified in Section 17050.

B. National Institute of Standards and Technology (NIST).

C. NSF International (NSF).

1.03 DEFINITIONS

A. As specified in Section 17050.

1.04 SUBMITTALS

A. Furnish submittals as specified in Sections 01330 and 17050.

1.05 QUALITY ASSURANCE

A. As specified in Section 17050.

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.

1.07 PROJECT OR SITE CONDITIONS

A. As specified in Section 17050.

1.08 WARRANTY

A. As specified in Section 17050.

1.09 MAINTENANCE

A. As specified in Section 17050.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. One of the following or equal:
1. Endress+Hauser: Promag 53.
2. Rosemount: 8700E.
3. Krohne: IFC.
4. Yokogawa: AXF.
5. ABB: Watermaster.

2.02 MANUFACTURED UNITS

A. Magnetic flowmeter:
1. General:
a. Magnetic flowmeters obtain the flow velocity by measuring the changes of induced voltage of the conductive fluid passing across a controlled magnetic field.
b. Complete zero stability shall be an inherent characteristic of the flowmeter system.
c. Include for each magnetic flow metering system:
1) A metering tube with electrodes (sensor).
2) Signal cable.
3) Transmitter integral or remote as indicated on the Drawings.
4) Flowmeter grounding rings.

2. Performance requirements:
    a. Accuracy:
        1) 0.25 percent of flow rate from 10 to 100 percent of full scale for velocities ranging between 1.9 to 10 feet per second.
    b. Repeatability:
        1) 0.25 percent of rate.
3. Element:
    a. Metering tube:
        1) Constructed of carbon steel or Type 304 stainless steel (unless specifically noted otherwise in the instrument data sheets).
        2) Liner material in conformance with:
            a) Manufacturer's recommendations for the intended service.
            b) NSF certified for all drinking water applications.
        3) Electrodes type and material in conformance with:
            a) Manufacturer's recommendations for the intended service.
            b) Utilize a minimum of 2, self-cleaning electrodes.
        4) Meter terminal housing NEMA Type 4X for non-hazardous areas.
        5) Meter terminal housing NEMA Type 4X, Class 1 Division 2, Group D for hazardous areas.
        6) Meter coating consisting of epoxy painted finish.
        7) Components:
            a) 2 grounding rings:
                (1) Which are in conformance with the manufacturer's bore and material recommendation for the meter's intended service.
                (2) Designed to protect and shield from abrasion of the liner's edge interface at the meter's end.
                (3) 316L Stainless Steel.
4. Transmitter:
    a. Power supply:
        1) 120 VAC.
        2) Power consumption: 60 VA maximum.
    b. Outputs:
        1) As noted in the instrument data sheets.
        2) For all instruments with 4 to 20 mA HART or digital bus protocol, provide a Device Type Manager (DTM) certification by FDT group.
    c. Microprocessor-based signal converter/transmitter.
    d. Utilize DC pulse technique to drive flux-producing coils.
    e. Contain a 6-digit display for flow rate, percent of span, and totalizer.
    f. Operator keypad interface.
    g. Integral zero return to provide consistent zero output signals in response to an external dry contact closure.
    h. Integral low flow cut-off zero return.
    i. Programmable parameters including:
        1) Meter size.
        2) Full-scale flow rate.
        3) Magnetic field frequency.
        4) Time constant.
    j. Data retention for a minimum of 5 years without auxiliary main or battery power.
    k. Self-diagnostics and automatic data checking.

l. Protected terminals and fuses in a separate compartment, which isolates field connection from electronics.
m. Ambient operating temperature limits of -5 to 140 degrees Fahrenheit (-20 to 60 degrees Celsius).

2.03 ACCESSORIES

A. Stainless steel tag labeled as specified in the Contract Documents.

B. Provide sunshades for all transmitters located outdoors.

C. Provide galvanic isolation gaskets, nylon/Teflon flange bolt insulation bushings and nylon washers on all meters installed on pipes with cathodic protection.

D. Electronic tester for calibration verification and diagnostics.
1. Transmitter shall have continuous internal meter verification method comparing current meter system values to base line value.
2. Should variance in readings be determined exceeding a preset limit the transmitter will provide an alarm condition via a configurable discrete output.

2.04 SOURCE QUALITY CONTROL

A. As specified in Section 17050.

B. Factory calibrate each flow metering system at a facility that is traceable to the NIST.

C. A real-time computer generated printout of the actual calibration date indication actual velocities and as read values of the flow tube.
1. Flow calibration report of the manufacturers flow lab calibration procedure shall be shipped with the meter system.
2. Minimum calibration shall be a 3 point calibration including 1, 3, and 10 feet per second velocities for every meter and transmitter system.
3. Manufacturer shall archive all calibration reports for future reference.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 17050.

3.04 FIELD QUALITY CONTROL

A. As specified in Section 17050.

B. Provide manufacturer’s services to perform start-up and calibration or verification.

3.05 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.

3.06 CLEANING

A. As specified in Section 17050.

3.07 DEMONSTRATION AND TRAINING

A. As specified in Section 17050.

B. Demonstrate performance of all instruments to the Engineer before commissioning.

3.08 PROTECTION

A. As specified in Section 17050.

3.09 SCHEDULES

A. Instrument Data Sheets included in this Section.

B. The provided information does not necessarily include all required instruments.

C. Provide all instruments identified in the Contract Documents:
   1. Instruments may be indicated on the Drawings, specified in the Specifications, or both.

END OF SECTION

A/E:	**Carollo Engineers**	**MAGNETIC FLOWMETERS**				**INSTRUMENT DATA SHEETS**			
						Spec. No.		**Rev.**	
Contractor:		**No**	**By**	**Date**	**Revision**	17302			
Project:	8930A11					**Contract**		**Date**	
Customer:	San Luis Obispo County								
Plant:	Los Osos					**Req.**		**P.O.**	
Location:	San Luis Obispo County, CA								
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	1		**Instrument Tag No.**		**04-FE/FIT-503**		**04-FE/FIT603**		**10-FE/FIT-010**	
	2		**Service**		Plant Drain Pump Station		Stormwater Pump Station		Plant Influent	
	3		**P&ID**		04N01		04N02		10N01	
	4	C	**Line Size / Schedule**		6”		4”		10”	
	5	O	**Line Material**		Ductile Iron, CM Lined		Ductile Iron, CM Lined		Ductile Iron, EC Lined	
	6	N	**Connection Type/ Pressure Rating**		150 lb ANSI. Flange		150 lb ANSI. Flange		150 lb ANSI. Flange	
	7	N	**Connection Materials**		316L SS		316L SS		316L SS	
	8		**Tube Size**				4”		10”	
E	9		**Tube Material**		Mfr Standard		Mfr Standard		Mfr Standard	
L	10		**Liner Material**		PTFE		PTFE		PTFE	
E	11	M	**Electrode Type**		Mfg Standard		Mfg Standard		Mfg Standard	
M	12	E	**Electrode Material**		Tantalum		Tantalum		Tantalum	
E	13	T	**Meter Casing**		Mfr Standard		Mfr Standard		Mfr Standard	
N	14	E	**Power Supply**	**Phase**	120 VAC	1P	120 VAC	1P	120 VAC	1P
T	15	R	**Grounding Type & Matl.**		Grounding Rings 316L SS		Grounding Rings 316L SS		Grounding Rings 316L SS	
	16		**Enclosure Class**		NEMA 4X		NEMA 4X		NEMA 4X, CL 1 Div 2	
	17		**Other**							
	18		**Fluid**		Plant drain		Storm water		Influent water	
	19	F	**Max Flow**		500 GPM		200 GPM		3928 GPM	
	20	L	**Min Velocity**		1.17 f/s		0.53 f/s		0.84 f/s	
	21	U	**Min Flow**	**Norm Flow**	100 GPM	250 GPM	150 GPM	200 GPM	200 GPM	1,389 GPM
	22	I	**Min Temp**	**Max Temp**	41° F	85° F	41° F	85° F	41° F	85° F
	23	D	**Min Press**	**Max Press**	25.9 psig	46.2 psig	25.9 psig	46.2 psig	25.9 psig	46.2 psig
	24		**Vacuum Possibility**		N/A		N/A		N/A	
	25		**Conductivity**							
T	26		**Function**							
R	27		**Mounting**		Remote		Remote		Remote	
A	28		**Enclosure Class**		NEMA 4X		NEMA 4X		NEMA 4X, Class 1 Div 2, Group D	
N	29		**Length Signal Cable**							
S	30		**Type Span Adjustment**							
M	31		**Power Supply**		110VAC, 60Hz, 15 VA		110VAC, 60Hz, 15 VA		110VAC, 60Hz, 15 VA	
I	32		**Transmitter Output**		4-20 mA HART		4-20 mA HART		4-20 mA HART	
			Relay Outputs		Form C		Form C		Form C	
T	33		**Accuracy**		0.25%		0.25%		0.25%	
T	34		**Calibrated Range**		0-600 GPM		0-200 GPM		0-3,928 GPM	
E	35		**Empty Pipe Detection**							
R	36		**Bi-Directional Flow**		N/A		N/A		N/A	
	37		**Display Scale Size**	**Range**						
	38		**Alarm Contact No.**	**Form**						
	39		**Manufacturer**							
	40		**Element (Meter) Model No.**							
	41		**Transmitter (Inst.) Model No.**							

Notes:

A/E:	**Carollo Engineers**	**MAGNETIC FLOWMETERS**				**INSTRUMENT DATA SHEETS**				
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	1		**Instrument Tag No.**		**28-FE/FIT-186**		**31-FE/FIT-241**		**31-FE/FIT-242**	
	2		**Service**		Sec. Effluent		UV Channel No. 1		UV Channel No. 2	
	3		**P&ID**		28N03		31N01		31N02	
	4	C	**Line Size / Schedule**		10”		10”		10”	
	5	O	**Line Material**		Ductile Iron, CM Lined		Ductile Iron, CM Lined		Ductile Iron, CM Lined	
	6	N	**Connection Type/ Pressure Rating**		150 lb ANSI. Flange		150 lb ANSI. Flange		150 lb ANSI. Flange	
	7	N	**Connection Materials**		316L SS		316L SS		316L SS	
	8		**Tube Size**		10”					
E	9		**Tube Material**		Mfr Standard		Mfr Standard		Mfr Standard	
L	10		**Liner Material**		PTFE		PTFE		PTFE	
E	11	M	**Electrode Type**		Mfg Standard		Mfg Standard		Mfg Standard	
M	12	E	**Electrode Material**		Tantalum		Tantalum		Tantalum	
E	13	T	**Meter Casing**		Mfr Standard					
N	14	E	**Power Supply**	**Phase**	120 VAC	1P	120 VAC	1P	120 VAC	1P
T	15	R	**Grounding Type & Matl.**		Grounding Rings 316L SS		Grounding Rings 316L SS		Grounding Rings 316L SS	
	16		**Enclosure Class**		NEMA 4X		NEMA 4X		NEMA 4X	
	17		**Other**							
	18		**Fluid**		Sec. Effluent		Filter Effluent		Filter Effluent	
	19	F	**Max Flow**		2,800 GPM		1,460 GPM		1,460 GPM	
	20	L	**Min Velocity**		0.84 f/s		0.84 f/s		0.84 f/s	
	21	U	**Min Flow**	**Norm Flow**	200 GPM	694 GPM	200 GPM	830 GPM	200 GPM	830 GPM
	22	I	**Min Temp**	**Max Temp**	41° F	85° F	41° F	85° F	41° F	85° F
	23	D	**Min Press**	**Max Press**	25.9 psig	46.2 psig	25.9 psig	46.2 psig	25.9 psig	46.2 psig
	24		**Vacuum Possibility**		N/A		N/A		N/A	
	25		**Conductivity**							
T	26		**Function**							
R	27		**Mounting**		Remote		Integral		Integral	
A	28		**Enclosure Class**		NEMA 4X		NEMA 4X		NEMA 4X	
N	29		**Length Signal Cable**							
S	30		**Type Span Adjustment**							
M	31		**Power Supply**		110VAC, 60Hz, 15 VA		110VAC, 60Hz, 15 VA		110VAC, 60Hz, 15 VA	
I	32		**Transmitter Output**		4-20 mA HART		4-20 mA HART		4-20 mA HART	
			Relay Outputs		Form C		Form C		Form C	
T	33		**Accuracy**		0.25%		0.25%		0.25%	
T	34		**Calibrated Range**		0-2,800 GPM		0-1,460 GPM		0-1,460 GPM	
E	35		**Empty Pipe Detection**							
R	36		**Bi-Directional Flow**							
	37		**Display Scale Size**	**Range**						
	38		**Alarm Contact No.**	**Form**						
	39		**Manufacturer**							
	40		**Element (Meter) Model No.**							
	41		**Transmitter (Inst.) Model No.**							

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	1		**Instrument Tag No.**		**31-FE/FIT-243**		**40-FE/FIT-307**		**50-FE/FIT-124**	
	2		**Service**		UV Channel No. 3		Tertiary Effluent		Secondary Clarifier No. 1 RAS	
	3		**P&ID**		31N03		40N03		50N01	
	4	C	**Line Size / Schedule**		10”		10”		6”	
	5	O	**Line Material**		Ductile Iron, CM Lined		Ductile Iron, CM Lined		Ductile Iron, EPU Lined	
	6	N	**Connection Type/ Pressure Rating**		150 lb ANSI. Flange		150 lb ANSI. Flange		150 lb ANSI. Flange	
	7	N	**Connection Materials**		316L SS		316L SS		316L SS	
	8		**Tube Size**							
E	9		**Tube Material**		Mfr Standard		Mfr Standard		Mfr Standard	
L	10		**Liner Material**		PTFE		PTFE		PTFE	
E	11	M	**Electrode Type**		Mfg Standard		Mfg Standard		Mfg Standard	
M	12	E	**Electrode Material**		Tantalum		316L SS		Tantalum	
E	13	T	**Meter Casing**		Mfr Standard		Mfr Standard		Mfr Standard	
N	14	E	**Power Supply**	**Phase**	120 VAC	1P	120 VAC	1P	120 VAC	1P
T	15	R	**Grounding Type & Matl.**		Grounding Rings 316L SS		Grounding Rings 316L SS		Grounding Rings 316L SS	
	16		**Enclosure Class**		NEMA 4X		NEMA 4X		NEMA 4X, Class 1 Div 2	
	17		**Other**							
	18		**Fluid**		Filter Effluent		Recycled Water		RAS	
	19	F	**Max Flow**		1,460 GPM		3,000 GPM		600 GPM	
	20	L	**Min Velocity**		0.84 f/s		0.42 f/s		0.79 f/s	
	21	U	**Min Flow**	**Norm Flow**	200 GPM	830 GPM	100 GPM	500 GPM	120 GPM	250 GPM
	22	I	**Min Temp**	**Max Temp**	41° F	85° F	41° F	85° F	41° F	85° F
	23	D	**Min Press**	**Max Press**	25.9 psig	46.2 psig	110 psig	130 psig	25.9 psig	46.2 psig
	24		**Vacuum Possibility**							
	25		**Conductivity**							
T	26		**Function**							
R	27		**Mounting**		Integral		Remote		Remote	
A	28		**Enclosure Class**		NEMA 4X		NEMA 4X		NEMA 4X	
N	29		**Length Signal Cable**							
S	30		**Type Span Adjustment**							
M	31		**Power Supply**		110VAC, 60Hz, 15 VA		110VAC, 60Hz, 15 VA		110VAC, 60Hz, 15 VA	
I	32		**Transmitter Output**		4-20 mA HART		4-20 mA HART		4-20 mA HART	
			Relay Outputs		Form C		Form C		Form C	
T	33		**Accuracy**		0.25%		0.25%		0.25%	
T	34		**Calibrated Range**		0-1,460 GPM		0-300 GPM		0-600 GPM	
E	35		**Empty Pipe Detection**							
R	36		**Bi-Directional Flow**							
	37		**Display Scale Size**	**Range**						
	38		**Alarm Contact No.**	**Form**						
	39		**Manufacturer**							
	40		**Element (Meter) Model No.**							
	41		**Transmitter (Inst.) Model No.**							

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	1		**Instrument Tag No.**		**50-FE/FIT-125**		**50-FE/FIT-126**		**50-FE/FIT-127**	
	2		**Service**		Secondary Clarifier No. 2 RAS		RAS Discharge		WAS Discharge	
	3		**P&ID**		50N01		50N03		50N03	
	4	**C**	**Line Size / Schedule**		6”		6”		6”	
	5	**O**	**Line Material**		Ductile Iron, EPU Lined		Ductile Iron, CM Lined		Ductile Iron, EC Lined	
	6	**N**	**Connection Type/ Pressure Rating**		150 lb ANSI. Flange		150 lb ANSI. Flange		150 lb ANSI. Flange	
	7	**N**	**Connection Materials**		316L SS		316L SS		316L SS	
	8		**Tube Size**		6”		6”		6”	
E	9		**Tube Material**		Mfr Standard		Mfr Standard		Mfr Standard	
L	10		**Liner Material**		PTFE		PTFE		PTFE	
E	11	**M**	**Electrode Type**		Mfg Standard		Mfg Standard		Mfg Standard	
M	12	**E**	**Electrode Material**		Tantalum		Tantalum		Tantalum	
E	13	**T**	**Meter Casing**		Mfr Standard		Mfr Standard		Mfr Standard	
N	14	**E**	**Power Supply**	**Phase**	120 VAC	1P	120 VAC	1P	120 VAC	1P
T	15	**R**	**Grounding Type & Matl.**		Grounding Rings 316L SS		Grounding Rings 316L SS		Grounding Rings 316L SS	
	16		**Enclosure Class**		NEMA 4X, Class 1 Div 2		NEMA 4X, Class 1 Div 2		NEMA 4X, Class 1 Div 2	
	17		**Other**							
	18		**Fluid**		RAS		RAS		WAS	
	19	**F**	**Max Flow**		600 GPM		710 GPM		550 GPM	
	20	**L**	**Min Velocity**		0.79 f/s		2.93 f/s		2.23 f/s	
	21	**U**	**Min Flow**	**Norm Flow**	120 GPM	250 GPM	250 GPM	500 GPM	190 GPM	325 GPM
	22	**I**	**Min Temp**	**Max Temp**	41° F	85° F	41° F	85° F	41° F	85° F
	23	**D**	**Min Press**	**Max Press**	25.9 psig	46.2 psig	25.9 psig	46.2 psig	25.9 psig	46.2 psig
	24		**Vacuum Possibility**		N/A		N/A		N/A	
	25		**Conductivity**							
T	26		**Function**							
R	27		**Mounting**		Remote		Remote		Remote	
A	28		**Enclosure Class**		NEMA 4X		NEMA 4X		NEMA 4X	
N	29		**Length Signal Cable**							
S	30		**Type Span Adjustment**							
M	31		**Power Supply**		110VAC, 60Hz, 15 VA		110VAC, 60Hz, 15 VA		110VAC, 60Hz, 15 VA	
I	32		**Transmitter Output**		4-20 mA HART		4-20 mA HART		4-20 mA HART	
			Relay Outputs		Form C		Form C		Form C	
T	33		**Accuracy**		0.25%		0.25%		0.25%	
T	34		**Calibrated Range**		0-600 GPM		0-900 GPM		0-700 GPM	
E	35		**Empty Pipe Detection**							
R	36		**Bi-Directional Flow**							
	37		**Display Scale Size**	**Range**						
	38		**Alarm Contact No.**	**Form**						
	39		**Manufacturer**							
	40		**Element (Meter) Model No.**							
	41		**Transmitter (Inst.) Model No.**							

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	1		**Instrument Tag No.**		**50-FE/FIT-425**		**50-FE/FIT-429**		**50-FE/FIT-309**	
	2		**Service**		Dewatering Train No. 1		Dewatering Train No. 2		Plant Water Distribution	
	3		**P&ID**		50N10		50N11		50N12	
	4	C	**Line Size / Schedule**		6”		6”		4”	
	5	O	**Line Material**		Ductile Iron, EPU Lined		Ductile Iron, EPU Lined		Ductile Iron, EPU Lined	
	6	N	**Connection Type/ Pressure Rating**		150 lb ANSI. Flange		150 lb ANSI. Flange		150 lb ANSI. Flange	
	7	N	**Connection Materials**		316L SS		316L SS		316L SS	
	8		**Tube Size**						4”	
E	9		**Tube Material**		Mfr Standard		Mfr Standard		Mfr Standard	
L	10		**Liner Material**		PTFE		PTFE		PTFE	
E	11	M	**Electrode Type**		Mfg Standard		Mfg Standard		Mfg Standard	
M	12	E	**Electrode Material**		Tantalum		Tantalum		316L SS	
E	13	T	**Meter Casing**							
N	14	E	**Power Supply**	**Phase**	120 VAC	1P	120 VAC	1P	120 VAC	1P
T	15	R	**Grounding Type & Matl.**							
	16		**Enclosure Class**		NEMA 4X, Class 1 Div 2		NEMA 4X, Class 1 Div 2		NEMA 4X, Class 1 Div 2	
	17		**Other**							
	18		**Fluid**		TWAS		TWAS		Plant Water	
	19	F	**Max Flow**		110 GPM		110 GPM		700 GPM	
	20	L	**Min Velocity**		0.70 f/s		0.70 f/s		1.32 f/s	
	21	U	**Min Flow**	**Norm Flow**	60 GPM	85 GPM	60 GPM	85 GPM	50 GPM	100 GPM
	22	I	**Min Temp**	**Max Temp**	41° F	85° F	41° F	85° F	41° F	85° F
	23	D	**Min Press**	**Max Press**	40 psig	100 psig	40 psig	100 psig	110 psig	130 psig
	24		**Vacuum Possibility**		N/A		N/A		N/A	
	25		**Conductivity**							
T	26		**Function**							
R	27		**Mounting**		Remote		Remote		Remote	
A	28		**Enclosure Class**		NEMA 4X		NEMA 4X		NEMA 4X	
N	29		**Length Signal Cable**							
S	30		**Type Span Adjustment**							
M	31		**Power Supply**		110VAC, 60Hz, 15 VA		110VAC, 60Hz, 15 VA		110VAC, 60Hz, 15 VA	
I	32		**Transmitter Output**		4-20 mA HART		4-20 mA HART		4-20 mA HART	
			Relay Outputs		Form C		Form C		Form C	
T	33		**Accuracy**		0.25%		0.25%		0.25%	
T	34		**Calibrated Range**		0-110 GPM		0-110 GPM		0-700 GPM	
E	35		**Empty Pipe Detection**							
R	36		**Bi-Directional Flow**							
	37		**Display Scale Size**	**Range**						
	38		**Alarm Contact No.**	**Form**						
	39		**Manufacturer**							
	40		**Element (Meter) Model No.**							
	41		**Transmitter (Inst.) Model No.**							

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	1		**Instrument Tag No.**		**60-FE/FIT-710**		**60-FE/FIT-734**		**70-FE/FIT-720**	
	2		**Service**		Groundwater discharge		Non-potable water distribution		Fire water discharge	
	3		**P&ID**		60N01		60N05		70N01	
	4	**C**	**Line Size / Schedule**		2”		2”		8”	
	5	**O**	**Line Material**		Galvanized Steel		Galvanized Steel		Ductile Iron, CM Lined	
	6	**N**	**Connection Type/ Pressure Rating**		150 lb ANSI. Flange		150 lb ANSI. Flange		150 lb ANSI. Flange	
	7	**N**	**Connection Materials**		316L SS		316L SS		316L SS	
	8		**Tube Size**		2”		2”			
E	9		**Tube Material**		Mfg Standard		Mfr Standard		Mfr Standard	
L	10		**Liner Material**		Polyurethane		Polyurethane		Polyurethane	
E	11	**M**	**Electrode Type**		Mfg Standard		Mfg Standard		Mfg Standard	
M	12	**E**	**Electrode Material**		316L SS		316L SS		316L SS	
E	13	**T**	**Meter Casing**		Mfr Standard		Mfr Standard		Mfr Standard	
N	14	**E**	**Power Supply**	**Phase**	120 VAC	1P	120 VAC	1P	120 VAC	1P
T	15	**R**	**Grounding Type & Matl.**		Grounding Rings 316L SS		Grounding Rings 316L SS		Grounding Rings 316L Specifications Sections	
	16		**Enclosure Class**		NEMA 4X		NEMA 4X		NEMA 4X	
	17		**Other**							
	18		**Fluid**		Potable water		Potable water		Fire water	
	19	**F**	**Max Flow**		40 GPM		70 GPM		1,150 GPM	
	20	**L**	**Min Velocity**		1.05 f/s		2.12 f/s		1.98 f/s	
	21	**U**	**Min Flow**	**Norm Flow**	10 GPM	15 GPM	20 GPM	30 GPM	300 GPM	750 GPM
	22	**I**	**Min Temp**	**Max Temp**	41° F	85° F	41° F	85° F	41° F	85° F
	23	**D**	**Min Press**	**Max Press**	25.9 psig	46.2 psig	25.9 psig	46.2 psig	45 psig	65 psig
	24		**Vacuum Possibility**		N/A		N/A		N/A	
	25		**Conductivity**							
T	26		**Function**							
R	27		**Mounting**		Remote		Remote		Integral	
A	28		**Enclosure Class**		NEMA 4X		NEMA 4X		NEMA 4X	
N	29		**Length Signal Cable**							
S	30		**Type Span Adjustment**							
M	31		**Power Supply**		110VAC, 60Hz, 15 VA		110VAC, 60Hz, 15 VA		110VAC, 60Hz, 15 VA	
I	32		**Transmitter Output**		4-20 mA HART		4-20 mA HART		4-20 mA HART	
			Relay Outputs		Form C		Form C		Form C	
T	33		**Accuracy**		0.25%		0.25%		0.25%	
T	34		**Calibrated Range**		0-50 GPM		0-70 GPM		0-1,000 GPM	
E	35		**Empty Pipe Detection**							
R	36		**Bi-Directional Flow**							
	37		**Display Scale Size**	**Range**						
	38		**Alarm Contact No.**	**Form**						
	39		**Manufacturer**							
	40		**Element (Meter) Model No.**							
	41		**Transmitter (Inst.) Model No.**							

Notes:

A/E:	**Carollo Engineers**	**MAGNETIC FLOWMETERS**				**INSTRUMENT DATA SHEETS**				
						Spec. No.		**Rev.**		
Contractor:		**No**	**By**	**Date**	**Revision**	17302				
Project:	8930A11					**Contract**		**Date**		
Customer:	San Luis Obispo County									
Plant:	Los Osos					**Req.**		**P.O.**		
Location:	San Luis Obispo County, CA									
BOM No.:						**By**	**Chk**	**App**		
File:										

	1	**Instrument Tag No.**		**60-FE/FIT-764**						
	2	**Service**		Potable water distribution						
	3	**P&ID**		60N08						
	4	**C**	1.5”	1.5”						
	5	**O**	Galvanized Steel	Galvanized Steel						
	6	**N**	150 lb ANSI. Flange	150 lb ANSI. Flange						
	7	**N**	316L SS	316L SS						
	8		1.5”	1.5”						
E	**9**		Mfr Standard	Mfr Standard						
L	**10**		Polyurethane	Polyurethane						
E	**11**	**M**	Mfg Standard	Mfg Standard						
M	**12**	**E**	316L SS	316L SS						
E	**13**	**T**	Mfr Standard	Mfr Standard						
N	**14**	**E**	120 VAC / 120 VAC							
T	**15**	**R**	Grounding Rings 316L SS	Grounding Rings 316L SS						
	16		NEMA 4X	NEMA 4X						
	17									
	18		Potable water	Potable water						
	19	**F**	40 GPM	40 GPM						
	20	**L**	.33 f/s	0.33 f/s						
	21	**U**	2 GPM / 2 GPM							
	22	**I**	41° F / 41° F							
	23	**D**	25.9 psig / 25.9 psig							
	24		N/A	N/A						
	25									
T	**26**	**Function**								
R	**27**	**Mounting**		Remote						
A	**28**	**Enclosure Class**		NEMA 4X						
N	**29**	**Length Signal Cable**								
S	**30**	**Type Span Adjustment**								
M	**31**	**Power Supply**		110VAC, 60Hz, 15 VA						
I	**32**	**Transmitter Output**		4-20 mA HART						
		Relay Outputs		Form C						
T	**33**	**Accuracy**		0.25%						
T	**34**	**Calibrated Range**		0-70 GPM						
E	**35**	**Empty Pipe Detection**								
R	**36**	**Bi-Directional Flow**								
	37	**Display Scale Size**	**Range**							
	38	**Alarm Contact No.**	**Form**							
	39	**Manufacturer**								
	40	**Element (Meter) Model No.**								
	41	**Transmitter (Inst.) Model No.**								

Notes:

SECTION 17316

FLOW MEASUREMENT - ROTAMETERS (VARIABLE AREA FLOWMETERS)

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Rotameters (variable area flowmeters).

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 - Common Work Results for Process Control and Instrumentation Systems.

C. Provide all instruments identified in the Contract Documents.

1.02 REFERENCES

A. As specified in Section 17050.

1.03 DEFINITIONS

A. As specified in Section 17050.

1.04 SUBMITTALS

A. Furnish submittals as specified in Sections 01330 and 17050.

1.05 QUALITY ASSURANCE

A. As specified in Section 17050.

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. As specified in Section 17050.

1.07 PROJECT OR SITE CONDITIONS

A. As specified in Section 17050.

1.08 WARRANTY

A. As specified in Section 17050.

1.09 MAINTENANCE

A. As specified in Section 17050.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. One of the following or equal:
   1. ABB.
   2. Brooks.
   3. King Instrument Company.

2.02 MANUFACTURED UNITS

A. Rotameters:
   1. General:
      a. Variable area type flowmeters with local flow indication.
      b. Glass tube type.
      c. Metal tube type:
         1) For polymer applications provide a metal meter tube.
   2. Performance requirements:
      a. Flow range:
         1) As specified in instrument data sheets or instrument index.
      b. Accuracy:
         1) Glass tube: Within 2.0 percent of range.
         2) Metal tube: Within 5.0 percent of range.
         3) Repeatability: 0.50 percent of range.
   3. Element:
      a. Flow tube:
         1) Glass tube: Borosilicate glass, or as required to be compatible with the process conditions.
      b. Metal tube with magnetic follower: Type 316 stainless steel.
      c. Turndown: 10 to 1.
      d. Process temperature:
         1) Glass tube: 32 to 200 degrees Fahrenheit.
         2) Metal tube: -20 to 320 degrees Fahrenheit.
      e. Maximum process pressure:
         1) Glass tube: 100 pounds per square inch gauge.
         2) Metal tube: 450 pounds per square inch gauge.

3) Size tube for the largest of the following:
a) 2.0 times the normal flow rate.
b) 1.2 times the maximum flow rate.
c) 4.0 times the minimum flow rate.

f. Float:
1) Design to provide the widest possible immunity band change for lowest pressure loss.
2) Metal tube rotameters: Float with encapsulated magnet.

4. Components:
a. Seals: O-rings or packing glands fully compatible with process fluid.
b. Integral needle valve for flow control.

5. Scale:
a. Metal tube: Dial indicator with rotatable magnet coupled to magnet encapsulated in rotameter float.

6. Other:
a. Process connection:
1) As indicated on the Mechanical Drawings.
b. Mounting:
1) As indicated on the Drawings.
2) Provide all necessary hardware for rotameter mounting.

2.03 ACCESSORIES (NOT USED)

2.04 SOURCE QUALITY CONTROL

A. As specified in Section 17050.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 17050.

B. Coordinate the installation with all trades to ensure that the mechanical system has all necessary appurtenances including weld-o-lets, valves, etc. for proper installation of instruments.

3.04 FIELD QUALITY CONTROL

A. As specified in Section 17050.

3.05 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.

3.06 CLEANING

A. As specified in Section 17050.

3.07 DEMONSTRATION AND TRAINING

A. As specified in Section 17050.

B. Demonstrate performance of all instruments to the ENGINEER before commissioning.

3.08 PROTECTION

A. As specified in Section 17050.

3.09 SCHEDULES

A. The provided information does not necessarily include all required instruments. Provide all instruments identified in the Contract Documents:
   1. Instruments may be indicated on the Drawings, specified in the Specifications, or both.

END OF SECTION

A/E:	**Carollo Engineers**			**VARIABLE AREA FLOWMETERS (ROTAMETERS)**							
								Spec. No.		**Rev.**	
Contractor:				**No**	**By**	**Date**	**Revision**	17316			
Project:	8930A11							**Contract**		**Date**	
Customer:	San Luis Obispo County										
Plant:	Los Osos							**Req.**		**P.O.**	
Location:	San Luis Obispo County, CA										
BOM No.:								**By**	**Chk**	**App**	
File:											

	1	**Instrument Tag Number**		**03-FI-289A**		**03-FI-289B**					
	2	**Service**		NaOCl		NaOCl					
G	3	**P&ID**		03N01		03N01					
E	4	**Function**		Local Indicator		Local Indicator					
N	5	**Mounting**		Line		Line					
E	6	**Power Supply**		N/A		N/A					
R	7	**Conn. Size**	**Type**								
A	8	**Inlet Dir.**	**Outlet Dir.**	Vert.	Vert.	Vert.	Vert.				
L	9	**Fitting Material**		PVDF		PVDF					
	10	**Packing or O-ring Mat'l.**		Kalrez		Kalrez					
	11	**Enclosure Type**		N/A		N/A					
	12	**Size**	**Float Guide**								
M	13	**Tube Mat'l.**	**Float Mat'l.**	Glass	Tantalum	Glass	Tantalum				
E	14	**Meter Scale: Lgth. &Type**									
T	15	**Meter Scale Range**									
E	16	**Meter Factor**		1		1					
R	17	**Rated Accuracy**		± 2% of full range		± 2% of full range					
	18	**Hyd. Calib. Required**									
F	19	**Fluid**		NaOCl 12.5%		NaOCl 12.5%					
L	20	**Color or Transparency**		Clear		Clear					
U	21	**Max. Flow Rate**		24GPH		24GPH					
I	22	**Norm Flow**	**Min Flow**	20GPH	0 GPH	20GPH	0 GPH				
D	23	**Oper. Sp. Gr. (Liq.)**		1.2		1.2					
	24	**Max. Oper. Viscosity**									
D	25	**Oper. Press.**	**Oper. Temp.**	60 psig	32-85F	60 psig	32-85F				
A	26	**Oper. Density (Gas)**									
T	27	**Std. Dens.**	**Mol. Wgt.**								
A	28	**Max. Allow. Press. Drop**									
	29	**Other**									
E	30	**Extension Well Mat'l.**		N/A		N/A					
X	31	**Gasket Mat'l.**		N/A		N/A					
T	32	**Other**		N/A		N/A					
X	33	**Xmtr Output**		N/A		N/A					
M	34	**Xmtr Enclosure Class**		N/A		N/A					
T	35	**Scale Range**		N/A		N/A					
R	36	**Other**		N/A		N/A					
A	37	**# Contacts**	**Form**	N/A	N/A	N/A	N/A				
L	38	**Rating**	**Housing**	N/A	N/A	N/A	N/A				
M	39	**Action**		N/A		N/A					
	40	**Other**		N/A		N/A					
	41	**Valve Size & Material**		N/A		N/A					
O	42	**Valve Location**		N/A		N/A					
P	43	**Cnst. Diff. Relay Mat'l.**		N/A		N/A					
T	44	**Purge Meter Tubing**		N/A		N/A					
S	45	**Airset**		N/A		N/A					
	46	**Other**		N/A		N/A					
	47	**Manufacturer**									
	48	**Model Number**									
	49	**Tube Number**									
	50	**Float Number**									

Notes:

A/E:	**Carollo Engineers**		**VARIABLE AREA FLOWMETERS (ROTAMETERS)**								
									Spec. No.		**Rev.**
Contractor:			**No**	**By**	**Date**	**Revision**			17316		
Project:	8930A11								**Contract**		**Date**
Customer:	San Luis Obispo County										
Plant:	Los Osos								**Req.**		**P.O.**
Location:	San Luis Obispo County, CA										
BOM No.:									**By**	**Chk**	**App**
File:											

	1	**Instrument Tag Number**		**20-FI-453A**		**20-FI-453B**		**20-FI-287A**		**20-FI-287B**	
	2	**Service**		Polymer		Polymer		NaOCl		NaOCl	
G	3	**P&ID**		20N02		20N02		20N03		20N03	
E	4	**Function**		Local Indicator		Local Indicator		Local Indicator		Local Indicator	
N	5	**Mounting**		Line		Line		Line		Line	
E	6	**Power Supply**		N/A		N/A		N/A		N/A	
R	7	**Conn. Size**	**Type**								
A	8	**Inlet Dir.**	**Outlet Dir.**	Vert.	Vert.	Vert.	Vert.	Vert.	Vert.	Vert.	Vert.
L	9	**Fitting Material**		Stainless Steel		Stainless Steel		PVDF		PVDF	
	10	**Packing or O-ring Mat'l.**		Compatible with process fluid		Compatible with process fluid		Kalrez		Kalrez	
	11	**Enclosure Type**		N/A		N/A		N/A		N/A	
	12	**Size**	**Float Guide**								
M	13	**Tube Mat'l.**	**Float Mat'l.**	Metal	316 SS	Metal	316 SS	Glass	Tantalum	Glass	Tantalum
E	14	**Meter Scale: Lgth. &Type**									
T	15	**Meter Scale Range**									
E	16	**Meter Factor**		1		1		1		1	
R	17	**Rated Accuracy**		± 2% of full range		± 2% of full range		± 2% of full range		± 2% of full range	
	18	**Hyd. Calib. Required**									
F	19	**Fluid**		Polymer		Polymer		NaOCl 12.5%		NaOCl 12.5%	
L	20	**Color or Transparency**		Opaque		Opaque		Clear		Clear	
U	21	**Max. Flow Rate**		31GPH		31GPH		3 GPH		3 GPH	
I	22	**Norm Flow**	**Min Flow**	16GPH	1GPH	16GPH	1GPH	.75GPH	.2GPH	.75GPH	.2GPH
D	23	**Oper. Sp. Gr. (Liq.)**		1.05		1.05		1.2		1.2	
	24	**Max. Oper. Viscosity**									
D	25	**Oper. Press.**	**Oper. Temp.**	100 psig	32-85F	100 psig	32-85F	60 psig	32-85F	60 psig	32-85F
A	26	**Oper. Density (Gas)**									
T	27	**Std. Dens.**	**Mol. Wgt.**								
A	28	**Max. Allow. Press. Drop**									
	29	**Other**									
E	30	**Extension Well Mat'l.**		N/A		N/A		N/A		N/A	
X	31	**Gasket Mat'l.**		N/A		N/A		N/A		N/A	
T	32	**Other**		N/A		N/A		N/A		N/A	
X	33	**Xmtr Output**		N/A		N/A		N/A		N/A	
M	34	**Xmtr Enclosure Class**		N/A		N/A		N/A		N/A	
T	35	**Scale Range**		N/A		N/A		N/A		N/A	
R	36	**Other**		N/A		N/A		N/A		N/A	
A	37	**# Contacts**	**Form**	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
L	38	**Rating**	**Housing**	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
M	39	**Action**		N/A		N/A		N/A		N/A	
	40	**Other**		N/A		N/A		N/A		N/A	
	41	**Valve Size & Material**		N/A		N/A		N/A		N/A	
O	42	**Valve Location**		N/A		N/A		N/A		N/A	
P	43	**Cnst. Diff. Relay Mat'l.**		N/A		N/A		N/A		N/A	
T	44	**Purge Meter Tubing**		N/A		N/A		N/A		N/A	
S	45	**Airset**		N/A		N/A		N/A		N/A	
	46	**Other**		N/A		N/A		N/A		N/A	
	47	**Manufacturer**									
	48	**Model Number**									
	49	**Tube Number**									
	50	**Float Number**									

Notes:

A/E:	**Carollo Engineers**		**VARIABLE AREA FLOWMETERS (ROTAMETERS)**								
								Spec. No.		**Rev.**	
Contractor:			**No**	**By**	**Date**	**Revision**		17316			
Project:	8930A11							**Contract**		**Date**	
Customer:	San Luis Obispo County										
Plant:	Los Osos							**Req.**		**P.O.**	
Location:	San Luis Obispo County, CA										
BOM No.:								**By**	**Chk**	**App**	
File:											

	1	**Instrument Tag Number**		**20-FI-287C**		**20-FI-287D**		**20-FI-751A**		**20-FI-751B**	
	2	**Service**		NaOCl		NaOCl		Plant Water		Plant Water	
G	3	**P&ID**		20N03		20N03		20N03		20N03	
E	4	**Function**		Local Indicator		Local Indicator		Local Indicator		Local Indicator	
N	5	**Mounting**		Line		Line		Line		Line	
E	6	**Power Supply**		N/A		N/A		N/A		N/A	
R	7	**Conn. Size**	**Type**								
A	8	**Inlet Dir.**	**Outlet Dir.**	Vert.	Vert.	Vert.	Vert.	Vert.	Vert.	Vert.	Vert.
L	9	**Fitting Material**		PVDF		PVDF		Brass, PVC, or SS		Brass, PVC, or SS	
	10	**Packing or O-ring Mat'l.**		Kalrez		Kalrez		Compatible with process fluid		Compatible with process fluid	
	11	**Enclosure Type**		N/A		N/A		N/A		N/A	
	12	**Size**	**Float Guide**								
M	13	**Tube Mat'l.**	**Float Mat'l.**	Glass	Tantalum	Glass	Tantalum	Glass	316 SS	Glass	316 SS
E	14	**Meter Scale: Lgth. &Type**									
T	15	**Meter Scale Range**									
E	16	**Meter Factor**		1		1		1		1	
R	17	**Rated Accuracy**		± 2% of full range		± 2% of full range		± 2% of full range		± 2% of full range	
	18	**Hyd. Calib. Required**									
F	19	**Fluid**		NaOCl 12.5%		NaOCl 12.5%		Plant water		Plant water	
L	20	**Color or Transparency**		Clear		Clear		Clear		Clear	
U	21	**Max. Flow Rate**		3 GPH		3 GPH		20 GPM		20 GPM	
I	22	**Norm Flow**	**Min Flow**	.75GPH	.2GPH	.75GPH	.2GPH	10 GPM		10 GPM	5 GPM
D	23	**Oper. Sp. Gr. (Liq.)**		1.2		1.2		1.008		1.008	
	24	**Max. Oper. Viscosity**									
D	25	**Oper. Press.**	**Oper. Temp.**	60 psig	32-85F	60 psig	32-85F	40 psig	32-85F	40 psig	32-85F
A	26	**Oper. Density (Gas)**									
T	27	**Std. Dens.**	**Mol. Wgt.**								
A	28	**Max. Allow. Press. Drop**									
	29	**Other**									
E	30	**Extension Well Mat'l.**		N/A		N/A		N/A		N/A	
X	31	**Gasket Mat'l.**		N/A		N/A		N/A		N/A	
T	32	**Other**		N/A		N/A		N/A		N/A	
X	33	**Xmtr Output**		N/A		N/A		N/A		N/A	
M	34	**Xmtr Enclosure Class**		N/A		N/A		N/A		N/A	
T	35	**Scale Range**		N/A		N/A		N/A		N/A	
R	36	**Other**		N/A		N/A		N/A		N/A	
A	37	**# Contacts**	**Form**	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
L	38	**Rating**	**Housing**	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
M	39	**Action**		N/A		N/A		N/A		N/A	
	40	**Other**		N/A		N/A		N/A		N/A	
	41	**Valve Size & Material**		N/A		N/A		N/A		N/A	
O	42	**Valve Location**		N/A		N/A		N/A		N/A	
P	43	**Cnst. Diff. Relay Mat'l.**		N/A		N/A		N/A		N/A	
T	44	**Purge Meter Tubing**		N/A		N/A		N/A		N/A	
S	45	**Airset**		N/A		N/A		N/A		N/A	
	46	**Other**		N/A		N/A		N/A		N/A	
	47	**Manufacturer**									
	48	**Model Number**									
	49	**Tube Number**									
	50	**Float Number**									

Notes:

A/E:	**Carollo Engineers**			**VARIABLE AREA FLOWMETERS (ROTAMETERS)**							
								Spec. No.		**Rev.**	
Contractor:				**No**	**By**	**Date**	**Revision**	17316			
Project:	8930A11							**Contract**		**Date**	
Customer:	San Luis Obispo County										
Plant:	Los Osos							**Req.**		**P.O.**	
Location:	San Luis Obispo County, CA										
BOM No.:								**By**	**Chk**	**App**	
File:											

	1	**Instrument Tag Number**		**20-FI-751C**		**20-FI-751D**		**21-FI-752A**		**21-FI-752B**	
	2	**Service**		Plant Water		Plant Water		Plant Water		Plant Water	
G	3	**P&ID**		20N03		20N03		21N01		21N01	
E	4	**Function**		Local Indicator		Local Indicator		Local Indicator		Local Indicator	
N	5	**Mounting**		Line		Line		Line		Line	
E	6	**Power Supply**		N/A		N/A		N/A		N/A	
R	7	**Conn. Size**	**Type**								
A	8	**Inlet Dir.**	**Outlet Dir.**	Vert.	Vert.	Vert.	Vert.	Vert.	Vert.	Vert.	Vert.
L	9	**Fitting Material**		Brass, PVC, or SS		Brass, PVC, or SS		Brass, PVC, or SS		Brass, PVC, or SS	
	10	**Packing or O-ring Mat'l.**		Compatible with process fluid		Compatible with process fluid		Compatible with process fluid		Compatible with process fluid	
	11	**Enclosure Type**		N/A		N/A		N/A		N/A	
	12	**Size**	**Float Guide**								
M	13	**Tube Mat'l.**	**Float Mat'l.**	Glass	316 SS	Glass	316 SS	Glass	316 SS	Glass	316 SS
E	14	**Meter Scale: Lgth. &Type**									
T	15	**Meter Scale Range**									
E	16	**Meter Factor**		1		1		1		1	
R	17	**Rated Accuracy**		± 2% of full range		± 2% of full range		± 2% of full range		± 2% of full range	
	18	**Hyd. Calib. Required**									
F	19	**Fluid**		Plant Water		Plant Water		Plant Water		Plant Water	
L	20	**Color or Transparency**		Clear		Clear		Clear		Clear	
U	21	**Max. Flow Rate**		20 GPM		20 GPM		20 GPM		20 GPM	
I	22	**Norm Flow**	**Min Flow**	10 GPM	5 GPM	10 GPM	5 GPM	10 GPM	5 GPM	10 GPM	5 GPM
D	23	**Oper. Sp. Gr. (Liq.)**		1.008		1.008		1.008		1.008	
	24	**Max. Oper. Viscosity**									
D	25	**Oper. Press.**	**Oper. Temp.**	40 psig	32-85F	40 psig	32-85F	40 psig	32-85F	40 psig	32-85F
A	26	**Oper. Density (Gas)**									
T	27	**Std. Dens.**	**Mol. Wgt.**								
A	28	**Max. Allow. Press. Drop**									
	29	**Other**									
E	30	**Extension Well Mat'l.**		N/A		N/A		N/A		N/A	
X	31	**Gasket Mat'l.**		N/A		N/A		N/A		N/A	
T	32	**Other**		N/A		N/A		N/A		N/A	
X	33	**Xmtr Output**		N/A		N/A		N/A		N/A	
M	34	**Xmtr Enclosure Class**		N/A		N/A		N/A		N/A	
T	35	**Scale Range**		N/A		N/A		N/A		N/A	
R	36	**Other**		N/A		N/A		N/A		N/A	
A	37	**# Contacts**	**Form**	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
L	38	**Rating**	**Housing**	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
M	39	**Action**		N/A		N/A		N/A		N/A	
	40	**Other**		N/A		N/A		N/A		N/A	
	41	**Valve Size & Material**		N/A		N/A		N/A		N/A	
O	42	**Valve Location**		N/A		N/A		N/A		N/A	
P	43	**Cnst. Diff. Relay Mat'l.**		N/A		N/A		N/A		N/A	
T	44	**Purge Meter Tubing**		N/A		N/A		N/A		N/A	
S	45	**Airset**		N/A		N/A		N/A		N/A	
	46	**Other**		N/A		N/A		N/A		N/A	
	47	**Manufacturer**									
	48	**Model Number**									
	49	**Tube Number**									
	50	**Float Number**									

Notes:

A/E:	**Carollo Engineers**	**VARIABLE AREA FLOWMETERS (ROTAMETERS)**	
Contractor:		**No / By / Date / Revision**	**Spec. No.** 17316 / **Rev.**
Project:	8930A11		**Contract** / **Date**
Customer:	San Luis Obispo County		
Plant:	Los Osos		**Req.** / **P.O.**
Location:	San Luis Obispo County, CA		
BOM No.:			**By** / **Chk** / **App**
File:			

	1	**Instrument Tag Number**		**31-FI-230**		**23-FI-750**		**28-FI-181**		**32-FI-281B**	
	2	**Service**		Filter Effl. Sample		Plant Water		Sec. Effl. Sample		NaOCl	
G	3	**P&ID**		30N01		23N01		28N01		32N05	
E	4	**Function**		Local Indicator		Local Indicator		Local Indicator		Local Indicator	
N	5	**Mounting**		Line		Line		Line		Line	
E	6	**Power Supply**		N/A		N/A		N/A		N/A	
R	7	**Conn. Size**	**Type**								
A	8	**Inlet Dir.**	**Outlet Dir.**	Vert.	Vert.	Vert.	Vert.	Vert.	Vert.	Vert.	Vert.
L	9	**Fitting Material**		Brass, PVC, or SS		Brass, PVC, or SS		Brass, PVC, or SS		PVDF	
	10	**Packing or O-ring Mat'l.**		Compatible with process fluid		Compatible with process fluid		Compatible with process fluid		Kalrez	
	11	**Enclosure Type**		N/A		N/A		N/A		N/A	
	12	**Size**	**Float Guide**								
M	13	**Tube Mat'l.**	**Float Mat'l.**	Glass	316 SS	Glass	316 SS	Glass	316 SS	Glass	Tantalum
E	14	**Meter Scale: Lgth. &Type**									
T	15	**Meter Scale Range**									
E	16	**Meter Factor**		1		1		1		1	
R	17	**Rated Accuracy**		± 2% of full range		± 2% of full range		± 2% of full range		± 2% of full range	
	18	**Hyd. Calib. Required**									
F	19	**Fluid**		Plant Water		Plant Water		Secondary Effluent		NaOCl 12.5%	
L	20	**Color or Transparency**		Clear		Clear		Clear		Clear	
U	21	**Max. Flow Rate**		750 ml/min		20GPM		750 ml/min		5 ml/min	
I	22	**Norm Flow**	**Min Flow**		200 ml/min	10GPM	5GPM		200 ml/min	2.3 ml/min	.8 ml/min
D	23	**Oper. Sp. Gr. (Liq.)**		1.008		1.008		1.008		1.2	
	24	**Max. Oper. Viscosity**									
D	25	**Oper. Press.**	**Oper. Temp.**	40 psig	32-85F	40 psig	32-85F	40 psig	32-85F	60 psig	32-85F
A	26	**Oper. Density (Gas)**									
T	27	**Std. Dens.**	**Mol. Wgt.**								
A	28	**Max. Allow. Press. Drop**									
	29	**Other**									
E	30	**Extension Well Mat'l.**		N/A		N/A		N/A		N/A	
X	31	**Gasket Mat'l.**		N/A		N/A		N/A		N/A	
T	32	**Other**		N/A		N/A		N/A		N/A	
X	33	**Xmtr Output**		N/A		N/A		N/A		N/A	
M	34	**Xmtr Enclosure Class**		N/A		N/A		N/A		N/A	
T	35	**Scale Range**		N/A		N/A		N/A		N/A	
R	36	**Other**		N/A		N/A		N/A		N/A	
A	37	**# Contacts**	**Form**	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
L	38	**Rating**	**Housing**	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
M	39	**Action**		N/A		N/A		N/A		N/A	
	40	**Other**		N/A		N/A		N/A		N/A	
	41	**Valve Size & Material**		N/A		N/A		N/A		N/A	
O	42	**Valve Location**		N/A		N/A		N/A		N/A	
P	43	**Cnst. Diff. Relay Mat'l.**		N/A		N/A		N/A		N/A	
T	44	**Purge Meter Tubing**		N/A		N/A		N/A		N/A	
S	45	**Airset**		N/A		N/A		N/A		N/A	
	46	**Other**		N/A		N/A		N/A		N/A	
	47	**Manufacturer**									
	48	**Model Number**									
	49	**Tube Number**									
	50	**Float Number**									

Notes:

A/E:	**Carollo Engineers**		**VARIABLE AREA FLOWMETERS (ROTAMETERS)**								
									Spec. No.		**Rev.**
Contractor:			**No**	**By**	**Date**	**Revision**			17316		
Project:	8930A11								**Contract**		**Date**
Customer:	San Luis Obispo County										
Plant:	Los Osos								**Req.**		**P.O.**
Location:	San Luis Obispo County, CA										
BOM No.:									**By**	**Chk**	**App**
File:											

	1	**Instrument Tag Number**		**32-FI-281C**		**32-FI-281D**		**50-FI-121**		**50-FI-122**	
	2	**Service**		Hypo		Hypo		Plant Water		Plant Water	
G	3	**P&ID**		32N05		32N05		50N02		50N02	
E	4	**Function**		Local Indicator		Local Indicator		Local Indicator		Local Indicator	
N	5	**Mounting**		Line		Line		Line		Line	
E	6	**Power Supply**		N/A		N/A		N/A		N/A	
R	7	**Conn. Size**	**Type**								
A	8	**Inlet Dir.**	**Outlet Dir.**	Vert.	Vert.	Vert.	Vert.	Vert.	Vert.	Vert.	Vert.
L	9	**Fitting Material**		PVDF		PVDF		Brass, PVC, or SS		Brass, PVC, or SS	
	10	**Packing or O-ring Mat'l.**		Kalrez		Kalrez		Compatible with process fluid		Compatible with process fluid	
	11	**Enclosure Type**		N/A		N/A		N/A		N/A	
	12	**Size**	**Float Guide**								
M	13	**Tube Mat'l.**	**Float Mat'l.**	Glass	Tantalum	Glass	Tantalum	Glass	316 SS	Glass	316 SS
E	14	**Meter Scale: Lgth. &Type**									
T	15	**Meter Scale Range**									
E	16	**Meter Factor**		1		1		1		1	
R	17	**Rated Accuracy**		± 2% of full range		± 2% of full range		± 2% of full range		± 2% of full range	
	18	**Hyd. Calib. Required**									
F	19	**Fluid**		NaOCl 12.5%		NaOCl 12.5%		Plant Water		Plant Water	
L	20	**Color or Transparency**		Clear		Clear		Clear		Clear	
U	21	**Max. Flow Rate**		38 ml/min		38 ml/min		NOTE 1		NOTE 1	
I	22	**Norm Flow**	**Min Flow**	15 ml/min	7.5 ml/min	15 ml/min	7.5 ml/min				
D	23	**Oper. Sp. Gr. (Liq.)**		1.2		1.2		1.008		1.008	
	24	**Max. Oper. Viscosity**									
D	25	**Oper. Press.**	**Oper. Temp.**	60 psig	32-85F	60 psig	32-85F	30 psig	32-85F	30 psig	32-85F
A	26	**Oper. Density (Gas)**									
T	27	**Std. Dens.**	**Mol. Wgt.**								
A	28	**Max. Allow. Press. Drop**									
	29	**Other**									
E	30	**Extension Well Mat'l.**		N/A		N/A		N/A		N/A	
X	31	**Gasket Mat'l.**		N/A		N/A		N/A		N/A	
T	32	**Other**		N/A		N/A		N/A		N/A	
X	33	**Xmtr Output**		N/A		N/A		N/A		N/A	
M	34	**Xmtr Enclosure Class**		N/A		N/A		N/A		N/A	
T	35	**Scale Range**		N/A		N/A		N/A		N/A	
R	36	**Other**		N/A		N/A		N/A		N/A	
A	37	**# Contacts**	**Form**	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
L	38	**Rating**	**Housing**	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
M	39	**Action**		N/A		N/A		N/A		N/A	
	40	**Other**		N/A		N/A		N/A		N/A	
	41	**Valve Size & Material**		N/A		N/A		N/A		N/A	
O	42	**Valve Location**		N/A		N/A		N/A		N/A	
P	43	**Cnst. Diff. Relay Mat'l.**		N/A		N/A		N/A		N/A	
T	44	**Purge Meter Tubing**		N/A		N/A		N/A		N/A	
S	45	**Airset**		N/A		N/A		N/A		N/A	
	46	**Other**		N/A		N/A		N/A		N/A	
	47	**Manufacturer**									
	48	**Model Number**									
	49	**Tube Number**									
	50	**Float Number**									

Notes:
1. Coordinate Flow Range with Pump Seal Manufacturer.

A/E:	**Carollo Engineers**			**VARIABLE AREA FLOWMETERS (ROTAMETERS)**							
								Spec. No.		**Rev.**	
Contractor:				**No**	**By**	**Date**	**Revision**	17316			
Project:	8930A11							**Contract**		**Date**	
Customer:	San Luis Obispo County										
Plant:	Los Osos							**Req.**		**P.O.**	
Location:	San Luis Obispo County, CA										
BOM No.:								**By**	**Chk**	**App**	
File:											

	1	**Instrument Tag Number**		**50-FI-123**		**50-FI-423**		**50-FI-427**		**60-FI-281E**	
	2	**Service**		Plant Water		Plant Water		Plant Water		NaOCl	
G	3	**P&ID**		50N02A		50N12		50N12		60N03	
E	4	**Function**		Local Indicator		Local Indicator		Local Indicator		Local Indicator	
N	5	**Mounting**		Line		Line		Line		Line	
E	6	**Power Supply**		N/A		N/A		N/A		N/A	
R	7	**Conn. Size**	**Type**								
A	8	**Inlet Dir.**	**Outlet Dir.**	Vert.	Vert.	Vert.	Vert.			Vert.	Vert.
L	9	**Fitting Material**		Brass, PVC, or SS		Brass, PVC, or SS		Brass, PVC, or SS		PVDF	
	10	**Packing or O-ring Mat'l.**		Compatible with process fluid		Compatible with process fluid		Compatible with process fluid		Kalrez	
	11	**Enclosure Type**		N/A		N/A				N/A	
	12	**Size**	**Float Guide**								
M	13	**Tube Mat'l.**	**Float Mat'l.**	Glass	316 SS	Glass	316 SS	Glass	316 SS	Glass	Tantalum
E	14	**Meter Scale: Lgth. &Type**									
T	15	**Meter Scale Range**									
E	16	**Meter Factor**		1		1		1		1	
R	17	**Rated Accuracy**		± 2% of full range		± 2% of full range		± 2% of full range		± 2% of full range	
	18	**Hyd. Calib. Required**									
F	19	**Fluid**		Plant Water		Plant Water		Plant Water		NaOCl 12.5%	
L	20	**Color or Transparency**		Clear		Clear		Clear		Clear	
U	21	**Max. Flow Rate**		NOTE 1		NOTE 1		NOTE 1		5 ml/min	
I	22	**Norm Flow**	**Min Flow**							2.3 ml/min	.8 ml/min
D	23	**Oper. Sp. Gr. (Liq.)**		1.0		1.0		1.0		1.2	
	24	**Max. Oper. Viscosity**		1.008		1.008		1.008			
D	25	**Oper. Press.**	**Oper. Temp.**	30 psig	32-85F	60 psig	32-85F	60 psig	32-85F	60 psig	32-85F
A	26	**Oper. Density (Gas)**									
T	27	**Std. Dens.**	**Mol. Wgt.**								
A	28	**Max. Allow. Press. Drop**									
	29	**Other**									
E	30	**Extension Well Mat'l.**		N/A		N/A		N/A		N/A	
X	31	**Gasket Mat'l.**		N/A		N/A		N/A		N/A	
T	32	**Other**		N/A		N/A		N/A		N/A	
X	33	**Xmtr Output**		N/A		N/A		N/A		N/A	
M	34	**Xmtr Enclosure Class**		N/A		N/A		N/A		N/A	
T	35	**Scale Range**		N/A		N/A		N/A		N/A	
R	36	**Other**		N/A		N/A		N/A		N/A	
A	37	**# Contacts**	**Form**	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
L	38	**Rating**	**Housing**	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
M	39	**Action**		N/A		N/A		N/A		N/A	
	40	**Other**		N/A		N/A		N/A		N/A	
	41	**Valve Size & Material**		N/A		N/A		N/A		N/A	
O	42	**Valve Location**		N/A		N/A		N/A		N/A	
P	43	**Cnst. Diff. Relay Mat'l.**		N/A		N/A		N/A		N/A	
T	44	**Purge Meter Tubing**		N/A		N/A		N/A		N/A	
S	45	**Airset**		N/A		N/A		N/A		N/A	
	46	**Other**		N/A		N/A		N/A		N/A	
	47	**Manufacturer**									
	48	**Model Number**									
	49	**Tube Number**									
	50	**Float Number**									

Notes:
1. Coordinate Flow Range with Pump Seal Manufacturer.

A/E:	**Carollo Engineers**	**VARIABLE AREA FLOWMETERS (ROTAMETERS)**									
								Spec. No.		**Rev.**	
Contractor:		**No**	**By**	**Date**	**Revision**			17316			
Project:	8930A11							**Contract**		**Date**	
Customer:	San Luis Obispo County										
Plant:	Los Osos							**Req.**		**P.O.**	
Location:	San Luis Obispo County, CA										
BOM No.:								**By**	**Chk**	**App**	
File:											

	1	**Instrument Tag Number**		**60-FI-281F**		**31-FI-288**					
	2	**Service**		NaOCl		NaOCl					
G	3	**P&ID**		60N03		31N01					
E	4	**Function**		Local Indicator		Local Indicator					
N	5	**Mounting**		Line		Line					
E	6	**Power Supply**		N/A		N/A					
R	7	**Conn. Size**	**Type**								
A	8	**Inlet Dir.**	**Outlet Dir.**	Vert.	Vert.	Vert.	Vert.				
L	9	**Fitting Material**		PVDF		PVDF					
	10	**Packing or O-ring Mat'l.**		Kalrez		Kalrez					
	11	**Enclosure Type**		N/A		N/A					
	12	**Size**	**Float Guide**								
M	13	**Tube Mat'l.**	**Float Mat'l.**	Glass	Tantalum	Glass	Tantalum				
E	14	**Meter Scale: Lgth. &Type**									
T	15	**Meter Scale Range**									
E	16	**Meter Factor**		1		1					
R	17	**Rated Accuracy**		± 2% of full range		± 2% of full range					
	18	**Hyd. Calib. Required**									
F	19	**Fluid**		NaOCl 12.5%		NaOCl 12.5%					
L	20	**Color or Transparency**		Clear		Clear					
U	21	**Max. Flow Rate**		3 GPH		0-24 GPH					
I	22	**Norm Flow**	**Min Flow**	.75 GPH	.2 GPH	20GPH	0 GPH				
D	23	**Oper. Sp. Gr. (Liq.)**		1.2		1.2					
	24	**Max. Oper. Viscosity**									
D	25	**Oper. Press.**	**Oper. Temp.**	60 psig	32-85F	60 psig	32-85F				
A	26	**Oper. Density (Gas)**									
T	27	**Std. Dens.**	**Mol. Wgt.**								
A	28	**Max. Allow. Press. Drop**									
	29	**Other**									
E	30	**Extension Well Mat'l.**		N/A		N/A		N/A		N/A	
X	31	**Gasket Mat'l.**		N/A		N/A		N/A		N/A	
T	32	**Other**		N/A		N/A		N/A		N/A	
X	33	**Xmtr Output**		N/A		N/A		N/A		N/A	
M	34	**Xmtr Enclosure Class**		N/A		N/A		N/A		N/A	
T	35	**Scale Range**		N/A		N/A		N/A		N/A	
R	36	**Other**		N/A		N/A		N/A		N/A	
A	37	**# Contacts**	**Form**	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
L	38	**Rating**	**Housing**	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
M	39	**Action**		N/A		N/A		N/A		N/A	
	40	**Other**		N/A		N/A		N/A		N/A	
	41	**Valve Size & Material**		N/A		N/A		N/A		N/A	
O	42	**Valve Location**		N/A		N/A		N/A		N/A	
P	43	**Cnst. Diff. Relay Mat'l.**		N/A		N/A		N/A		N/A	
T	44	**Purge Meter Tubing**		N/A		N/A		N/A		N/A	
S	45	**Airset**		N/A		N/A		N/A		N/A	
	46	**Other**		N/A		N/A		N/A		N/A	
	47	**Manufacturer**									
	48	**Model Number**									
	49	**Tube Number**									
	50	**Float Number**									

Notes:

SECTION 17401

PRESSURE/VACUUM MEASUREMENT - DIAPHRAGM AND ANNULAR SEALS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Diaphragm seals.
   2. Annular seals.

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 - Common Work Results for Process Control and Instrumentation Systems.

C. Provide all seals identified in the Contract Documents.

1.02 REFERENCES

A. As specified in Section 17050.

1.03 DEFINITIONS

A. As specified in Section 17050.

1.04 SUBMITTALS

A. Furnish submittals as specified in Sections 01330 and 17050.

B. Additional requirements:
   1. Product data:
      a. Manufacturer's installation instructions.
      b. Seal type.
      c. Body materials.
      d. Diaphragm material.
      e. Fill fluid type.
      f. Seal size.
      g. Options.
      h. Process connection.

1.05 QUALITY ASSURANCE

A. As specified in Section 17050.

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.

1.07 PROJECT OR SITE CONDITIONS

A. As specified in Section 17050.

1.08 WARRANTY

A. As specified in Section 17050.

1.09 MAINTENANCE

A. As specified in Section 17050.

B. Provide spare annular seal for every size indicated in the project.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Diaphragm seals:
   1. For chemical applications, liquids containing solids, and liquids with pulsating flow having pressures less than or equal to 15 pounds per square inch gauge: One of the following or equal:
      a. Ashcroft:
         1) Flushing connection: Type 741.
         2) Without flushing connection: Type 740.
      b. Mansfield and Green:
         1) Flushing connection: Type SGT.
         2) Without flushing connection: Type SBT.
      c. Wika, Type L990.40.
      d. Rosemount.

2. For chemical applications, liquids containing solids, and liquids with pulsating flow having pressures greater than or equal to 15 pounds per square inch gauge: One of the following or equal:
    a. Ashcroft:
        1) Flushing connection: Type 201.
        2) Without flushing connection: Type 200.
        3) Saddle mount: Type 205.
    b. Mansfield and Green:
        1) Flushing connection: Type SG.
        2) Without flushing connection: Type SB.
        3) Saddle mount: Type SJ.
    c. Wika:
        1) Type L990.10.
        2) Saddle mount: L910.ZA.
    d. Rosemount.

B. Annular seals:
    1. One of the following or equal:
        a. Red Valve.
        b. Ashcroft Iso-Ring.
        c. Onyx Valve.

2.02 MANUFACTURED UNITS

A. Diaphragm seals:
    1. General:
        a. Diaphragm seal and pressure instrument shall be assembled by pressure instrument manufacturer and shipped as an assembly.
    2. Requirements:
        a. Seal type:
            1) Metallic diaphragm: Welded to upper housing.
            2) Elastomer diaphragm: Bonded to upper housing.
        b. Process connection: 1 inch NPT or Saddle flange.
        c. Instrument connection: 1/2 inch NPT.
        d. Flushing connections:
            1) Provide 1/4-inch flushing connection in diaphragm lower housing or provide flushing ring.
            2) Flush port plug: Same material of construction as diaphragm lower housing.
            3) Provide diaphragm seals with flushing connections for the following services:
                a) Polymer (area 51).
                b) Aluminum Sulfate (area 32).
                c) Scum pump station (area 23).
        e. Provide fill/bleed connection.
        f. Mounting: As indicated in the Contract Documents.
        g. Nuts and bolts: Type 316 stainless steel.
        h. Materials of construction:
            1) Sewage, sludge, liquids containing solids, and liquids with pulsating flow having pressures less than or equal to 15 pounds per square inch:
                a) Diaphragm: Type 316 stainless steel.

b) Lower housing: Type 316 stainless steel.
c) Upper housing: Manufacturer's standard.
d) Fill fluid: Silicon oil.

2) Sewage, sludge, liquids containing solids, and liquids with pulsating flow having pressures greater than 15 pounds per square inch:
   a) Diaphragm: Type 316 stainless steel.
   b) Lower housing: Type 316 stainless steel.
   c) Upper housing: Manufacturer's standard.
   d) Fill fluid: Silicon oil.

3) Aluminum Sulfate:
   a) Diaphragm: Tantalum.
   b) Lower Housing: Type 316 stainless steel.
   c) Upper Housing: Manufacturer's standard.
   d) Fill Fluid: Silicon oil.

4) Sodium hypochlorite:
   a) Diaphragm: Tantalum.
   b) Lower Housing: Titanium.
   c) Upper Housing: Manufacturer's standard.
   d) Fill Fluid: Halocarbon.

2.03 ACCESSORIES

A. Provide field fill kits.

2.04 SOURCE QUALITY CONTROL

A. As specified in Section 17050.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 17050.

B. Coordinate the installation with all trades to ensure that the mechanical system has all necessary appurtenances including weld-o-lets, valves, etc. for proper installation of instruments.

C. Do not use Teflon thread seal tape on pressure instruments with silicon oil fill fluid.

3.04 FIELD QUALITY CONTROL

A. As specified in Section 17050.

3.05 ADJUSTING (NOT USED)

3.06 CLEANING

A. As specified in Section 17050.

3.07 DEMONSTRATION AND TRAINING

A. As specified in Section 17050.

3.08 PROTECTION

A. As specified in Section 17050.

3.09 SCHEDULES

A. The provided information does not necessarily include all required instruments. Provide all instruments identified in the Contract Documents:
   1. Instruments may be indicated on the Drawings, in the Specifications or both.

END OF SECTION

SECTION 17402

PRESSURE/VACUUM MEASUREMENT - INSTRUMENT VALVES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Valve manifolds and instrument valves.

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 01660 - Testing, Training, and Commissioning.
      c. Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

C. Provide all instruments identified in the Contract Documents.

1.02 REFERENCES

A. As specified in Section 17050.

B. International Organization for Standardization (ISO):
   1. 9001 - Quality Management Systems - Requirements.

C. National Institute of Standards and Technology (NIST).

1.03 DEFINITIONS

A. As specified in Section 17050.

1.04 SUBMITTALS

A. Furnish submittals as specified in Sections 01330 and 17050.

B. Provide complete documentation covering the traceability of all calibration instruments.

C. Additional requirements:
   1. Product data:
      a. Valve type.

b. Body material.
c. Size.
d. Options.

2. Shop drawings:
   a. Mounting details for all manifold valves.

1.05 QUALITY ASSURANCE

A. As specified in Section 17050.

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.

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.

B. Protect valve manifolds and protective coatings from damage during handling and installation. Repair coating where damaged.

1.07 PROJECT OR SITE CONDITIONS

A. Project environmental conditions as specified in Section 17050.
   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.

1.09 MAINTENANCE

A. As specified in Section 17050.

B. Furnish all parts, materials, fluids, etc. necessary for operation, maintenance, and calibration purposes throughout the warranty period. Deliver all of these supplies before completion of the Testing Phase specified in Section 01660.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Valve manifold manufacturers: One of the following or equal:
   1. Anderson Greenwood.
   2. Hex Valve.
   3. Noshok.
   4. Rosemount.

B. Block and bleed valve manufacturers: One of the following or equal:
   1. Anderson Greenwood.
   2. Hex Valve.

C. Gauge valve manufacturers: One of the following or equal:
   1. Anderson Greenwood.
   2. Hex Valve.

2.02 MANUFACTURED UNITS

A. Valve manifolds:
   1. General:
      a. Provide 2-valve or 3-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 Fahrenheit.
      g. Materials of construction:
         1) Body material: Type 316 stainless steel.
         2) O-Ring: Teflon®.
      h. 2-Valve manifolds:
         1) 1 isolation valve and 1 drain/vent and calibration valve.
      i. 3-Valve manifolds:
         1) 2 isolation valves and 1 equalizing valve for differential pressure applications.
         2) Plugged vent connections used for vent/drain or calibration.

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.
      d. Valve shall not be used with fluids with high solids content, such as raw wastewater or sludge.

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.

C. Provide sunshades for outdoor installations.

2.04 SOURCE QUALITY CONTROL

A. As specified in Section 17050.

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.
1. 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 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 17050.

B. Coordinate the installation with all trades to ensure that the mechanical system has all necessary appurtenances including weld-o-lets, valves, etc. for proper installation of instruments.

3.04 FIELD QUALITY CONTROL

A. As specified in Section 17050.

B. Provide manufacturer's services to perform start-up and calibration or verification.

3.05 ADJUSTING

A. As specified in Section 17950.

B. 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.

3.06 CLEANING

A. As specified in Section 17050.

3.07 DEMONSTRATION AND TRAINING

A. As specified in Section 17050.

B. Demonstrate performance of all instruments to the ENGINEER before commissioning.

3.08 PROTECTION

A. As specified in Section 17050.

3.09 SCHEDULES

A. The provided information does not necessarily include all required instruments. Provide all instruments identified in the Contract Documents:
   1. Instruments may be indicated on the Drawings, specified in the Specifications, or both.

END OF SECTION

SECTION 17403

PRESSURE/VACUUM MEASUREMENT - SWITCHES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. 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 01660 - Testing, Training, and Commissioning.
      c. Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
      d. Section 17401 - Pressure/Vacuum Measurement - Diaphragm and Annular Seals.
      e. 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.

B. National Electrical Manufacturers Association (NEMA):
   1. 250 - Enclosures for Electrical Equipment (1,000 Volts Maximum).

C. National Institute of Standards and Technology (NIST).

1.03 DEFINITIONS

A. As specified in Section 17050.

1.04 SUBMITTALS

A. Furnish submittals as specified in Sections 01330 and 17050.

B. Additional requirements:
   1. Product data:
      a. Accessories such as diaphragm seals, valve manifold, snubbers, and pulsation dampeners.

1.05 QUALITY ASSURANCE

A. As specified in Section 17050.

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.

1.07 PROJECT OR SITE CONDITIONS

A. Project environmental conditions as specified in Section 17050.
   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.

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 completion of the Testing Phase specified in Section 01660.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Mechanical type pressure switch: One of the following or equal:
   1. Ashcroft B Series Type 400.

2. United Electric Controls 400 Series.
3. United Electric Controls 120 Series.
4. ASCO S-Series.

2.02 MANUFACTURED UNITS

A. Mechanical type pressure switches:
1. General:
   a. Pressure switch shall be diaphragm or diaphragm-sealed piston type.
2. Performance requirements:
   a. Pressure range:
      1) As specified in data sheets following this Section.
   b. Accuracy:
      1) Within 1.0 percent of range.
   c. Repeatability:
      1) 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. 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.
   f. Fixed deadband.
   g. Switch elements:
      1) Snap acting.
      2) Single pole-double throw (SPDT).
      3) Hermetically sealed.
      4) Rated at 5 A, 125/250 VAC.
      5) Automatic reset type.
   h. Enclosure:
   i. Epoxy coated NEMA Type 4X for non-hazardous areas.
   j. Epoxy coated NEMA Type 4X Rated Class 1, Division 2, Group D for hazardous areas.
   k. Switch mounting:
      1) Process connection: 1/2-inch NPT.
4. Components:
   a. 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. Provide integral diaphragm seals as indicated on the Drawings and as specified in Section 17401:
1. Diaphragm seal and pressure switch shall be assembled by manufacturer and shipped as an assembly.

C. Furnish gauge valves as specified in Section 17402.

2.04 SOURCE QUALITY CONTROL

A. As specified in Section 17050.

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.
1. 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 (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 17050.

B. Coordinate the installation with all trades to ensure that the mechanical system has all necessary appurtenances including weld-o-lets, valves, etc. for proper installation of instruments.

3.04 FIELD QUALITY CONTROL

A. As specified in Section 17050.

B. Provide manufacturer's services to perform start-up and calibration or verification.

3.05 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.

3.06 CLEANING

A. As specified in Section 17050.

3.07 DEMONSTRATION AND TRAINING

A. As specified in Section 17050.

B. Demonstrate performance of all instruments to the Engineer before commissioning.

3.08 PROTECTION

A. As specified in Section 17050.

3.09 SCHEDULES

A. The provided information does not necessarily include all required instruments. Provide all instruments specified in the Contract Documents:
   1. Instruments may be indicated on the Drawings, specified in the Specifications or both.

END OF SECTION

A/E:	**Carollo Engineers**	**PRESSURE/VACUUM SWITCHES**						
						Spec. No.		**Rev.**
Contractor:		**No**	**By**	**Date**	**Revision**	17403		
Project:	8930A11					**Contract**		**Date**
Customer:	San Luis Obispo County							
Plant:	Los Osos					**Req.**		**P.O.**
Location:	San Luis Obispo County, CA							
BOM No.:						**By**	**Chk**	**App**
File:								

DEVICE	1	**Type**	Press: X Vacuum: Comp.: Diff.Press: Other
	2	**Setting**	Set in Field: Factory Set: X Internal: External: Dial:
	3	**Dead Band**	**Fixed: X Adj.: Min.: Other:**
	4	**Mtl : Body Seat Tube**	
	5	**Element Type**	Diaphragm: Bourdon: Bellows: Other
	6	**Material**	Bronze: SS: Alloy St.: Other
	7	**Connection**	½ in NPT √ Bottom: Back:
	8	**Mounting**	Local: Surface: Flush:
	9	**Accuracy**	
	10	**Other**	
SWITCH	11	**Type**	Mercury: Snap: Other
	12	**Quantity**	Single: Dual: Other
	13	**Form**	SPST: SPDT: DPDT: Other
	14	**Rating: Amps Volts Hertz**	
	15	**Other**	
	16	**Load**	Inductive: Non-Inductive: √
	17	**Enclosure**	General Purpose: Weatherproof: None: Explosion proof:
	18	**Enclosure Class**	
	19	**Conduit Connection**	MFR STD: Other
	20	**Other**	
	21	**Manufacturer**	
	22	**Model No.**	

Rev	Tag Number	Adj. Range	SP Process	Signal SP	Op. Temp.	P&ID	Service	Notes
	28-PSH-185	0-60 psig		25 psig		28N03	Flash Mix Pump No. 1	
	28-PSH-186	0-60 psig		25 psig		28N03	Flash Mix Pump No. 2	
	40-PSH-301	0-200 psig		160 psig		40N01	Effluent Pump No. 1	
	40-PSH-302	0-200 psig		160 psig		40N01	Effluent Pump No. 2	
	40-PSH-303	0-200 psig		160 psig		40N02	Effluent Pump No. 3	
	40-PSH-304	0-200 psig		160 psig		40N02	Effluent Pump No. 4	
	50-PSH-121	0-30 psig		15 psig		50N02	RAS/WAS Pump No. 1	**1**
	50-PSH-122	0-30 psig		15 psig		50N02	RAS/WAS Pump No. 2	**1**
	50-PSH-123	0-30 psig		15 psig		50N02A	RAS/WAS Pump No. 3	**1**
	50-PSH-423	0-100 psig		60 psig		50N10	Dewatering Feed Pump No. 1	**1**
	50-PSH-427	0-100 psig		60 psig		50N11	Dewatering Feed Pump No. 2	**1**

Notes:
Refer to Section 17401 for additional diaphragm seal requirements.
Refer to Section 17402 for additional instrument valve requirements.
1. Rated Class 1 Division 2, Group D.

SECTION 17404

PRESSURE/VACUUM MEASUREMENT - GAUGES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. 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 - Common Work Results for Process Control and Instrumentation Systems.
      c. Section 17401 - Pressure/Vacuum Measurement - Diaphragm and Annular Seals.
      d. 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.

B. American Society of Mechanical Engineers (ASME):
   1. B40.100 - Pressure Gauges and Gauge Attachments.

C. National Institute of Standards and Technology (NIST).

1.03 DEFINITIONS

A. As specified in Section 17050.

1.04 SUBMITTALS

A. Furnish submittals as specified in Sections 01330 and 17050.

B. Additional requirements:
   1. Product data:
      a. Accessories such as diaphragm seals, valve manifold, snubbers, and pulsation dampeners.

1.05 QUALITY ASSURANCE

A. As specified in Section 17050.

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.

1.07 PROJECT OR SITE CONDITIONS

A. As specified in Section 17050.

1.08 WARRANTY

A. As specified in Section 17050.

1.09 MAINTENANCE

A. As specified in Section 17050.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Manufacturers: One of the following or equal:
   1. Ashcroft:
      a. Maximum pressure less than 10 pounds per square inch:
         1) Chemical Facility Area 32 Model 1188.
         2) All Other Areas: Model 1189.
      b. Maximum pressure greater than or equal to 10 pounds per square inch:
         1) Chemical Facility Area 32: Model 1279
         2) All Other Areas: Model 1379.
   2. Wika.
   3. Ametek U.S. Gauge.

2.02 MANUFACTURED UNITS

A. General:
   1. Pressure gauge assembly shall include pressure sensing element, gauge case, and dial mechanism.

B. Performance requirements:
   1. Pressure range:
      a. As specified in the Contract Documents.
   2. Accuracy:
      a. Grade 2A, as defined by ASME B40.100.
      b. Within 1.0 percent of span after friction errors are eliminated by tapping or vibration.
      c. Maximum allowable friction inaccuracy: Within 1.0 percent of span.
   3. Element:
      a. Where the maximum pressure is less than 10 pounds per square inch, provide socket and bellows; for all other pressure ranges, employ a Bourdon tube.
      b. Socket tips for bellows and Bourdon tube:
         1) Materials: Type 316 stainless steel.
      c. Overpressure: Minimum 130 percent of maximum range pressure without damage to gauge or sensing element.
      d. Wetted materials: Type 316 stainless steel.
   4. Dial gauge:
      a. Dial size: 4-1/2 inches.
      b. Dial case material:
      c. Maximum pressure less than 10 pounds per square inch:
         1) Chemical Facility Area 32: Phenolic
         2) All Other Areas: Aluminum.
      d. Maximum pressure greater than or equal to 10 pounds per square inch:
         1) Chemical Facility Area 32: Phenolic
         2) All Other Areas: Aluminum.
      e. Provide safety gauge with rupture disk and blow out back.
      f. Dial face: Gasketed shatterproof glass.
      g. Provide gauge locks where possible.
      h. Hermetically sealed.
      i. Connection and mounting:
         1) Direct mounted and suitable for outdoor installation.
         2) 1/2 inch NPT.
         3) Connection material: Stainless steel.
      j. 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.

B. Provide diaphragm seals as specified in the Contract Documents and in Section 17401:
   1. Diaphragm seal and pressure gauge shall be assembled by manufacturer and shipped as an assembly.

C. Provide means for gauge isolation as specified in Section 17402:
   1. Mount valve manifold integrally to the gauge.
   2. Valve manifold and pressure gauge shall be assembled by manufacturer and shipped as an assembly.

2.04 SOURCE QUALITY CONTROL

A. As specified in Section 17050.

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 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 17050.

B. Coordinate the installation with all trades to ensure that the mechanical system has all necessary appurtenances including weld-o-lets, valves, etc. for proper installation of instruments.

3.04 FIELD QUALITY CONTROL

A. As specified in Section 17050.

B. Provide manufacturer's services to perform start-up and calibration or verification.

3.05 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.

3.06 CLEANING

A. As specified in Section 17050.

3.07 DEMONSTRATION AND TRAINING

A. As specified in Section 17050.

B. Demonstrate performance of all instruments to the Engineer before commissioning:

3.08 PROTECTION

A. As specified in Section 17050.

3.09 SCHEDULES

A. The provided information does not necessarily include all required instruments. Provide all instruments identified in the Contract Documents:
   1. Instruments may be indicated on the Drawings, specified in the Specifications or both.

END OF SECTION

A/E:	**Carollo Engineers**	**PRESSURE GAUGES**						
						Spec. No.	**Rev.**	
Contractor:		**No**	**By**	**Date**	**Revision**	17404		
Project:	8930A11					**Contract**	**Date**	
Customer:	San Luis Obispo County							
Plant:	Los Osos					**Req.**	**P.O.**	
Location:	San Luis Obispo County, CA							
BOM No.:						**By**	**Chk**	**App**
File:								

1	**Type**	Direct Rdg.: √	Receiver:	Other:		
2	**Mounting**	Surface: Local:		Flush:		
3	**Dial**	Diameter: 4.5”	Color:			
4	**Case**	**Cast Iron:**	**Aluminum:** √	**Phenolic:** √	**Polished SS**	**Other:**
5	**Ring**	Screwed:	Hinged:	Slip:	Std:	Other:
6	**Blowout Protection**	None:	Disc:	Front:	Other:	Mfr. Std.
7	**Lens**	Glass: √	Plastic:			
8	**Options**	Siphon: N/A	Material:			
9	**Other**	Snubber:				
10	**Other**	Pressure Limit Valve: N/A				
11	**Other**	Movement Damping: N/A				
12	**Nominal Accuracy Required**					
13	**Pressure Element**	Bourdon: √	Bellows:	Other:		
14	**Element Material**	Bronze:	Steel:	Type SS: 316 √	Other:	
15	**Socket Material**	Bronze:	Steel:	SS: 316	Other:	
16	**Connection**	¼ in.:	½ in.: √	Bottom:	Other:	
17	**Movement**	Dampened:	Standard: √	Other:		
18	**Diaphragm Seal**	Mfr.:	Wetted Part Mat’l:	Type:		
19	**Other**	Other Mat’l:	Fill Fluid:	Model:		
20	**Manufacturer**					
21	**Model No.**					

Rev	**Tag Number**	**Range**	**P&ID**	**Service**	**Notes**
	04-PI-501	0-60 psig	04N01	Plant Drain Pump No. 1	
	04-PI-502	0-60 psig	04N01	Plant Drain Pump No. 2	
	04-PI-601	0-30 psig	04N02	Storm Water Pump No. 1	
	04-PI-602	0-30 psig	04N02	Storm Water Pump No. 2	
	11-PI-071A	-5-0”WC	11N01	Odor Control Fan No.1 Suction	
	11-PI-071B	0-15”WC	11N01	Odor Control Fan No.1 Discharge	
	11-PI-072A	-5-0”WC	11N01	Odor Control Fan No.2 Suction	
	11-PI-072B	0-15”WC	11N01	Odor Control Fan No.2 Discharge	
	20 PI-750	0-60 psig	20N03	Oxidation Ditch Chemical Feed	

Notes:
Refer to Section 17402 for additional instrument valve requirements.

A/E:	**Carollo Engineers**	**PRESSURE GAUGES**							
						Spec. No.		**Rev.**	
Contractor:		**No**	**By**	**Date**	**Revision**	17404			
Project:	8930A11					**Contract**		**Date**	
Customer:	San Luis Obispo County								
Plant:	Los Osos					**Req.**		**P.O.**	
Location:	San Luis Obispo County, CA								
BOM No.:						**By**	**Chk**	**App**	
File:									

1	**Type**	Direct Rdg.: √		Receiver:		Other:
2	**Mounting**	Surface: Local:				Flush:
3	**Dial**	Diameter: 4.5”			Color:	
4	**Case**	**Cast Iron:**	**Aluminum: √**	**Phenolic: √**	**Polished SS**	**Other:**
5	**Ring**	Screwed:	Hinged:	Slip:	Std:	Other:
6	**Blowout Protection**	None:	Disc:	Front:	Other:	Mfr. Std.
7	**Lens**	Glass: √			Plastic:	
8	**Options**	Siphon: N/A			Material:	
9	**Other**	Snubber:				
10	**Other**	Pressure Limit Valve: N/A				
11	**Other**	Movement Damping: N/A				
12	**Nominal Accuracy Required**					
13	**Pressure Element**	Bourdon: √		Bellows:		Other:
14	**Element Material**	Bronze:	Steel:		Type SS: 316 √	Other:
15	**Socket Material**	Bronze:	Steel:		SS: 316	Other:
16	**Connection**	¼ in.:	½ in.: √		Bottom:	Other:
17	**Movement**	Dampened:	Standard: √		Other:	
18	**Diaphragm Seal**	Mfr.:		Wetted Part Mat’l:		Type:
19	**Other**	Other Mat’l:		Fill Fluid:		Model:
20	**Manufacturer**					
21	**Model No.**					

Rev	Tag Number	Range	P&ID	Service	Notes
	23-PI-130	0-30psig	23N01	Scum Pump Station	
	28-PI-181	0-30 psig	28N01	Filter Influent Pump No. 1	
	28-PI-182	0-30 psig	28N01	Filter Influent Pump No. 2	
	28-PI-183	0-30 psig	28N02	Filter Influent Pump No. 3	
	28-PI-184	0-30 psig	28N02	Filter Influent Pump No. 4	
	28-PI-185	0-60 psig	28N03	Flash Mix Pump No. 1	
	28-PI-186	0-60 psig	28N03	Flash Mix Pump No. 2	
	28-PI-187	0-30 psig	28N03	Flash Mix Pumps Suction Header	
	32-PI-271	0-60 psig	32N02	Alum Pump No. 1	
	32-PI-272	0-60psig	32N03	Alum Pump No. 2	
	32-PI-281	0-100 psig	32N05	Sodium Hypochlorite Pump No. 1	
	32-PI-282	0-100 psig	32N06	Sodium Hypochlorite Pump No. 2	
	32-PI-283	0-160 psig	32N07	Sodium Hypochlorite Pump No. 3	

Notes:
Refer to Section 17402 for additional instrument valve requirements.

A/E:	**Carollo Engineers**	**PRESSURE GAUGES**						
						Spec. No.	**Rev.**	
Contractor:		**No**	**By**	**Date**	**Revision**	17404		
Project:	8930A11					**Contract**	**Date**	
Customer:	San Luis Obispo County							
Plant:	Los Osos					**Req.**	**P.O.**	
Location:	San Luis Obispo County, CA							
BOM No.:						**By**	**Chk**	**App**
File:								

1	**Type**	Direct Rdg.: √	Receiver:	Other:		
2	**Mounting**	Surface: Local:		Flush:		
3	**Dial**	Diameter: 4.5”	Color:			
4	**Case**	**Cast Iron:**	**Aluminum:** √	**Phenolic:** √	**Polished SS**	**Other:**
5	**Ring**	Screwed:	Hinged:	Slip:	Std:	Other:
6	**Blowout Protection**	None:	Disc:	Front:	Other:	Mfr. Std.
7	**Lens**	Glass: √	Plastic:			
8	**Options**	Siphon: N/A	Material:			
9	**Other**	Snubber:				
10	**Other**	Pressure Limit Valve: N/A				
11	**Other**	Movement Damping: N/A				
12	**Nominal Accuracy Required**					
13	**Pressure Element**	Bourdon: √	Bellows:	Other:		
14	**Element Material**	Bronze:	Steel:	Type SS: 316 √	Other:	
15	**Socket Material**	Bronze:	Steel:	SS: 316	Other:	
16	**Connection**	¼ in.:	½ in.: √	Bottom:	Other:	
17	**Movement**	Dampened:	Standard: √	Other:		
18	**Diaphragm Seal**	Mfr.:	Wetted Part Mat’l:	Type:		
19	**Other**	Other Mat’l:	Fill Fluid:	Model:		
20	**Manufacturer**					
21	**Model No.**					

Rev	Tag Number	Range	P&ID	Service	Notes
	32-PI-284	0-160 psig	32N08	Sodium Hypochlorite Pump No. 4	
	32-PI-285	0-160 psig	32N09	Sodium Hypochlorite Pump No. 5	
	40-PI-301	0-200 psig	40N01	Effluent Pump No. 1	
	40-PI-302	0-200 psig	40N01	Effluent Pump No. 2	
	40-PI-303	0-200 psig	40N02	Effluent Pump No. 3	
	40-PI-304	0-200 psig	40N02	Effluent Pump No. 4	
	40-PI-306	0-200 psig	40N03	Effluent Discharge Header	
	40-PI-310	0-200 psig	40N03	Out of compliance return	
	40-PI-311	0-200 psig	40N03	Out of compliance return	
	40-PI-312	0-200 psig	40N03	Out of compliance return	
	40-PI-313	0-100 psig	40N03	Out of compliance return	
	40-PI-314	0-60 psig	40N03	Out of compliance return	
	40-PI-315	0-60 psig	40N03	REW to Odor Control Facility	

Notes:
Refer to Section 17402 for additional instrument valve requirements.

A/E:	**Carollo Engineers**	**PRESSURE GAUGES**							
						Spec. No.		**Rev.**	
Contractor:		**No**	**By**	**Date**	**Revision**	17404			
Project:	8930A11					**Contract**		**Date**	
Customer:	San Luis Obispo County								
Plant:	Los Osos					**Req.**		**P.O.**	
Location:	San Luis Obispo County, CA								
BOM No.:						**By**	**Chk**	**App**	
File:									

1	**Type**	Direct Rdg.: √		Receiver:		Other:
2	**Mounting**	Surface: Local:				Flush:
3	**Dial**	Diameter: 4.5”			Color:	
4	**Case**	**Cast Iron:**	**Aluminum:** √	**Phenolic:** √	**Polished SS**	**Other:**
5	**Ring**	Screwed:	Hinged:	Slip:	Std:	Other:
6	**Blowout Protection**	None:	Disc:	Front:	Other:	Mfr. Std.
7	**Lens**	Glass: √			Plastic:	
8	**Options**	Siphon: N/A			Material:	
9	**Other**	Snubber:				
10	**Other**	Pressure Limit Valve: N/A				
11	**Other**	Movement Damping: N/A				
12	**Nominal Accuracy Required**					
13	**Pressure Element**	Bourdon: √		Bellows:		Other:
14	**Element Material**	Bronze:	Steel:		Type SS: 316 √	Other:
15	**Socket Material**	Bronze:	Steel:		SS: 316	Other:
16	**Connection**	¼ in.:	½ in.: √		Bottom:	Other:
17	**Movement**	Dampened:	Standard: √		Other:	
18	**Diaphragm Seal**	Mfr.:		Wetted Part Mat’l:		Type:
19	**Other**	Other Mat’l:		Fill Fluid:		Model:
20	**Manufacturer**					
21	**Model No.**					

Rev	Tag Number	Range	P&ID	Service	Notes
	50-PI-122A	0-30 psig	50N02	RAS/WAS Pump No. 2 Seal Water	
	50-PI-122B	0-30 psig	50N02	RAS/WAS Pump No. 2 Discharge	
	50-PI-123A	0-30 psig	50N02A	RAS/WAS Pump No. 3 Seal Water	
	50-PI-123B	0-30 psig	50N02A	RAS/WAS Pump No. 3 Discharge	
	50-PI-423A	0-30 psig	50N10	Dewatering Feed Pump No. 1 Suction	
	50-PI-423B	0-100 psig	50N10	Dewatering Feed Pump No. 1 Discharge	
	50-PI-121	0-30 psig	50N01	RAS/WAS Pump No. 1 Suction	
	50-PI-122	0-30 psig	50N01	RAS/WAS Pump No. 2 Suction	
	50-PI-123	0-30 psig	50N01	RAS/WAS Pump No. 3 Suction	
	50-PI-121A	0-30 psig	50N02	RAS/WAS Pump No. 1 Seal Water	
	50-PI-121B	0-30 psig	50N02	RAS/WAS Pump No. 1 Discharge	

Notes:
Refer to Section 17402 for additional instrument valve requirements.

A/E:	**Carollo Engineers**	**PRESSURE GAUGES**						
						Spec. No.	**Rev.**	
Contractor:		**No**	**By**	**Date**	**Revision**	17404		
Project:	8930A11					**Contract**	**Date**	
Customer:	San Luis Obispo County							
Plant:	Los Osos					**Req.**	**P.O.**	
Location:	San Luis Obispo County, CA							
BOM No.:						**By**	**Chk**	**App**
File:								

1	**Type**	Direct Rdg.: √	Receiver:	Other:		
2	**Mounting**	Surface: Local:		Flush:		
3	**Dial**	Diameter: 4.5”	Color:			
4	**Case**	**Cast Iron:**	**Aluminum:** √	**Phenolic:** √	**Polished SS**	**Other:**
5	**Ring**	Screwed:	Hinged:	Slip:	Std:	Other:
6	**Blowout Protection**	None:	Disc:	Front:	Other:	Mfr. Std.
7	**Lens**	Glass: √	Plastic:			
8	**Options**	Siphon: N/A	Material:			
9	**Other**	Snubber:				
10	**Other**	Pressure Limit Valve: N/A				
11	**Other**	Movement Damping: N/A				
12	**Nominal Accuracy Required**					
13	**Pressure Element**	Bourdon: √	Bellows:	Other:		
14	**Element Material**	Bronze:	Steel:	Type SS: 316 √	Other:	
15	**Socket Material**	Bronze:	Steel:	SS: 316	Other:	
16	**Connection**	¼ in.:	½ in.: √	Bottom:	Other:	
17	**Movement**	Dampened:	Standard: √	Other:		
18	**Diaphragm Seal**	Mfr.:	Wetted Part Mat’l:	Type:		
19	**Other**	Other Mat’l:	Fill Fluid:	Model:		
20	**Manufacturer**					
21	**Model No.**					

Rev	Tag Number	Range	P&ID	Service	Notes
	50-PI-427A	0-30 psig	50N11	Dewatering Feed Pump No. 2 Suction	
	50-PI-427B	0-100 psig	50N11	Dewatering Feed Pump No. 2 Discharge	
	50-PI-423	0-100 psig	50N12	Dewatering Feed Pump No. 1 Seal Water	
	50-PI-427	0-100 psig	50N12	Dewatering Feed Pump No. 2 Seal Water	
	51-PI-431	0-160 psig	51N01	Screw Press No. 1 Plant Water Supply	
	51-PI-432	0-160 psig	51N02	Screw Press No. 2 Plant Water Supply	

Notes:
Refer to Section 17402 for additional instrument valve requirements.

A/E:	**Carollo Engineers**	**PRESSURE GAUGES**							
						Spec. No.		**Rev.**	
Contractor:		**No**	**By**	**Date**	**Revision**	17404			
Project:	8930A11					**Contract**		**Date**	
Customer:	San Luis Obispo County								
Plant:	Los Osos					**Req.**		**P.O.**	
Location:	San Luis Obispo County, CA								
BOM No.:						**By**	**Chk**	**App**	
File:									

1	**Type**	Direct Rdg.: √		Receiver:		Other:
2	**Mounting**	Surface: Local:				Flush:
3	**Dial**	Diameter: 4.5”			Color:	
4	**Case**	**Cast Iron:**	**Aluminum:** √	**Phenolic:** √	**Polished SS**	**Other:**
5	**Ring**	Screwed:	Hinged:	Slip:	Std:	Other:
6	**Blowout Protection**	None:	Disc:	Front:	Other:	Mfr. Std.
7	**Lens**	Glass: √			Plastic:	
8	**Options**	Siphon: N/A			Material:	
9	**Other**	Snubber:				
10	**Other**	Pressure Limit Valve: N/A				
11	**Other**	Movement Damping: N/A				
12	**Nominal Accuracy Required**					
13	**Pressure Element**	Bourdon: √		Bellows:		Other:
14	**Element Material**	Bronze:	Steel:		Type SS: 316 √	Other:
15	**Socket Material**	Bronze:	Steel:		SS: 316	Other:
16	**Connection**	¼ in.:	½ in.: √		Bottom:	Other:
17	**Movement**	Dampened:	Standard: √		Other:	
18	**Diaphragm Seal**	Mfr.:		Wetted Part Mat’l:		Type:
19	**Other**	Other Mat’l:		Fill Fluid:		Model:
20	**Manufacturer**					
21	**Model No.**					

Rev	Tag Number	Range	P&ID	Service	Notes
	60-PI-711	0-30 psig	60N01	Ground Water Well Pump No. 1	
	60-PI-712	0-30 psig	60N02	Ground Water Well Pump No. 2	
	60-PI-713	0-30 psig	60N03	FE/MN Filter Inlet	
	60-PI-734	0-160 psig	60N05	Non-Potable Water Supply Header (W2)	
	60-PI-764	0-160 psig	60N08	Potable Water Supply Header (W1)	

Notes:
Refer to Section 17402 for additional instrument valve requirements.

SECTION 17405

PRESSURE/VACUUM MEASUREMENT - DIRECT

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Pressure transmitters and indicators.

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 01660 - Testing, Training, and Commissioning.
      c. Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
      d. Section 17401 - Pressure/Vacuum Measurement - Diaphragm and Annular Seals.
      e. Section 17402 - Pressure/Vacuum Measurement - Instrument Valves.
      f. Section 17950 - Testing, Calibration, and Commissioning.

C. Provide all instruments identified in the Contract Documents.

1.02 REFERENCES

A. As specified in Section 17050.

1.03 DEFINITIONS

A. As specified in Section 17050.

B. NEMA:
   1. Type 4X enclosure in accordance with NEMA 250.

C. 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 Sections 01330 and 17050.

B. Provide complete documentation covering the traceability of all calibration instruments.

1.05 QUALITY ASSURANCE

A. As specified in Section 17050.

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.

1.07 PROJECT OR SITE CONDITIONS

A. Project environmental conditions as specified in Section 17050.
   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.

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 the completion of the Testing Phase specified in Section 01660.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. One of the following or equal:
   1. Rosemount: 3051 Series.

2. Yokogawa: EJA Series.
3. ABB: 264 Series.
4. Endress & Hauser: Cerabar S Series.

2.02 MANUFACTURED UNITS

A. Pressure transmitters – direct:
   1. General:
      a. Pressure transmitter assembly shall include a diaphragm type pressure transducer and microprocessor based transmitter for measurement of gauge, vacuum, or absolute pressure.
   2. Performance requirements:
      a. Maximum ratio of total instrument range to calibrated span: 10 to 1.
      b. Accuracy:
         1) Reference accuracy: 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:
         1) Verify all material compatibilities with the instrument manufacturer.
      d. Process connection: As specified in the Instrument Data Sheets.
   4. Transmitter:
      a. Power supply:
         1) 24 VDC - 2 wire loop powered.
         2) Power consumption: 3 VA maximum.
      b. Outputs:
         1) Isolated 4-20mA DC with HART communication protocol.
      c. Provided with electronic microprocessor.
      d. Adjustments: Adjustable electronic zero and span, with elevated or suppressed zero as required by application. Adjustment shall be possible without mechanical fulcrum points or handheld configurator.
      e. Local display:
         1) 5-digit LCD.
         2) Scaled in engineering units.
      f. Enclosure: NEMA Type 4X.
      g. Over range protection: To maximum process line pressure.
      h. Conduit: 1/2 inch male NPT.
   5. Components:
      a. Transmitter mounting:
         1) As specified in the Instrument Data Sheets.
         2) Provide all necessary hardware for transmitter mounting.

2.03 ACCESSORIES

A. Provide valve manifolds as specified in Section 17402:
   1. Mount valve manifold integrally to the transmitter.
   2. Valve manifold and transmitter shall be assembled by Manufacturer and shipped as an assembly.
   3. Provide remote or integral diaphragm seals as specified in the Instrument Data Sheets and in Section 17401.

B. Provide sunshades for outdoor installations.

2.04 SOURCE QUALITY CONTROL

A. As specified in Section 17050.

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 National Institute of Standards and Technology.
   1. 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 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 17050.

B. Coordinate the installation with all trades to ensure that the mechanical system has all necessary appurtenances including weld-o-lets, valves, etc. for proper installation of instruments.

3.04 FIELD QUALITY CONTROL

A. As specified in Section 17050.

B. Provide manufacturer's services to perform start-up and calibration or verification.

3.05 ADJUSTING

A. As specified in Section 17950.

3.06 CLEANING

A. As specified in Section 17050.

3.07 DEMONSTRATION AND TRAINING

A. As specified in Section 17050.

3.08 PROTECTION

A. As specified in Section 17050.

3.09 SCHEDULES

A. The provided information does not necessarily include all required instruments. Provide all instruments identified in the Contract Documents:
   1. Instruments may be indicated on the Drawings, specified in the Specifications, or both.

END OF SECTION

A/E:	**Carollo Engineers**		**PRESSURE TRANSMITTERS**						
							Spec. No.		**Rev.**
Contractor:			**No**	**By**	**Date**	**Revision**	17405		
Project:	8930A11						**Contract**		**Date**
Customer:	San Luis Obispo County								
Plant:	Los Osos						**Req.**		**P.O.**
Location:	San Luis Obispo County, CA								
BOM No.:							**By**	**Chk**	**App**
File:									
GENERAL	**1**	**Instrument Tag No.**	60-PIT-734				40-PIT-306		
	2	**Service**	Non-Potable Water				Tertiary Effluent		
	3	**P&ID**	60N05				40N03		
SERVICE	**4**	**Pressure**	60-80 psig				110-130 psig		
	5	**Process Temperature**	35-70 deg F				35-70 deg F		
	6	**Ambient Temperature**	70 deg F				70 deg F		
TRANSMITTER	**7**	**Manufacture**							
	8	**Model No.**							
	9	**Pressure Transmitter Type**	Direct				Direct		
	10	**Calibrated Span**	0-120 psig				0-200 psig		
	11	**Accuracy**	0.3% of SPAN				0.3% of SPAN		
	12	**Adjustable Range**					0-200 psig		
	13	**Output Signal**	4-20 Ma HART				4-20 Ma HART		
	14	**Body Rating**	NEMA 4X				NEMA 4X		
BODY	**15**	**Process Flange Type**	Threaded				Threaded		
	16	**Drain/Vent**	None				None		
	17	**Process Flange**	MNPT				MNPT		
	18	**Adapters**							
	19	**Wetted O-Ring**							
	20	**Housing**							
	21	**Bolts**							
	22	**Mounting Brackets**							
	23	**Conduit Entry Size**							
ELEMENT	**24**	**Isolating Diaphragm**	316 SS				316 SS		
	25	**Fill Fluid**	Silicone				Silicone		
OPTIONS	**26**	**Certification / Approval Type**							
	27	**Meter**	LCD				LCD		
	28	**Zero Span & Adjustment**							
	29	**Surge Protection**							
	30	**Custom Configuration**							
MANIFOLD	**31**	**Manufacturer**							
	32	**Model Number**							
	33	**Manifold Style**	As indicated on Drawings				As indicated on Drawings		
	34	**Manifold Type**	As indicated on Drawings				As indicated on Drawings		

Notes:
Refer to Section 17402 for additional instrument valve requirements.

A/E:	**Carollo Engineers**	**PRESSURE TRANSMITTERS**							
						Spec. No.		**Rev.**	
Contractor:		**No**	**By**	**Date**	**Revision**	17405			
Project:	8930A11					**Contract**		**Date**	
Customer:	San Luis Obispo County								
Plant:	Los Osos					**Req.**		**P.O.**	
Location:	San Luis Obispo County, CA								
BOM No.:						**By**	**Chk**	**App**	
File:									

GENERAL	**1**	**Instrument Tag No.**	60-PIT-764	
	2	**Service**	Potable Water	
	3	**P&ID**	60N08	
SERVICE	**4**	**Pressure**	60-80 psig	
	5	**Process Temperature**	35-70 deg F	
	6	**Ambient Temperature**	70 deg F	
TRANSMITTER	**7**	**Manufacture**		
	8	**Model No.**		
	9	**Pressure Transmitter Type**	Direct	
	10	**Calibrated Span**	0-120 psig	
	11	**Accuracy**	0.3% of SPAN	
	12	**Adjustable Range**		
	13	**Output Signal**	4-20 Ma HART	
	14	**Body Rating**	NEMA 4X	
BODY	**15**	**Process Flange Type**	Threaded	
	16	**Drain/Vent**	None	
	17	**Process Flange**	MNPT	
	18	**Adapters**		
	19	**Wetted O-Ring**		
	20	**Housing**		
	21	**Bolts**		
	22	**Mounting Brackets**		
	23	**Conduit Entry Size**		
ELEMENT	**24**	**Isolating Diaphragm**	316 SS	
	25	**Fill Fluid**	Silicone	
OPTIONS	**26**	**Certification / Approval Type**		
	27	**Meter**	LCD	
	28	**Zero Span & Adjustment**		
	29	**Surge Protection**		
	30	**Custom Configuration**		
MANIFOLD	**31**	**Manufacturer**		
	32	**Model Number**		
	33	**Manifold Style**	As indicated on Drawings	
	34	**Manifold Type**	As indicated on Drawings	

Notes:
Refer to Section 17402 for additional instrument valve requirements.

SECTION 17406

PRESSURE/VACUUM MEASUREMENT - DIFFERENTIAL

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Differential pressure transmitters and indicators.

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 01660 - Testing, Training, and Commissioning.
      c. Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
      d. Section 17401 - Pressure/Vacuum Measurement - Diaphragm and Annular Seals.
      e. 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.

B. National Institute of Standards and Technology (NIST).

1.03 DEFINITIONS

A. As specified in Section 17050.

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 the URV. The calibrated range corresponds to the pressure signal sent from the transmitter.

1.04 SUBMITTALS

A. Furnish submittals as specified in Sections 01330 and 17050.

B. Product data:
   1. Accessories such as diaphragm seals, valve manifold, snubbers, and pulsation dampeners.

C. Provide complete documentation covering the traceability of all calibration instruments.

1.05 QUALITY ASSURANCE

A. As specified in Section 17050.

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.

1.07 PROJECT CONDITIONS

A. Project environmental conditions as specified in Section 17050.
   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.

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 the completion of the Testing Phase specified in Section 01660.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. One of the following or equal:
   1. Rosemount Series.
   2. Yokogawa EJA Series.
   3. ABB 264 Series.
   4. Endress + Hauser Deltabar S Series.
   5. SMAR LD300 Series.

2.02 MANUFACTURED UNITS

A. Pressure transmitters - differential:
   1. General:
      a. Differential pressure transmitter assembly shall include a diaphragm-type pressure transducer and microprocessor-based transmitter for measurement of differential pressure.
      b. Differential pressure transmitters shall be used for liquid level measurement as indicated on the Drawings.
   2. Performance requirements:
      a. As specified in data sheets or instrument index.
      b. Maximum ratio of total instrument range to calibrated span: 10 to 1.
      c. 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 differential pressure transmitter.
      b. Diaphragm material: Stainless steel .
      c. Wetted materials: Stainless steel.
         1) Process material compatibility:
            a) Verify all material compatibilities with the instrument Manufacturer.
      d. Diaphragm fill fluid: Silicon Oil.
      e. Process connection: Mount to flange in vertical plane with extension.
   4. Transmitter:
      a. Power supply:
         1) 24 VDC - loop powered.
         2) Power consumption: 3 VA maximum.
      b. Outputs:
         1) Isolated 4-20 mA DC with HART communication protocol.
      c. Provided with electronic microprocessor.
      d. Adjustments: Adjustable electronic zero and span, with elevated or suppressed zero as required by application. Adjustment shall be possible without mechanical fulcrum points or handheld configurator.
      e. Square root extraction for flow calculation.

f. Local display:
    1) 5-digit LCD.
    2) Scaled in engineering units.
g. Enclosure: NEMA Type 7 as shown on the Drawings.
h. Overrange protection: To maximum process line pressure.
i. Conduit connection: 1/2 inch male NPT.

5. Components:
    a. Transmitter mounting:
        1) As specified in the data sheets or instrument index.
        2) Provide all necessary hardware for transmitter mounting.

2.03 ACCESSORIES

A. Provide 3-valve manifold as specified in Section 17402:
    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 Integral diaphragm seals as indicated on the Drawings and as specified in Section 17401.
    1. Diaphragm seal and transmitter shall be assembled by manufacturer and shipped as an assembly.

C. Provide extended 4-inch Class 150 flanged diaphragm for tank or vessel level measurement:
    1. Flanged diaphragm and transmitter shall be assembled by Manufacturer and shipped as an assembly.

D. Provide sunshades for outdoor installations.

2.04 SOURCE QUALITY CONTROL

A. As specified in Section 17050.

B. Each differential pressure transmitter shall be factory calibrated with 5-point calibration 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.

B. Coordinate the installation with all trades to ensure that the mechanical system has all necessary appurtenances including weld-o-lets, valves, etc. for proper installation of instruments.

3.02 FIELD QUALITY CONTROL

A. As specified in Section 17050.

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:
   1. 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.

3.05 DEMONSTRATION AND TRAINING

A. As specified in Section 17050.

B. Demonstrate performance of all instruments to the ENGINEER before commissioning:

3.06 PROTECTION

A. As specified in Section 17050.

3.07 SCHEDULES

A. The provided information does not necessarily include all required instruments. Provide all instruments identified in the Contract Documents:
   1. Instruments may be indicated on the Drawings, specified in the Specifications, or both.

END OF SECTION

A/E:	**Carollo Engineers**		**DIFFERENTIAL PRESSURE TRANSMITTERS**						
							Spec. No.		**Rev.**
Contractor:			**No**	**By**	**Date**	**Revision**	17406		
Project:	8930A11						**Contract**		**Date**
Customer:	San Luis Obispo County								
Plant:	Los Osos						**Req.**		**P.O.**
Location:	San Luis Obispo County, CA								
BOM No.:							**By**	**Chk**	**App**
File:									

GENERAL	**1**	**Instrument Tag No.**	PDIT-411	PDIT-412
	2	**Service**	Sludge Tank	Sludge Tank
	3	**P&ID**	50N08	50N09
SERVICE	**4**	**Pressure**	12 ft WC	12 ft WC
	5	**Process Temperature**	35-70 deg F	35-70 deg F
	6	**Ambient Temperature**		
TRANSMITTER	**7**	**Manufacturer**		
	8	**Model No.**		
	9	**Pressure Transmitter Type**	Differential	Differential
	10	**Calibrated Span**	0-20 ft WC	0-20 ft WC
	11	**Accuracy**	0.3% of SPAN	0.3% of SPAN
	12	**Adjustable Range**		
	13	**Output Signal**	4-20 mA	4-20 mA
	14	**Body Rating**	As shown on the DWGS	As shown on the DWGS
BODY	**15**	**Process Flange Type**	316 SS	316 SS
	16	**Drain/Vent**	N/A	N/A
	17	**Process Flange**	ANSI Class 150	ASTM A 307, Grade B
	18	**Adapters**		
	19	**Wetted O-Ring**		
	20	**Housing**		
	21	**Bolts**		
	22	**Mounting Brackets**		
	23	**Conduit Entry Size**		
ELEMENT	**24**	**Isolating Diaphragm**	Stainless Steel	Stainless Steel
	25	**Fill Fluid**	Silicon Oil	Silicon Oil
OPTIONS	**26**	**Certification / Approval Type**		
	27	**Meter**	LCD	LCD
	28	**Zero Span & Adjustment**		
	29	**Surge Protection**		
	30	**Custom Configuration**		
MANIFOLD	**31**	**Manufacturer**		
	32	**Model Number**		
	33	**Manifold Style**	3-valve	3-valve
	34	**Manifold Type**	316 SS	316 SS

Notes:
Refer to Section 17401 for additional diaphragm seal requirements.
Refer to Section 17402 for additional instrument valve requirements.

SECTION 17407

PRESSURE MEASUREMENT - SUBMERSIBLE

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Submersible pressure transmitters.

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 01660 - Testing, Training, and Commissioning.
      c. Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
      d. Section 17950 - Testing, Calibration, and Commissioning.

C. Provide all instruments identified in the Contract Documents.

1.02 REFERENCES

A. As specified in Section 17050.

B. National Institute of Standards and Technology (NIST).

1.03 DEFINITIONS

A. As specified in Section 17050.

1.04 SUBMITTALS

A. Furnish submittals as specified in Sections 01330 and 17050.

B. Provide complete documentation covering the traceability of all calibration instruments.

1.05 QUALITY ASSURANCE

A. As specified in Section 17050.

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.

1.07 PROJECT OR SITE CONDITIONS

A. Project environmental conditions as specified in Section 17050.
   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.

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 the completion of the Testing Phase specified in Section 01660.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Submersible level measurement with 2-wire integral transmitter:
   1. One of the following or equal:
      a. Endress+Hauser, Waterpilot FMX21.
      b. GE Druck, PTX-1830.
      c. Siemens, A1000i.

2.02 MANUFACTURED UNITS

A. Submersible level measurement with 2-wire integral transmitter:
   1. General:
      a. Pressure is measured through a diaphragm-type measuring cell and converted to linear pressure measurement.
      b. Each submersible pressure transmitter system shall include:
         1) Signal cable, including pressure compensation tube.

2) Transducer probe with integral transmitter.
3) Transmitter cable termination box.

2. Performance requirements:
   a. Accuracy:
      1) 0.3 percent of range.
   b. Repeatability:
      1) 0.25 percent of full scale.
   c. Rangeability:
      1) 3:1.
   d. Range:
      1) As indicated on the contract documents.
3. Element:
   a. Sensor housing shall be Type 316L stainless steel or titanium with ceramic, Teflon-coated, or titanium diaphragm.
   b. Protective cap shall be manufacturer's recommended material, chemically resistant to process fluid.
   c. Slip resistant extension cable with pressure compensation tube with Teflon filter.
   d. Enclosure for probe and transmitter assembly shall be NEMA Type 4X.
4. Transmitter:
   a. Power supply:
      1) 24 VDC: 2 wire loop powered.
      2) Power consumption: 18 VA maximum.
   b. Outputs:
      1) Isolated 4 to 20 milliamperes DC.
   c. Without display.
   d. Ambient operating temperature limits of -10 to 70 degrees Celsius (-14 to 158 degrees Fahrenheit).
   e. Transmitter shall be integral to probe housing.
5. Transmitter cable termination box:
   a. NEMA Type 4X.
   b. Equipped with filter or desiccant chamber to eliminate moisture from the pressure compensation tube.
   c. Termination for signal wires and pressure compensation tube.

2.03 ACCESSORIES

A. Type 316L stainless steel mounting clamp with Type 304 stainless steel mounting screws.

B. Provide cable clamp and strain relief.

C. Provide computer cable adapter with Windows® software.

D. Provide sunshade for outdoor installations.

2.04 SOURCE QUALITY CONTROL

A. As specified in Section 17050.

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.
   1. 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 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 17050.

B. Coordinate the installation with all trades to ensure that the mechanical system has all necessary appurtenances including weld-o-lets, valves, etc. for proper installation of instruments.

3.04 FIELD QUALITY CONTROL

A. As specified in Section 17050.

B. Provide manufacturer's services to perform start-up and calibration or verification.

3.05 ADJUSTING

A. As specified in Section 17950.

3.06 CLEANING

A. As specified in Section 17050.

3.07 DEMONSTRATION AND TRAINING

A. As specified in Section 17050.

3.08 PROTECTION

A. As specified in Section 17050.

3.09 SCHEDULES

A. Instrument Data Sheets included in this Section.

B. The provided information does not necessarily include all required instruments.

C. Provide all instruments identified in the Contract Documents:
   1. Instruments may be indicated on the Drawings, specified in the Specifications, or both.

END OF SECTION

A/E:		**Carollo Engineers**		**SUBMERSIBLE PRESSURE INSTRUMENTS**						
								Spec. No.		**Rev.**
Contractor:				**No**	**By**	**Date**	**Revision**	17407		
Project:		8930A11						**Contract**		**Date**
Customer:		San Luis Obispo County								
Plant:		Los Osos						**Req.**		**P.O.**
Location:		San Luis Obispo County, CA								
BOM No.:								**By**	**Chk**	**App**
File:										
G E N	**1**	**Instrument Tag Number**	LIT-711	LIT-712						
	2	**Service**	Potable Water	Potable Water						
	3	**P&ID**	60 N01	60 N02						
	4	**Fluid Type**	Water	Water						
	5	**Fluid Specific Gravity**	1.0	1.0						
P R O B E	**6**	**Type**	Submersible	Submersible						
	7	**Measuring Cell Material**	Diaphragm	Diaphragm						
	8	**Probe Body Material**	MFR's Recommended for Intended Service	MFR's Recommended for Intended Service						
	9	**Op. Temp. Range**	40-80 deg F	40-80 deg F						
	10	**Op. Pressure Range**	0- ft	0- ft						
	11	**Other**								
	12	**Other**								
C A B L E	**13**	**Style**	Mfg. Std	Mfg. Std						
	14	**Signal Cable Length**	As Required	As Required						
	15	**Other**								
	16	**Other**								
	17	**Other**								
T R A N S M I T T E R	**18**	**Type**	Integral	Integral						
	19	**Operating Mode**	Continuous	Continuous						
	20	**Enclosure**	NEMA 4X	NEMA 4X						
	21	**Mounting**								
	22	**Temperature Range**	-10 to 70 deg. C	-10 to 70 deg. C						
	23	**Measurement Range**	0-200 ft	0-200 ft						
	24	**Power Supply**	24 VDC	24 VDC						
	25	**Accuracy**	0.3 % of range	0.3 % of range						
	26	**Display**	LCD	LCD						
	27	**Output**	4-20 mA	4-20 mA						
	28	**Calibration**								
	29	**Status Relay**								
	30	**Manufacturer**								
	31	**Model No.**								
	32	**Elect. Entry**								
	33	**Other**								
O P T S	**33**									
	34									
	35									
	36									

Notes:

SECTION 17505

ANALYZERS – RESIDUAL CHLORINE

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Residual chlorine analyzers.

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 01660 - Testing, Training, and Commissioning.
      c. Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

C. Provide all instruments identified in the Contract Documents.

1.02 REFERENCES

A. As specified in Section 17050.

B. National Institute of Standards and Technology (NIST).

1.03 DEFINITIONS

A. As specified in Section 17050.

1.04 SUBMITTALS

A. Furnish submittals as specified in Sections 01330 and 17050.

B. Provide complete documentation covering the traceability of all calibration instruments.

1.05 QUALITY ASSURANCE

A. As specified in Section 17050.

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. As specified in Section 17050.

1.07 PROJECT OR SITE CONDITIONS

A. Project environmental conditions as specified in Section 17050.
   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.

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 the completion of the Testing Phase specified in Section 01660.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Provide the following or equal:
   1. Siemens Wallace and Tiernan Micro 2000 with SFC Transmitter.
   2. Chemscan A-2000.

2.02 MANUFACTURED UNITS

A. General:
   1. Total chlorine residual monitoring system.
      a. System shall measure total chlorine residual as the sum of hypochlorous acid, hypochlorite ion, and monochloramine.
      b. System shall utilize the amperometric method with bare electrodes, pH buffer solution, and potassium iodide reagent to provide continuous online measurement of total chlorine.

c. System shall include all components necessary for a fully functioning system.
    1) Sample Flow System:
        a) A continuous sample shall be delivered to the analyzer.
        b) A flushing type Y-strainer and throttling valve shall be provided in the sample line as well as a 3-way valve for calibration water.
        c) The Y-strainer shall divide the sample into two streams. The larger stream shall continuously flush the strainer element and the smaller stream shall flow to the analyzer. A small portion of this flow shall be regulated and delivered to the analyzing cell using a peristaltic pump.
        d) The peristaltic pump head shall be capable of metering the sample as well as two reagents.
        e) Pump speed shall be fixed at 2 rpm for monitoring and control applications.
        f) The reagents shall combine with the sample before entering the cell flow block.
        g) In the cellblock, the three-electrode cell shall be immersed in the sample and a rotating impeller shall maintain a constant velocity across the electrode surfaces. The impeller shall also agitate the grit used to clean deposits from the electrodes, improving the stability of calibration.
        h) The three-electrode cell shall produce an electrical current signal proportional to the oxidant concentration in the biased sample.
d. System shall be suitable for measurement of total chlorine in municipal wastewater.
e. Automatic temperature compensation shall be included as standard.
f. The analyzer shall not lose sensitivity due to extended periods of samples containing no chlorine.

B. Three-electrode amperometric cell with the following attributes:
    1. Bare Platinum disc-working electrode.
    2. Second bare Platinum disc counter electrode.
    3. Silver/Silver Chloride reference electrode shall be provided to give stability and sensitivity down to 2 percent of full scale, regardless of changes in sample characteristics.
        a. Bias circuitry shall compare the potential of the measuring electrode to that of the Silver/Silver Chloride reference electrode and automatically bias the measuring electrode to maintain a fixed potential to screen out interferences from contaminants even at very low residual readings.

C. Reagent System:
    1. To bias the sample and provide pH adjustment, a buffer/Iodate solution, matched to the residual range and Potassium Iodide shall be fed via the peristaltic pump.
    2. The reagents shall be reacted together within a Viton® reaction tube to produce a stable bias for the analyzer.

D. Transmitter:
   1. Provides power for all components of the chlorine residual monitoring system.
      a. Power Supply:
         1) 120VAC.
         2) Power consumption: 30 watts maximum.
      b. Outputs:
         1) One 4-20mA isolated output with span programmable over any portion of the chlorine residual range.
         2) Relay Outputs:
            a) Two SPST relay contacts.
            b) Selectable to activate on the following conditions:
               (1) High or low sample concentration.
               (2) Analyzer system warning.
               (3) Analyzer system shutdown.
      c. Components:
         1) Manufacturer's cables.
      d. Display:
         1) Graphical display, resolution 128 x 64 pixels, white background illumination.
      e. Enclosure:
         1) NEMA 4X.
   2. Provides local indication of total chlorine residual.

E. All mounting hardware required to install all system components.

2.03 ACCESSORIES

A. Provide a NEMA 4X non-metallic enclosure to house each chlorine analyzer system including the transmitter, analyzer, reagents, and 120VAC disconnect switch.

B. Provide sun shield for outdoor installations.

2.04 SOURCE QUALITY CONTROL

A. Refer to 17050.

B. Provide complete documentation covering the traceability of all calibration instruments.

C. Submit a real-time computer generated printout of the actual calibration data indicating apparent and actual residuals at 20 percent, 40 percent, 60 percent, 80 percent, and 100 percent of the calibrated range to the ENGINEER at least 30 days before shipment of the systems 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.

B. Installation of system and associated piping and tubing shall be in strict accordance with manufacturer's installation requirements.

C. Coordinate the installation with all trades to ensure that the mechanical system has all necessary appurtenances including weld-o-lets, valves, etc., for proper installation of instruments.

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 17050.

3.04 FIELD QUALITY CONTROL

A. As specified in Section 17050.

B. Manufacturer's field services.

3.05 ADJUSTING

A. As specified in Section 17950.

3.06 CLEANING

A. As specified in Section 17050.

3.07 DEMONSTRATION AND TRAINING

A. As specified in Section 17050.

3.08 PROTECTION

A. As specified in Section 17050.

3.09 SCHEDULES

A. 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 the Specifications, or both.

END OF SECTION

A/E:	**Carollo Engineers**	**CHLORINE RESIDUAL ANALYZERS**							
						Spec. No.		**Rev.**	
Contractor:		**No**	**By**	**Date**	**Revision**	17505			
Project:	8930A11					**Contract**		**Date**	
Customer:	San Luis Obispo County								
Plant:	Los Osos					**Req.**		**P.O.**	
Location:	San Luis Obispo County, CA								
BOM No.:						**By**	**Chk**	**App**	
File:									

GENSMPL UNIT	**1**	**Tag No. / Sample Unit / Transmitter**	**40-AE/AIT-308**	**60-AI/AIT-713**
	2	**Service**	Residual Chlorine	Residual Chlorine
	3	**P&ID**	40N03	60N03
	4	**Type**	Amperometric	Amperometric
	5	**Enclosure**	NEMA 4X	NEMA 4X
	6	**Sampling Method**	Slip Stream	Slip Stream
	7	**Operating Temperature Range**	35-120 degrees F	35-120 degrees F
	8	**Sample Temperature Range**	40-80 degrees F	40-80 degrees F
	9	**Sample Flow Required**	MFD Requirement	MFD Requirement
	10	**Manufacturer**		
	11	**Model No.**		
	12	**Other**		
CABLE	**13**	**Style**	Mfr Std	Mfr Std
	14	**Length**		
	15	**Model No.**		
	16	**Other**		
	17	**Other**		
TRANSMITTER	**18**	**Type**	Control Unit and Display	Control Unit and Display
	19	**Enclosure**	NEMA 4X	NEMA 4X
	20	**Mounting**	Surface	Surface
	21	**Accuracy**	See spec.	
	22	**Range**	0-30 PPM	0-15 PPM
	23	**Power Requirements**	115 VAC, 60 HZ	115 VAC, 60 HZ
	24	**Display**	LCD	LCD
	25	**Resolution**		
	26	**Output**	4-20 mA	4-20 mA
	27	**Calibration**		
	28	**Manufacturer**		
	29	**Model No.**		
	30	**Other**		
	31	**Other**		
	32	**Other**		
OPTS	**33**			
	34			
	35			
	36			
	37			
	38			

Notes:

A/E:	**Carollo Engineers**	**CHLORINE RESIDUAL ANALYZERS**							
						Spec. No.		**Rev.**	
Contractor:		**No**	**By**	**Date**	**Revision**	17505			
Project:	8930A11					**Contract**		**Date**	
Customer:	San Luis Obispo County								
Plant:	Los Osos					**Req.**		**P.O.**	
Location:	San Luis Obispo County, CA								
BOM No.:						**By**	**Chk**	**App**	
File:									

G	**1**	**Tag No. / Sample Unit / Transmitter**	**40-AE/AIT-715**	
E	**2**	**Service**	Residual Chlorine	
N	**3**	**P&ID**	60N03	
S	**4**	**Type**	Amperometric	
M	**5**	**Enclosure**	NEMA 4X	
P	**6**	**Sampling Method**	Slip Stream	
L	**7**	**Operating Temperature Range**	35-120 degrees F	
	8	**Sample Temperature Range**	40-80 degrees F	
U	**9**	**Sample Flow Required**	MFD Requirement	
N	**10**	**Manufacturer**		
I	**11**	**Model No.**		
T	**12**	**Other**		
C	**13**	**Style**	Mfr Std	
A	**14**	**Length**		
B	**15**	**Model No.**		
L	**16**	**Other**		
E	**17**	**Other**		
	18	**Type**	Control Unit and Display	
T	**19**	**Enclosure**	NEMA 4X	
R	**20**	**Mounting**	Surface	
A	**21**	**Accuracy**	See spec.	
N	**22**	**Range**	0-15 PPM	
S	**23**	**Power Requirements**	115 VAC, 60 HZ	
M	**24**	**Display**	LCD	
I	**25**	**Resolution**		
T	**26**	**Output**	4-20 mA	
T	**27**	**Calibration**		
E	**28**	**Manufacturer**		
R	**29**	**Model No.**		
	30	**Other**		
	31	**Other**		
	32	**Other**		
	33			
O	**34**			
P	**35**			
T	**36**			
S	**37**			
	38			

Notes:

SECTION 17506

ANALYZERS - DISSOLVED OXYGEN (DO)

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Dissolved oxygen (DO) analyzer.

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 01660 - Testing, Training, and Commissioning.
      c. Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
      d. Section 17950 - Testing, Calibration, and Commissioning.

C. Provide all instruments identified in the Contract Drawings.

1.02 REFERENCES

A. As specified in Section 17050.

B. National Electrical Manufacturers Association (NEMA):
   1. 250 – Enclosures for Electrical Equipment (1000 V Maximum).

C. National Institute of Standards and Technology (NIST).

1.03 DEFINITIONS

A. As specified in Section 17050.

B. NEMA:
   1. Type 4X enclosure in accordance with NEMA 250.
   2. Type 6P enclosure in accordance with NEMA 250.

C. Specific definitions:
   1. DO - Dissolved oxygen.

1.04 SUBMITTALS

A. Furnish submittals as specified in Sections 01330 and 17050.

B. Provide complete documentation covering the traceability of all calibration instruments.

1.05 QUALITY ASSURANCE

A. As specified in Section 17050.

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.

1.07 PROJECT OR SITE CONDITIONS

A. Project environmental conditions as specified in Section 17050.

1.08 WARRANTY

A. As specified in Section 17050.

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 the completion of the Testing Phase specified in Section 01660.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. One of the following or equal:
   1. Hach LDO probe with Hach sc200 controller.

2.02 MANUFACTURED UNITS

A. DO analyzer:
   1. General:
      a. DO analyzer for continuous monitoring of dissolved oxygen in liquid.
   2. Performance requirements:
      a. Measuring range: 0 to 20 parts per million (ppm).
      b. Sensor accuracy:
         1) Within 0.2 ppm for values above 1 ppm.
         2) Within 0.1 ppm for values below 1 ppm.
      c. Repeatability: Within 0.5 percent of span.
      d. Response time:
         1) 90 percent value: Less than 40 seconds.
         2) 95 percent value: Less than 60 seconds.
   3. Element:
      a. Optical type that measures the fluorescence or luminescence of a ruthenium or platinum coated sensor.
      b. Using no membrane, electrodes, or electrolyte.
      c. Drift: less than 1 percent per year.
      d. Automatic self-diagnostics.
      e. Integral temperature sensor.
      f. Maximum pressure: 150 pounds per square inch.
      g. Power supply: From transmitter through the sensor cable.
      h. Enclosure: NEMA Type 6P.
   4. Transmitter:
      a. Power supply:
         1) 120 VAC.
         2) Power consumption: 75 VA maximum.
      b. Outputs:
         1) Isolated 4 to 20 milliamperes DC with HART communication protocol.
      c. Microprocessor based with features resident in non-volatile memory.
      d. Display dissolved oxygen content with 0.01 ppm resolution over a range of 0.00 to 9.99 ppm and 0.1 ppm resolution over a range of 10.0 to 20.0 ppm.
      e. Display temperature with 0.2 degree Celsius accuracy.
      f. Enclosure rating: NEMA Type 4X.
      g. Automatic temperature compensation.
   5. Components:
      a. Manufacturer’s cable for sensor to transmitter connection.

2.03 ACCESSORIES

A. Calibration equipment:
   1. Provide components recommended by the manufacturer to verify calibration.

B. Provide sunshade for outdoor installations.

C. Provide a ball float mount kit for mounting the sensor.

2.04 SOURCE QUALITY CONTROL

A. As specified in Section 17050.

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.
   1. 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 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 17050.

3.04 FIELD QUALITY CONTROL

A. As specified in Section 17050.

B. Manufacturer's field services.

3.05 ADJUSTING

A. As specified in Section 17950.

3.06 CLEANING

A. As specified in Section 17050.

3.07 DEMONSTRATION AND TRAINING

A. As specified in Section 17050.

3.08 PROTECTION

A. As specified in Section 17050.

3.09 SCHEDULES

A. The provided information does not necessarily include all required instruments. Provide all instruments identified in the Contract Documents:
   1. Instruments may be indicated on the Drawings, specified in the Specifications, or both.

END OF SECTION

A/E:	**Carollo Engineers**	**ANALYZERS - DISSOLVED OXYGEN (DO)**							
						Spec. No.		**Rev.**	
Contractor:		**No**	**By**	**Date**	**Revision**	17506			
Project:	8930A11					**Contract**		**Date**	
Customer:	San Luis Obispo County								
Plant:	Los Osos					**Req.**		**P.O.**	
Location:	San Luis Obispo County, CA								
BOM No.:						**By**	**Chk**	**App**	
File:									

G	**1**	**Tag No.**	**20-AE/AIT-095**	**20-AE/AIT-105**
E	**2**	**Service**	Oxidation Ditch No. 1	Oxidation Ditch No. 2
N	**3**	**P&ID**	20N01	20N02
S	**4**	**Type**	Luminescent, Immersion type	Luminescent, Immersion type
E	**5**	**Operating Temperature Range**	32 to 122 degrees Fahrenheit	32 to 122 degrees Fahrenheit
N	**6**	**Resolution**	Below 10 ppm: ±0.07 ppm or mg/L, ±0.1% saturation Above 10 ppm: ±0.01 ppm or mg/L, ±0.1% saturation	Below 10 ppm: ±0.07 ppm or mg/L, ±0.1% saturation Above 10 ppm: ±0.01 ppm or mg/L, ±0.1% saturation
S	**7**	**Sensitivity**	±0.5% of span	±0.5% of span
O	**8**	**Repeatability**	±0.5% of span	±0.5% of span
R	**9**	**Accuracy**	± 0.1 ppm Below 1 ppm; ± 0.2 ppm Above 1 ppm; ± 0.2% of span	± 0.1 ppm Below 1 ppm; ± 0.2 ppm Above 1 ppm; ± 0.2% of span
	10	**Manufacturer**		
	11	**Model No.**		
C	**12**	**Style**	Mfr Std.	Mfr Std.
A	**13**	**Length**		
B	**14**	**Model No.**		
L	**15**	**Other**		
E	**16**	**Other**		
	17	**Type**	Control Unit and Display	Microprocessor-based
T	**18**	**Enclosure**	NEMA 4X	NEMA 4X
R	**19**	**Mounting**	Surface	Surface
A	**20**	**Range**	0-20mg/L	0-20mg/L
N	**21**	**Repeatability**	±0.05% of range	±0.05% of range
S	**22**	**Power Requirements**	120 VAC	120 VAC
M	**23**	**Display**	Graphic dot matrix LCD with LED backlighting	Graphic dot matrix LCD with LED backlighting
I	**24**	**Resolution**	240 x 160 pixels	240 x 160 pixels
T	**25**	**Number of sensor input channels**		
T	**26**	**Outputs**	4 to 20 MA with HART	4 to 20 MA with HART
E	**27**	**Manufacturer**		
R	**28**	**Model No.**		
	29	**Ambient Operating Temperature**	-4 to 140 degrees Fahrenheit	-4 to 140 degrees Fahrenheit
	30	**Relays**		
O	**31**	**Mounting Kit**		
P	**32**	**Cleaning**		
T	**33**	**Power cord**		

Notes:

SECTION 17509

ANALYZERS - TURBIDITY

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Turbidity analyzers (turbidimeters).

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 01660 - Testing, Training, and Commissioning.
      c. Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
      d. Section 17950 - Testing, Calibration, and Commissioning.

C. Provide all instruments identified in the Contract Documents.

1.02 REFERENCES

A. As specified in Section 17050.

B. CSA International (CSA).

C. National Institute of Standards and Technology (NIST).

D. United States Environmental Protection Agency (USEPA):
   1. Method 180.1 – Determination of Turbidity by Nephilometry.

1.03 DEFINITIONS

A. As specified in Section 17050.

1.04 SUBMITTALS

A. Furnish submittals as specified in Sections 01330 and 17050.

B. Provide complete documentation covering the traceability of all calibration instruments.

1.05 QUALITY ASSURANCE

A. As specified in Section 17050.

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.

1.07 PROJECT OR SITE CONDITIONS

A. Project environmental conditions as specified in Section 17050.
   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.

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 the completion of the Testing Phase specified in Section 01660.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. One of the following or equal:
   1. Low range turbidimeters: Incandescent type:
      a. HACH 1720E sensor with sc200 controller.

2.02 MANUFACTURED UNITS

A. Low range turbidimeters: Incandescent type:
   1. Turbidimeter:
      a. The turbidimeter shall be a microprocessor-based, continuous-reading, on-line nephelometric instrument meeting all design and performance

criteria in accordance with USEPA method 180.1. Each turbidity system shall consist of a 1 sensor and 1 transmitter.

b. Light shall be directed through the surface of the sample and the detector shall be immersed in the sample, eliminating glass windows and flow cells.

c. Optical components shall be mounted in a sealed head assembly that can be removed easily for calibration/service, without disturbing sample flow.

d. The turbidimeter body shall be constructed of corrosion-resistant polystyrene, and shall include an internal bubble trap to vent entrained air from the sample stream.

e. The turbidimeter shall offer the choice of Formazin-based (20 or 1 NTU) or instrument comparison-based calibration methods.

f. User selectable signal averaging, bubble rejection, alarm, and recorder output hold, and self-test diagnostics shall be provided.

2. Performance requirements:

a. Range: 0 to 10 nephelometric turbidity units (NTU).

b. Accuracy:

1) Within 2 percent of reading or within 0.020 NTU (whichever is greater) from 0 to 40 NTU.

2) Within 5 percent of reading from 40 to 100 NTU.

c. Resolution: 0.001 NTU.

d. Repeatability: Better than within 1.0 percent of reading or within 0.020 NTU, whichever is greater.

e. Response time:

1) Initial response in 1 minute.

2) 15 seconds with internal bubble trap.

f. Sample flow required: 250 to 750 milliliter per minute (4.0 to 11.9 gallons per hour).

g. Storage temperature: -20 degrees Celsius to 60 degrees Celsius (- 4 degrees Fahrenheit to 140 degrees Fahrenheit).

h. Operating temperature: 0 degrees Celsius to 40 degrees Celsius (32 degrees Fahrenheit to 104 degrees Fahrenheit).

i. Operating humidity: 5 to 95 percent non-condensing.

j. Sample temperature: 0 degrees Celsius to 50 degrees Celsius (32 degrees Fahrenheit to 122 degrees Fahrenheit).

3. Transmitter:

a. The graphical interface unit shall be a microprocessor-based device capable of functioning with a single sensor, and as a digital interface link between turbidimeters and other communication devices through a digital bus communications.

b. All turbidimeters on the network shall have RS232 serial input/output capability for 2-way communication to a computer or 1-way communication to a printer to record or print real-time turbidity data, calibration history, and current set points.

c. The interface unit shall allow operators to control sensor and network functions with user-friendly, menu-driven software, and shall provide data logging of measurement data from up to 8 turbidimeters for 1 hour, 24 hours or 30 days, and the capability to transfer data to a computer or printer via an RS232 serial input/output device.

d. The interface unit and separate DC power supply shall be housed in NEMA Type 4X (indoor) industrial plastic enclosures.

e. Piping connections:
   1) Sample inlet fitting: 1/4 inch NPT female, 1/4 inch compression fitting.
   2) Drain fitting 1/2 inch NPT female, 1/2 inch hose barb.
f. Communications distance:
   1) Maximum node-to-node distance: 400 meters (1,312 feet).
   2) Maximum total cable length: 500 meters (1,640 feet).
g. Enclosures NEMA Type 4X/IP66.
h. Certification:
   1) Safety listed by ETL in accordance with UL3101-1.
   2) Certified by ETL in accordance with CSA C22.2 No. 1010.1.
   3) CE Certified by HACH Company in accordance with EN 61010-1.
   4) Emissions FCC Part 15, Class A Canadian Interference-Causing Equipment Regulation ICES-003, Class A.
i. Power supply:
   1) 120 VAC.
   2) Power consumption: 40 VA maximum.
j. Outputs:
   1) Isolated 4 to 20 milliamperes DC with HART communication protocol.
   2) Relay outputs:
      a) 2 Form C contact.
      b) Rated 5 amps at 230 VAC.
      c) Programmable.
   3) Output span programmable over any portion of the 0 to 10 NTU range.

2.03 ACCESSORIES

A. Mounting brackets as required or as indicated on the Drawings.

B. Provide sunshades for outdoor installations.

C. Flushing solenoids for cleaning the probe as recommended by the manufacturer.

D. Provide NEMA 4X non-metallic cabinet with viewing window for each turbidimeter system which includes the analyzer, transmitter, and 120VAC disconnect switch.

2.04 SOURCE QUALITY CONTROL

A. As specified in Section 17050.

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.
   1. 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 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 17050.

B. Coordinate the installation with all trades to ensure that the mechanical system has all necessary appurtenances including weld-o-lets, valves, etc. for proper installation of instruments.

3.04 FIELD QUALITY CONTROL

A. As specified in Section 17050.

B. Provide manufacturer's services to perform start-up and calibration or verification.

3.05 ADJUSTING

A. As specified in Section 17950.

3.06 CLEANING

A. As specified in Section 17050.

3.07 DEMONSTRATION AND TRAINING

A. As specified in Section 17050.

3.08 PROTECTION

A. As specified in Section 17050.

3.09 SCHEDULES

A. The provided information does not necessarily include all required instruments. Provide all instruments identified in the Contract Documents:
   1. Instruments may be indicated on the Drawings, specified in the Specifications, or both.

END OF SECTION

A/E:	**Carollo Engineers**		**TURBIDITY ANALYZER**							
							Spec. No.		**Rev.**
Contractor:			**No**	**By**	**Date**	**Revision**	17509		
Project:	8930A11						**Contract**		**Date**
Customer:	San Luis Obispo County								
Plant:	Los Osos						**Req.**		**P.O.**
Location:	San Luis Obispo County, CA								
BOM No.:							**By**	**Chk**	**App**
File:									

G	**1**	**Tag No.**	**Sample Unit**	**Transmitter**	**28-AE/AIT-181**	**30-AE/AIT-230**
E	**2**	**Service**			Filter Influent	Filter Effluent
N	**3**	**P&ID**			20 N01	30 N01
S	**4**	**Type**			Low Range	Low Range
M	**5**	**Enclosure**			Nephelometric	Nephelometric
P	**6**	**Sampling Method**			0 to 40° C	0 to 40° C
L	**7**	**Operating Temperature Range**			0 to 50° C	0 to 50° C
	8	**Sample Temperature Range**			Nephelometric	Nephelometric
U	**9**	**Sample Flow Required**			250 to 750 mL/minute	250 to 750 mL/minute
N	**10**	**Manufacturer**				
I	**11**	**Model No.**				
T	**12**	**Other**				
C	**13**	**Style**			N/A	
A	**14**	**Length**				
B	**15**	**Model No.**				
L	**16**	**Other**				
E	**17**	**Other**				
	18	**Type**			Control Unit and Display	Control Unit and Display
T	**19**	**Enclosure**			NEMA 4X/IP66	NEMA 4X/IP66
R	**20**	**Mounting**			Surface Mount	Surface Mount
A	**21**	**Accuracy**			±2 percent of reading or ±0.020 NTU , ±5 percent of reading from 10 to 40 NTU	±2 percent of reading or ±0.020 NTU , ±5 percent of reading from 10 to 40 NTU
N	**22**	**Range**			0 – 100 nephelometric turbidity units	0 – 100 nephelometric turbidity units
S	**23**	**Power Requirements**			115 VAC, 60 Hz	115 VAC, 60 Hz
M	**24**	**Display**			Transreflective	Transreflective
I	**25**	**Resolution**			0.0001 NTU up to 9.9999 NTU 0.001 NTU from 10.000 to 99.999 NTU	0.0001 NTU up to 9.9999 NTU 0.001 NTU from 10.000 to 99.999 NTU
T	**26**	**Output**			4-20 mA with HART	4-20 mA with HART
T	**27**	**Calibration**			0-40 NTU	0-40 NTU
E	**28**	**Manufacturer**				
R	**29**	**Model No.**				
	30	**Other**				
	31	**Other**				
	32	**Other**				
	33					
O	**34**					
P	**35**					
T	**36**					
S	**37**					
	38					

Notes:

SECTION 17515

ULTRAVIOLET INTENSITY METERS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Ultraviolet (UV) intensity meters.

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 01660 - Testing, Training, and Commissioning.
      c. Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
      d. Section 17950 - Testing, Calibration, and Commissioning.

C. Provide all instruments identified in the Contract Documents.

1.02 REFERENCES

A. As specified in Section 17050.

B. National Institute of Standards and Technology (NIST).

1.03 DEFINITIONS

A. As specified in Section 17050.

1.04 SUBMITTALS

A. Furnish submittals as specified in Sections 01330 and 17050.

B. Provide complete documentation covering the traceability of all calibration instruments.

1.05 QUALITY ASSURANCE

A. As specified in Section 17050.

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.

1.07 PROJECT OR SITE CONDITIONS

A. Project environmental conditions as specified in Section 17050.
   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.

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 the completion of the Testing Phase specified in Section 01660.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. One of the following or equal:
   1. UV intensity meter of UV supplier listed in Section 11287. However, meters provided must meet the specifications listed herein.
   2. WEDECO Ideal Horizons:
      a. Model UC.

2.02 MANUFACTURED UNITS

A. UV intensity analyzers:
   1. General:
      a. UV intensity meter systems shall be capable of detecting the spectra of UV light used for disinfection.
      b. Calibrated to accommodate the range of UV intensity required for the process.
      c. Factory calibrated, with no field calibration necessary.

d. Simulating the spectral curve of cell inactivation.
e. Insensitive to external day-light spectra.

2. Performance requirements:
   a. Measuring range:
      1) 0 to 100 W/m^2.
   b. Accuracy:
      1) Within 5 percent.
   c. Selectivity:
      1) Greater than 99 percent at 254 nanometer.
   d. Linearity:
      1) Within 1 percent.
   e. 0 degrees Celsius to 40 degrees Celsius.
3. Element:
   a. Constructed of quartz/brass.
4. Transmitter:
   a. Display:
      1) Digital display UV intensity in W/m^2.
   b. Power supply:
      1) 120 VAC.
   c. Outputs:
      1) Isolated 4 to 20 milliamperes DC with HART communication protocol.

2.03 ACCESSORIES

A. Provide sunshades for outdoor installations.

2.04 SOURCE QUALITY CONTROL

A. As specified in Section 17050.

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.
   1. 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 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 17050.

B. Coordinate the installation with all trades to ensure that the mechanical system has all necessary appurtenances including weld-o-lets, valves, etc. for proper installation of instruments.

3.04 FIELD QUALITY CONTROL

A. As specified in Section 17050.

B. Provide manufacturer's services to perform start-up and calibration or verification.

3.05 ADJUSTING

A. As specified in Section 17950.

3.06 CLEANING

A. As specified in Section 17050.

3.07 DEMONSTRATION AND TRAINING

A. As specified in Section 17050.

3.08 PROTECTION

A. As specified in Section 17050.

3.09 SCHEDULES

A. The provided information does not necessarily include all required instruments. Provide all instruments identified in the Contract Documents:
   1. Instruments may be indicated on the Drawings, specified in the Specifications, or both.

END OF SECTION

SECTION 17516

ULTRAVIOLET TRANSMITTANCE MONITORS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Full-body UV transmittance meters.

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 01660 - Testing, Training, and Commissioning.
      c. Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
      d. Section 17950 - Testing, Calibration, and Commissioning.

C. Provide all instruments identified in the Contract Documents.

1.02 REFERENCES

A. As specified in Section 17050.

B. National Electrical Manufacturers Association (NEMA):
   1. 250 - Enclosures for Electrical Equipment (1000 V Maximum).

C. National Institute of Standards and Technology (NIST).

1.03 DEFINITIONS

A. As specified in Section 17050.

B. NEMA: Type 4X enclosure in accordance with NEMA 250.

1.04 SUBMITTALS

A. Furnish submittals as specified in Sections 01330 and 17050.

B. Provide complete documentation covering the traceability of all calibration instruments.

1.05 QUALITY ASSURANCE

A. As specified in Section 17050.

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.

1.07 PROJECT OR SITE CONDITIONS

A. Project environmental conditions as specified in Section 17050.
   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.

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 the completion of the Testing Phase specified in Section 01660.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. One of the following or equal:
   1. UV transmittance monitor of UV supplier listed in Section 11287. However, monitors provided must meet the specifications listed herein.
   2. Hach UVAS-SC Probe, 2 mm with SC200 controller.
   3. WEDECO Ideal Horizons:
      a. Model HIPPO.

2.02 MANUFACTURED UNITS

A. UV transmittance monitors
   1. General:
      a. UV transmittance meter systems shall measure the UV transmittance of wastewater.
      b. Continuous monitoring of UV transmittance independent of UV intensity sensor.
      c. Integrated in channel or tank with the radiation source immersed in water.
      d. With quartz sleeve of the lamp and the sensor cleaned automatically by pneumatic wiping mechanism.
      e. Measurement of UV transmittance to specify water quality.
      f. UV measurement device:
         1) Type 316 stainless steel 1.4571/316Ti/quartz.
   2. Performance requirements:
      a. 3 percent full scale accuracy.
   3. Element:
      a. UV radiation source:
         1) Mercury low-pressure lamp.
      b. UV sensors:
      c. Calibrated selectivity greater than 99 percent at 254 nanometer. Non-aging, temperature stability up to 70 degrees Celsius for continuous operation.
      d. UV transmission (1 centimeters) measurement range: 5 to 100 percent.
      e. No battery backup required.
      f. NEMA Type 4X/IP 65 weatherproof corrosion resistant enclosure.
      g. Neither pump nor pipe work required.
      h. Direct in-channel measurement without the need of a filter.
      i. Stainless steel quartz tube protector.
   4. Transmitter:
      a. NEMA Type 4X/IP65 thermoplastic cabinet with instrumentation window.
      b. Wall mounting.
      c. Display of UV transmission (percent).
      d. RS-232 serial interface.
      e. Analog output, selectable 0 to 20 milliamperes or 4 to 20 milliamperes.
      f. Maximum distance to junction box: 8 meters.
         1) Power supply:
            a) 120 VAC.
         2) Outputs:
            a) Isolated 4 to 20 meters DC with HART communication protocol.
   5. Components:
      a. Virtually maintenance free via automatic wiper system.

2.03 ACCESSORIES

A. Provide sunshades for outdoor installations.

2.04 SOURCE QUALITY CONTROL

A. As specified in Section 17050.

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.
   1. 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 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 17050.

B. Coordinate the installation with all trades to ensure that the mechanical system has all necessary appurtenances including weld-o-lets, valves, etc. for proper installation of instruments.

3.04 FIELD QUALITY CONTROL

A. As specified in Section 17050

B. Provide manufacturer's services to perform start-up and calibration or verification.

3.05 ADJUSTING

A. As specified in Section 17950.

3.06 CLEANING

A. As specified in Section 17050.

3.07 DEMONSTRATION AND TRAINING

A. As specified in Section 17050.

3.08 PROTECTION

A. As specified in Section 17050.

3.09 SCHEDULES

A. The provided information does not necessarily include all required instruments. Provide all instruments identified in the Contract Documents:
   1. Instruments may be indicated on the Drawings, specified in the Specifications, or both.

END OF SECTION

SECTION 17601

TEMPERATURE MEASUREMENT - TEMPERATURE SWITCH

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Temperature switch instruments.

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 01660 - Testing, Training, and Commissioning.
      c. Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
      d. Section 17950 - Testing, Calibration, and Commissioning.

C. Provide all instruments identified in the Contract Documents.

1.02 REFERENCES

A. As specified in Section 17050.

B. National Institute of Standards and Technology (NIST).

1.03 DEFINITIONS

A. As specified in Section 17050.

1.04 SYSTEM DESCRIPTION (NOT USED)

1.05 SUBMITTALS

A. Furnish submittals as specified in Sections 01330 and 17050.

B. Provide complete documentation covering the traceability of all calibration instruments.

1.06 QUALITY ASSURANCE

A. As specified in Section 17050.

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.

1.07 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 17050.

1.08 PROJECT OR SITE CONDITIONS

A. Project environmental conditions as specified in Section 17050.
   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.

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

A. As specified in Section 17050.

1.12 SYSTEM START-UP (NOT USED)

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 COMMISSIONING (NOT USED)

1.15 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 the completion of the Testing Phase specified in Section 01660.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. One of the following or equal:
   1. Ashcroft B Series.
   2. United Electric 400 Series.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS (NOT USED)

2.04 MANUFACTURED UNITS

A. Temperature switches:
   1. General:
      a. Temperature switch shall be bulb type with snap-action switch element.
   2. Performance requirements:
      a. Temperature range:
      b. Accuracy:
         1) Within 2.0 percent of range.
      c. Repeatability:
         1) Within 2.0 percent of range.
   3. Element:
      a. Sensing element material: Stainless steel.
      b. Sensing element shall not require ambient temperature compensation.
      c. Switch elements:
         1) Snap acting.
         2) Hermetically sealed, rated Class1 Division 2, Group D.

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS (NOT USED)

2.07 ACCESSORIES

A. Thermowell:
   1. Unless otherwise noted, provide thermowell with each temperature switch.
   2. Process connection: 3/4 inch NPT.
   3. Thermowell material: Type 316L stainless steel.
   4. Stem style: Temperature Switch Manufacturer Standard.
   5. Immersion depth:
      a. Minimum 3 inches or 10 times the diameter of the sensor protection tube, whichever is larger.
      b. Where pipe diameter is inadequate for appropriate immersion depth, install thermowell in an elbow on the axis of the pipe.

B. Provide sunshades for outdoor installations.

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE-QUALITY-CONTROL

A. As specified in Section 17050.

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:
   1. 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 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 17050.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 REINSTALLATION (NOT USED)

3.07 FIELD QUALITY CONTROL

A. As specified in Section 17050.

B. Manufacturer's field services.

3.08 ADJUSTING

A. As specified in Section 17950.

3.09 CLEANING

A. As specified in Section 17050.

3.10 DEMONSTRATION AND TRAINING

A. As specified in Section 17050.

3.11 PROTECTION

A. As specified in Section 17050.

3.12 SCHEDULES

A. The provided information does not necessarily include all required instruments. Provide all instruments identified in the Contract Documents:
   1. Instruments may be indicated on the Drawings, specified in the Specifications or both.

END OF SECTION

SECTION 17602

TEMPERATURE MEASUREMENT - TEMPERATURE GAUGE

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Temperature 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 01660 - Testing, Training, and Commissioning.
      c. Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
      d. Section 17950 - Testing, Calibration, and Commissioning.

C. Provide all instruments identified in the Contract Documents.

1.02 REFERENCES

A. As specified in Section 17050.

B. National Institute of Standards and Technology (NIST).

1.03 DEFINITIONS

A. As specified in Section 17050.

1.04 SYSTEM DESCRIPTION (NOT USED)

1.05 SUBMITTALS

A. Furnish submittals as specified in Sections 01330 and 17050.

B. Provide complete documentation covering the traceability of all calibration instruments.

1.06 QUALITY ASSURANCE

A. As specified in Section 17050.

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.

1.07 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 17050.

1.08 PROJECT OR SITE CONDITIONS

A. Project environmental conditions as specified in Section 17050.
   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.

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

A. As specified in Section 17050.

1.12 SYSTEM START-UP (NOT USED)

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 COMMISSIONING (NOT USED)

1.15 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 the completion of the Testing Phase specified in Section 01660.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Bimetallic type temperature gauge: One of the following or equal:
   1. Ashcroft Type EI.
   2. Weiss Instruments Series BM.
   3. Noshok 300 Series.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS (NOT USED)

2.04 MANUFACTURED UNITS

A. Bimetallic type temperature gauges:
   1. General:
      a. Temperature gauges shall consist of a bimetallic temperature sensor with a dial-type temperature gauge.
   2. Performance requirements:
      a. Temperature range:
         1) As indicated in the Contract Documents.
      b. Accuracy:
         1) ±1.0 percent of range.
   3. Element:
      a. Type: Bimetallic.
      b. Stem material: Stainless steel.
      c. Temperature gauge sensor shall be tamperproof, hermetically sealed, and silicon dampened.
      d. Process connection: 1/2 inch NPT.
   4. Dial gauge:
      a. Dial size: 3 inches.
      b. Dial case material: Stainless steel.
      c. Dial face: Gasketed shatterproof glass.
      d. Orientation: Straight or angled as required to provide most convenient direct viewing.
      e. Mounting: Direct mounted and suitable for outdoor installation.
      f. External adjustable recalibration screw.

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS (NOT USED)

2.07 ACCESSORIES

A. Thermowell:
   1. Unless otherwise noted, provide thermowell with each temperature gauge.
   2. Process connection: As indicated in the contract documents.
   3. Thermowell material: Material compatible with the service fluid identified and recommended by the manufacturer for the process condition.
   4. Stem style: Straight or tapered.
   5. Immersion depth:
      a. Minimum 3 inches or 10 times the diameter of the sensor protection tube or thermowell, whichever is larger.

B. Provide sunshades for outdoor installations.

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL

A. As specified in Section 17050.

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.
   1. 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 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 17050.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 REINSTALLATION (NOT USED)

3.07 FIELD QUALITY CONTROL

A. As specified in Section 17050.

A. Manufacturer's field services.

3.08 ADJUSTING

A. As specified in Section 17950.

3.09 CLEANING

A. As specified in Section 17050.

3.10 DEMONSTRATION AND TRAINING

A. As specified in Section 17050.

3.11 PROTECTION

A. As specified in Section 17050.

3.12 SCHEDULES

A. The provided information does not necessarily include all required instruments. Provide all instruments identified in the Contract Documents:
   1. Instruments may be indicated on the Drawings, specified in the Specifications or both.

END OF SECTION

SECTION 17622

WEIGHT MEASUREMENT - STRAIN GAUGE

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Electronic strain weight measurement systems for the following:
      a. Drum and day tank type scales.

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 01660 - Testing, Training, and Commissioning.
      c. Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
      d. Section 17950 - Testing, Calibration, and Commissioning.

C. Provide all instruments identified in the Contract Documents.

1.02 REFERENCES

A. As specified in Section 17050.

B. National Electrical Manufacturers Association (NEMA):
   1. 250 - Enclosures for Electrical Equipment (1000 V Maximum).

C. National Institute of Standards and Technology (NIST).

1.03 DEFINITIONS

A. As specified in Section 17050.

B. NEMA:
   1. Type 4X enclosure in accordance with NEMA 250.
   2. Type 6 enclosure in accordance with NEMA 250.

1.04 SYSTEM DESCRIPTION (NOT USED)

1.05 SUBMITTALS

A. Furnish submittals as specified in Sections 01330 and 17050.

B. Provide complete documentation covering the traceability of all calibration instruments.

1.06 QUALITY ASSURANCE

A. As specified in Section 17050.

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.

1.07 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 17050.

1.08 PROJECT OR SITE CONDITIONS

A. Project environmental conditions as specified in Section 17050.
   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.

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

A. As specified in Section 17050.

1.12 SYSTEM START-UP (NOT USED)

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 COMMISSIONING (NOT USED)

1.15 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 the completion of the Testing Phase specified in Section 01660.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. One of the following or equal:
   1. Small platform scales:
      a. Force Flow/Floquip.
      b. Fairbanks Scales, Inc.
      c. Hardy Instruments.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS (NOT USED)

2.04 MANUFACTURED UNITS

A. General:
   1. Provide a complete integrated system consisting of scale, load cells, indicating display unit, weight transmitter, and interconnecting cables required for weight measurement.

B. Performance requirements:
   1. Small platform scales:
      a. Range: As indicated in the Contract Documents.
      b. Accuracy: 0.25 percent full scale.
   2. Truck scales:
      a. Range: As indicated in the Contract Documents.
      b. Calibration accuracy: Less than or equal to 0.1 percent rated output.
      c. Non-linearity: Less than or equal to 0.05 percent full scale.
      d. Creep: Less than or equal to 0.03 percent full scale.
      e. Hysteresis: Less than or equal to 0.02 percent full scale.
      f. Repeatability: Less than or equal to 0.02 percent full scale.
      g. Zero stability: Less than or equal to 5 percent full scale.
      h. Minimum capacity: 66,000 pounds.
      i. Rated output (mV/V): 2 within 0.1 percent.
      j. Temperature effect on sensitivity (percent/10 degrees Celsius): Less than or equal to 0.0100 percent.
      k. Excitation voltage: 5 to 15 Volts.
      l. Operating temperature range: -40 degrees Celsius to +80 degrees Celsius.
      m. Safe load limit (percent of capacity): 200 percent.
      n. Ultimate load (percent of capacity): 300 percent.
      o. Load cell material: Stainless steel.
      p. Sealing: Hermetically sealed.

C. Load cells:
   1. Small platform scales:
      a. Use load cells of the shear beam strain gauge resistive type.
      b. Design platform assembly shall be designed to protect load cells and cable from damage by rough handling and use.
      c. Steel construction with sealed leads (NEMA 6). Where multiple load cells are used to support the platform or structure, connect their signal

leads to a single NEMA 4X junction box. Use cables specifically designed for load cell applications.

d. Provide a single cable to transmit load cell signals to a remote weight indicator. Provide cable as required.

e. Size platform suitable for drums, tote bins, or tanks indicated on the Drawings:

1) Platform shall have a heavy duty rigid deck design, reinforced to prevent flexing under load. In order to facilitate easy loading, overall platform height shall be no more than as shown on Contract Document.

2) Equip platform with hold down lugs designed to secure base of tote bins.

f. Provide platforms with a corrosion resistant epoxy coating and to be compatible with the chemical that is to be weighed.

g. Provide platform scales with a 150 percent safe overload capacity.

h. Scales shall have mechanical stops or other means to minimize possible damage to load cells due to impact loading.

i. Scales, drums, tanks and tote bins shall be properly secured against shifting and tipping due to possible seismic movement. Any hold down lugs shall be compatible with chemical tanks.

j. Platforms for horizontal drums shall have a mechanism to prevent drums from rolling.

k. Load cells in supporting frames to be rated for the seismic zone in which they are used:

1) Incorporate seismic restraints in structure to prevent sideways motion of the tank.

2) Provide a means for replacing damaged load cells.

D. Transmitter:

1. Small platform scales:

a. Capable of continuously monitoring a single platform scales.

b. Microprocessor-based type with backlit alphanumeric digital display and integral membrane keypad for accessing functions.

c. Capable of monitoring tare weight, gross weight, net remaining, and daily usage of each scale:

1) Capable of calculating total amount used and rate of feed.

d. Provide a keypad to accept operator entry of tare weights, specific gravity of chemical and low-level alarm points.

e. Provide an integral power supply for load cells.

f. Operating temperature range: 14 to 122 degrees Fahrenheit

g. NEMA 4X enclosure.

h. Power supply:

1) 120 VAC.

2) Power consumption: 150 VA.

i. Outputs:

1) Isolated 4 to 20 milliamperes DC for each scale.

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS (NOT USED)

2.07 ACCESSORIES

A. Provide sunshades for outdoor installations.

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL

A. As specified in Section 17050.

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.
   1. 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 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 17050.

B. Coordinate the installation with all trades to ensure that the mechanical system has all necessary appurtenances for proper installation of instruments.

C. Install platform scales and load cells level, to within manufacturer's specified tolerances.

D. Utilize an independent scale and weight set to calibrate the scales(s).

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 REINSTALLATION (NOT USED)

3.07 FIELD QUALITY CONTROL

A. As specified in Section 17050.

B. Provide manufacturer's services to perform start-up and calibration or verification.

C. Manufacturer's field service:

3.08 ADJUSTING

A. As specified in Section 17950.

3.09 CLEANING

A. As specified in Section 17050.

3.10 DEMONSTRATION AND TRAINING

A. As specified in Section 17050.

3.11 PROTECTION

A. As specified in Section 17050.

3.12 SCHEDULES

A. The provided information does not necessarily include all required instruments. Provide all instruments identified in the Contract Documents:
   1. Instruments may be indicated on the Drawings, specified in the Specifications, or both.

END OF SECTION

A/E:		**WEIGHT TRANSMITTERS STRAIN GAUGE**							
						Spec. No.		**Rev.**	
Contractor:		**No**	**By**	**Date**	**Revision**	17622			
Project:	8930A11					**Contract**		**Date**	
Customer:	San Luis Obispo County								
Plant:	Los Osos					**Req.**		**P.O.**	
Location:	San Luis Obispo County, CA								
BOM No.:						**By**	**Chk**	**App**	
File:									

GENERAL	**1**	**Tag No.**	**32-WE/WIT-270**
	2	**Service**	**Al. Sulfate Tank**
	3	**P&ID**	**32N01**
PLATFORM	**4**	**Manufacturer**	
	5	**Model Number**	
	6	**Fluid**	Aluminum Sulfate
	7	**Size**	4.25'x4.25'
	8	**Capacity**	4000 lbs.
	9	**Finish**	
TRANSMITTER	**10**	**Manufacturer**	
	11	**Model No.**	
	12	**Accuracy**	0.25% full scale
	13	**Calibrated Range**	0-4000 lbs
	14	**Body Rating**	NEMA 4X
	15	**Output Signal**	4-20 MA
	16	**High-High Level Setpoint**	
	17	**High Level Setpoint**	
	18	**Low Level Setpoint**	
	19	**Low-Low Level Setpoint**	
	20	**Power Supply**	120 VAC
	21	**Operating Temp**	14-122 deg. F
	22	**Dimensions**	
DISPLAY	**23**	**Scale Size**	
	24	**Keypad**	
	25	**Indicator Mounting**	Surface
OPTIONS	**26**	**Chart Recorders**	Mfr. Standard
	27	**Locking Tare Adjust Knob**	Mfr. Standard
	28	**Other**	
	29	**Other**	
	30	**Other**	

Notes:

A/E:			**WEIGHT TRANSMITTERS STRAIN GAUGE**						
							Spec. No.	**Rev.**	
Contractor:			**No**	**By**	**Date**	**Revision**	17622		
Project:	8930A11						**Contract**	**Date**	
Customer:	San Luis Obispo County								
Plant:	Los Osos						**Req.**	**P.O.**	
Location:	San Luis Obispo County, CA								
BOM No.:							**By**	**Chk**	**App**
File:									

GENERAL	**1**	**Tag No.**	**51-WE/WIT-441**
	2	**Service**	**Polymer Tank**
	3	**P&ID**	**51N04**
PLATFORM	**4**	**Manufacturer**	
	5	**Model Number**	
	6	**Fluid**	Polymer
	7	**Size**	5’ x 5’
	8	**Capacity**	4000 lbs
	9	**Finish**	
TRANSMITTER	**10**	**Manufacturer**	
	11	**Model No.**	
	12	**Accuracy**	0.25% full scale
	13	**Calibrated Range**	0-4000 lbs
	14	**Body Rating**	NEMA 4X
	15	**Output Signal**	4-20 MA
	16	**High-High Level Setpoint**	
	17	**High Level Setpoint**	
	18	**Low Level Setpoint**	
	19	**Low-Low Level Setpoint**	
	20	**Power Supply**	120 VAC
	21	**Operating Temp**	14-122 deg. F
	22	**Dimensions**	
DISPLAY	**23**	**Scale Size**	
	24	**Keypad**	
	25	**Indicator Mounting**	Surface
OPTIONS	**26**	**Chart Recorders**	Mfr. Standard
	27	**Locking Tare Adjust Knob**	Mfr. Standard
	28	**Other**	
	29	**Other**	
	30	**Other**	

Notes:

A/E:		**WEIGHT TRANSMITTERS STRAIN GAUGE**							
						Spec. No.		**Rev.**	
Contractor:		**No**	**By**	**Date**	**Revision**	17622			
Project:	8930A11					**Contract**		**Date**	
Customer:	San Luis Obispo County								
Plant:	Los Osos					**Req.**		**P.O.**	
Location:	San Luis Obispo County, CA								
BOM No.:						**By**	**Chk**	**App**	
File:									

GENERAL	**1**	**Tag No.**	**51-WE/WIT-442**
	2	**Service**	**Polymer Tank**
	3	**P&ID**	**51N04**
PLATFORM	**4**	**Manufacturer**	
	5	**Model Number**	
	6	**Fluid**	Polymer
	7	**Size**	5’ x 5’
	8	**Capacity**	4000 lbs
	9	**Finish**	
TRANSMITTER	**10**	**Manufacturer**	
	11	**Model No.**	
	12	**Accuracy**	0.25% full scale
	13	**Calibrated Range**	0-4000 lbs
	14	**Body Rating**	NEMA 4X
	15	**Output Signal**	4-20 MA
	16	**High-High Level Setpoint**	
	17	**High Level Setpoint**	
	18	**Low Level Setpoint**	
	19	**Low-Low Level Setpoint**	
	20	**Power Supply**	120 VAC
	21	**Operating Temp**	14-122 deg. F
	22	**Dimensions**	
DISPLAY	**23**	**Scale Size**	
	24	**Keypad**	
	25	**Indicator Mounting**	Surface
OPTIONS	**26**	**Chart Recorders**	Mfr. Standard
	27	**Locking Tare Adjust Knob**	Mfr. Standard
	28	**Other**	
	29	**Other**	
	30	**Other**	

Notes:

A/E:			**WEIGHT TRANSMITTERS STRAIN GAUGE**						
							Spec. No.	**Rev.**	
Contractor:			**No**	**By**	**Date**	**Revision**	17622		
Project:	8930A11						**Contract**	**Date**	
Customer:	San Luis Obispo County								
Plant:	Los Osos						**Req.**	**P.O.**	
Location:	San Luis Obispo County, CA								
BOM No.:							**By**	**Chk**	**App**
File:									

GENERAL	**1**	**Tag No.**	**51-WE/WIT-443**
	2	**Service**	**Polymer Tank**
	3	**P&ID**	**51N04**
PLATFORM	**4**	**Manufacturer**	
	5	**Model Number**	
	6	**Fluid**	
	7	**Size**	
	8	**Capacity**	0-4000 lb.
	9	**Finish**	
TRANSMITTER	**10**	**Manufacturer**	
	11	**Model No.**	
	12	**Accuracy**	0.25% full scale
	13	**Calibrated Range**	
	14	**Body Rating**	NEMA 4X
	15	**Output Signal**	4-20 MA
	16	**High-High Level Setpoint**	
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	24	**Keypad**	
	25	**Indicator Mounting**	
OPTIONS	**26**	**Chart Recorders**	Mfr. Standard
	27	**Locking Tare Adjust Knob**	Mfr. Standard
	28	**Other**	
	29	**Other**	
	30	**Other**	

Notes:

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 and marshalling panels.
      b. Control panels furnished as part of equipment systems specified in other Divisions, such as vendor control panels (VCPs) and chemical feed panels.
      c. Control components.
      d. Control panel installation.

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 - Seismic Design Criteria.
      c. Section 16050 - Common Work Results for Electrical.
      d. Section 16075 - Electrical Identification.
      e. Section 16262 - Variable Frequency Drives 0.50 - 50 Horsepower.
      f. Section 16412 - Low Voltage Molded Case Circuit Breakers.
      g. Section 16422 - Motor Starters.
      h. Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
      i. Section 17733 - Control Systems – Network Materials and Equipment.

C. Provide all instruments identified in Contract Documents.

1.02 REFERENCES

A. As specified in Section 17050.

B. Institute of Electrical and Electronics Engineers (IEEE):
   1. C62.41.1 – Guide on the Surge Environment in Low-Voltage (1000 V and less) AC Power Circuits.

C. National Electrical Code (NEC).

D. National Electrical Manufacturer's Association (NEMA):
   1. 250 - Enclosures for Electrical Equipment (1000 V Maximum).

E. National Institute of Standards and Technology (NIST).

F. Underwriters Laboratories Inc. (UL):
   1. 508 - Industrial Control Equipment.
   2. 508A - Standard for Industrial Control Panels.
   3. 913 - Standard for Intrinsically Safe Apparatus and Associated Apparatus for Use in Class I, II, III, Division 1, Hazardous (Classified) Locations.
   4. 1283 - Standard for Electromagnetic Interference Filters.
   5. 1449 - Standard for Surge Protective Devices.

1.03 DEFINITIONS

A. As specified in Section 17050.

B. NEMA:
   1. Type 1 enclosure in accordance with NEMA 250.
   2. Type 4 enclosure in accordance with NEMA 250.
   3. Type 4X enclosure in accordance with NEMA 250.
   4. Type 7 enclosure in accordance with NEMA 250.
   5. Type 12 enclosure in accordance with NEMA 250.

C. Specific definitions:
   1. 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 non-certified 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:
   1. Completed and installed panel work shall safely withstand seismic requirements at the project site as specified in Section 16050. Enclosures and internal equipment shall be braced to prevent damage from specified forces.

1.05 SUBMITTALS

A. Provide submittals as specified in Sections 01330 and 17050.

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:
         1) 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:
         1) 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.

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:
         1) 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. 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.

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 components and equipment with UL 508 listing.
   2. All control panels shall be UL 508A labeled, unless the equipment in the panel and the design in the contract documents cannot be reasonably modified to meet the requirements for UL 508A labeling:
   3. Provide fuses for all equipment that is not UL or UR listed.

1.07 DELIVERY, STORAGE AND HANDLING

A. Project environmental conditions as specified in Section 17050.
   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.

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

A. As specified in Section 17050.

1.12 SYSTEM START-UP (NOT USED)

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 COMMISSIONING (NOT USED)

1.15 MAINTENANCE (NOT USED)

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 1 manufacturer.

2.02 EXISTING PRODUCTS

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. Provide enclosures in accordance with the plant area electrical work requirements listed in Specification 16050.

2. Enclosures shall have the following properties:
   a. NEMA Type 1: Steel.
   b. NEMA Type 4: Steel with gasketed door, rain tight.
   c. NEMA Type 4X: Type 316 stainless steel.
   d. NEMA Type 4X: Polycarbonate or fiberglass reinforced polyester (FRP) in corrosive areas where stainless steel is incompatible. NEMA 4X Non-metallic enclosures are not an acceptable substitute for stainless steel unless indicated on the Drawings.
   e. NEMA Type 12: Steel with gasketed door, dust-tight.
   f. NEMA Type 7: Cast aluminum.

B. Bolting material:
   1. Commercial quality 1/2-inch diameter, stainless steel hex-head grade 5 bolts, nuts and washers, with unified coarse (UNC) threads.
   2. Carriage bolts for attaching end plates.
   3. All other bolted joints shall have S.A.E. standard lock washers.

2.04 MANUFACTURED UNITS

A. Panels/enclosures:
   1. Manufacturers: One of the following or equal:
      a. Rittal.
      b. Hoffman Engineering.
      c. Saginaw Control & Engineering.
   2. Panel assembly:
      a. General guidelines for panel fabrication include:
         1) Continuous welds ground smooth.
         2) Exposed surfaces free of burrs and sharp edges.
         3) Base formed of heavy channel iron, either galvanized or powder coated, minimum 1/2 inch holes at 12 inch spacing to accommodate anchoring of freestanding enclosures to floor.
      b. Construct enclosure and mounting panel using stretcher level quality sheet metal having minimum thickness not less than the following sizes (U.S. Standard Gauge):

Enclosure Height (inches)	Minimum Enclosure Steel Thickness (gauge)	Minimum Back Mounting Panel Thickness (gauge)
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 3-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, 3-point latching mechanism on each door:
        a) Provide 2 keys per panel.
        b) All locks keyed alike.
    3) For large type NEMA Type 4 and NEMA Type 4X cabinets, not available with 3-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 apply for NEMA Type 4X non-metallic enclosures:
    a. Fiberglass construction.
    b. 10 gauge plate steel reinforcing on the sides, top, and bottom.
    c. All seams sealed.
    d. Fiberglass hinges with no exposed metal parts.
    e. Captivate stainless steel door screws.
    f. Provisions for internal, sidewall, mounting panels either by welded channels to the interior, or by welded collar studs.
    g. Provide aluminum mounting panels.
    h. Non-metallic enclosures are not an acceptable substitute for stainless steel unless indicated on the Drawings.

4. Outdoor panels. Supplementary requirements for panels located outdoors are as follows:
    a. All enclosures located outdoors shall be explicitly designed and rated for outdoor service by the manufacturer.
    b. Door hardware: stainless steel.
    c. Provide rain canopy and sun shield.
    d. Bases: Heavy channel, gasketed stainless steel bases, flanges up, for anchoring to pad.

B. Arrangement of components:
1. Arrange panel internal components for external conduit and piping to enter into panel either from above or below.
2. Arrange panel instruments and control devices in a logical configuration associating pushbutton and selector switches with related readout devices, or as indicated on the Drawings.
3. Mount internal control components on an internal back-panel. Devices may be mounted on the side-panel only by special permission from the ENGINEER.
4. All control panel mounted operator interface devices shall be mounted between 3 feet and 6 feet above finished floor.

C. Overcurrent protection:
1. Main overcurrent device:
    a. Where the electrical power supply voltage to the control panel is more than 120 VAC, provide the panel with a flange mounted disconnect handle operating a molded case circuit breaker, and provide a control power transformer for 120 VAC circuits:
        1) Door-mounted disconnect handles are not acceptable.
        2) Mechanically 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 120 VAC:
        1) Provide an internal breaker with the line side terminals covered by a barrier.
        2) Provide a nameplate prominently positioned on the control panel identifying the location of the power source and a warning statement requiring the source to be disconnected before opening the door to the enclosure.
2. Provide circuit breakers as specified in Section 16412.
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 120 VAC 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 5-ampere fuse for each discrete input loop.
    d. An individual 1/2-ampere fuse for each 4 to 20 milliamperes 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 to 20 milliamperes 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. Manufacturer: One of the following or equal:
        1) Ferraz Shawmut.
        2) Littelfuse.
        3) Bussmann.
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:
        1) As specified in Section 16075.
    c. Manufacturer: One of the following or equal:
        1) Phoenix Contact.
        2) Allen-Bradley 1492-FB Series B.
7. Control circuit breakers:
    a. DIN rail mounting on 35 millimeters rail.
    b. Manual OPEN-CLOSE toggle switch.
    c. Rated 250 VAC.
    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:
        1) As specified in Section 16075.
    g. Manufacturer: One of the following or equal:
        1) Phoenix Contact.
        2) ABB.
        3) Allen-Bradley Series.
        4) Square D.

D. Conductors and cables:
1. Power and control wiring:
    a. Materials: Stranded, soft annealed copper.

b. Insulation: 600 volts type MTW.
c. Minimum sizes:
1) Primary power distribution: 12 AWG.
2) Secondary power distribution: 14 AWG.
3) Control: 16 AWG.
d. Color:
1) AC power (line and load): BLACK.
2) AC power (neutral): WHITE.
3) AC control: RED.
4) DC power and control (ungrounded): BLUE.
5) DC power and control (grounded): WHITE with BLUE stripe.
6) Ground: GREEN.

2. Signal cables:
a. Materials: Stranded, soft annealed copper.
b. Insulation: 600 volts, PVC outer jacket.
c. Minimum size: 18 AWG paired triad.
d. Overall aluminum shield (tape).
e. Copper drain wire.
f. Color:
1) 2 Conductor:
a) Positive (+): BLACK.
b) Negative (-): WHITE, RED.
2) 3 Conductor:
a) Positive (+): BLACK.
b) Negative (-): RED.
c) Signal: WHITE.
g. Insulate the foil shielding and exposed drain wire for each signal cable with heat shrink tubing.

E. Conductor identification:
1. Identify each conductors and cables with unique wire numbers as specified in Section 16075.
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 surge protection for all control panels.
6. 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 120 VAC control wiring:
1) 120 VAC: Grey colored ducts.
2) 24 VDC: White colored ducts.

7. 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.
8. The free ends of cable ties shall be cut flush after final adjustment and fastening.
9. Provide supports at the ends of cables to prevent mechanical stresses at the termination of conductors.
10. Support panel conductors where necessary to keep them in place.
11. Wiring to rear terminals on panel-mount instruments shall be run in nonmetallic duct secured to horizontal brackets run adjacent to the instruments.
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 120 VAC devices interconnected with the control panel including, but not limited to:
    a. Solenoid valves.
    b. Instruments both mounted in the control panel and remotely connected to the control panel.

2.05 EQUIPMENT (NOT USED)

2.06 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.
2. Air conditioner:
    a. All NEMA 4X panels mounted outdoors shall be provided with a closed circuit air conditioning system to minimize the degradation of panel internal components due to the salt air environment of the project site
    b. Provide solid-state cabinet coolers or air conditioning units on all outdoor panels containing electronic components such as local operator interface (LOI) units, panel instruments, programmable logic controllers, or remote I/O.
    c. Provide filters on intake and exhaust openings.
    d. Increase panel sizes as needed to accommodate cooling units.
    e. Enclosure rating: NEMA Type 4X.
    f. Closed loop design.
    g. Power Supply: 120 VAC.
    h. Utilize a CFC-free refrigerant.
    i. Manufacturers: The following or approved equal:
        1) Kooltronic Integrity Series 21.
3. 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 120 VAC power.

2) There are no electronics or moisture-sensitive devices in the enclosure.
3) The panel is smaller than 38 inches high.

4. 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 Fahrenheit.
   d. Manufacturer: The following or equal:
      1) Hoffman ATEMNC.
5. Fan ventilation:
   a. Muffin style:
      1) Provide 2 door/cabinet mounted vent fans for every 72 inches of cabinet width.
      2) Provide Finger Guard kit.
      3) Filter kit with 2 spare filters for each intake fan.
      4) Provide bezel and gasket kit.
   b. Temperature control switch and alarm:
      1) Power: 120 VAC.
      2) Bimetallic temperature senor.
      3) Adjustable setpoint range 30 degrees Fahrenheit to 140 degrees Fahrenheit.
      4) Hoffman ATEM series or equal.

B. Corrosion Control:
   1. Provide all outdoor panels with internal corrosion inhibiting vapor capsules or strips:
      a. Hoffman, model A-HCI.
      b. Northern International Corporation, model Zerust VC.

C. Panel meters:
   1. Pointer type:
      a. Suitable for panel mounting.
      b. Minimum scale length: 3 inches.
      c. Calibrated in engineering units.
      d. Accuracy: Within 2 percent of span.
      e. NEMA Type 4/IP65 sealed front metal bezel.
      f. Manufacturer: The following or equal:
         1) Yokogawa.
   2. Digital process indicators:
      a. General:
         1) Integral provisions for scaling.
         2) Scale to process engineering units.
         3) Switch programmable decimal points.
         4) NEMA Type 4/IP65 sealed front bezel.
      b. Current and voltage indicators:
         1) 3 1/2 - digit minimum.
         2) Minimum character height: 0.5 inches.
         3) Accuracy:
            a) AC/DC volts: Within (0.1 percent of reading plus 2 digit).

b) DC current: 4 to 20 milliamperes: within (0.1 percent of reading plus 1 digit).
c) DC voltage: 0 to 10 volts: Within (0.1 percent of reading plus 1 digit).

c. Operating voltage: 120 VAC.
d. Operating temperature: 0 degrees Celsius to 60 degrees Celsius.
1) Manufacturer: One of the following or equal:
a) Red Lion.
b) Action Instruments Visipak.

3. Digital bar graph meter:
a. Self-contained instruments that display process signals directly in engineering units, both in decimal format and as a bar graph display.
b. Suitable for panel mounting.
c. LED display:
1) Not less than 3 decimal digits.
2) Not less than a 101 segment LED bar graph.
d. Input signal:
1) All conventional current loops and voltage control signals.
e. Minimum sample rate of once per second.
f. Provisions for field adjustable scaling and/or offset.
g. Accuracy shall be within 1 least significant digit.
h. Manufacturer: One of the following or equal:
1) Ametek Dixson.
2) Yokogawa.
3) Weschler Instruments.

4. Counters:
a. 6 digits.
b. Switch selectable inputs:
1) Switch contacts.
2) CMOS.
3) TTL.
4) Magnetic pickup.
5) RLC sensors.
c. Selectable up/down control via external signal.
d. Remote reset.
e. Remote inhibit to prevent accumulating counts.
f. Programmable to enable or disable front panel reset.
g. Non-volatile memory to retain all data upon loss of supply power.
h. Sunlight readable.
i. Operating temperature: 0 degrees Celsius to 50 degrees Celsius.
j. Manufacturer: The following or equal:
1) Red Lion PAX Series.

D. Pilot devices:
1. General:
a. Provide operator pushbuttons, switches, and pilot lights, from a single manufacturer.
b. Size:
1) 30.5 millimeters.
c. Heavy duty.

d. Pushbuttons:
    1) Contacts rated:
        a) NEMA Type A600.
    2) Furnish 1 spare normally open and normally closed contact with each switch.
e. Selector switches:
    1) Contacts rated:
        a) NEMA Type A600.
        b) Knob type:
    2) Furnish 1 spare normally open contact and normally closed contact with each switch.
    3) Provisions for locking in the OFF position where lockout provisions are indicated on the Drawings.
f. Pilot lights:
    1) Type:
        a) LED for interior installations.
        b) Incandescent for exterior installations.
    2) Push to test.
    3) Lamp color:
        a) On/Running/Start: Red.
        b) Off/Stop: Green.
        c) Power: White.
        d) Alarm: Amber.
        e) Status or normal condition: Red.
        f) Opened: Red.
        g) Closed: Green.
        h) Failure: Amber.

2. Provide pilot devices in accordance with the plant area electrical work requirements listed in Specification 16050.
3. Clean, dry areas (C):
    a. NEMA Type 4/13.
    b. Manufacturer: One of the following or equal:
        1) Allen-Bradley Type 800T.
        2) Square D Class 9001 Type K.
        3) General Electric Type CR104P.
        4) IDEC TWTD.
4. Wet, damp, corrosive, or outdoor areas (W, X, or D):
    a. NEMA Type 4X.
    b. Corrosion resistant.
    c. Exterior parts of high impact strength fiberglass reinforced polyester or multiple-layer epoxy coated zinc.
    d. Manufacturer: One of the following or equal:
        1) Cutler Hammer Type E34.
        2) Square D Class 9001 Type SK.
        3) Allen-Bradley Type 800H.
        4) IDEC TWTD.
5. Hazardous (Classified) Areas/Class I Division 2 (H):
    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. Manufacturer: One of the following or equal:
    1) Cutler Hammer Type E34.
    2) Allen-Bradley Type 800H.

E. 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 Celsius.
5. Operating temperature: 0 degrees Celsius to 55 degrees Celsius.
6. Supply power: 9 to 30 VDC.
7. Manufacturer: The following or equal:
    a. Phoenix Contact.

F. 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: -20 degrees Celsius to +65 degrees Celsius.
2. Manufacturer: One of the following or equal:
    a. Phoenix Contact MCR Series.
    b. Acromag 1500, 600T, 800T, Flat Pack or ACR Series.
    c. Action Instruments Q500 Series or Ultra SlimPakII.
    d. AGM electronics Model TA-4000.

G. Relays:
1. General:
    a. For all types of 120 VAC relays, provide surge protection across the coil of each relay.
    b. For all types of 24 VDC relays, provide a free-wheeling diode across the coil of each relay.
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. Manufacturer: One of the following or equal:
1) Phoenix Contact PLC series.
2) Potter and Brumfield Type KRP or KUP.
3) IDEC R* series. (* = H, J, R, S, U).
4) Allen-Bradley Type 700 H Series.
5) Square D Type K.

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. Manufacturer: One of the following or equal:
1) Square D type 8501 Type K.
2) IDEC TWTD.

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:
    1) For off delay use true power off time delay relays. Where the required timing range exceeds capability of the off delay relay use signal off delay where power loss will not cause undesirable operation or pneumatic time delay relays.
e. Minimum poles: 2PDT.
f. Units include adjustable dial with graduated scale covering the time range in each case.
g. Minimum timing range: 0.1 seconds to 10 minutes, or as required for the application.
h. Manufacturer: One of the following or equal:
    1) IDEC RTE series.
    2) Agastat type Series 7000 series (pneumatic).
    3) Allen-Bradley type 700HR Series.

H. Terminal blocks:
1. Din rail mounting on 35 mm rail.
2. Suitable for specified AWG wire.
3. Rated for 30 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 - 40 degree Celsius to 105 degrees Celsius.
8. Terminals: Plainly identified to correspond with markings on the diagrams:
    a. 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 1 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. Manufacturer: One of the following or equal:
    a. Phoenix Contact UK5 Series.
    b. Allen-Bradley Series 1492.
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: The following or equal:
        1) Panduit.

I. Surge protection devices:
1. Control panel power:
    a. 120-volt control power source: Non-UPS powered:
        1) Provide surge protection device (SPD) for panel power entrances:
            a) Nominal 120 VAC with a nominal clamping voltage of 200 volts.

b) Non-faulting and non-interrupting design.
c) A response time of not more than 5 nanoseconds.

2) Control panel power system level protection, non-UPS powered:
a) Design to withstand a maximum 10 kA test current of a 8/20 µs waveform according to IEEE C62.41.1Category C Area.
b) For panels receiving power at 120 VAC, provide surge protection at secondary of main circuit breaker.
c) Provide both normal mode noise protection (between current carrying conductors) and common mode (between current carrying conductor and neutral) surge protection.
d) DIN rail mounting.
e) Attach wiring to the SPD by means of a screw type cable-clamping terminal block:
(1) Gas-tight connections.
(2) The terminal block: Fabricated of non-ferrous, non-corrosive materials.
f) Visual status indication of MOV status on the input and output circuits.
g) Dry contact rated for at least 250 VAC, 1 Amp for remote status indication.
h) Meeting the following requirements:
(1) Response time: Less than or equal to 100 ns.
(2) Attenuation: Greater than or equal to -40 dB at 100 kilovolt-hertz as determined by a standard 50 ohms insertion test.
(3) Safety approvals:
(a) UL 1283 (EMI/RFI Filter).
(b) UL 1449 2nd Edition.
i) Manufacturer: One of the following or equal:
(1) Phoenix Contact type SFP TVSS/Filter.
(2) Liebert Accuvar series.
(3) Islatrol.

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.
(1) Surge protection is not required for 120 VAC circuits that are only used for panel lights and receptacles.
b) For panels receiving power at 480 VAC, provide surge protection on the 120 VAC control power transformer secondary.
3) MCOV: 150 VAC.
4) Surge capability (8/20 microsecond wave): 10 kA.
5) Peak let-through: 620V L-N, 850V L-G.
6) Manufacturer: One of the following or equal:
a) Phoenix Contact Plugtrab PT series
b) MTL Surge Technologies MA15 series

2. Instrument, data and signal line protectors (traditional I/O) – panel mounted:
a. Surge protection minimum requirements: Withstand a 10 kA test current of a 8/20 µs 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 2 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 Manufacturer: One of the following or equal:
    1) Phoenix Contact Plugtrab Series.
    2) Bournes Series 1800.

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. Manufacturer: One of the following or equal:
        1) Plugtrab PT Series.
        2) MTL TP48 Series.

J. Beacons:
1. Manufacturer: One of the following or equal:
    a. Federal Signal Corp Starfire Series.
    b. Allen-Bradley 855 B *-* 10 Series.
    c. Edwards Model: Model 102.

K. Horns:
1. Electromechanical:
    a. Manufacturer: One of the following or equal:
        1) Federal Signal 350 or 31X Series.
        2) Edwards: 878EX or 879EX Series.
2. Electronic:
    a. Manufacturer: One of the following or equal:
        1) Federal Signal 300GCX or 300X Series.
        2) Allen-Bradley 855H or 855XH Series.
        3) Edwards 5530M 5533MD Series.
3. Rated 80 dB minimum at 10 feet.

L. 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 120 VAC to 24 volt DC or other DC voltages required or as required for the application.
3. Provide backup 24 VDC power supply units to automatically supply the load upon failure of the primary supply.
4. Provide power supply arrangement that is configured with several modules to supply adequate power in the event of a single module failure:
    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 1 set of dry contacts configured to change state on failure for monitoring and signaling purposes.

9. Output regulation: Within 0.05 percent for a 10 percent line change or a 50 percent load change:
    a. With remote voltage sensing.
10. Operating temperature range: 0 degrees Celsius to 50 degrees Celsius.
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. Manufacturer: One of the following or equal:
    a. Phoenix Contact Quint series.
    b. IDEC PS5R series.
    c. Sola.
    d. Acopian.
    e. PULS.

M. 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) 3-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: 20 to 30 VDC.
        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 to 20 milliamperes signals without Hart® communications capability:
        1) Designed and approved for use with 4 to 20 milliamperes analog signals.
        2) Designed for powering 2 and/or 3 wire transmitters in hazardous locations and repeating and/or generating the current to the safe area.
        3) Supply voltage: 20 to 30 VDC.

c. Transmitter and converters for use with 4 to 20 milliamperes signals with Hart® communications capability:
   1) Designed and approved for use with 4 to 20 milliamperes analog signals.
   2) Designed for powering 2 and/or 3 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: 20 to 30 VDC.

3. Manufacturer: One of the following or equal:
   a. Phoenix Contact ME Series.
   b. Pepperl + Fuchs.

N. Starters:
1. Magnetic motor starters:
   a. As specified in Section 16422.
2. Integral self-protected starters:
   a. As specified in Section 16422.

O. Variable frequency drives:
1. As specified in Section 16262.

P. Limit switches:
1. NEMA Type 4X.
2. AC contact rating 120 volts, 10 A.
3. DC contact rating 125 volts, 0.4 A.
4. Provide robust actuation mechanism not prone to degradation.
5. Provide complete actuator mechanism with all required hardware.
6. Allows for contact opening even during contact weld condition.
7. UL approved.
8. Operating temperature range: -18 degrees to +110 degrees Celsius (0 degrees to 230 degrees Fahrenheit).
9. Manufacturer: One of the following or equal:
   a. Allen-Bradley 802.
   b. Honeywell HDLS.
   c. Omron D4.
   d. Eaton E47, E49, E50.
   e. ABB equal.

2.07 ACCESSORIES

A. As specified in Section 17050.

B. Provide panels with an inside protective pocket to hold the panel Drawings. Ship panels with 1 copy of accepted Shop Drawings including, but not limited to, schematic diagram, connection diagram, and layout drawing of control wiring and components in a sealed plastic bag stored in the panel drawing pocket.

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 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. 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 or equipment Specifications. 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 1 luminaire for each section, on the interior of the panel, spaced evenly along the top-front of the enclosure door opening(s):
      a. Covered or guarded.
      b. Provide On-Off door-activated switches where indicated on the Drawings.
      c. Provide 18-watt fluorescent lamp for indoor enclosures:
         1) Provide additional fixtures for every 36 inches of width.
      d. Provide 40 watt incandescent lamp for exterior enclosures:
         1) Provide additional fixtures for every 36 inches of width.

H. Receptacles:
   1. Provide 1 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 (24 VDC) 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.

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES

A. Finishes:
1. Metallic (non-stainless):
   a. Metal surfaces of panels shall be prepared by chemical cleaning and mechanical abrasion in accordance with the finish manufacturer's recommendations to achieve a smooth, well-finished surface.
   b. Scratches or blemishes shall be filled before finishing. 1 coat of zinc phosphate shall be applied 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:
   a. 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.

2.11 SOURCE QUALITY CONTROL

A. As specified in 17050.

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.
   1. 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 PREPARATION (NOT USED)

3.03 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:
   1. Undercoat floor mounted panels.

F. Provide a full size equipment-grounding conductor in accordance with NEC included with the power feeder. Terminate to the incoming power circuit-grounding terminal.

G. 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.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIRS/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 FIELD QUALITY CONTROL

A. As specified in Section 17050.

3.08 ADJUSTING (NOT USED)

3.09 CLEANING

A. As specified in Section 17050.

3.10 DEMONSTRATION AND TRAINING (NOT USED)

3.11 PROTECTION

A. As specified in Section 17050.

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 17712

CONTROL SYSTEMS - UNINTERRUPTIBLE POWER SUPPLIES 10 KVA AND BELOW

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Single-phase double conversion uninterruptible power supplies rated 10 kilovolt-amperes and below.

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.
      a. Items involving electrical, control, and instrumentation construction may be indicated on the Drawings or specified in the Specifications that do not apply specifically to electrical, control and instrumentation systems.
   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 - Seismic Design Criteria.
      c. Section 16050 - Common Work Results for Electrical.
      d. Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.02 REFERENCES

A. As specified in Sections 16050 and 17050.

B. American National Standards Institute (ANSI):
   1. ANSI C62.41 (IEEE 587) - Guide for Surge Voltages in Low Voltage AC Power Circuits.

C. Federal Communications Commission (FCC):
   1. FCC Part 15, Class A.
   2. FCC Part 15, Class B.

D. Institute of Electrical and Electronic Engineers (IEEE):
   1. IEEE 519 - Standard Practices and Requirements for Harmonic Control in Electrical Power Systems.
   2. IEEE 1184 - Guide for the Selection and Sizing of Batteries for Uninterruptible Power Systems.

E. International Organization for Standardization (ISO):
   1. ISO 9001.

F. National Electrical Manufacturers Association (NEMA):
   1. NEMA PE1 - Uninterruptible Power Systems Specification and Performance Verification.

G. Underwriters Laboratories, Inc. (UL):
   1. UL 1778 - Standard for Uninterruptible Power Supply Systems and Equipment.

1.03 DEFINITIONS

A. As specified in Sections 16050 and 17050.

B. Specific definitions:
   1. Critical load: Load supplied by the UPS.
   2. MOV: Metal oxide varistor.

1.04 SYSTEM DESCRIPTION

A. Provide complete, factory-assembled, wired, and tested, true on-line double conversion UPS equipment including, but not limited to, rectifier, DC bus, inverter, battery charger, batteries, automatic bypass, and ancillary components as specified herein and as indicated on the Drawings.

B. UPS loads as indicated on the Drawings.

1.05 SUBMITTALS

A. Furnish submittals as specified in Sections 01330 and 17050.

B. Product data:
   1. Manufacturer and model number.
   2. Catalog data.
   3. Dimensions:
      a. Height.
      b. Width.
      c. Depth.
      d. Weight.
   4. Ratings:
      a. Input voltage.
      b. Output voltage.
      c. Input/output power factor.
      d. Efficiency.
      e. Harmonic distortion.
      f. Runtime.
   5. Noise specifications.
   6. Heat dissipation.
   7. Warranties and maintenance contracts:
   8. All communications requirements such as software, cards, etc.
   9. Alarms and status available for remote monitoring and system health.

C. Shop drawings:
   1. Power distribution block diagrams.
   2. Front and rear views of equipment enclosures:
      a. Front elevation including all control and indicating devices.

3. Support points and weight of overall equipment.
4. Schematic and control wiring diagrams including, but not limited to:
   a. Line and load terminals.
   b. Alarm and status terminals.
   c. Manual maintenance bypass switch terminals.
   d. External wiring requirements for all communication signals.
5. Switching and overcurrent protective devices.

D. Calculations:
1. Include derating for temperature and elevation as necessary.
2. UPS sizing computation:
   a. Apply safety factors as specified in this Section.
   b. Provide itemized list of critical loads, including individual VA and watt ratings.
3. Battery time calculation based on specified runtime.
4. Total battery recharge time as a function of capacity utilized.

E. Design data:
1. Design mounting and anchorage for seismic design criteria specified in Section 01612:
   a. Provide seismic kits as required to meet design criteria.

F. Record documents:
1. Provide Record Drawings of installed unit(s) including layout and wiring.

G. Manufacturer's field reports.

H. Operation and maintenance manuals:
1. System instruction manuals that describe troubleshooting, installation, operations, and safety procedures.
2. Recommendations for maintenance procedures and intervals.
3. Battery data / replacement information.
4. Parts list.

1.06 QUALITY ASSURANCE

A. Manufacturer qualifications:
1. A minimum of 10 years experience in the design, manufacture, and testing of solid-state UPS systems.
2. ISO 9001 certified.

B. Regulatory requirements for complete UPS system:
1. UL listed per UL Standard 1778
2. IEEE C62.41, Categories A & B.
3. FCC 15:
   a. Greater than 2,000 VA - Class A.
   b. Less than 2,000 VA - Class B.

1.07 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 17050.

1.08 PROJECT OR SITE CONDITIONS

A. As specified in Section 17050.

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

A. As specified in Section 17050.

1.12 SYSTEM START-UP (NOT USED)

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 COMMISSIONING (NOT USED)

1.15 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Double-conversion true-online UPS manufacturers, one of the following or equal:
   1. Free-standing UPS, 700-3,000 VA:
      a. Emerson Network Power - Liebert GXT3 (700 - 3,000 VA).
      b. Eaton Corporation - Powerware 9120 (700 - 3,000 VA).
   2. Rack-mounted UPS, 700-3,000 VA:
      a. Emerson Network Power - Liebert GXT3 (700 - 3,000 VA).
      b. Eaton Corporation - Powerware 9125 RM (700 - 3,000 VA).

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS (NOT USED)

2.04 MANUFACTURED UNITS

A. Double conversion true on-line UPS system requirements:
   1. System characteristics:
      a. Provide rack-mount or free-standing UPS as specified and as indicated on the Drawings.
      b. The minimum VA rating of the UPS shall be greater than or equal to the safety factor (as indicated in the UPS schedule) times the connected load or 700 VA, whichever is greater.
      c. Battery runtime at full load and site ambient temperature as indicated in the UPS schedule.
      d. Efficiency greater than 85 percent AC-AC, all modes.
      e. Acoustical noise:
         1) Less than 55 dBA at 5 feet.

f. Output connections:
   1) Receptacles:
      a) 700-2,500 VA units:
         (1) Provide a minimum of four NEMA Type 5-15R or Type 5-20R receptacles.
      b) 3,000 VA units:
         (1) Provide a minimum of four NEMA Type 5-20R receptacles.
         (2) Provide at least one NEMA Type L5-30R receptacle.
   2) Provide hardwired connections as indicated on the Drawings.
g. Protection:
   1) Undervoltage:
      a) Operate on battery power if incoming source voltage goes below UPS system limits of operation.
   2) Overvoltage:
      a) Operate on battery power if incoming source voltage exceeds UPS system limits of operation.
   3) Overcurrent:
      a) Provide input and output current-limiting protection to ensure adequate overcurrent protection for UPS.
   4) Surge protection:
      a) MOV-based.

2. Electrical characteristics:
   a. AC input:
      1) Single phase.
      2) Voltage as indicated in the UPS schedule.
         a) Fully functional within +10 percent, -15 percent of nominal voltage at full load without depleting battery.
         b) 120 V input:
            (1) 2-wire plus ground.
         c) 208/120 V or 240/120 input:
            (1) 3-wire plus ground.
      3) Current:
         a) Reflected total harmonic distortion (THD) less than 25 percent at rated load.
      4) Frequency range of operation:
         a) 57-63 Hz.
      5) Power factor:
         a) Not less than 0.95 lagging at rated load.
   b. AC output:
      1) Single phase.
      2) Voltage:
         a) Regulation:
            (1) ±3 percent for 3,000 VA rating and below.
            (2) ±5 percent for greater than 3,000 VA rating - static load.
            (3) ±10 percent for greater than 3,000 VA rating - dynamic load.
         b) Total harmonic distortion (THD) when operating on incoming power:
            (1) Not more than 3 percent for linear loads with a crest factor of 3:1.
            (2) Not more than 5 percent for non-linear loads with a crest factor of 3:1.

c) Transient response:
(1) ±7 percent for a 20-100 percent step load.
(2) Transient recovery time to nominal voltage within 166 milliseconds.

3) Load power factor:
a) UPS shall be capable of supporting the critical loads for all power factors experienced for their full range of operation.

4) Frequency regulation:
a) Within ±3.5 Hz when on utility power.
b) Within ±1.0 Hz when on UPS power.

3. Environmental requirements:
a. Operating ambient temperature:
1) UPS module: 50 degrees Fahrenheit to 104 degrees Fahrenheit (10 degrees Celsius to 40 degrees Celsius).
2) Battery: 68 degrees Fahrenheit to 86 degrees Fahrenheit (20 degrees Celsius to 30 degrees Celsius).

b. Operating altitude:
1) Project site conditions as specified in Sections 16050 and 17050.

4. System components:
a. Surge protective devices:
1) MOV-supplied protection.

b. Inverter:
1) Pulse-width modulated AC output signal.
2) Overload withstand minimum time without transferring to bypass:
a) 101 to 110 percent for 2 minutes.
b) 111 to 125 percent for 10 seconds.
c) 126 to 150 percent for 1 second.
d) Greater than 150 percent for 96 milliseconds.
3) Transfer load to bypass when overload capacity is exceeded.

c. Battery rectifier/charger:
1) Recharge batteries to 90 percent in 6 hours or less.

d. Batteries:
1) VRLA (valve regulated lead acid), sealed, maintenance free.
2) Minimum 3-year float service life at 25 degrees Celsius.
3) Integral to UPS enclosure or housed in a matching enclosure.
4) Less than and including 6,000 VA: Hot-swappable.
5) Automatically perform routine battery health monitoring and provide visual, audible, and/or serial warnings if abnormal battery conditions exist.

e. Automatic bypass switch:
1) Integral to UPS system.
2) Sense UPS overload, inverter failure, or overtemperature, and automatically transfer loads to source power.
3) Maximum detect and transfer time of 4-6 milliseconds.
4) Automatic re-transfer without power interruption to critical load.
5) Input shall match output in phase, voltage, frequency, and grounding.
6) Rated to carry the full input current of the UPS.
7) Provide ability for manual operation.

f. Manual maintenance bypass switch:
1) Provides isolation of the UPS for maintenance purposes.

2) Make-before-break design so that UPS can be isolated from the critical loads by placing these loads on source power without interruption of operation.
3) Utility and UPS status indications.
4) Supply necessary input/output cords and receptacles for connections with power source and UPS.
5) Transfer time less than 6 milliseconds.
6) Rated to carry the full input current of the UPS.
7) Standalone UL-listed.
8) Input match output in phase, voltage, frequency, and grounding.
9) UPS input connection and UPS output plug:
   a) 700 to 3,000 VA units: NEMA receptacle and plug to match UPS connections.
10) Utility and load connections:
   a) As indicated on the Drawings.
11) 700 to 3,000 VA units: One of the following or equal:
   a) Liebert Micropod 2U.
   b) Powerware Powerpass 9125.
12) Above 3,000 VA units: By manufacturer of UPS, with connections matched for operation with UPS.

g. UPS chassis:
   1) Electrically isolate from AC output neutral.
   2) Include an equipment ground terminal.

h. Cooling:
   1) Forced air cooled.

i. Locally displayed system indicators:
   1) Audible alarms during abnormal conditions:
      a) UPS fault or overload condition.
      b) Battery on.
      c) Low battery.
      d) Automatic bypass on/off.
      e) Input power on.
      f) Battery testing mode.

j. Controls:
   1) Front-panel pushbuttons:
      a) UPS start-up, shutdown, and manual bypass (for automatic bypass).
      b) Testing.
      c) Visual/audible alarms reset.
   2) Applicable controls as specified in Communications Requirements.

k. Alarm contacts:
   1) Where specified in the UPS schedule provide relay interface card and required interposing relays for 120 VAC discrete input status signals:
      a) Low battery.
      b) UPS alarm.
      c) On UPS power.

l. Communications requirements:
   1) RS-232.

2) Rack Mounted UPS:
   a) Ethernet via SNMP - allow remote indication of all alarms and status signals present in the UPS:
   b) Provide manufacturer’s software as required.
3) Operator workstation UPS:
   a) USB - allow remote indication of all alarms and status signals present in the UPS:
   b) Provide manufacturer’s software as required.

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS (NOT USED)

2.07 ACCESSORIES (NOT USED)

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. Install equipment in accordance with manufacturer's instructions.

B. Do not utilize extension cords, adapters, or other electrical connectors for UPS input.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIRS/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 FIELD QUALITY CONTROL

A. Perform inspections and test procedures before UPS startup:
   1. Inspect equipment for signs of damage.
   2. Verify installation as indicated on the Drawings and specified in the Specifications.
   3. Inspect cabinets for foreign objects.
   4. Verify neutral and ground conductors are properly sized and terminated.
   5. Inspect battery cases.
   6. Inspect batteries for proper polarity.

7. Check power and control wiring for tightness.
8. Check terminal connectors for tightness.
9. Ensure connection and voltage of the battery string(s).

3.08 ADJUSTING (NOT USED)

3.09 CLEANING

A. As specified in Section 17050.

3.10 DEMONSTRATION AND TRAINING (NOT USED)

3.11 PROTECTION

A. As specified in Section 17050.

3.12 SCHEDULES

Tag	Minimum Runtime	Input Voltage / Connection	Safety Factor	Notes
UPS-1 (Electrical Building Network Panel NP-1)	1 hour	120V Plug	1.5	Rack Mount, Ethernet communications
UPS-2 (Dewatering Building Electrical Room Network Panel NP-2)	1 hour	120V Plug	1.5	Rack Mount, Ethernet communications
UPS-UV (UV VCP)	1 hour	120V Plug	1.5	Panel Mount, provide relay interface card
UPS-Main (Administration Building Network Rack NR-Main)	1 hour	120V Plug	1.5	Rack Mount, Ethernet communications
Operator Workstation	1 hour	120V Plug	1.5	Free Standing, USB communications
Development Workstation	1 hour	120V Plug	1.5	Free Standing, USB communications

END OF SECTION

SECTION 17713

CONTROL SYSTEMS - SCADA CONSOLES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes requirements for:
   1. SCADA consoles.

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 17050 - Common Work Results for Process Control and Instrumentation Systems.
      d. Section 17950 - Testing, Calibration, and Commissioning.

C. Provide all instruments identified in the Contract Documents.

1.02 REFERENCES

A. As specified in Section 17050.

B. CSA International (CSA).

C. International Organization for Standardization (ISO):
   1. 9001 - Quality Management Systems - Requirements.

D. Underwriters Laboratories, Inc. (UL).

1.03 DEFINITIONS

A. As specified in Section 17050.

1.04 SYSTEM DESCRIPTION

A. Provide all consoles as identified in the Contract Documents.

1.05 SUBMITTALS

A. Furnish submittals as specified in Sections 01330 and 17050.

B. Shop drawings:
   1. Provide complete structural details for each fabricated panel as indicated on the Drawings.
   2. Panel front view showing equipment arrangement and dimensional information.
   3. Internal interconnecting wiring diagrams showing terminal strips and all devices:
      a. Identify each wire within the panel.
      b. Identify all wire numbers, terminal numbers, device names, and numbers, fuse sizes, equipment ratings, voltages.
   4. External power sources:
      a. Show power distribution panel and circuit.
   5. Cross-references to related drawings.

C. Bill of materials with detailed description of components and equipment data sheets.
   1. Include fields for:
      a. Cable number/I.D. and terminations.
      b. Factory data sheets for system modules and devices.
      c. Colors for all cabinets and console.

D. Calculations:
   1. Cooling calculations: Submit in accordance with requirements to allow a maximum of 90 degrees Fahrenheit within panels.
   2. Seismic calculation: Detailed calculations on the SCADA Consoles to prove the SCADA consoles and anchorage are suitable for the seismic requirements at the project site and as specified in Section 16050.
   3. Mounting details to comply with site conditions.
   4. Stamped by a Professional Engineer registered in the State where the project is being constructed.

E. Drawing plan:
   1. Elevation and section drawings for all console requirements, listing:
      a. Console, equipment, architectural, mechanical, and electrical project elements, features and measurements.
      b. Color chart and samples of laminate surfaces for color selection for console, millwork, and furniture provided by the manufacturer.
   2. Provide in PDF format.

F. Console installation plan:
   1. Project-specific documentation:
      a. Console plan.
      b. Elevation.
      c. Section drawings.

G. Installation instructions:
   1. Written instructions must detail the complete installation of the SCADA consoles including rigging, moving, and setting into place.
   2. Provide anchorage instructions and requirements for the SCADA consoles based on the seismic requirements of the project site.
   3. Installation acceptance and sign-off documentation.

1.06 QUALITY ASSURANCE

A. As specified in Section 17050.

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. Manufacture consoles at ISO certified facilities:
   1. ISO Standard 9001 - Quality Systems - Model for Quality Assurance in Design/Development, Production, Installation, and Servicing.

1.07 DELIVERY, STORAGE, AND HANDLING

A. As specified in section 17050.

1.08 PROJECT OR SITE CONDITIONS

A. Project environmental conditions as specified in Section 17050.
   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.

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING

A. Provide, in writing, 30 working days before shipment of the SCADA consoles, all installation requirements for these consoles.

1.11 WARRANTY

A. As specified in Section 17050.

1.12 SYSTEM START-UP (NOT USED)

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 COMMISSIONING (NOT USED)

1.15 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. One of the following or equal:
   1. Tresco Consoles:
      a. Series 4800.
   2. Evans Consoles:
      a. Strategy series.

2.02 MANUFACTURED UNITS

A. Detailed design, fabrication, and installation of control consoles; including system modules, control devices, power supplies, and components.

B. Include the following:
   1. Wireways.
   2. Conductors.
   3. Nameplates.
   4. Accessories and appurtenances for complete panels as.
   5. Complete and operable consoles in accordance with the Contract Documents.

C. Consoles consist of tiered equipment modules with:
   1. Work surface covered with high-pressure plastic laminate.
   2. Exterior panels covered with plastic laminate.
   3. Front and rear access doors mounted with quick-release hinges.
   4. Polyurethane work surface front edge.
   5. Structural frames formed by 12 gauge cold rolled steel forming an open architecture within the console that supports the equipment, exterior panels, work surfaces and recessed monitor shelves:
      a. Fasten exterior panels to frame structure with concealed quick-release hinges.
   6. Structural and frame components furnished by electrostatic powder coating or sprayed with epoxy paint.
   7. Modular construction and mechanical attached components to accommodate knock down shipping and installation in an existing building.
   8. Fabricate so that all components fit through a standard 35-inch door opening.
   9. Slide-out keyboard tray under console top.

D. Provide a modular, flexible design that enables equipment modules to be assembled or repositioned using standard hand tools.

E. Provide adjustable console levelers to accommodate uneven floor conditions:
   1. Up to 1.75 inches across the entire length of the console.

F. Open desktop design with a recessed monitor well to house CRT and/or flat panel LCD monitors.

G. Work surface:
   1. Assembled with draw bolts and splines for flush, tight joints.
   2. Constructed of, minimum, 1-inch particleboard core, finished with high-pressure plastic laminate.
   3. Supported by a 12-gauge steel cantilever system.

4. Designed to withstand a 200-pound-per-square-foot load.

H. External panels:
1. Doors fastened with adjustable, quick release hinges.
2. Supported from the console frame with hanging clips.
3. Gables fastened with threaded inserts and bolts.

I. Equipment mounts:
1. Fabricated with 16-gauge perforated metal to facilitate airflow to equipment and to support equipment loads.
2. Mounted on extra-heavy duty steel bearing full extension slides.
3. Positioned on shelf pins installed in metal vertical support bars for height adjustability.
4. Access to equipment through removable front or rear panels.

J. Electrical:
1. Internal cable routing integral to the Console frame design.
2. Incorporate electrical outlets mounted internally to structural steel frame and externally in architectural panels to accommodate mounted equipment, task lighting, and ventilation fans.
3. Components UL/CSA approved.

K. Ventilation:
1. Provide supplementary ventilation in the absence of floor supplied forced air.
2. Internal fans, coolers, or air conditioning units with thermostatic control for internal air circulation.
3. Filters on intake and exhaust openings.
4. Maximum fan noise ratings not to exceed 35 decibels in free air.

2.03 MATERIALS (NOT USED)

2.04 MANUFACTURED UNITS (NOT USED)

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS (NOT USED)

2.07 ACCESSORIES

A. Valance:
1. Taper to extend over the monitor shelf:
   a. Match radius of curvatures to console configuration.
2. Construct curved valances of formed fiberglass.
3. Construct straight or mitered valances of multi-piece aluminum extrusions.
4. Cap sides with a milled, contoured metal molding.
5. Finish metallic parts with electrostatic powder coating.
6. Front edge.

B. Task lighting system:
1. Integrated into valance to illuminate work surface.
2. Low profile, dimmable xenon flicker-free without creating hotspots or pools of light on work surface.
3. Provide mounting brackets to fully support lighting system:

a. Bottom opening to allow light to illuminate work surface.
b. Soften and diffuse generated reflective light to prevent, glare, hot spots, or shining in the operators eyes.

4. Locate support posts to allow positioning of flat screen monitors between valance support posts and monitor shelf apron.

C. Furnish 1 can of touch-up paint for each color on the console.

D. Provide sunshades for outdoor installations.

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION

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 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 17050.

B. Install panels in accordance with the manufacturer's submitted and reviewed seismic design.

C. Provide on-site services of a manufacturer certified and qualified console technician to assist CONTRACTOR with assembly and installation of consoles.

D. Provide technician time to assemble and align consoles in final installed locations:
   1. Technicians time to end upon written acceptance of console installation by OWNER and Owner's Representative.

E. Provide equipment, tools, materials, and labor for handling, moving, assembling, and installing consoles under direction of Manufacturer's technician.

F. Verify that power, telephone, and network connections line-up with entry areas on consoles.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 REINSTALLATION (NOT USED)

3.07 FIELD QUALITY CONTROL

A. As specified in Section 17050.

B. Replace components or complete units that are deemed unacceptable by OWNER or Owner's Representative:
   1. OWNER or Owner's Representative are the sole parties responsible for determining acceptance and their decision is final.

3.08 ADJUSTING

A. As specified in Section 17950.

3.09 CLEANING

A. As specified in Section 17050.

3.10 DEMONSTRATION AND TRAINING (NOT USED)

3.11 PROTECTION

A. As specified in Section 17050.

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 17720

CONTROL SYSTEMS – PROGRAMMABLE LOGIC CONTROLLERS HARDWARE

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Programmable logic controller (PLC) based control systems hardware.

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 - Common Work Results for Process Control and Instrumentation Systems.
      c. Section 17710 - Control System - Panels, Enclosures, and Panel Components.
      d. Section 17733 - Control Systems - Network Materials and Equipment.
      e. Section 17761 - Control Systems - PLC Programming Software.
      f. Section 17762 - Control Systems - SCADA Software.

1.02 REFERENCES

A. As specified in Section 17050.

1.03 DEFINITIONS

A. As specified in Section 17050.

B. Specific definitions:
   1. CPU: Central processing unit.
   2. I/O: Input/Output.

1.04 SYSTEM DESCRIPTION

A. Provide all PLC hardware as indicated on the Drawings, equipment specifications, and as specified in this Section.

1.05 SUBMITTALS

A. Furnish submittals as specified in Sections 01330 and 17050.

B. Product data:
   1. CPU:
      a. Processor type.
      b. Processor speed.
      c. Memory.
      d. Internal processor battery backup time.
   2. I/O modules:
      a. Type.
      b. Standard wiring diagram.

C. Calculations:
   1. Submit calculations or documented estimate to verify that memory requirements of this Section are met, including spare requirements. If possible, use PLC manufacturer's calculation or estimating worksheet.
   2. Submit calculations to verify that spare I/O requirements of this Section are met.
   3. Submit calculations to verify that PLC power supply requirements of this Section are met.

1.06 QUALITY ASSURANCE

A. Provide PLC hardware manufactured at facilities certified to the quality standards of ISO 9001.

B. Additional requirements:
   1. Provide PLC system components by a single manufacturer:
      a. Third-party communication modules may be used only for communication or network media functions not provided by the PLC manufacturer.
   2. Use PLC manufacturer approved hardware, such as cable, mounting hardware, connectors, enclosures, racks, communication cable, splitters, terminators, and taps.
   3. All PLC hardware, CPUs, I/O devices, and communication devices shall be new, free from defects and produced by manufacturers regularly engaged in the manufacture of these products.

1.07 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 17050.

1.08 PROJECT OR SITE CONDITIONS

A. As specified in Section 17050.

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

A. As specified in Section 17050.

1.12 SYSTEM START-UP (NOT USED)

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 COMMISSIONING (NOT USED)

1.15 MAINTENANCE

A. As specified in Section 17050.

B. In addition to the spare parts requirements in Section 17050, furnish:
   1. 1 spare CPU for every type of CPU in the system.
   2. 3 spare I/O cards for every type of I/O card in the system.
   3. 2 spare power supplies for every power supply in the system.
   4. 1 spare network and/or communications card for every network or communications card in the system.
   5. 1 spare base for every base size in the system.

C. Installed spare requirements:
   1. I/O points:
      a. Provide total of 25 percent spare I/O capacity for each type of I/O signal at every PLC.
      b. Wire all spare I/O points to field terminal blocks in the PCM.
   2. PLC backplane capacity:
      a. 25 percent or 3 spare backplane slots, whichever is greater.
   3. PLC memory:
      a. 50 percent spare program volatile memory.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Acceptable manufacturers:
   1. PLC-1 and PLC-2:
      a. Allen-Bradley ControlLogix, no equal.
   2. Packaged system/vendor PLCs:
      a. Allen-Bradley Logix family, no equal.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS (NOT USED)

2.04 MANUFACTURED UNITS

A. Programmable logic controller:
   1. Construction:
      a. Furnish plug-in modular system.
      b. Chassis wired logic is not acceptable.
      c. Provide PLCs capable of operating in a hostile industrial environment without fans, air conditioning, or electrical filtering:
         1) Temperature: 0 to 60 degrees Celsius.
         2) RFI: 80 to 1,000 MHz.
         3) Vibration: 10 to 500 Hertz.
         4) Humidity: 5 to 95 percent.

d. Provide internal power supplies designed to protect against over voltage and frequency distortion characteristics frequently encountered with the local power utility.
e. Design the PLC system to function as a stand-alone unit that performs all of the control functions described herein completely independent from the functions of the SCADA system PC-based operator interfaces:
    1) Failure of the SCADA system shall not impact data acquisition, control, scaling, alarm checking, or communication functions of the PLC.

2. Components general:
    a. Provide each PLC with the functionality required to implement the control strategies and database shown and specified in the Contract Documents.
    b. Furnish each PLC with floating point math and PID controller modulating algorithms.
    c. Provide each CPU with internal fault analysis incorporating a fail-safe mode and a dry contact output for remote location alarming, as well as a local indicator on the PLC frame in the event of a fault in the PLC.
3. Central processing unit:
    a. Configure each central processor unit so that it contains all the software relays, timers, counters, number storage registers, shift registers, sequencers, arithmetic capability, and comparators necessary to perform the specified control functions.
    b. Capable of interfacing with all discrete inputs, analog inputs, discrete outputs, and analog outputs to meet the specified requirements including the spare and expansion requirements
    c. Capable of supporting and implementing closed loop floating-point math and PID control that is directly integrated into the CPU control program.
    d. Design the power supply to contain capacitors to provide for orderly shutdown in the event the incoming power does not meet specifications:
        1) Cease operation under this condition and force all outputs off.
4. Memory:
    a. CPU program memory:
        1) 16 Mbytes for ControlLogix (Process PLCs).
        2) For vendor PLCs provide sufficient memory as required for the application.
    b. Non-volatile memory: On-board complementary metal oxide semi-conductor (CMOS), electrically erasable programmable read only memory (EEPROM), PCMCIA, compact flash card, or SD card.
    c. Supply with an internal lithium battery to retain non-volatile memory during power outages of up to 30 days.
        1) Battery to retain charge for minimum 1 year during normal operations.
        2) Furnish with an indicator showing the status of the batteries on the OIS graphic screen to alarm the operator that the batteries should be changed.
    d. Supply with sufficient memory to implement the specified control functions plus a reserve capacity as specified with the requirements of this Section:
        1) This reserve capacity:
            a) Totally free from any system use.
        2) Programmed in a multi-mode configuration with multiple series or parallel contacts, counters, timers, and arithmetic functions.

5. Programming:
    a. Provide a system where processors are programmed by:
        1) Portable laptop computer both locally and via the PLC data network.
        2) SCADA engineer's console via the PLC data network.
6. PLC power supply:
    a. Input: 120 VAC.
    b. Provide each PLC power supply sized to meet the following requirements:
        1) 120 VAC RMS plus or minus 15 percent, continuously.
        2) 120 VAC RMS plus or minus 30 percent, maximum 30 seconds.
        3) 120 VAC RMS plus or minus 100 percent, maximum 17 milliseconds.
        4) Line spikes at 1,000 VAC:
            a) 5,000 microseconds duration.
            b) 0.05 percent maximum duty cycle.
    c. Mounted in the PLC housing.
    d. Sized to power all modules mounted in that housing including an average module load for any empty housing slots plus 50 percent above that total.
7. PLC input/output, I/O modules:
    a. General:
        1) Compatible with all of the PLCs being furnished under the contract and by the same manufacturer as the PLCs.
        2) Provide I/O modules that:
            a) Isolated in accordance with IEEE Surge Withstand Standards and NEMA Noise Immunity Standards.
            b) Provide A/D and D/A converters with optically or galvanically isolated inputs and outputs.
            c) Accept dual ended inputs.
        3) The commoning of grounds between I/O points is not acceptable.
        4) Modules that are removable without having to disconnect wiring from the module's terminals:
            a) Utilize a swing-arm or plug-in wiring connector.
        5) Provide at each PLC location the I/O modules required to provide the I/O points, including designated future I/O points, contained in the I/O Lists and/or shown on the P&IDs, control schematics, or described in the control strategies:
            a) Provide at each PLC location an installed spare capacity in accordance with the requirements of this Section.
            b) Wire all spares provided to the field terminal strip.
        6) Condition, filter, and check input signals for instrument limit conditions.
        7) Filter, scale, and linearize the raw signal into an engineering units based measurement.
        8) Alarm measurements for high, low, rate-of-change limits, and alarm trends.
        9) Provide external fuses mounted on the field connection terminal block for all discrete input, discrete output, and analog input I/O points.
        10) When multiple cards of the same I/O type are provided and parallel equipment, instrumentation, or redundant processes exist, distribute I/O among cards to ensure that a single card failure will not render an entire process unavailable.
    b. Discrete input modules:
        1) Defined as contact closure inputs from devices external to the input module.

2) Provide inputs that are optically isolated from low energy common mode transients to 1,500 volts peak from users wiring or other I/O modules.
3) Individually isolated inputs.
4) With LED's to indicate status of each discrete input.
5) Input signal level: 120 VAC.
6) Provide input module points that are individually fused with blown fuse indicator lights, mounted external of the module on the output terminal strip:
a) Coordinate external fuse size with the protection located on the module, so that the external fuse opens first under a fault condition.

c. Discrete output modules:
1) Defined as contact closure outputs for ON/OFF operation of devices external to the output module:
a) Triac outputs may be used, with the permission of the Engineer, care must be used in applying this type of modules to ensure that the leakage current through the output device does not falsely signal or indicate an output condition.
2) Optically isolated from inductively generated, normal mode and low energy, common mode transients to 1,500 volts peak.
3) LEDs to indicate status of each output point.
4) Each output point: Individually isolated.
5) Output signal level: 120 VAC.

d. Analog input modules:
1) Signal type: 4 to 20 mA DC.
2) Analog to digital conversion: Minimum 12-bit precision with the digital result entered into the processor.
3) The analog to digital conversion updated with each scan of the processor.
4) Individually isolated each input.
5) Provide individually fused analog input module points with blown fuse indicator lights, mounted external of the module on the output terminal strip:
a) Coordinate the size of the external fuse with the protection located on the module, so that the external fuse opens first under a fault condition.

e. Analog output modules:
1) Signal type: 4 to 20 mA DC.
2) Individual isolated output points each rated for loads of up to 1,200 ohms.

f. Specialty I/O modules:

8. Communications modules:
a. Network communications modules:
1) General:
a) Install communications modules in the PLC backplane.
2) Ethernet:
a) Ports: 1 RJ-45 Fiber optic.
b) Communication rate: 100 Mbit/s.
3) Provide all network taps, connectors, termination resistors, drop cables, and trunk cables necessary for remote I/O communications.

9. PLC Housing:
    a. Mount the PLC power supply, CPU, rack, and I/O modules in a suitable standard PLC backplane or housing.
    b. Provide spare slots in each PLC and RIO location in accordance with the requirements of this Section.
    c. Provide blank slot filler module for each spare slot.

B. SCADA system interface:
    1. As specified in Section 17733 and Section 17762.

C. Programming:
    1. As specified in Section 17761.

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS (NOT USED)

2.07 ACCESSORIES (NOT USED)

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL

A. As specified in Section 17050.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 17050.

B. Utilize personnel to accomplish, or supervise the physical installation of all elements, components, accessories, or assemblies:
    1. Employ installers who are skilled and experienced in the installation and connection of all elements, components, accessories, and assemblies.

C. All components of the control system including all data network cables are the installation responsibility of the ICSC unless specifically noted otherwise.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 REINSTALLATION (NOT USED)

3.07 FIELD QUALITY CONTROL

A. As specified in Section 17050.

3.08 ADJUSTING (NOT USED)

3.09 CLEANING

A. As specified in Section 17050.

3.10 DEMONSTRATION AND TRAINING

A. As specified in Section 17050.

B. Tailor training specifically for this Project that reflects the entire control system installation and configuration.

C. Perform training by pre-approved and qualified representatives of the ICSC and or manufacturer of the PLC hardware:
   1. A representative of the ICSC may perform the training only if the representative has completed the Manufacturer's training course for the PLC hardware.

3.11 PROTECTION

A. As specified in Section 17050.

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 17721

CONTROL SYSTEMS – HUMAN MACHINE INTERFACE HARDWARE

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Human machine interface (HMI) control systems hardware.

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 - Common Work Results for Process Control and Instrumentation Systems.
      c. Section 17712 - Control Systems - Uninterruptible Power Supplies 10 kVA and Below.
      d. Section 17730 - Control Systems - SCADA Computer Equipment.
      e. Section 17762 - Control Systems - SCADA Software.
      f. Section 17765 - Control Systems - Human Machine Interface Software.

1.02 REFERENCES

A. As specified in Section 17050.

B. International Organization for Standardization (ISO):
   1. 9001 - Quality Management Systems - Requirements.

C. National Electrical Manufacturers Association (NEMA):
   1. 250 - Enclosures for Electrical Equipment (1000 V Maximum).

1.03 DEFINITIONS

A. As specified in Section 17050.

B. NEMA:
   1. Type 4X enclosure in accordance with NEMA 250.

1.04 SYSTEM DESCRIPTION

A. Provide all HMI hardware identified in the Contract Documents.

1.05 SUBMITTALS

A. Furnish submittals in accordance with Sections 01330 and 17050.

B. Product data:
   1. Complete manufacturer's brochures for each item of equipment.
   2. Manufacturer's operation and installation instructions.
   3. Additional requirements:
      a. Display type and size.
      b. Operator input.
      c. Processor type and speed.
      d. Memory size.
      e. Programming protocols.
      f. Communication protocols.
      g. Power requirements.
      h. Operating temperature and humidity ranges. NEMA ratings.

C. Shop drawings:
   1. At a minimum, furnish the following:
      a. System block diagram showing relationship and connections between devices provided. Include manufacturer and model information, and address settings.
      b. Mounting drawings with dimensions and elevations for each equipment location, including identification of all components, preparation and finish data, and nameplates.
      c. Electrical connection diagrams.
      d. Complete grounding requirements.
   2. Furnish data sheets for each component together with a technical product brochure or bulletin:
      a. Manufacturer's model number.
      b. Project equipment tag.
   3. Complete and detailed bills of materials identified by each cabinet. Include with each bill of material item the following:
      a. Quantity.
      b. Description.
      c. Manufacturer.
      d. Part numbers.

D. Operation and maintenance manuals:
   1. Complete installation, operations, calibration, and testing manuals as described in Section 17050.

E. Record documents:
   1. Electrical connection diagrams revised to reflect any changes made in the field and submitted as record Drawings.

1.06 QUALITY ASSURANCE

A. As specified in Section 17050.

B. Examine the complete set of Contract Documents and verify that the HMI equipment is compatible with the installed conditions.

C. Notify the Engineer if any installation condition does not meet the manufacturer's recommendations or specifications.

D. Provide HMI hardware manufactured at facilities certified to the quality standards of ISO Standard 9001 - Quality Systems - Model for Quality Assurance in Design/Development, Production, Installation, and Servicing.

1.07 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 17050.

1.08 PROJECT OR SITE CONDITIONS

A. Project environmental conditions as specified in Section 17050.
   1. Provide HMI equipment suitable for the installed site conditions including, but not limited to, site altitude, site seismic conditions, humidity, and ambient temperatures.

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

A. As specified in Section 17050.

1.12 SYSTEM START-UP (NOT USED)

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 COMMISSIONING (NOT USED)

1.15 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. One of the following, No Equal:
   1. Allen-Bradley: PanelView Plus.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS (NOT USED)

2.04 MANUFACTURED UNITS

A. Human machine interface:
   1. General:
      a. Provide human machine interfaces located on the face of the PCM as indicated on the Drawings or as specified in the equipment specifications.
      b. NEMA 4X rated.

c. Human machine interface consists of graphical display screen with operator input capabilities.
d. Capable of stand-alone operation in conjunction with 1 PLC.
e. Equipped with data network communication capabilities.

2. Display:
   a. Type: ColorTFT LCD screen.
   b. Resolution: 640 by 480 pixels.
   c. Size: 10.4 inch.
   d. Easy display viewing at any angle in various ambient light conditions.
   e. Operator input: Configurable touch screen.
   f. Screen update speed: The screen update speed and screen change speed less than 1 second.
   g. Provide following features for outdoor use:
      1) Anti-glare screen overlay.
      2) Luminescence: Minimum 450 Nits.
3. Graphic configuration:
   a. Easily configured graphics by:
      1) Portable laptop computer both locally and via the PLC data network.
      2) SCADA Engineer's console via the PLC data network.
   b. As specified in Section 17765.
4. Memory:
   a. Application: 512MB RAM.
5. CPU: Minimum 100 MHz.
6. Communications:
   a. Ethernet.
7. Environment:
   a. Temperature: 0 to 50 degrees Celsius.
   b. Relative humidity: 10 to 90 percent.
8. Electrical:
   a. Power supply:
      1) 120 VAC.

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS (NOT USED)

2.07 ACCESSORIES

A. Human machine interface programming software:
   1. As specified in Section 17765.

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL

A. As specified in Section 17050.

PART 3 EXECUTION

3.01 EXAMINATION

A. As specified in Section 17050.

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 17050.

B. All components of the control system including all data network cables are the installation responsibility of the ICSC unless specifically noted otherwise.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 REINSTALLATION (NOT USED)

3.07 FIELD QUALITY CONTROL

A. As specified in Section 17050.

3.08 ADJUSTING (NOT USED)

3.09 CLEANING

A. As specified in Section 17050.

3.10 DEMONSTRATION AND TRAINING

A. As specified in Section 17050.

3.11 PROTECTION

A. As specified in Section 17050.

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 17730

CONTROL SYSTEMS - SCADA COMPUTER EQUIPMENT

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. PC-based SCADA system hardware, including:
      a. SCADA Servers.
      b. Operator Workstations.
      c. Portable Computer.
      d. Printers.
      e. Workstation UPS.
      f. Industrial Panel Mounted Monitors.
      g. Industrial Panel Mounted Computers.

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 - Common Work Results for Process Control and Instrumentation Systems.
      c. Section 17712 - Control Systems - Uninterruptible Power Supplies 10 KVA and Below.
      d. Section 17950 - Testing, Calibration, and Commissioning.

1.02 REFERENCES

A. As specified in Section 17050.

1.03 DEFINITIONS

A. As specified in Section 17050.

B. Specific definitions:
   1. CAL: Client access license.
   2. RAID: Redundant array of independent disks.
   3. SNMP: Simple network management protocol.

1.04 SYSTEM DESCRIPTION

A. Provide all SCADA computer equipment identified in the Contract Documents.

B. Miscellaneous requirements:
   1. All material used in satisfying the equipment requirements shall be new and unused and must be actively marketed by the original equipment manufacturer for new applications at the time of the factory demonstration test. The CONTRACTOR shall not use equipment destined for installation or spare parts for the OWNER's system for any reason other than development and testing of the system.

1.05 SUBMITTALS

A. Furnish submittals as specified in Sections 01330 and 17050.

B. Shop drawings:
   1. Prepare and submit a seismic mounting installation detail drawing for review.

1.06 QUALITY ASSURANCE

A. As specified in Section 17050.

1.07 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 17050.

1.08 PROJECT OR SITE CONDITIONS

A. As specified in Section 17050.

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

A. As specified in Section 17050.

1.12 SYSTEM STARTUP (NOT USED)

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 COMMISSIONING (NOT USED)

1.15 MAINTENANCE

A. Servers:
   1. Provide a 3-year on-site manufacturer's service plan, with 2-year unlimited phone support.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Commonality:
   1. The SCADA system shall utilize the same brand and type of computer for like functions throughout the system.
   2. Where possible, use the same processor family throughout.
   3. Use a single PC computer manufacturer throughout the Project.

B. Manufacturers:
   1. As indicated below.

C. Systems management architecture:
   1. All processors, servers, workstations, network software, bridges, and other manageable objects shall have simple network management protocol (SNMP) agents included.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS (NOT USED)

2.04 MANUFACTURED UNITS

A. General:
   1. The hardware identified in this Section is considered the minimum, acceptable configuration. It is the CONTRACTOR's responsibility to upgrade and expand the hardware configuration if necessary to satisfy software and system performance requirements of the Project.
   2. Proposed substitutions must meet or exceed the specifications of the equipment listed.

B. Servers:
   1. Manufacturer: One of the following and no equal, in order to match existing.
      a. Dell PowerEdge.
      b. IBM xSeries.
   2. General:
      a. SCADA servers: Intel-based, server-class PCs. Windows 2008 Server is the required operating system, alternates will not be allowed. Include 4 Client Access Licenses (CALs).
      b. Provide a complete set of backup/restore recovery CDs such that the SCADA server may be restored to factory condition in the event of a catastrophic hard drive failure. Software recovery from a partition on the hard disk drive is not acceptable.
   3. The SCADA servers shall meet the following minimum requirements:
      a. Manufacturer: Dell PowerEdge or approved equal.
      b. Form factor: Rack MountTower.
      c. Processor speed: Intel Xeon3.8 GHz 800 MHz Front Side Bus.
      d. Cache: 2 MB integrated L2.
      e. Main memory: 2 GB.
      f. Hard disk(s): 200 GB Ultra 320 SCSI, 10,000 rpm.
      g. Hard disk quantity: 2.
      h. Hard disk configuration: RAID 10.
      i. Network cards: Two each 1000 Base TX.

j. Optical drives: 16X DVD-+/-RW.
k. Serial RS232 port.
l. 4 USB ports.
m. Modem: 56 Kbps (minimum), V.92 compliant.
n. Power supply: Redundant.
o. Mouse: Wireless Optical, wheel type, 3 button (Count wheel click as 1 button).
p. Keyboard: Wireless Windows 104-key.

4. Server monitors shall meet the following minimum requirements:
   a. Manufacturer:
      1) Dell.
      2) Viewsonic.
      3) Approved equal.
   b. Viewing area: 17 inches.
   c. Type: LCD, TFT active matrix.
   d. Color: Black.
5. Applicable equipment:
   a. Rack Mounted Primary SCADA Server.
   b. Rack Mounted Primary Historian Server.
   c. Rack Mounted Terminal Services Server.

C. Network attached storage (NAS):
1. Manufacturer:
   a. Dell, Series PowerVault NF.
   b. Snap Server, Series 520.
   c. Linksys, Series NSS6000.
2. The NAS device shall meet the following minimum requirements:
   a. 4-Bay network storage system chassis with hot swappable disk drives.
   b. Form factor: 19-inch Rack Mount.
   c. Processor speed: Minimum 1000 MHz.
   d. Cache: Minimum 1 MB integrated L2.
   e. Main memory: Minimum 512 MB.
   f. Drive type: 3.5 inch SATA.
   g. Total drive capacity: 4TB raw capacity.
   h. RAID options: RAID 6.
   i. Network connection: Dual RJ-45, auto failover gigabit Ethernet ports auto-sensing 10/100/1000Base-T.
   j. 2 USB ports.
   k. Power supply: Dual redundant failover 120 VAC.
   l. Data storage, access and management software:
      1) Programmable one-button or scheduled backup.
      2) Supports sequencing between multiple NAS devices and/or USB external disks/hard drives.
      3) Network file protocol: Microsoft networks CIFS/SMB, NFS.
      4) Web interface protocol: HTTP.
      5) Network transport protocol: TCP/IP.
      6) Security features:
         a) Integrated share, user, domain/ADS modes.
         b) Encrypted network logins.
   m. Warranty: 2 year hardware, 90 day software support.
3. Applicable equipment:
   a. Rack Mounted Network Attached Storage.

D. Workstations:
   1. Manufacturer:
      a. Dell Optiplex.
   2. General:
      a. General purpose, PC-architecture computers running the Windows 7 professional.
      b. Stand-alone workstations, not combined with any SCADA servers.
      c. Provide a complete set of backup/restore recovery CDs such that the portable computer may be restored to factory condition in the event of a catastrophic hard drive failure. Software recovery from a partition on the hard disk drive is not acceptable.
      d. Form factor: Tower.
      e. Processor speed: Intel Core i3, 3.3 GHz or better.
      f. Main memory: 4GB DDR3 SDRAM at 1600 MHz.
      g. Cache: 2MB integrated L2 Advanced Transfer cache.
      h. Graphics card: PCIe with 128 MB memory, DualDVI capable.
      i. Hard disk: 500 GB, SATA, 6Gb/s; 16.0 MB databurst cache minimum.
      j. Sound card: SoundBlaster Live.
      k. Speakers: Desktop Stereo Speakers.
      l. Network card: 10/100/1000 Base TX.
      m. Optical drives:
         1) Operator workstation: 16X DVD+/-RW combo with DVD burning software.
         2) Engineering/Development workstation: 16X DVD+/-RW with DVD burning software.
   3. Serial RS232 port:
      a. 4 USB ports.
      b. Modem: 56 Kbps (minimum), V.92 compliant.
      c. Mouse: Wireless Optical, wheel type, 3 button (Count wheel click as one button).
      d. Keyboard: Wireless Windows 104-key.
      e. Color: Black.
   4. Applicable equipment:
      a. Administration Building Operator Workstation.
      b. Administration Building Development Workstation.
      c. Mid-Town Standby Power Building Operator Workstation.
   5. LCD workstation monitors shall meet the following minimum requirements:
      a. LCD manufacturer:
         1) Dell UltraSharp Series.
         2) Approved equal.
      b. Viewing area: 21.5 inches.
      c. Aspect ratio: 16:9.
      d. Pixel pitch: 0.294 mm.
      e. Resolution: 1280 by 1024, 16 million colors.
      f. Interface: VGA and DVI.
      g. Type: TFT active matrix.
      h. Viewing angle: ±80 degrees, horizontal and vertical.
      i. Contrast ratio: 800:1.
      j. Pixel format: True SXCA with support for VGA, SVGA, and XGA.
      k. Full screen image at all resolutions.
      l. Glass surface: RGB stripe, anti-glare hard coat screen.

6. Include each operator position an audible alarm with external volume control to allow adjustment to a level between 50-75 dBA. Capable of 2 distinctly different tones controlled by the user interface software and selectable by the user.

E. Industrial panel-mounted monitor:
   a. Provide a complete set of all required cables.
   b. Provide manufacturer's user and maintenance manuals.
   c. Industrial panel-mounted monitor:
      1) Display size: 20-inch minimum.
      2) Type: Active Matrix Color TFT LCD display with resistive antiglare touchscreen.
      3) Rating: NEMA Type 12.
      4) Faceplate/bezel material: Stainless steel.
      5) Enclosure Mounting: Panel-Mount.
      6) Minimum resolution: 1600 x 1200.
      7) Minimum contrast ratio: 800:1.
      8) MTBF: Minimum 50,000 hours.
      9) Operating temperature: 0 - 50 Degrees Celsius.
      10) Operating relative humidity: 20 – 90 percent non-condensing.
      11) Power supply: 120 VAC.
      12) Resistive touch option to a computer via USB and RS-232 Serial ports.
      13) Manufacturers: One of the following or equal:
         a) Hope Industrial Systems.
2. Applicable equipment:
   a. PCM-1 Operator Workstation.
   b. PCM-2 Operator Workstation.

F. Industrial panel computer:
1. Industrial panel-mounted monitor with separate PC-architecture computer running the Windows 7 Professional (NTFS) operating system.
   a. Provide a complete set of backup/restore recovery CDs such that the computer may be restored to factory condition in the event of a catastrophic hard drive failure. Software recovery from a partition on the hard disk drive is not acceptable.
   b. Provide a complete set of all required cables and software.
   c. Provide manufacturer's user and maintenance manuals.
   d. Computer shall meet the following minimum requirements:
      1) Processor speed: Intel Core i3, 3.3 GHz or better.
      2) Main memory: 4GB DDR3 SDRAM at 1600 MHz.
      3) Hard disk: 500 GB, SATA, 6Gb/s; 8.0 MB databurst cache minimum.
      4) Video card: 64 MB DDR RAM.
      5) Serial RS232 port.
      6) 2 PCI slots.
      7) 4 USB slots.
      8) 8X DVD/RW SATA.
      9) Internal 56 Kbps, V.92 modem.
      10) Network port: 10/100/1000 Base TX, Ethernet LAN.
      11) Power supply: 120 VAC.
      12) Manufacturers: The following or equal:
         a) Dell Optiplex.

2. Applicable equipment:
   a. PCM-1 Operator Workstation.
   b. PCM-2 Operator Workstation.

G. Wireless keyboard and wireless mouse:
   1. Provide a 104 key wireless keyboard and optical wireless mouse with each PCM that has a panelmount workstation.

H. Printers:
   1. Color laser printer:
      a. Manufacturer:
         1) HP Color LaserJet 3500 Printer.
         2) Approved equal.
      b. The laser printer shall meet the following minimum requirements:
         1) Print speed, black (best quality mode): Up to 12 pages/minute; Print Quality (color): 600 by 600.
         2) Memory: 64 MB.
         3) Duplexing: Not required.
         4) Minimum of 64 MB memory.
         5) Connectivity: 100 Base TX.
         6) Media sizes: Letter.
         7) Include a minimum of 2 paper trays.
         8) Provide a spare toner cartridge of each type.

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS (NOT USED)

2.07 ACCESSORIES

A. Uninterruptible power supply (UPS).
   1. Workstation UPS:
      a. As specified in Section 17712 for UPS requirements.

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 17050.

B. General:
   1. Each display monitor shall be secured to the console or other work surface.
   2. Install equipment and cabling so that, in the event of an earthquake, seismic movement will not damage cables. In particular, provide appropriate slack in cables.

C. Each device with a unique IP address shall be individually labeled with it IP address. The labeling must be printed; handwritten labels will not be accepted.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 FIELD QUALITY CONTROL

A. As specified in Section 17950.

3.08 ADJUSTING (NOT USED)

3.09 CLEANING

A. As specified in Section 17050.

3.10 DEMONSTRATION AND TRAINING

A. As specified in Section 17050.

B. Training:
   1. As specified in Section 17050.

3.11 PROTECTION (NOT USED)

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 17733

CONTROL SYSTEMS - NETWORK MATERIALS AND EQUIPMENT

PART 1 GENERAL

1.01 SUMMARY

A. Section includes requirements for:
   1. Materials and equipment used in process control and LAN networks including:
      a. Network switches.
      b. Routers.
      c. Patch panels and other data network hardware.
      d. Related accessories.

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 - Common Work Results for Process Control and Instrumentation Systems.
      c. Section 17730 - Control Systems - SCADA Computer Equipment.
      d. Section 17950 - Testing, Calibration, and Commissioning.

1.02 REFERENCES

A. As specified in Section 17050.

B. TIA/EIA Standards:
   1. TIA/EIA-568-B (Series), Commercial Building Telecommunications Standards.
   2. TIA/EIA-569 (Series), "Commercial Building Standard for Telecommunications Pathways and Spaces.
   3. IEEE Series 802 standards.

1.03 DEFINITIONS

A. As specified in Section 17050.

1.04 SYSTEM DESCRIPTION

A. Provide all network equipment identified in the Contract Documents.

1.05 SUBMITTALS

A. Furnish submittals as specified in Sections 01330 and 17050.

B. Product Data:
   1. Include information on all test equipment.
   2. Manufacturer’s operation and installation instructions.

C. Shop Drawings:
   1. Complete set of drawings including but not limited to:
      a. System block diagram showing relationship and connections between devices provided under this Contract and existing equipment. Include manufacturer and model information, and address settings.
      b. Network riser diagram.
      c. Network port diagram, which physically locates all, ports within the facility, and identifies their patch panel and switch port.
      d. Fiber splicing diagram, which shows appropriate termination of each fiber and appropriate splicing of each fiber for each fiber optic cable.
      e. Construction drawings for all equipment cabinets, including dimensions, identification of all components, preparation and finish data, nameplates
      f. Electrical connection diagrams.
      g. Complete grounding requirements.
   2. Furnish Data sheets for each component together with a technical product brochure or bulletin:
      a. Manufacturer's model number.
      b. Project equipment tag.
   3. Complete and detailed bills of materials broken up by each cabinet. Each bill of material item will include the following:
      a. Quantity.
      b. Description.
      c. Manufacturer.
      d. Part numbers.

D. Test Reports:
   1. As specified in Section 17950 and noted herein.
   2. Signed test results as described in PART 3 of this Section.
   3. Test results shall include:
      a. Narrative describing the test procedures followed.
      b. Block diagram of test set up.
      c. Manufacturer’s information on test equipment used.
      d. Detailed test results.
      e. A narrative summarizing the results of the testing and identifying any further action required.

E. Operating Manuals:
   1. Complete installation, operation, calibration, and testing manuals as specified in Section 17050.

F. Record Drawings:
   1. As specified in Section 17050.
   2. Electrical connection diagrams shall be revised to reflect any changes made in the field and submitted as record drawings.

1.06 QUALITY ASSURANCE

A. As specified in Section 17050.

1.07 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 17050.

1.08 PROJECT OR SITE CONDITIONS

A. As specified in Section 17050.

1.09 WARRANTY

A. As specified in Section 17050.

1.10 MAINTENANCE

A. Spare parts:
   1. Provide 3 spare fuses for each size and type used or supplied under any Division of these Specifications.
   2. Provide spare fuse cabinet(s):
      a. Metal cabinet with hinged door and shelves or fuse holders.
      b. Gray enamel finish.
      c. Mount near equipment and label "Spare Fuses" on face of cabinet.
      d. Suitable pocket inside door of each cabinet with typewritten spare fuse inventory in clear plastic protective insert.
      e. Provide as many cabinets as required to hold entire spare fuse inventory.

PART 2 PRODUCTS

2.01 MANUFACTURED UNITS

A. Ethernet switches:
   1. Enterprise Ethernet Switches:
      a. ES-M-P.
      b. ES-M-S.
      c. Manufacturers - One of the following:
         1) Cisco Catalyst 3750.
         2) No Equal.
      d. Properties:
         1) Hardware:
            a) 19-inch rack mountable.
            b) Power supply:
               (1) Provide redundant power supplies.
               (2) 120 VAC, 60 Hertz, 1 phase 250 Watts.
            c) Console management port.
            d) Slots for the addition of 8 port modules as described below.
         2) Performance:
            a) Latency: less than 10.2 microseconds.
            b) Switch fabric speed: 18.3 Gbps, minimum.

c) Address Table Size: 8,000 entries, minimum.
d) Gigabit throughput.

3) Environment:
a) Operating Temperature Range: 32 to 104 degrees Fahrenheit.
b) Humidity: 15 to 95 percent, non-condensing.

4) Capable of performing basic switching without special programming or configurations. Additional features available through software setup includes but not limited to:
a) Port Monitoring.
b) Remote switch management.
c) Port Security.
d) Switch meshing.
e) Rapid Spanning Tree protocol.

5) Capable of adding or swapping modules without interrupting the network.

6) Connector Type:
a) Fiber: LC.
b) Copper: RJ-45.

7) Modules:
a) Copper ports
(1) 10/100/1000-Base-T:
(2) Protocol: IEEE 802.3u Type 100Base-TX; 802.3ab Type 1000Base-T.
(3) Auto-sensing.
b) SFP Ports:
(1) Provide for all fiber optic connections.
(2) Protocol: IEEE 802.3z Type 1000Base-SX.
(3) Full duplex.
c) Provide modules required to provide network connections as indicated on the Drawings:
(1) As required to provide the number of connections required plus 20 percent spare ports of each type used.

8) Spare Parts:
a) Provide the following spare components:
(1) 1 spare module of each type provided.
(2) 1 spare Ethernet switch backplane.
(3) 1 spare Ethernet switch power supply.

2. Process Floor Ethernet Switches:
a. ES-1-P.
b. ES-1-S.
c. ES-2-P.
d. ES-2-S.
e. All vendor control panels (VCP).
f. Manufacturers - One of the following:
1) Cisco IE-3000 Series.
2) No Equal.
g. Properties:
1) Hardware:
a) Power supply:
(1) Provide redundant power supplies.
(2) 24 VDC, 350 Watts per power supply.

2) Performance:
   a) Switch fabric speed: 8 Gbps, minimum.
3) Environment:
   a) Operating Temperature Range: 32 to 131 degrees Fahrenheit.
   b) Humidity: 15 to 95 percent, non-condensing.
4) Capable of performing basic switching without special programming or configurations. Additional features available through software setup includes but not limited to:
   a) Remote switch management.
   b) Port Security.
   c) Rapid Spanning Tree protocol.
5) Base Unit:
   a) 2 Dual purpose ports:
      (1) 10/100/1000 Base-T Copper.
      (2) SFP module slot.
   b) 10/100 Base-T copper ports.
6) Expansion modules:
   a) 100BASE-X SFP Ethernet ports
      (1) Provide for all 100BASE Fiber optic connections.
      (2) IE-3000-4SM.
      (3) IE-3000-8SM.
7) Provide SFP transceiver modules as required for all fiber optic connections.
8) Connector type:
   a) Fiber: LC.
   b) Copper: RJ-45.
   c) Provide modules required to provide network connections as indicated on the Drawings:
      (1) As required to provide the number of connections required plus 20 percent spare ports of each type used.
9) Mounting:
   a) Control panel or 19-inch rack mount as indicated on the Drawings
   b) Provide hardware for 19-inch rack mounting hardware as required.

B. Patch panels:
   1. All optical fibers shall be provided with strain relief and terminated at a fiber patch panel. All patch panel terminations shall be LC type. Final connections between the patch panel and the fiber optic network equipment shall be made via fiber optic patch cords.
   2. All fibers, active and dark, shall be terminated at the patch panels.
   3. Interconnect and patch panel housings shall provide space for excess fiber and provide strain relief for the fiber cable.
   4. Fiber cables shall be installed such that the outer sheath of the cable is carried into the interconnect enclosure or patch panels before breaking out buffer tubes.
   5. Fiber cables will have a service loop of no less than 40 feet prior to entering the interconnected enclosure or patch panels.
   6. Category 6A Patch Panels:
      a. Manufacturer:
         1) Ortronics Clarity 10G.
         2) No equal.

b. Patch Panels and Connectors shall meet the following (minimum) requirements:
    1) Category 6A, T568B.2-10.
    2) Center tuned to Clarity 10G patch cords.
    3) RJ-45 patch cord termination: S110 UTP-STP cable termination.
    4) Capacity: 24 ports (maximum).
    5) Mounting: 19-inch rack mount.
    6) Accessories: Rear cable management bracket, individual port labels.
c. Provide patch cables as required to support all network devices.

7. Fiber Patch Panels:
    a. All fiber optic strands shall be spliced to LC pigtails.
    b. Fiber termination shall be with pigtails that plug into adapter panels within the fiber splice cabinet. All pigtails shall be fusion spliced. All splices shall utilize appropriate splice trays and shall use heat shrink sleeves or splice protection covers.
    c. Control panel mounted patch panels:
        1) Application: Use for the termination of a single cable inside PCM-1 and PCM-2 cabinets and in all vendor control panels requiring fiber optic communication as indicated on the Drawings.
        2) Wall mounted fiber interconnects shall be provided as complete units including the housing, the connector panels and the fiber connectors.
        3) Wall mounted fiber interconnects shall provide physical protection for both the incoming cable and the outgoing patch cords.
        4) Capacity: As shown on the drawings, minimum 6 connections.
        5) Accessories:
            a) Door lock.
            b) Blanks for unused connector panels.
        6) Manufacturers:
            a) Corning Cable Systems, Wall Mount Connector Housing.
            b) Or equal.
    d. Rack Mounted Fiber Patch Panel:
        1) Application: Use for the termination of one or more fiber cables terminating on open EIA racks and in enclosures with EIA racks.
            a) NR-MAIN.
            b) NP-1.
            c) NP-2.
        2) Fiber patch panels shall be provided as complete units including the housing, the connector panels, mounting hardware and the fiber connectors.
        3) Patch panels shall be provided with hardware for standard 19-inch rack mounting, as required.
        4) Capacity: As shown in the Contract Documents.
        5) Manufacturers:
            a) Fiber Splice and Patch Cabinets:
                (1) NP-1 & NP-2:
                    (a) Ortonics rack mount fiber patch and splice cabinet, model OR-FC02U-C. Provide quantity as required to terminate all fibers.
                    (b) No equal.

(2) NR-MAIN:
(a) Ortonics rack mount fiber patch and splice cabinet, model OR-FC02U-C. Provide quantity as required to terminate all fibers.
(b) No equal.

b) Adapter panels:
(1) Ortronics LC duplex (12-fiber) single mode adapters (blue), model OR-OFP-LCD12AC.
(2) No equal.

c) Pigtails:
(1) Ortronics connector pigtail, 12-fiber, OFNR SMF, 2 meters, model OR-626TC4ZR-RZ002M.
(2) No equal.

d) Fusion Splice Tray:
(1) Ortronics fusion splice tray for 12 fibers, model OR-FST2-F012.
(2) No equal.

e) Heat shrink sleeves:
(1) Ortronics heat shrink sleeves, model OR-20500043.
(2) No equal.

C. Below-grade fiber optic splice enclosures (Project interface point between LOWRF and Collection systems):
1. Splice enclosures shall be chosen from the following list. Enclosure type and trays shall be sized to terminate all fibers from the collection systems to LOWRF.
a. Manufacturer:
1) Preformed Coyote Runt.
2) Preformed Coyote Pup.
3) Preformed 6.5” Coyote.

D. Network racks:
1. NR-MAIN (Server Rack):
a. Manufacturer:
1) Ortronics Mighty Mo 10 Server Rack, model OR-MM107SVR.
2) No equal.
b. Properties:
1) 19-inch rack mount.
2) Side rail cable management.
3) Four post aluminum frame with steel EIA rails.
4) Provided vented shelf.
5) Velcro cable wraps.
6) 20 Amp surge protected metered power strip.
7) Seismic rated.
2. NR-MAIN (Cable Management Rack):
a. Manufacturer:
1) Ortronics Mighty Mo 6 Cable Management Rack, model OR-MM6706.
2) No equal.
b. Properties:
1) 19-inch rack mount.
2) Side rail cable management.

3) Two post aluminum frame with steel EIA rails.
4) Provided vented shelf.
5) Velcro cable wraps.
6) 20 Amp surge protected metered power strip.
7) Seismic rated.

3. Network rack accessories:
   a. Anchor kit:
      1) Chatsworth concrete floor anchor kit, model 40604-001.
      2) Chatsworth wood floor anchor kit, model 40604-001.
      3) No equal.
   b. Cable management:
      1) Ortronics feed-through management panels, OR-60400129.
      2) Ortronics cable management rings, OR-60400017.
      3) Ortronics cable runway mounting bracket, OR-MM6CRB06.
      4) No equal.
   c. Filler panels:
      1) Ortronics 1RU blank filler panel, OR-MMCFPS-1-B.
      2) Ortronics 2RU blank filler panel, OR-MMCFPS-2-B.
      3) Ortronics 4RU blank filler panel, OR-MMCFPS-4-B.
      4) No equal.

E. Cable Runways (Administration Building Server Room):
   1. Provide cable runways in the administration building server room as shown on the Drawings.
      a. Runway Manufacturer:
         1) Chatsworth black universal 12” runway, model 10250-712.
         2) Chatsworth runway j-bolt kit, model 11308-001.
         3) Chatsworth runway wall mount, model 11420-701.
         4) Chatsworth runway splice kit, model 11301-701.
         5) Chatsworth runway junction kit, model 10488-701.
         6) No equal.

F. Network Panels (NP-1 & NP-2):
   1. Manufacturers - One of the following, no equal:
      a. Ortronics MightyMo Pivoting Wall Mount Cabinet.
   2. Properties:
      a. IP20.
      b. Metal Wall Mount Cabinets.
      c. Textured polyester scratch and corrosion resistant coating.
      d. Curved safety glass front door.
      e. Removable side panels.
      f. Solid rear door.
      g. Front door quarter-turn key lock.
      h. Double hinged cabinet providing front and rear access using 3-point (door, wall, center section) design.
      i. Self-locking center-to-wall section latches in two locations.
      j. Accessories:
         1) Grounding kit.
         2) Rack angles.

3) Fan Tray
4) Cable manager.

3. Provide enclosure sized to accommodate all equipment shown on the drawings and to accommodate all accessories listed above.

G. Enclosed SCADA Workstation Cabinet (Mid-Town Standby Power Building):
1. Manufacturers - One of the following:
a. Hoffman PROLINE Gold Series Computer Workstation.
b. Approved equal.
2. Properties:
a. NEMA 12.
3. 14 gauge steel body.
4. 14 and 16 gauge steel doors and covers.
5. Integral keyboard and mouse drawer.
6. Seamless foam-in-place gasket on all doors and covers.
7. Smoke gray 0.25-inch-thick polycarbonate window on upper front door.
8. Solid lower front and full rear doors with keylocking swing door handles.
9. Latching/locking system on upper front door.
10. Internal rails to facilitate mounting of internal components.
11. Accessories:
a. Thermoplastic data pocket.
b. Side folding shelf.
c. 19 inch rack angles as required to mount internal components.
d. Cable organizer.
e. Fan kit.
f. Power strip.

H. KVM Drawer:
1. Manufacturers - One of the following, no equal:
a. IBM Flat Panel Console Kit.
1) Model Number: 172317X.
2. Properties:
a. Rack space required: Maximum 1RU.

2.02 ACCESSORIES

A. Provide duplex patch cords to connect the interface cards provided with the associated patch panels.
1. All patch cords will be Category 6A.

B. Furnish accessories as specified in Section 17730.

PART 3 EXECUTION

3.01 INSTALLATION

A. As specified in Section 17050.

B. All racks shall be level and plumb.

C. Install Velcro wrap on all cable bundles within the network rack/enclosure.

D. Refer to Appendix J for additional County Installation Requirements.

E. All cables and equipment shall be installed in strict conformance with the manufacturer's recommendations:
   1. Cables shall be installed avoiding sharp bends.
   2. Install cable using lubricant designed for cable pulling.
   3. Cable ties or other cable supports shall be installed without crimping the LAN cables.
   4. Install LAN cables without splices.
   5. Installed bend radii shall not exceed 4 times the cable diameter.
   6. Terminated all pairs at the jack and the patch panel.

F. Install cables a minimum of 40 inches away from electrical motors and transformers.

G. Install cables a minimum of 12 inches away from fluorescent lighting.

H. Individual pairs will be untwisted less than 1/2 inch at termination points.

I. All cables and terminations shall be labeled with cable designations as described in the DIVISION 16 specifications.

J. Each data port shall be individually labeled with its patch panel/switch port ID:
   1. Labeling must be printed - no handwritten labels will be allowed.

K. At the completion of the wiring installation, provide the following documentation:
   1. A plan-view of the premise(s) showing the jack numbering scheme.
   2. A printed certification report for the entire wiring installation showing compliance with all ANSI/EIA/TIA specifications for data cable.
   3. Reports such as those generated by Fluke DSP cable certification equipment meet this requirement.
   4. Each device with a unique IP address shall be individually labeled with its IP address. The labeling must be printed; handwritten labels will not be allowed.

3.02 ADJUSTING

A. Perform all firmware installations, configuration and other set up, as required, to place the network into proper operation.

3.03 CLEANING

A. As specified in Section 17050.

3.04 DEMONSTRATION AND TRAINING

A. As specified in Section 17050.

B. After completion of the cable system tests and before placing the system in operation, power up all devices installed on the LAN and verify communication between the devices.

C. Verify that all equipment is operable on the network simultaneously. Confirm that all network device communications settings are properly configured.

END OF SECTION

SECTION 17761

CONTROL SYSTEMS - PLC PROGRAMMING SOFTWARE

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Development software to be used with the specified PLC hardware.

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 01660 - Testing, Training, and Commissioning.
      c. Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
      d. Section 17720 - Control Systems - Programmable Logic Controllers Hardware.

1.02 REFERENCES

A. As specified in Section 17050.

1.03 DEFINITIONS

A. As specified in Section 17050.

B. Specific definitions:
   1. Development operating software: The software provided by the PLC manufacturer for use in programming the PLC.
   2. Application software: The software that is programmed specifically for the Project.

1.04 SYSTEM DESCRIPTION (NOT USED)

1.05 SUBMITTALS

A. Furnish submittals as specified in Sections 01330 and 17050.

B. Product data:
   1. Programming languages.
   2. Operating system requirements.

C. Control logic:
   1. Fully annotated copy of programmed PLC logic.
   2. Cross-referenced index of all PLC registers or points.

D. Provide application software for the specific Project process requirements.
   1. Fully annotated copy of programmed PLC logic in its native format.
   2. Cross-referenced index of all PLC registers or points.

1.06 QUALITY ASSURANCE

A. As specified in Section 17050.

1.07 DELIVERY, STORAGE, AND HANDLING (NOT USED)

1.08 PROJECT OR SITE CONDITIONS (NOT USED)

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

A. As specified in Section 17050.

1.12 SYSTEM START-UP (NOT USED)

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 COMMISSIONING (NOT USED)

1.15 MAINTENANCE

A. As specified in Section 17050.

B. Provide system upgrades and maintenance fixes for a period of 2 years from completion of the Testing Phase, specified in Section 01660.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. The PLC programming software system shall be manufactured by PLC hardware manufacturer.

B. One of the following or equal:
   1. Rockwell Software:
      a. RSLogix 500 for MicroLogix PLCs.
      b. RSLogix 5000 for ControlLogix and CompactLogix PLCs.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS (NOT USED)

2.04 MANUFACTURED UNITS

A. PLC programming software:
   1. Furnish operating software capable of monitoring and/or control of the PLCs via the PLC data network:
      a. Contain diagnostics to collect troubleshooting and performance data and display it in easy to understand graphs and tables.
      b. Monitor devices at each drop on the PLC data network for proper communications.
      c. Provide the ability to program all PLCs on the PLC data network from the engineer's console.
   2. Operating system:
      a. Microsoft Windows 7.
   3. The PLC programming software shall be suitable for the PLCs specified under Section 17720.
   4. PLC programming software for all programming, monitoring, searching, and editing:
      a. Usable both online, while connected to the PLC, and off-line.
      b. The operating software shall display multiple series and parallel contacts, coils, timers, counters, and mathematical function blocks.
      c. Capable of disabling/forcing all inputs, outputs, and coils to simulate the elements of the ladder logic, forced elements shall be identifiable by means of color change.
      d. Include a search capability to locate any address or element and its program location.
      e. Display at the EC, PLC status information, such as faults and communication errors and amount of memory remaining.
   5. The PLC programming software shall support the following programming languages:
      a. RSLogix 500.
         1) Ladder Diagram.
      b. RSLogix 5000.
         1) Ladder Diagram.
         2) Function Block Diagram.
   6. Generate a PLC program printout, which is fully documented, through the PLC programming software:
      a. Fully documented program listings include, as a minimum, appropriate rungs, address, and coils shown with comments to clarify to a reader what that segment of the program accomplishes on an individual line by line basis.
      b. Include a sufficient embedded comment for every rung of the program explaining the control function accomplished in said rung.
      c. Use a mnemonic associated with each contact, coil, etc, that describes its function.
      d. Utilize the tag and loop identification as contained in the P&IDs:
         1) If additional internal coils, timers, etc. are used for a loop they shall contain the loop number.
      e. Provide a cross-reference report of program addresses.

7. Software functions automatically without operator intervention, except as required to establish file names and similar information:
    a. Furnish the operating system software that is the standard uncorrupted product of the PLC manufacturer with the following minimum functions:
        1) Respond to demands from a program request.
        2) Dynamic allocation of the resources available in the PLC. These resources include main memory usage, computation time, peripheral usage, and I/O channel usage.
        3) Allotment of system resources based on task priority levels such that a logical allocation of resources and suitable response times are ensured.
        4) Queuing of requests in order of priority if one or more requested resources are unavailable.
        5) Resolution of contending requests for the same resource in accordance with priority.
        6) Service requests for execution of one program by another.
        7) Transfer data between programs as requested.
        8) Management of all information transfers to and from peripheral devices.
        9) Control and recovery from all program fault conditions.
        10) Diagnose and report real-time hardware device errors.
8. Program execution:
    a. Application software - program execution scheduled on a priority basis:
        1) A multilevel priority interrupt structure is required.
        2) Enter into a list of pending programs a program interrupted by a higher priority program:
            a) Resume its execution once it becomes the currently highest priority program.
        3) Schedule periodic programs.
        4) Base the allocation of resources to a time-scheduled program on its relative priority and the availability of resources.
9. Start-up and restart:
    a. Provide software that initializes and brings a PLC or any microprocessor based hardware unit from an inactive condition to a state of operational readiness.
    b. Initialization:
        1) Determination of system status before start-up of initializing operating system software and initializing application software.
        2) Loading of all memory resident software, initializing timers, counters, and queues, and initialization of all dynamic database values.
10. Shutdown:
    a. Where possible provide orderly shutdown capability for shutdowns resulting from equipment failure, including other PLC processor failures, primary power failure, or a manually entered shutdown command.
    b. Upon loss of primary power, a high-priority hardware interrupt initiates software for an immediate, orderly shutdown.
    c. Hardware is quickly and automatically commanded to a secure state in response to shutdown command or malfunction.
    d. Alarm PLC failure at the operator interface level.

11. Diagnostics:
    a. Furnish diagnostic programs with the PLC software package to detect and isolate hardware problems and assist maintenance personnel in discovering the causes for system failures.
    b. Use the manufacturer's standard diagnostic routines as much as possible.
    c. Furnish diagnostic software and test programs for each significant component in the control system.
    d. As a minimum, provide diagnostic routines to test for power supply, central processing unit, memory, communications, and I/O bus failures.
12. Calendar/time program:
    a. The calendar/time program to update the second, minute, hour, day, month, and year and transfer accurate time and date information to all system level and application software.
    b. Variations in the number of days in each month and in leap years must be handled automatically by the program.
    c. The operator must be able to set or correct the time and date from any operator interface, only at the highest security level.
13. Algorithms:
    a. Implementation of algorithms for the determinations of control actions and special calculations involving analog and discrete data.
    b. Algorithms must be capable of outputting positional or incremental control outputs or providing the product of calculations.
    c. Algorithms must include alarm checks where appropriate.
    d. Provide, as a minimum, the following types of algorithms:
        1) Performs functions such as summing several variables, raising to a power, roots, dividing, multiplying, and subtracting.
        2) A switch algorithm, which reads the current, value from its input address and stores it as the value of its output address. 2 types of switches shall be accommodated, 2 outputs with 1 input and 1 output with 2 inputs.
        3) A 3-mode proportional - integral - derivative, PID, controller algorithm, with each of the 3 modes independently adjustable, supporting both direct and reverse acting modes.
        4) Lead, lag, dead time, and ratio compensators.
        5) Integration and totalization of analog process variables.
14. Furnish a comprehensive database for the analog inputs, calculated values, control modules, and outputs:
    a. In addition, provide spare database points for future expansion.
15. One integrated database can be utilized for all types of analog points or separate databases for each type, in either case the database for each point must include all specified aspects.
16. All portions of the database must be available for use by the display, report, and other specified software modules.
17. All of the data fields and functions specified below must be part of the point definition database at the operator interface. Provide the capability to define new database points through the point display specified below as well as modifying defined points through these displays. This point definition and modification must include all of the features and functions defined below. The analog database software must support the following functions and attributes:
    a. Analog input signal types:
        1) Provide software at the RTUs and PLCs to read variable voltage/ current signals and pulse duration/frequency type analog input signals.

b. Input accuracy:
   1) Inputs must be read with an accuracy of ±0.05 percent full scale or better.
   2) Data conversion errors must be less than 0.05 percent full scale.
   3) Pulse accumulation error less than or equal to 1 count of actual input count at a scan rate of once a minute.
   4) Maintain for a minimum of 1 year the system accuracy stated above without adjustments.
c. Blocking:
   1) Provide mechanisms to inhibit or block the scanning and/or processing of any analog input through the operator interface.
   2) For any input so blocked, the operator may manually enter a value to be used as the input value.
d. Filtering:
   1) For each analog input provide a first order lag digital filter with an adjustable filter factor.
e. Linearizing:
   1) Where analog inputs require square root extraction or other linearization, provide a mechanism to condition the filtered data before the process of scaling and zero suppression takes place.
f. Calculated values:
   1) Provide means to allow for pseudo-inputs calculated by algebraic and/or Boolean expressions utilizing real inputs, other calculated value, constants, etc.
   2) These values must be handled the same as real inputs in terms of record keeping, alarming, etc.
g. Scaling and zero suppression:
   1) Provide a conversion program to convert input values into engineering units in a floating-point format.
h. Alarms:
   1) Provide an alarm program to check all analog variables against high-high, high, low, and low-low alarm limits.
   2) When an analog value exceeds a set limit, it must be reported as an alarm based on individually set priority level for each alarm point.
   3) Provide an adjustable hysteresis band in order to prevent excessive alarms when a variable is hovering around an alarm limit.
   4) Report return to normal shall also be reported.
   5) Must be possible to inhibit alarms based on external events, i.e., lock-out low pump flow alarm when the pump is off.
i. Averages:
   1) Provide a program to calculate and store hourly, daily, and monthly averages of analog variables.
   2) Continuously compute averages, i.e., the average for the current period to the present point in time must be stored in memory and available for use in displays, etc.
   3) Update hourly averages each minute or at the polling interval for the selected variable.
   4) Update daily averages at least once each hour and calculate using the results of the hourly averages.
   5) Update monthly averages at least once each day and calculate using the results of the daily averages.

6) At the end of each averaging period, store the average values for the period on the hard disk for historical record keeping and reset the present period average register to the present value of the variable.
7) The active database must include the present period average and previous period average for each variable and averaging period.

j. Totals:
1) Provide a program to calculate and store hourly, daily, and monthly totalization of analog variables.
2) Assign a scaling factor to each variable to convert to the appropriate units based on a 1-minute totalizing interval.
3) Assign a separate factor for each totalizing interval.
4) Variables for which totalization is inappropriate must have scaling factors of zero.
5) At the end of each totalizing period, store the totalized values for the period on the hard disk for historical record keeping and reset the present period totalization register to zero.
6) The active database must include the present period total and previous period total for each variable and totalizing period.

k. Engineering units:
1) Provide software to allow the system and the operator to convert all the measured analog variables to any desired engineering units.
2) The operator must be able to view displays and generate reports of any measured variable in one or more engineering units such as flow in gpm, mgd, cfs, and acre-feet per day.
3) Pre-program the conversion of the engineering units, and if not pre-programmed, the operator must be able to program new engineering unit conversions by using simple methods, i.e., multiplication of the database attributes by a constant.
4) The programming method must be at a level and compatible with the specified training of the operator and the Owner's personnel.
5) New conversions must not require the services of a special programmer and/or special, high-level, programming training.

l. Control modules:
1) For each control function configured, whether processed at the RTU, PLC, or operator interface, maintain a file of necessary data including input values, setpoints, constants, intermediate calculated values, output value and limit clamps, etc.
2) Input and output assignments, setpoints, and constants must be adjustable by the operator through the operator interface.
3) Provide control algorithms for manual control with output values adjustable by the operator.

m. Analog outputs:
1) Analog outputs must be maintained as part of the database.
2) These outputs must be adjustable manually by the operator through the operator interface or through automatic control algorithms.

18. Some of the above functions may be better accomplished in the data acquisition and graphic display software package; it is the responsibility of the ICSC to optimize the location of the various functions between all software packages.

B. General control functions:
1. Analog control functions:
a. PID, lead/lag, signal select, alarm, limit, delay, and time base.

b. Furnish the control system complete with a library of mathematical/ calculation software to support averaging, weighted average, addition, subtraction, multiplication, division, square root extraction, exponential, AND, OR, NAND, NOR, XOR and NXOR functions.
c. All math utilities must be linkable to process data points or manual inputs via control block configuration.
d. By linking control blocks to data points, the math library must support system unit conversion and calculation requirements.

2. Discrete control functions:
   a. AND, OR, NOT, EXCLUSIVE OR, comparators, delays and time base.
3. Software support:
   a. Retain in firmware all control and logic functions at each RTU and PLC and in RAM at the operator interface.
   b. Call each function as required by the configured controls to perform the intended function.
4. Control and status discrepancies:
   a. Generate a discrepancy/fail alarm for any pump, valve, or final control element if a discrepancy exists between a system or operator command and the device status.
   b. For example, the system commands to start (call), and the pump fails to start (run status report back), within predetermined operator programmable time delay (time disagree), and then a discrepancy (fail) alarm shall be generated.
   c. Involuntary change in the device's status must also generate an alarm:
      1) For example, a pump starts when not commanded to do so, or a pump shuts down while running even though it still has a command to run.
   d. Each command, status, and alarm must cause the color of the symbol to change.
   e. Because many discrete final control elements have a cycle time in excess of the scan interval, provide each control output with an associated delay period selected to be longer than the operating period of the control element:
      1) Delay periods for each final control element must be adjustable at the operator interface.
      2) List all time delays in the final documentation.
5. Some of the above functions may be better accomplished in the data acquisition and graphic display software package; it is the responsibility of the ICSC to optimize the location of the various functions between all software packages.

C. Control configuration:
1. Provide software to allow control strategies to be developed and their operation initiated through the operator interface.
2. Provide standardized control point displays for defining the control functions including the function type, input/output addresses, setpoints and tuning constants, etc.
3. Provide a mechanism to link separate control functions together into an integrated control strategy.
4. Provide a mechanism to download operational/control setpoints developed at any operator interface to any PLC or RTU for operational implementation.

5. Provide a mechanism to define and implement operational/control setpoints locally at the PLC or RTU and to upload them to the operator interface for operational record keeping.
6. Perform control configurations on-line at the operator interface, the PLC or RTU may be taken off-line when being configured or downloaded.

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS (NOT USED)

2.07 ACCESSORIES (NOT USED)

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL

A. As specified in Section 17050.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 17050.

B. General:
   1. The control system logic program shall reside at the PLC level.

C. Use the tag and loop identifications found on the P&IDs for all tags used and/or assigned as part of the application software work provided by the ICSC.

D. Program the PLC logic using Ladder Diagram or Function Block Diagram programming language.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION

A. Provide a minimum of 4 CD/DVD copies of the following:
   1. Application software:
      a. Finalized fully annotated copy of programmed PLC logic in its native format.
      b. Cross-referenced index of all PLC registers or points.

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 FIELD QUALITY CONTROL (NOT USED)

3.08 ADJUSTING (NOT USED)

3.09 CLEANING (NOT USED)

3.10 DEMONSTRATION AND TRAINING

A. As specified in Section 17050.

B. Training:
   1. Performed by pre-approved and qualified representatives of the ICSC and/or manufacturer of the local operator interface software. A representative of the ICSC may perform the training only if the representative has completed the manufacturer's training course for the PLC programming software.

3.11 PROTECTION (NOT USED)

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 17762

CONTROL SYSTEMS - SCADA SOFTWARE

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. SCADA system software to be used for application software development and real time operation of the SCADA system.

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 01660 - Testing, Training, and Commissioning.
      c. Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
      d. Section 17100 - Control Strategies.
      e. Section 17761 - Control Systems - PLC Programming Software.
      f. Section 17950 - Testing, Calibration, and Commissioning.

C. General requirements:
   1. Software provided under this Contract represents a complete and operating control software system. Achieve the functionality specified in this and other sections through a combination of standard control system software and application software developed specifically for this Project.
   2. The standard control software listed in this Section does not represent a comprehensive list of software necessary to implement the functional requirements of the Contract Documents. Provide all necessary supplemental drivers, utility software and application software, as required, to meet the functional requirements of the Contract Documents.
   3. Applications software requirements are described in Section 17100.
   4. License all software for proper operation as described in the Contract Documents.
   5. License all software provided under this Contract to the OWNER.

D. Provide copies of all software on CD, or equivalent media.

1.02 REFERENCES

A. As specified in Section 17050.

1.03 DEFINITIONS

A. As specified in Section 17050.

1.04 SYSTEM DESCRIPTION

A. SCADA system node descriptors:
   1. SCADA client workstation: Client workstations shall be provided with all graphic display and related software for interacting with the SCADA system data. SCADA client's displays shall operate on data maintained by the SCADA server. Display capabilities shall include, but not be limited to:
      a. Process mimic displays.
      b. Real time and historical trend displays.
      c. Alarm summary and sub-summary displays.
      d. System utilities.
   2. SCADA terminal server: Provide the SCADA terminal server with the required software and licenses to deploy instances of SCADA client workstation to SCADA terminal services clients.
   3. SCADA terminal services client: Provide the SCADA system terminal services client with the required software and licenses required to access and display all graphic displays deployed from the SCADA terminal server.
   4. SCADA development node: Provide the SCADA system development node with software and licenses required to edit the programs and configuration files as part of the system application development. Unless otherwise indicated, the development node shall be complete with run time software for fully testing the application programs. Functions required at the development node include:
      a. Edit the SCADA database.
      b. Edit graphic displays.
      c. Modify alarm files.
      d. Modify PLC programs.
      e. Modify programs and scripts executing at any of the workstations.
      f. Set up trends and historical displays.
      g. Edit user authorizations.
      h. Other functions as may be required to modify the SCADA system application software.
   5. SCADA server: Provide server nodes with software and licenses as needed to communicate with the PLCs and other data providers and maintain a real time database of system values. Unless otherwise indicated, server nodes shall be equipped with client software for the viewing of the real time data. The SCADA server will include input/output drivers for interfacing with field devices, and buffer historical data, and provide data for the historian node(s).. Provide redundant SCADA servers complete with software required for synchronization and auto-fail over. SCADA server will include separate network interface cards (NIC) for the SCADA to PLC network, SCADA to SCADA network, and SCADA server network when redundant fail over SCADA servers are provided.
   6. Historian server: The historian server collects real time data and compresses the values into historical records for trending and reporting. Unless otherwise indicated, the historian server shall archive data provided by the SCADA server. The server shall be provided with software for interfacing with standard report software packages via MS-SQL, ODBC and other standard interfaces

as described in this Section. Provide software required for collector redundancy when auto-fail over SCADA servers are supplied.

7. Alarm node: Each client workstation is equipped with an alarm window on the operator display with local annunciation. Where a separate alarm node has been indicated, this node shall handle the interface to telephone, paging and radio alarming systems.

B. General:

1. The CONTRACTOR shall provide SCADA software, as required for a complete and functional SCADA system as indicated on the Drawings and as specified in this Section:
   a. Provide software on the system nodes as follows:
      1) 2 – 1500 point minimum SCADA servers with Auto Fail-Over
         a) Primary server in Administration Building 19” rack.
         b) Secondary server at county headquarters.
      2) 1-1000 point minimum historian with collector redundancy
         a) Primary Historian server in Administration Building 19” rack.
         b) Secondary Historian server at county headquarters.
      3) SCADA Client workstations
         a) Operator workstation in Administration Building.
      4) SCADA Development workstations
         a) Development workstation in Administration Building.
      5) 1 – SCADA terminal server w/ four SCADA terminal services client licenses
         a) Terminal server in Administration Building 19” rack.
      6) 6 – SCADA terminal services clients
         a) PCM-1 workstation.
         b) PCM-1 RJ-45 Port.
         c) PCM-2 workstation.
         d) PCM-2 RJ-45 Port.
         e) Mid-Town Standby Power Building.
         f) Operator workstation in Administration Building.
   b. System configuration:
      1) The system consists of a primary and backup data servers configured for hot failover operation. Server nodes shall be equipped with I/O drivers from communicating with networked PLCs.
      2) Client machines obtain real time data from the I/O servers. The client machines shall monitor the status of the servers and re-establish data connections with a new server in case the primary server fails.

1.05 SUBMITTALS

A. Furnish submittals as specified in Sections 01330 and 17050.

B. Remote alarm database:

1. After development of the SCADA system database but before system startup, provide a list of points configured for alarming and submit to the OWNER and the ENGINEER. The OWNER/ENGINEER will identify critical alarms for use in

the extended alarming system (e.g. dialer system, paging) and provide response descriptions.

C. Alarm descriptions shall be of sufficient detail for an accurate review by the OWNER.

D. After all shop drawings submittals required herein have been favorably reviewed by the ENGINEER, the ICSC shall submit the following items, which must also be favorably reviewed and implemented prior to the start of system testing, the entire control system including all required software packages must be operational prior to the required factory acceptance test:
   1. All operator interface display submittals shall be in full color as they will appear on the display screen:
      a. This submittal shall be prepared after the requisite graphics meetings.
      b. The submittal shall include:
         1) Graphic displays.
         2) Trend displays.
         3) Alpha numeric displays.
         4) Alarm displays.
   2. Each display shall be uniquely titled:
      a. Locations for process data shall be clearly identified either through the use of simulated data or by showing variables on the displays and providing a reference list describing those variables.
      b. All dynamic points shall be identified by tag number as a minimum and their operation shall be described on separate sheets:
         1) Color change.
         2) Symbol change.
      c. Three sets of submittals, with screen prints in color on a white background, are required for review by the OWNER and ENGINEER.
      d. One set will be returned with comments.
   3. All periodic and custom reports for the entire control system:
      a. Locations for process data shall be clearly identified, either through the use of simulated data or by showing variables on the report and providing a reference list describing those variables.
      b. Three sets of reports shall be submitted for review by the ENGINEER.
      c. One set will be returned with comments.

E. Pre-acceptance test documentation as specified in the Sequencing article of this Section.

F. Operator's reference manual:
   1. The ICSC shall prepare and submit a user reference manual for the operator interface system for use by the operators. This manual shall be bound in a three-ring binder and meet the following minimum requirements:
      a. An index to the manual.
      b. A list of operator interface:
         1) Display screens.
         2) Trends.
         3) Reports.
         4) With display name and description.

c. A summary of all possible commands and operator inputs to these screens including setpoints:
   1) All control actions shall be included.
d. A control system block diagram with names and locations of major components.
e. Instructions for manually printing screens or reports.
   1) Real time.
   2) Historical.
f. A summary of security levels and their privileges and limitations.
g. Spaces for operators to make notes.

2. A copy of this manual shall be provided to each operator during training on the operator interface operations:
   a. The training class shall include a review of this manual with the operators in addition to more detailed instruction on the operator interface configuration and its use.

G. Review meeting minutes submittals:
   1. Graphics review meeting:
      a. Minutes of Graphic Review Meeting No. 1.
      b. Minutes of Graphic Review Meeting No. 2.
   2. Report review meeting:
      a. Minutes of Report Review Meeting No. 1.
      b. Minutes of Report Review Meeting No. 2.
   3. Alarm review meeting:
      a. Minutes of Alarm Review Meeting No. 1.
      b. Minutes of Alarm Review Meeting No. 2.

1.06 QUALITY ASSURANCE

A. As specified in Section 17050.

B. The manufacturer must have a formal and documented set of quality assurance procedures that are applied to the engineering design, development, and documentation of the software:
   1. The presence of a formal quality assurance department is required.

C. Software provided under this Section shall be included in the testing specified in Section 17950.

1.07 DELIVERY, STORAGE, AND HANDLING (NOT USED)

1.08 PROJECT OR SITE CONDITIONS (NOT USED)

1.09 SEQUENCING

A. The following items shall be submitted with the final sets of technical manuals required as specified in the Submittals article of this Section, 15 working days before the pre-commissioning test as specified in Section 17050:
   1. All program manuals supplied by the manufacturers with the standard software packages.
   2. All original program disks supplied by the manufacturers with the standard software packages, including any program revisions or updates issued by the manufacturers during the construction period.

3. All PLC program and operator interface application program files stored on labeled disks:
    a. The PLC program and operator interface application program file disks shall also be updated as required if any changes or corrections are required in this programming before Project completion.

B. Operator interface graphics generation:
1. The ICSC through the CONTRACTOR shall schedule the operator interface graphics meetings.
2. Topics shall include graphics for:
    a. HMI graphics.
    b. Data acquisition and graphics display system.
3. The OWNER and ENGINEER shall attend these meetings.
4. Graphics Meeting No. 1: Held in conjunction with the Preliminary Meeting as specified in Section 17050:
    a. The ICSC shall chair and develop an agenda three weeks in advance of the meeting, which shall address the basic criteria to be adhered to in the configuration and development of graphic displays:
        1) At this meeting, the ICSC shall distribute sample display formats for illustration purposes.
        2) As a minimum, this meeting shall address the following issues:
            a) All in plant and remote site areas and conventions for identifying tag names and descriptors.
            b) Designation of groups within each plant area along with tag names and descriptors.
            c) The assignment of individual control loops and inputs to specific groups.
            d) Organization of the systems universal display hierarchy.
            e) Paging schemes to be used to enable the movement from one display to another.
            f) An itemization of the type of display to be used at each level in the graphic hierarchy, i.e., pre-formatted displays, templates, custom graphics, etc.
            g) Color convention to be employed on all graphics for the annotation of various status information, differentiation between alarms based on alarm priority, background colors, static field colors and dynamic field colors.
            h) The utilization of blinking and conditional text.
            i) Definition of graphic symbolism to be used on the Project. This listing shall include but not be limited to symbols to be used for process instrumentation, process equipment, piping, vessels and valves:
                (1) All symbolism must be specific as opposed to generic in that shapes must define both function and type, i.e., specific symbols for each valve design, each pump design, each type of flowmeter, etc.
                (2) If the ICSC's library of shapes does not adequately describe plant or field conditions, the ICSC shall develop additional shapes to meet the plant or field requirements.
                (3) Shapes and symbols used on the P&IDs shall be used as a guideline.

j) Definition of all display select commands that enable the operator to move within the display hierarchy.
k) The utilization of cursor movement commands which enable the operator to move within a display.
l) Definition of control input commands which enable the operator to interact with face plates control stations and custom graphic displays to implement control functions.
m) Definition of data input commands which enable the operator to enter numeric values into the control system.
n) Definition of the utilization of "poke" points or fields that are dynamically sensitive to operator inputs to facilitate operator entry directly into graphic displays.
o) A review of graphic generation procedures.

b. Subsequent to the adjournment of Graphics Meeting No. 1, the ICSC shall prepare and formalize a document titled "Graphics Criteria" which shall contain detailed meeting minutes and a definition of all graphic guidelines to be adhered to:
1) This report shall be supplemented by graphic examples which illustrate the incorporation and application of each graphic criteria.
2) The report shall be submitted within 30 calendar days of the meeting's adjournment.

5. Graphics Meeting No. 2: Held in conjunction with the intermediate review meeting as specified in Section 17050:
a. Subsequent to the finalization of the overall system-wide graphics criteria, the ICSC shall develop graphic packages for the entire operator interfaces being furnished under this Project.
b. At this meeting the ICSC shall submit 5 copies including:
1) A review of the graphic package developed for the process areas for content and completeness.
2) A review of all data fields that display automatically updated process information.
3) A review of all required input commands associated with the graphic access and control manipulation.
c. Subsequent to the adjournment of Graphics Meeting No. 2, the ICSC shall prepare a formalized submittal of the graphic package for review along with the detailed meeting minutes:
1) The report shall be submitted within 30 calendar days of the meeting adjournment.

6. 10 additional displays shall be configured online during the pre-commissioning test period.

C. Report generation:
1. The ICSC through the CONTRACTOR shall schedule the report generation meetings.
2. The OWNER and ENGINEER shall attend these meetings.
3. Reports Meeting No. 1: Held in conjunction with the preliminary meeting as specified in Section 17050:
a. The ICSC shall chair and develop an agenda 3 weeks in advance for a meeting, which shall address the basic criteria to be adhered to in the configuration and development of the reports:
1) At this meeting, the ICSC shall distribute sample formats for illustration purposes.

2) As a minimum, this meeting shall address the following issues:
   a) All in plant and remote site data and conventions for identifying tag names and descriptors.
   b) Designation of groups within each plant area along with tag names and descriptors.
   c) The assignment of inputs to specific categories.
   d) Organization of the systems universal report categories.
   e) An itemization of the type of report available.
   f) Definition of terms to be used on the reports.
   g) Definition of all report commands that enable the operator to move within the report editor.
   h) The utilization of cursor movement commands which enable the operator to move within a report.
   i) Definition of data input commands which enable the operator to enter numeric values into the system.
   j) A review of report generation procedures.
3) Subsequent to the adjournment of the Report Meeting No. 1, the ICSC shall prepare and formalize a document titled "Report Criteria" which shall contain detailed meeting minutes and a definition of all report guidelines to be adhered to:
   a) This report shall be supplemented by report examples.
   b) The report shall be submitted within 30 calendar days of the meeting's adjournment.

4. Reports Meeting No. 2: Held in conjunction with the intermediate review meeting as specified in Section 17050:
   a. Subsequent to the finalization of the overall report format criteria, the ICSC shall develop report packages for review.
   b. At this meeting the ICSC shall submit 5 copies including:
      1) A review of the report package developed for the process area(s) for content and completeness.
      2) A review of all data fields for process information.
      3) A review of all required input commands associated with the report access and control manipulation.
   c. Subsequent to the adjournment of Report Meeting No. 2, the ICSC shall prepare a formalized submittal of the report package for review along with the detailed meeting minutes:
      1) The report shall be submitted within 30 calendar days of the meetings adjournment.
5. 10 additional reports shall be configured online during the pre-commissioning test period.

D. Alarming priority:
   1. The ICSC through the CONTRACTOR shall schedule the alarming priority meetings.
   2. The OWNER and ENGINEER shall attend these meetings.
   3. Alarming Priority Meeting No. 1: Held in conjunction with the preliminary meeting as specified in Section 17050:
      a. The ICSC shall chair and develop an agenda 3 weeks in advance for a meeting, which shall address the basic criteria to be adhered to in the prioritization of alarms:
         1) At this meeting, the ICSC shall distribute a listing of all plant alarms identified by tag names and descriptors.

2) As a minimum, this meeting shall address the following issues:
   a) Criteria for prioritizing alarms including alarming priority levels. (i.e., Priority 3 - alarm at SCADA; Priority 2 – alarm at SCADA and autodialer; Priority 1 – alarm at SCADA, autodialer, and plant shutdown.)
   b) Alarm display banner basic criteria.
3) Subsequent to the adjournment of the Alarming Priority Meeting No. 1, the ICSC shall prepare and formalize a document titled "Alarm Criteria" which shall contain detailed meeting minutes and a definition of all alarming guidelines to be adhered to:
   a) The report shall be submitted within 30 calendar days of the meeting's adjournment.

4. Alarming Priority Meeting No. 2: Held in conjunction with the intermediate review meeting as specified in Section 17050:
   a. Subsequent to the finalization of the overall alarm criteria, the ICSC shall develop an alarming priority spreadsheet that will be populated at this meeting.
   b. At this meeting the ICSC shall provide a spreadsheet including:
      1) A listing of all plant alarms identified by tag names and descriptors.
      2) For each alarm listed include a location to enter the alarm priority assignment.
      3) For each alarm listed include a location to enter specific comments related to that alarm.
   c. Subsequent to the adjournment of Alarming Priority Meeting No. 2, the ICSC shall prepare a formalized submittal of the alarming priority spreadsheet for review along with the detailed meeting minutes:
      1) The spreadsheet and meeting minutes shall be submitted within 30 calendar days of the meetings adjournment.

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

A. As specified in Section 17050.

1.12 SYSTEM START-UP (NOT USED)

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 COMMISSIONING (NOT USED)

1.15 MAINTENANCE

A. Provide 2-year extended manufacturer’s warranty as follows:
   1. Dedicated technical support department or handled by programming staff or distributor.
   2. Telephone support available 24 hours per day.
   3. Email and web support addresses.
   4. FTP download area.
   5. Knowledge base.

6. Bulletin board service.
7. Field service.
8. Warranty shall commence from the date specified in Section 17050.

B. Provide system upgrades and maintenance fixes for a period of 2 years from the completion of the Testing Phase, specified in Section 01660.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. One of the following, no equal:
1. Wonderware InTouch 9.5 with patches 01, 02, and 03 installed.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS (NOT USED)

2.04 MANUFACTURED UNITS

A. General:
1. Unless otherwise indicated, provide all run time and development software licensed for:
   a. No direct limits on the number of connections to a server machine.
   b. Provide the number of client licenses as indicated by the number of machines shown or specified, the addition of a new client shall not require an upgrade to the server license.
2. Provide software and licenses as required to implement the system architecture and functionality as indicated on the Drawings and as described in the System Description article of this Section.
3. License/registered all software in the OWNER's name.
4. Turn all software installed on the workstation, over to the OWNER with disks, keys, and manuals.
5. The system software specified as part of this Section support SCADA system functions including, but not limited to:
   a. Human machine interface (HMI) process graphics development and display.
   b. Real time point database development and display.
   c. Historical database generation, collection, and display.
   d. Alarming subsystem.
   e. Trending and report subsystems.
   f. Drivers and interfaces.
6. PLC programming software is specified in Section 17761.

B. Operating system software:
1. Provide all workstations and servers with operating system software compatible with the software provided under this Section:
   a. Client nodes: Windows 7 Professional.
   b. Server nodes: Windows 2008 Server.

2. Provide all operating system software as a clean install. Where workstations have been loaded with OEM versions of software containing trial software or other advertisements, remove the OEM software and reinstall the operating system and all drivers from the original installation disks.
3. Provide all workstations with recovery disks.

C. SCADA HMI run time software:
1. Provide run time software and licenses for all control system workstations provided.
2. Include client licenses for I/O server machines.
3. License all software in the OWNER's name.

D. SCADA I/O server software:
1. Provide software and licenses for a full SCADA system node including I/O drivers.
2. Provide drivers for all control system devices as indicated on the Drawings.
3. Configure historical data collectors to provide data for the historical database on all I/O servers.
4. License all software in the OWNER's name.

E. Development workstations:
1. For development workstations provide all software for the generation and modification of the graphic screens, SCADA system databases, access control files and supervisory control programs.
2. The development node contains all client software and licenses for use as an additional operator display.
3. The development node shall be equipped with I/O drivers for live testing of screens and control programs.
4. License all software in the OWNER's name.

F. Historian server:
1. Provide the latest version of the historian software.
2. Use data collectors to buffer historical data in the event of a loss of communication with the history server.
3. Provide Microsoft SQL client access licenses for all nodes in the system plus an allowance for 50 percent expansion.

G. Licensing:
1. Provide hardware keys will utilize the USB form factor.

H. Alarm dialer software:
1. Install the alarm dialer software on the workstation identified as the alarm node.
2. The alarm software shall interface with the SCADA system via the SCADA system client software and provide an interface to the appropriate external alarming system.
3. Provide 1 copy of the alarm dialing software:
   a. SCADAlarm Event Notification Software by Wonderware.
   b. Or equal.

I. Miscellaneous software:
   1. Provide the following support software for use on the SCADA system computers. Install all software on the appropriate system node. Provide all software CD/DVD media. License all software to the OWNER:
      a. Provide Symantec's Norton Ghost software for the backup of all system nodes to a common file server.
      b. Provide 2 copies Microsoft Office Professional Edition 2012 for generating and editing of reports.
      c. Provide 1 copy of Sytech xlReporter Suite for the development of report templates and the event scheduling of automatically generated reports.
      d. Provide all nodes with virus protection software.

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS (NOT USED)

2.07 ACCESSORIES (NOT USED)

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 17050.

B. Install all required software improvement modules (SIMs). At the completion of the Project, and provide installation disk(s) containing all SIMs used on the Project to the OWNER.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 FIELD QUALITY CONTROL

A. Test all software provided as part of this Section as part of the system tests specified in Section 17950.

B. Provide training by a factory-authorized vendor.

C. The CONTRACTOR shall cover the costs of tuition, training materials, and related fees.

3.08 ADJUSTING (NOT USED)

3.09 CLEANING (NOT USED)

3.10 DEMONSTRATION AND TRAINING

A. As specified in Section 17050.

3.11 PROTECTION (NOT USED)

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 17765

CONTROL SYSTEMS - HUMAN MACHINE INTERFACE SOFTWARE

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Application software to be used in conjunction with the specified human machine interface (HMI) hardware.

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 01660 - Testing, Training, and Commissioning.
      c. Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
      d. Section 17100 - Control Strategies.

C. General requirements:
   1. Software provided under this Contract represent a complete and operating control software system. Achieve the functionality specified in this and other sections through a combination of standard control system software and application software developed specifically for this Project.
   2. The standard control software listed in this Section does not represent a comprehensive list of software necessary to implement the functional requirements specified in the Contract Documents. Provide all necessary supplemental drivers, utility software and application software, as required, to meet the functional requirements specified in the Contract Documents.
   3. Applications software requirements are specified in Section 17100.
   4. License all software for proper operation as specified in the Contract Documents.
   5. License all software provided under this Contract to the Owner.

1.02 REFERENCES

A. As specified in Section 17050.

1.03 DEFINITIONS

A. As specified in Section 17050.

1.04 SYSTEM DESCRIPTION

A. Provide all HMI hardware as specified in the Contract Documents.

1.05 SUBMITTALS

A. Furnish submittals as specified in Sections 01330 and 17050.

B. Product data:
   1. Complete manufacturer's brochures that identify HMI software and options. Mark up to clearly show options and components to be provided, and cross out any options or components that will not be provided.
   2. Manufacturer's installation instructions.

C. Graphic screens:
   1. Color printouts of each graphic screen and control pop-ups.

D. Operation and maintenance manuals:
   1. Complete installation, operation, and testing manuals.
   2. Complete color printouts of each graphic screen and control pop-ups.

1.06 QUALITY ASSURANCE

A. As specified in Section 17050.

B. System compatibility:
   1. The software must be the standard operating software system designed specifically for use with the HMI hardware.
   2. The software must be furnished and developed by the manufacturer of the HMI hardware.

1.07 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 17050.

1.08 PROJECT OR SITE CONDITIONS (NOT USED)

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

A. As specified in Section 17050.

1.12 SYSTEM START-UP (NOT USED)

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 COMMISSIONING (NOT USED)

1.15 MAINTENANCE

A. As specified in Section 17050.

B. Provide system upgrades and maintenance fixes for a period of 2 years from the completion of the Testing Phase, specified in Section 01660.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Provide the HMI graphic software system manufactured by the HMI hardware manufacturer.

B. One of the following, no equal:
   1. Rockwell Software FactoryTalk View Machine Edition.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS (NOT USED)

2.04 MANUFACTURED UNITS

A. Human machine interface software:
   1. Provide a complete software package to be used for programming the necessary screens and operator interaction with the HMIs.
   2. Operating system:
      a. Microsoft Windows 7.
   3. Furnish software with preconfigured symbols, objects, graphics, and imported bitmaps for the generation of the displays.
   4. Software must allow bitmaps to be imported or exported to or from other applications.
   5. Capable of generating custom reports, complete with screen prints.
   6. Capable of working with multiple screens concurrently.
   7. Provide dialog boxes for defining object attributes.
   8. Configure objects using fill in dialog boxes.
   9. Furnish graphic and text editor that allows custom formatting in order to customize and change the appearance of objects and text:
      a. Allow selection of different fill patterns to define object status.
   10. As a minimum, provide the following object capabilities:
      a. Operator inputs:
         1) Momentary pushbutton.
         2) Maintained pushbutton.
         3) Latched pushbutton.
         4) Multistate pushbutton.
         5) Keypad enable button.
         6) Cursor point.
      b. Control list selectors:
         1) Standard control list.
         2) Piloted control list.
      c. Global objects.

d. Display objects:
    1) Bar graph.
    2) Scale.
    3) Message display.
    4) Multistate indicator.
    5) List indicator.
    6) Numeric data display.
e. Screen selector objects:
    1) Go to.
    2) Return.
    3) Screen list selector.
f. Embedded variables:
    1) Time.
    2) Date.
    3) Numeric variable.
g. Graphics:
    1) Lines.
    2) Shapes.
    3) Freeform drawings.
    4) Imported graphics.
    5) Background text.
    6) Selection table for standard ISA symbols.
    7) PID controller faceplate.
h. Alarm screens.

11. Documentation:
    a. Provide complete user documentation, including examples of how to operate the various modules within the system.
    b. Provide the documentation in electronic format, HTML based with the ability to search for topics by keyword or search or specific text.
12. On-line Help:
    a. Provide an on-line "help" facility, based upon Windows standard Hypertext:
        1) Useful, context-sensitive information on the operation of the package:
            a) That can be invoked on-line through a point-and-click operation.
            b) The "help" facility must also support the ability to perform full text word search, add custom comments, bookmark topics, copy and pasting into another application, printing, and use of system fonts and colors.

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS (NOT USED)

2.07 ACCESSORIES (NOT USED)

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL

A. As specified in Section 17050.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 17050.

B. All tags used and/or assigned as part of the application programming work are to use the tag and loop identifications found on the P&IDs.

C. Station graphics:
   1. Configure the graphic display for each device both in the treatment plant, and/or process area, including but not limited to:
      a. Symbols for:
         1) Pumps.
         2) Valves.
         3) Major instruments.
         4) Flowmeters.
         5) Pressure transmitter.
      b. Alarm symbols including intrusion alarm.
      c. Relevant test and operational data.
      d. Status for each controller or controlled device:
         1) Hand.
         2) Off.
         3) Automatic.
         4) Local.
         5) Remote.
         6) Run.
         7) Call.
         8) Fail.
         9) Open.
         10) Close.
         11) Hold.
         12) Modulate.
      e. Depict a change of state of pumps and valves by a change in color.
   2. Production and usage bar graph:
      a. Depict the production for each site and/or piece of equipment, as determined during the requisite graphics meeting, within the treatment plant, summarized to type, and total usage, with a bar graph and numeric value for each analog value.
   3. System level summary:
      a. Show the level for the plant influent and effluent production, etc, via a display using bar graphs and numbers, as determined during the requisite graphics meeting.
   4. Furnish a minimum of 20 screens, to be directed by the Engineer and Owner, during construction for each HMI.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 REINSTALLATION (NOT USED)

3.07 FIELD QUALITY CONTROL (NOT USED)

3.08 ADJUSTING (NOT USED)

3.09 CLEANING (NOT USED)

3.10 DEMONSTRATION AND TRAINING

A. As specified in Section 17050.

B. Perform the training using pre-approved and qualified representatives of the ICSC and or manufacturer of the HMI software:
   1. A representative of the ICSC may perform the training only if the representative has completed the manufacturer's training course for the HMI software.

3.11 PROTECTION (NOT USED)

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 17901

SCHEDULES - FIELD INSTRUMENTS

PART 1 GENERAL

1.01 SUMMARY

A. The Schedules - Field Instruments 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 Instrument Index are defined on the Drawings.

PART 2 PRODUCTS

Not Used.

PART 3 EXECUTION

3.01 SCHEDULES FIELD INSTRUMENTS

A. Schedules - Field Instruments attached.

END OF SECTION

DWG	TAG	SERVICE	RANGE	SETPOINT	MIN FLOW	MAX FLOW	NORMAL FLOW
03N01	LE-326	ULTRASONIC LEVEL METER	0-16 FT				
03N01	LE-327	ULTRASONIC LEVEL METER	0-16 FT				
03N01	FI-289A	ROTAMETER	0-24 GPH				
03N01	FI-289B	ROTAMETER	0-24 GPH				
04N01	PI-501	PRESSURE INDICATOR	0-60 PSIG				
04N01	PI-502	PRESSURE INDICATOR	0-60 PSIG				
04N01	LE-504	ULTRASONIC LEVEL METER	0-23 FT				
04N01	FE-503	FLOW METER	0-600 GPM		100 GPM	500 GPM	250 GPM
04N01	LSH-500	LEVEL SWITCH HIGH		19.5 FT			
04N01	LSLL-500	LEVEL SWITCH LOW-LOW		2 FT			
04N02	PI-601	PRESSURE INDICATOR	0-30 PSIG				
04N02	PI-602	PRESSURE INDICATOR	0-30 PSIG				
04N02	LE-600	ULTRASONIC LEVEL METER	0-20 FT				
04N02	FE-603	FLOW METER	0-200 GPM		150 GPM	200 GPM	150 GPM
04N02	LSH-603	LEVEL SWITCH HIGH		12 FT			
04N02	LSLL-603	LEVEL SWITCH LOW-LOW		2 FT			
10N01	LE-041	ULTRASONIC LEVEL TRANSMITTER	0-6 FT				
10N01	LE-051	ULTRASONIC LEVEL TRANSMITTER	0-6 FT				
10N01	LE-012	ULTRASONIC LEVEL TRANSMITTER	0-6 FT				
10N01	FE-010	FLOW METER	0-4.75 MGD		200 GPM	3,928.4 GPM	1,388.88 GPM
10N04	LE-042	ULTRASONIC LEVEL TRANSMITTER	0-6 FT				
10N04	LE-052	ULTRASONIC LEVEL TRANSMITTER	0-6 FT				
10N04	FSH-769K	FLOW SWITCH HIGH	FBV				
11N01	PI-071A	PRESSURE INDICATOR	-5-0"WC				
11N01	PI-071B	PRESSURE INDICATOR	0-15"WC				
11N01	PI-072A	PRESSURE INDICATOR	-5-0"WC				
11N01	PI-072B	PRESSURE INDICATOR	0-15"WC				
11N02	PI-070	PRESSURE INDICATOR	FBV				
11N02	FI-070	ROTAMETER	FBV				
11N02	FI-075A	ROTAMETER	FBV				
11N02	FI-075B	ROTAMETER	FBV				
11N02	FI-076	ROTAMETER	FBV				
11N02	FI-077A	ROTAMETER	FBV				
11N02	FI-077B	ROTAMETER	FBV				
20N01	AE-095	DISSOLVED OXYGEN	0-20mg/L				
20N02	FI-453A	POLYMER FLOW	0-31 GPH				
20N02	FI-453B	POLYMER FLOW	0-31 GPH				
20N02	AE-105	DISSOLVED OXYGEN	0-20mg/L				
20N03	PI-750	PRESSURE INDICATOR	0-60 PSIG				
20N03	FI-287A	ROTAMETER	0-3 GPH				
20N03	FI-287B	ROTAMETER	0-3 GPH				
20N03	FI-287C	ROTAMETER	0-3 GPH				
20N03	FI-287D	ROTAMETER	0-3 GPH				
20N03	FI-751A	ROTAMETER	0-20 GPM				
20N03	FI-751B	ROTAMETER	0-20 GPM				
20N03	FI-751C	ROTAMETER	0-20 GPM				
20N03	FI-751D	ROTAMETER	0-20 GPM				
20N03	FSH-769F	FLOW SWITCH HIGH	FBV				
20N03	FSH-769G	FLOW SWITCH HIGH	FBV				
21N01	FI-752A	ROTAMETER	0-20 GPM				
21N01	FSH-769H	FLOW SWITCH HIGH	FBV				
21N02	FI-752B	ROTAMETER	0-20 GPM				
21N02	FSH-769J	FLOW SWITCH HIGH	FBV				
23N01	PI-130	PRESSURE INDICATOR	0-30 PSIG				
23N01	FI-750	ROTAMETER	0-20 GPM				
23N01	LE-130	RADAR LEVEL TRANSMITTER	0-10 FT				
28N01	LE-180	ULTRASONIC LEVEL TRANSMITTER	0-13 FT				
28N01	LSH-189	LEVEL SWITCH HIGH		84 FT ELEV			
28N01	LSLL-189	LEVEL SWITCH LOW		73.5 FT ELEV			
28N01	PI-181	PRESSURE INDICATOR	0-30 PSIG				

DWG	TAG	SERVICE	RANGE	SETPOINT	MIN FLOW	MAX FLOW	NORMAL FLOW
28N01	PI-182	PRESSURE INDICATOR	0-30 PSIG				
28N01	FI-181	ROTAMETER	200-750 ml/min				
28N01	AE-181	TURBIDITY	0-40 NTU				
28N02	PI-183	PRESSURE INDICATOR	0-30 PSIG				
28N02	PI-184	PRESSURE INDICATOR	0-30 PSIG				
28N03	PSH-185	PRESSURE SWITCH HIGH	0-60 PSIG	25 PSIG			
28N03	PI-185	PRESSURE INDICATOR	0-60 PSIG				
28N03	PSH-186	PRESSURE SWITCH HIGH	0-60 PSIG	25 PSIG			
28N03	PI-186	PRESSURE INDICATOR	0-60 PSIG				
28N03	PI-187	PRESSURE INDICATOR	0-30 PSIG				
28N03	FE-186	FLOW METER	0-2800 GPM		200 GPM	2,800 GPM	694 GPM
30N01	AE-230	TURBIDITY	0-40 NTU				
30N01	FI-230	ROTAMETER	200-750 ml/min				
30N02	PI-214A	PRESSURE INDICATOR	FBTFS				
30N02	PI-214B	PRESSURE INDICATOR	FBTFS				
30N02	PI-215A	PRESSURE INDICATOR	FBTFS				
30N02	PI-215B	PRESSURE INDICATOR	FBTFS				
30N03	PI-224A	PRESSURE INDICATOR	FBTFS				
30N03	PI-224B	PRESSURE INDICATOR	FBTFS				
30N03	PI-225A	PRESSURE INDICATOR	FBTFS				
30N03	PI-225B	PRESSURE INDICATOR	FBTFS				
31N01	FI-288	ROTAMETER	0-24 GPH				
31N01	LE-241	ULTRASONIC LEVEL METER	0-6 FT				
31N01	AE-241B	UV INTENSITY	FBUVS				
31N01	LE-241A	ULTRASONIC LEVEL METER	FBUVS				
31N01	AE-241A	UV INTENSITY	FBUVS				
31N01	AE-240	UV TRANSMITTANCE METER	FBUVS				
31N01	LE-241B	ULTRASONIC LEVEL METER	FBUVS				
31N01	LE-241C	ULTRASONIC LEVEL METER	FBUVS				
31N01	AE-241C	UV INTENSITY	FBUVS				
31N01	FE-241	FLOW METER	0-1,460 GPM		200 GPM	1,460 GPM	830 GPM
31N02	LE-242B	ULTRASONIC LEVEL METER	FBUVS				
31N02	AE-242B	UV INTENSITY	FBUVS				
31N02	LE-242A	ULTRASONIC LEVEL METER	FBUVS				
31N02	LE-242	ULTRASONIC LEVEL METER	0-6 FT				
31N02	AE-242A	UV INTENSITY	FBUVS				
31N02	LE-242C	ULTRASONIC LEVEL METER	FBUVS				
31N02	AE-242C	UV INTENSITY	FBUVS				
31N02	FE-242	FLOW METER	0-1,460 GPM		200 GPM	1,460 GPM	830 GPM
31N03	AE-243A	UV INTENSITY	FBUVS				
31N03	AE-243B	UV INTENSITY	FBUVS				
31N03	AE-243C	UV INTENSITY	FBUVS				
31N03	FE-243	FLOW METER	0-1,460 GPM		200 GPM	1,460 GPM	830 GPM
31N03	LE-243A	ULTRASONIC LEVEL METER	FBUVS				
31N03	LE-243	ULTRASONIC LEVEL METER	0-6 FT				
31N03	LE-243B	ULTRASONIC LEVEL METER	FBUVS				
31N03	LE-243C	ULTRASONIC LEVEL METER	FBUVS				
31N03	FSH-769M	FLOW SWITCH HIGH	FBV				
32N01	WE-270	TOTE SCALE	0-4,000 LBS				
32N02	PI-271	PRESSURE INDICATOR	0-60 PSIG				
32N03	LSH-273	LEVEL SWITCH HIGH		1 FT			
32N03	PI-272	PRESSURE INDICATOR	0-60 PSIG				
32N04	LE-280	ULTRASONIC LEVEL	0-12 FT				
32N04	LSH-280	LEVEL SWITCH HIGH		1 FT			
32N05	FI-281B	ROTAMETER	0-5 ml/min				
32N05	FI-281D	ROTAMETER	0-38 ml/min				
32N05	FI-281C	ROTAMETER	0-38 ml/min				
32N05	PI-281	PRESSURE INDICATOR	0-100 PSIG				
32N06	PI-282	PRESSURE INDICATOR	0-100 PSIG				
32N07	PI-283	PRESSURE INDICATOR	0-160 PSIG				
32N08	PI-284	PRESSURE INDICATOR	0-160 PSIG				
32N09	PI-285	PRESSURE INDICATOR	0-160 PSIG				

DWG	TAG	SERVICE	RANGE	SETPOINT	MIN FLOW	MAX FLOW	NORMAL FLOW
32N10	FSH-796C	FLOW SWITCH HIGH	FBV				
32N10	FSH-796D	FLOW SWITCH HIGH	FBV				
32N10	FSH-796E	FLOW SWITCH HIGH	FBV				
40N01	PSH-301	PRESSURE SWITCH HIGH	0-200 PSIG	160 PSIG			
40N01	PI-301	PRESSURE GAUGE	0-200 PSIG				
40N01	PSH-302	PRESSURE SWITCH HIGH	0-200 PSIG	160 PSIG			
40N01	PI-302	PRESSURE GAUGE	0-200 PSIG				
40N02	PSH-303	PRESSURE SWITCH HIGH	0-200 PSIG	160 PSIG			
40N02	PI-303	PRESSURE GAUGE	0-200 PSIG				
40N02	PSH-304	PRESSURE SWITCH HIGH	0-200 PSIG	160 PSIG			
40N02	PI-304	PRESSURE GAUGE	0-200 PSIG				
40N03	PI-305	PRESSURE INDICATOR	FBHPTS				
40N03	PI-306	PRESSURE INDICATOR	0-200 PSIG				
40N03	PE-306	PRESS INDICATING TRANSMITTER	0-200 PSIG				
40N03	PI-310	PRESSURE INDICATOR	0-200 PSIG				
40N03	PI-311	PRESSURE INDICATOR	0-200 PSIG				
40N03	PI-312	PRESSURE INDICATOR	0-200 PSIG				
40N03	PI-313	PRESSURE INDICATOR	0-100 PSIG				
40N03	PI-314	PRESSURE INDICATOR	0-60 PSIG				
40N03	PI-315	PRESSURE INDICATOR	0-60 PSIG				
40N03	AE-308	CL2	0-30 PPM				
40N03	FE-307	FLOW METER	0-3000 GPM		100 GPM	500 GPM	3,000 GPM
50N01	FE-124	FLOW METER	0-600 GPM		120 GPM	250 GPM	600 GPM
50N01	FE-125	FLOW METER	0-600 GPM		120 GPM	250 GPM	600 GPM
50N01	PI-121	PRESSURE INDICATOR	0-30 PSIG				
50N01	PI-122	PRESSURE INDICATOR	0-30 PSIG				
50N01	PI-123	PRESSURE INDICATOR	0-30 PSIG				
50N02	FSL-121	FLOW SWITCH	Flow/No Flow				
50N02	FI-121	FLOW SWITCH	NOTE 1				
50N02	PSH-121	PRESSURE SWITCH HIGH	0-30 PSIG	15 PSIG			
50N02	PI-121A	PRESSURE INDICATOR	0-30 PSIG				
50N02	PI-121B	PRESSURE INDICATOR	0-30 PSIG				
50N02	FSL-122	FLOW SWITCH	Flow/No Flow				
50N02	FI-122	FLOW SWITCH	NOTE 1				
50N02	PSH-122	PRESSURE SWITCH HIGH	0-30 PSIG	15 PSIG			
50N02	PI-122A	PRESSURE INDICATOR	0-30 PSIG				
50N02	PI-122B	PRESSURE INDICATOR	0-30 PSIG				
50N02A	FSL-123	FLOW SWITCH	Flow/No Flow				
50N02A	FI-123	FLOW SWITCH	NOTE 1				
50N02A	PSH-123	PRESSURE SWITCH HIGH	0-30 PSIG	15 PSIG			
50N02A	PI-123A	PRESSURE INDICATOR	0-30 PSIG				
50N02A	PI-123B	PRESSURE INDICATOR	0-30 PSIG				
50N03	FE-126	RAS FLOW METER	0-900 GPM		250 GPM	710 GPM	500 GPM
50N03	FE-127	WAS FLOW METER	0-700 GPM		190 GPM	550 GPM	325 GPM
50N04	PI-401A	PRESSURE INDICATOR	FBBS				
50N04	PSH-401A	PRESSURE SWITCH HIGH	FBBS				
50N04	PI-401B	PRESSURE INDICATOR	FBBS				
50N04	PSH-401B	PRESSURE SWITCH HIGH	FBBS				
50N05	PI-402A	PRESSURE INDICATOR	FBBS				
50N05	PSH-402A	PRESSURE SWITCH HIGH	FBBS				
50N05	PI-402B	PRESSURE INDICATOR	FBBS				
50N05	PSH-402B	PRESSURE SWITCH HIGH	FBBS				
50N06	PI-403A	PRESSURE INDICATOR	FBBS				
50N06	PSH-403A	PRESSURE SWITCH HIGH	FBBS				
50N06	PI-403B	PRESSURE INDICATOR	FBBS				
50N06	PSH-403B	PRESSURE SWITCH HIGH	FBBS				
50N08	PDIT-411	PRESSURE DIFFERENTIAL TRANSMITTER	0-20 ft WC				
50N09	PDIT-412	PRESSURE DIFFERENTIAL TRANSMITTER	0-20 ft WC				
50N10	FE-425	FLOW METER					
50N10	PSH-423	PRESSURE SWITCH HIGH	0-100 PSIG	60 PSIG			

DWG	TAG	SERVICE	RANGE	SETPOINT	MIN FLOW	MAX FLOW	NORMAL FLOW
50N10	PI-423B	PRESSURE INDICATOR	0-100 PSIG				
50N10	PI-423A	PRESSURE INDICATOR	0-30 PSIG				
50N11	FE-429	FLOW METER	0-110 GPM		60 GPM	110 GPM	85 GPM
50N11	PSH-427	PRESSURE SWITCH HIGH	0-100 PSIG	60 PSIG			
50N11	PI-427B	PRESSURE INDICATOR	0-100 PSIG				
50N11	PI-427A	PRESSURE INDICATOR	0-30 PSIG				
50N12	FE-309	FLOW METER	0-700 GPM		50 GPM	700 GPM	100 GPM
50N12	PI-423	PRESSURE INDICATOR	0-100 PSIG				
50N12	FI-423	ROTAMETER	NOTE 1				
50N12	FSL-423	FLOW SWITCH	Flow/No Flow				
50N12	PI-427	PRESSURE INDICATOR	0-100 PSIG				
50N12	FI-427	ROTAMETER	NOTE 1				
50N12	FSL-427	FLOW SWITCH	Flow/No Flow				
51N01	PI-431	PRESSURE INDICATOR	0-160 PSIG				
51N02	PI-432	PRESSURE INDICATOR	0-160 PSIG				
51N04	FSH-769A	FLOW SWITCH HIGH	FBV				
51N04	FSH-769B	FLOW SWITCH HIGH	FBV				
51N04	LSH-440	LEVEL SWITCH HIGH		0.5 FT			
51N04	WE-441	TOTE SCALE	0-4,000 LBS				
51N04	WE-443	TOTE SCALE	0-4,000 LBS				
51N04	WE-442	TOTE SCALE	0-4,000 LBS				
51N05	PI-451A	PRESSURE INDICATOR	FBV				
51N05	PI-451B	PRESSURE INDICATOR	FBV				
51N05	PSH-451	PRESSURE SWITCH HIGH	FBV				
51N05	PI-452A	PRESSURE INDICATOR	FBV				
51N05	PI-452B	PRESSURE INDICATOR	FBV				
51N05	PSH-452	PRESSURE SWITCH HIGH	FBV				
51N06	PI-453A	PRESSURE INDICATOR	FBV				
51N06	PI-453B	PRESSURE INDICATOR	FBV				
51N06	PSH-453	PRESSURE SWITCH HIGH	FBV				
60N01	LE-711	LEVEL TRANSMITTER	0-200 FT	160 FT			
60N01	FE-710	FLOW METER	0-50 GPM		10 GPM	40 GPM	15 GPM
60N01	PI-711	PRESSURE INDICATOR	0-30 PSIG				
60N02	LE-712	LEVEL TRANSMITTER	0-200 FT	160 FT			
60N02	PI-712	PRESSURE INDICATOR	0-30 PSIG				
60N03	LE-715	LEVEL TRANSMITTER	0-35 FT				
60N03	AE-713	CL2	0-15 PPM				
60N03	AE-715	CL2	0-15 PPM				
60N03	FI-281E	ROTAMETER	0-5 ml/min				
60N03	FI-281F	ROTAMETER	0-3 GPH				
60N03	PI-713	PRESSURE INDICATOR	0-30 PSIG				
60N04	PI-731A	PRESSURE INDICATOR	FBV				
60N04	PI-731B	PRESSURE INDICATOR	FBV				
60N04	PSH-731	PRESSURE SWITCH HIGH	FBV				
60N04	PI-732A	PRESSURE INDICATOR	FBV				
60N04	PI-732B	PRESSURE INDICATOR	FBV				
60N04	PSH-732	PRESSURE SWITCH HIGH	FBV				
60N04	PI-733A	PRESSURE INDICATOR	FBV				
60N04	PI-733B	PRESSURE INDICATOR	FBV				
60N04	PSH-733	PRESSURE SWITCH HIGH	FBV				
60N05	FE-734	FLOW METER	0-70 GPM		20 GPM	70 GPM	30 GPM
60N05	PI-734	PRESSURE INDICATOR	0-160 PSIG				
60N05	PE-734	PRESSURE TRANSMITTER	0-120 PSIG				
60N05	PI-735	PRESSURE INDICATOR	FBHPTS				
60N06	LE-760	LEVEL TRANSMITTER	0-6 FT				
60N07	PI-761A	PRESSURE INDICATOR	FBV				
60N07	PI-761B	PRESSURE INDICATOR	FBV				
60N07	PSH-761	PRESSURE SWITCH HIGH	FBV				
60N07	PI-762A	PRESSURE INDICATOR	FBV				
60N07	PI-762B	PRESSURE INDICATOR	FBV				
60N07	PSH-762	PRESSURE SWITCH HIGH	FBV				

DWG	TAG	SERVICE	RANGE	SETPOINT	MIN FLOW	MAX FLOW	NORMAL FLOW
60N07	PI-763A	PRESSURE INDICATOR	FBV				
60N07	PI-763B	PRESSURE INDICATOR	FBV				
60N07	PSH-763	PRESSURE SWITCH HIGH	FBV				
60N08	FE-764	FLOW METER	0-40 GPM		2 GPM	40 GPM	10 GPM
60N08	PE-764	PRESSURE TRANSMITTER	0-120 PSIG				
60N08	PI-764	PRESSURE INDICATOR	0-160 PSIG				
60N08	PI-765	PRESSURE INDICATOR	FBHPTS				
70N01	PI-720B	PRESSURE INDICATOR	FBFPS				
70N01	PI-720A	PRESSURE INDICATOR	FBFPS				
70N01	FE-720	FLOW METER	0-1,150 GPM		300 GPM	1,150 GPM	750 GPM

NOTE 1: COORDINATE FLOW RANGE WITH PUMP SEAL MANUFACTURER

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. I/O list attached.

END OF SECTION

PLC I/O Listing for PLC

Tag	Loop	I/O	Location	Description 1	Description 2	Drawing #
F	186	AI	PLC		PLC	8930A1128N003.DWG
Z1	188	AI	PLC	POSITION	PLC	8930A1128N002.DWG
L	803	AI	PLC	FUEL LEVEL	PLC	8930A1170N004.DWG
Total AI Points = 3						
Z2	188	AO	PLC	POSITION	PLC	8930A1128N002.DWG
Total AO Points = 1						
HSAR	188	DI	PLC	REMOTE	PLC	8930A1128N002.DWG
ZSC	188	DI	PLC	CLOSED	PLC	8930A1128N002.DWG
ZSO	188	DI	PLC	OPENED	PLC	8930A1128N002.DWG
ZSC	713	DI	PLC	CLOSED	PLC	8930A1160N003.DWG
ZSO	713	DI	PLC	OPENED	PLC	8930A1160N003.DWG
ZSC	760	DI	PLC	CLOSED	PLC	8930A1160N006.DWG
ZSO	760	DI	PLC	OPENED	PLC	8930A1160N006.DWG
XSH	803	DI	PLC	INTERSTITIAL LEAK	PLC	8930A1170N004.DWG
LSH	804	DI	PLC	FUEL LEVEL	PLC	8930A1170N004.DWG
LSL	804	DI	PLC	FUEL LEVEL	PLC	8930A1170N004.DWG
XSH	804	DI	PLC	RUPTURE	PLC	8930A1170N004.DWG
Total DI Points = 11						
MSC	188	DO	PLC	CLOSE	PLC	8930A1128N002.DWG
MSC	713	DO	PLC	CLOSE	PLC	8930A1160N003.DWG
MSO	713	DO	PLC	OPEN	PLC	8930A1160N003.DWG
MSC	760	DO	PLC	CLOSE	PLC	8930A1160N006.DWG
MSO	760	DO	PLC	OPEN	PLC	8930A1160N006.DWG

PLC I/O Listing for PLC

Tag	Loop	I/O	Location	Description 1	Description 2	Drawing #

Total DO Points = 5

PLC I/O Listing for PLC-1

Tag	Loop	I/O	Location	Description 1	Description 2	Drawing #
L	130	AI	PLC-1		PLC-1	8930A1123N001.DWG
L	180	AI	PLC-1		PLC-1	8930A1128N001.DWG
A	181	AI	PLC-1	TURB	PLC-1	8930A1128N001.DWG
SB	181	AI	PLC-1	SPEED IN	PLC-1	8930A1128N001.DWG
SB	182	AI	PLC-1	SPEED IN	PLC-1	8930A1128N001.DWG
SB	183	AI	PLC-1	SPEED IN	PLC-1	8930A1128N002.DWG
SB	184	AI	PLC-1	SPEED IN	PLC-1	8930A1128N002.DWG
31-A	230	AI	PLC-1	TURB	PLC-1	8930A1130N001.DWG
W	270	AI	PLC-1		PLC-1	8930A1132N001.DWG
SB	271	AI	PLC-1	SPEED	PLC-1	8930A1132N002.DWG
SB	272	AI	PLC-1	SPEED	PLC-1	8930A1132N003.DWG
L	280	AI	PLC-1		PLC-1	8930A1132N004.DWG
SB	281	AI	PLC-1	SPEED	PLC-1	8930A1132N005.DWG
SB	282	AI	PLC-1	SPEED	PLC-1	8930A1132N006.DWG
SB	283	AI	PLC-1	SPEED	PLC-1	8930A1132N007.DWG
SB	284	AI	PLC-1	SPEED	PLC-1	8930A1132N008.DWG
SB	285	AI	PLC-1	SPEED	PLC-1	8930A1132N009.DWG
F	710	AI	PLC-1		PLC-1	8930A1160N001.DWG
L	711	AI	PLC-1		PLC-1	8930A1160N001.DWG
L	712	AI	PLC-1		PLC-1	8930A1160N002.DWG
A	713	AI	PLC-1	CL	PLC-1	8930A1160N003.DWG
I	714	AI	PLC-1	CURRENT	PLC-1	8930A1160N003.DWG
A	715	AI	PLC-1	CL	PLC-1	8930A1160N003.DWG
L	715	AI	PLC-1		PLC-1	8930A1160N003.DWG
F	720	AI	PLC-1		PLC-1	8930A1170N001.DWG
F	734	AI	PLC-1		PLC-1	8930A1160N005.DWG
P	734	AI	PLC-1		PLC-1	8930A1160N005.DWG

PLC I/O Listing for PLC-1

Tag	Loop	I/O	Location	Description 1	Description 2	Drawing #
L	760	AI	PLC-1		PLC-1	8930A1160N006.DWG
F	764	AI	PLC-1		PLC-1	8930A1160N008.DWG
P	764	AI	PLC-1		PLC-1	8930A1160N008.DWG
Total AI Points = 30						
SS	181	AO	PLC-1	SPEED OUT	PLC-1	8930A1128N001.DWG
SS	182	AO	PLC-1	SPEED OUT	PLC-1	8930A1128N001.DWG
SS	183	AO	PLC-1	SPEED OUT	PLC-1	8930A1128N002.DWG
SS	184	AO	PLC-1	SPEED OUT	PLC-1	8930A1128N002.DWG
F	247	AO	PLC-1		PLC-1	8930A1131N002.DWG
FC	271	AO	PLC-1	SPEED OUT	PLC-1	8930A1132N002.DWG
FC	272	AO	PLC-1	SPEED OUT	PLC-1	8930A1132N003.DWG
FC	281	AO	PLC-1	SPEED OUT	PLC-1	8930A1132N005.DWG
FC	282	AO	PLC-1	SPEED OUT	PLC-1	8930A1132N006.DWG
FC	283	AO	PLC-1	SPEED OUT	PLC-1	8930A1132N007.DWG
FC	284	AO	PLC-1	SPEED OUT	PLC-1	8930A1132N008.DWG
FC	285	AO	PLC-1	SPEED OUT	PLC-1	8930A1132N009.DWG
Total AO Points = 12						
JS1	001	DI	PLC-1	24V PWR SUP FAIL	PLC-1	8930A1170N002.DWG
JS2	001	DI	PLC-1	24V PWR SUP FAIL	PLC-1	8930A1170N002.DWG
JS3	001	DI	PLC-1	DIODE BRIDGE FAIL	PLC-1	8930A1170N002.DWG
TSH	001	DI	PLC-1	PLC TEMP	PLC-1	8930A1170N002.DWG
ZS	001	DI	PLC-1	INTRUSION	PLC-1	8930A1170N002.DWG
AUX1	111	DI	PLC-1	RUNNING	PLC-1	8930A1121N001.DWG
AUX2	111	DI	PLC-1	OL	PLC-1	8930A1121N001.DWG
HSAR	111	DI	PLC-1	REMOTE	PLC-1	8930A1121N001.DWG
TSH	111	DI	PLC-1	HI TEMP	PLC-1	8930A1121N001.DWG

PLC I/O Listing for PLC-1

Tag	Loop	I/O	Location	Description 1	Description 2	Drawing #
XS	111	DI	PLC-1	SHEAR PIN	PLC-1	8930A1121N001.DWG
XSH	111	DI	PLC-1	HI TORQUE	PLC-1	8930A1121N001.DWG
XSHH	111	DI	PLC-1	HI HI TORQUE	PLC-1	8930A1121N001.DWG
ZS	111	DI	PLC-1	SKIMMER ARM POS	PLC-1	8930A1121N001.DWG
AUX1	112	DI	PLC-1	RUNNING	PLC-1	8930A1121N002.DWG
AUX2	112	DI	PLC-1	OL	PLC-1	8930A1121N002.DWG
HSAR	112	DI	PLC-1	REMOTE	PLC-1	8930A1121N002.DWG
TSH	112	DI	PLC-1	HI TEMP	PLC-1	8930A1121N002.DWG
XS	112	DI	PLC-1	SHEAR PIN	PLC-1	8930A1121N002.DWG
XSH	112	DI	PLC-1	HI TORQUE	PLC-1	8930A1121N002.DWG
XSHH	112	DI	PLC-1	HI HI TORQUE	PLC-1	8930A1121N002.DWG
ZS	112	DI	PLC-1	SKIMMER ARM POS	PLC-1	8930A1121N002.DWG
HSAR	130	DI	PLC-1	REMOTE	PLC-1	8930A1123N001.DWG
ZSC	130	DI	PLC-1	CLOSED	PLC-1	8930A1123N001.DWG
ZSO	130	DI	PLC-1	OPENED	PLC-1	8930A1123N001.DWG
AUX1	131	DI	PLC-1	RUNNING	PLC-1	8930A1123N001.DWG
AUX2	131	DI	PLC-1	OL	PLC-1	8930A1123N001.DWG
HSAR	131	DI	PLC-1	REMOTE	PLC-1	8930A1123N001.DWG
MSH	131	DI	PLC-1		PLC-1	8930A1123N001.DWG
TSH	131	DI	PLC-1		PLC-1	8930A1123N001.DWG
AUX1	132	DI	PLC-1	RUNNING	PLC-1	8930A1123N001.DWG
AUX2	132	DI	PLC-1	OL	PLC-1	8930A1123N001.DWG
HSAR	132	DI	PLC-1	REMOTE	PLC-1	8930A1123N001.DWG
MSH	132	DI	PLC-1		PLC-1	8930A1123N001.DWG
TSH	132	DI	PLC-1		PLC-1	8930A1123N001.DWG
AUX1	181	DI	PLC-1	RUNNING	PLC-1	8930A1128N001.DWG
AUX2	181	DI	PLC-1	FAILED	PLC-1	8930A1128N001.DWG

PLC I/O Listing for PLC-1

Tag	Loop	I/O	Location	Description 1	Description 2	Drawing #
HSAR	181	DI	PLC-1	REMOTE	PLC-1	8930A1128N001.DWG
MSH	181	DI	PLC-1	MOISTURE	PLC-1	8930A1128N001.DWG
TSH	181	DI	PLC-1		PLC-1	8930A1128N001.DWG
AUX1	182	DI	PLC-1	RUNNING	PLC-1	8930A1128N001.DWG
AUX2	182	DI	PLC-1	FAILED	PLC-1	8930A1128N001.DWG
HSAR	182	DI	PLC-1	REMOTE	PLC-1	8930A1128N001.DWG
MSH	182	DI	PLC-1	MOISTURE	PLC-1	8930A1128N001.DWG
TSH	182	DI	PLC-1		PLC-1	8930A1128N001.DWG
AUX1	183	DI	PLC-1	RUNNING	PLC-1	8930A1128N002.DWG
AUX2	183	DI	PLC-1	FAILED	PLC-1	8930A1128N002.DWG
HSAR	183	DI	PLC-1	REMOTE	PLC-1	8930A1128N002.DWG
MSH	183	DI	PLC-1	MOISTURE	PLC-1	8930A1128N002.DWG
TSH	183	DI	PLC-1		PLC-1	8930A1128N002.DWG
AUX1	184	DI	PLC-1	RUNNING	PLC-1	8930A1128N002.DWG
AUX2	184	DI	PLC-1	FAILED	PLC-1	8930A1128N002.DWG
HSAR	184	DI	PLC-1	REMOTE	PLC-1	8930A1128N002.DWG
MSH	184	DI	PLC-1	MOISTURE	PLC-1	8930A1128N002.DWG
TSH	184	DI	PLC-1		PLC-1	8930A1128N002.DWG
AUX1	185	DI	PLC-1	RUNNING	PLC-1	8930A1128N003.DWG
AUX2	185	DI	PLC-1	OL	PLC-1	8930A1128N003.DWG
HSAR	185	DI	PLC-1	REMOTE	PLC-1	8930A1128N003.DWG
PSH	185	DI	PLC-1	PRESS	PLC-1	8930A1128N003.DWG
TSH	185	DI	PLC-1	TEMP	PLC-1	8930A1128N003.DWG
AUX1	186	DI	PLC-1	RUNNING	PLC-1	8930A1128N003.DWG
AUX2	186	DI	PLC-1	OL	PLC-1	8930A1128N003.DWG
HSAR	186	DI	PLC-1	REMOTE	PLC-1	8930A1128N003.DWG
PSH	186	DI	PLC-1	PRESS	PLC-1	8930A1128N003.DWG

PLC I/O Listing for PLC-1

Tag	Loop	I/O	Location	Description 1	Description 2	Drawing #
TSH	186	DI	PLC-1	TEMP	PLC-1	8930A1128N003.DWG
LSH	189	DI	PLC-1		PLC-1	8930A1128N001.DWG
LSLL	189	DI	PLC-1		PLC-1	8930A1128N001.DWG
HSAR	211	DI	PLC-1	REMOTE	PLC-1	8930A1130N002.DWG
ZSC	211	DI	PLC-1	CLOSED	PLC-1	8930A1130N002.DWG
ZSO	211	DI	PLC-1	OPENED	PLC-1	8930A1130N002.DWG
HSAR	221	DI	PLC-1	REMOTE	PLC-1	8930A1130N003.DWG
ZSC	221	DI	PLC-1	CLOSED	PLC-1	8930A1130N003.DWG
ZSO	221	DI	PLC-1	OPENED	PLC-1	8930A1130N003.DWG
HSAR	240	DI	PLC-1	REMOTE	PLC-1	8930A1131N001.DWG
ZSC	240	DI	PLC-1	CLOSED	PLC-1	8930A1131N001.DWG
ZSO	240	DI	PLC-1	OPENED	PLC-1	8930A1131N001.DWG
AUX2	247	DI	PLC-1	FAILED	PLC-1	8930A1131N002.DWG
HSAR	247	DI	PLC-1	REMOTE	PLC-1	8930A1131N001.DWG
ZSC	247	DI	PLC-1	CLOSED	PLC-1	8930A1131N001.DWG
ZSO	247	DI	PLC-1	OPENED	PLC-1	8930A1131N001.DWG
HSAR	248	DI	PLC-1	REMOTE	PLC-1	8930A1131N002.DWG
ZSC	248	DI	PLC-1	CLOSED	PLC-1	8930A1131N002.DWG
ZSO	248	DI	PLC-1	OPENED	PLC-1	8930A1131N002.DWG
HSAR	249	DI	PLC-1	REMOTE	PLC-1	8930A1131N003.DWG
ZSC	249	DI	PLC-1	CLOSED	PLC-1	8930A1131N003.DWG
ZSO	249	DI	PLC-1	OPENED	PLC-1	8930A1131N003.DWG
AUX1	271	DI	PLC-1	RUNNING	PLC-1	8930A1132N002.DWG
AUX2	271	DI	PLC-1	FAILED	PLC-1	8930A1132N002.DWG
HSAR	271	DI	PLC-1	REMOTE	PLC-1	8930A1132N002.DWG
LSH	271	DI	PLC-1	LEAK	PLC-1	8930A1132N002.DWG
AUX1	272	DI	PLC-1	RUNNING	PLC-1	8930A1132N003.DWG

PLC I/O Listing for PLC-1

Tag	Loop	I/O	Location	Description 1	Description 2	Drawing #
AUX2	272	DI	PLC-1	FAILED	PLC-1	8930A1132N003.DWG
HSAR	272	DI	PLC-1	REMOTE	PLC-1	8930A1132N003.DWG
LSH	272	DI	PLC-1	LEAK	PLC-1	8930A1132N003.DWG
LSH	273	DI	PLC-1		PLC-1	8930A1132N003.DWG
LSH	280	DI	PLC-1		PLC-1	8930A1132N004.DWG
AUX1	281	DI	PLC-1	RUNNING	PLC-1	8930A1132N005.DWG
AUX2	281	DI	PLC-1	FAILED	PLC-1	8930A1132N005.DWG
HSAR	281	DI	PLC-1	REMOTE	PLC-1	8930A1132N005.DWG
LSH	281	DI	PLC-1	LEAK	PLC-1	8930A1132N005.DWG
ZSC	281B	DI	PLC-1	CLOSED	PLC-1	8930A1132N005.DWG
ZSO	281B	DI	PLC-1	OPENED	PLC-1	8930A1132N005.DWG
ZSC	281C	DI	PLC-1	CLOSED	PLC-1	8930A1132N005.DWG
ZSO	281C	DI	PLC-1	OPENED	PLC-1	8930A1132N005.DWG
ZSC	281D	DI	PLC-1	CLOSED	PLC-1	8930A1132N005.DWG
ZSO	281D	DI	PLC-1	OPENED	PLC-1	8930A1132N005.DWG
AUX1	282	DI	PLC-1	RUNNING	PLC-1	8930A1132N006.DWG
AUX2	282	DI	PLC-1	FAILED	PLC-1	8930A1132N006.DWG
HSAR	282	DI	PLC-1	REMOTE	PLC-1	8930A1132N006.DWG
LSH	282	DI	PLC-1	LEAK	PLC-1	8930A1132N006.DWG
AUX1	283	DI	PLC-1	RUNNING	PLC-1	8930A1132N007.DWG
HSAR	283	DI	PLC-1	REMOTE	PLC-1	8930A1132N007.DWG
LSH	283	DI	PLC-1	LEAK	PLC-1	8930A1132N007.DWG
AUX1	284	DI	PLC-1	RUNNING	PLC-1	8930A1132N008.DWG
HSAR	284	DI	PLC-1	REMOTE	PLC-1	8930A1132N008.DWG
LSH	284	DI	PLC-1	LEAK	PLC-1	8930A1132N008.DWG
AUX1	285	DI	PLC-1	RUNNING	PLC-1	8930A1132N009.DWG
HSAR	285	DI	PLC-1	REMOTE	PLC-1	8930A1132N009.DWG

PLC I/O Listing for PLC-1

Tag	Loop	I/O	Location	Description 1	Description 2	Drawing #
LSH	285	DI	PLC-1	LEAK	PLC-1	8930A1132N009.DWG
AUX1	711	DI	PLC-1	RUNNING	PLC-1	8930A1160N001.DWG
AUX2	711	DI	PLC-1	OL	PLC-1	8930A1160N001.DWG
HSAR	711	DI	PLC-1	REMOTE	PLC-1	8930A1160N001.DWG
AUX1	712	DI	PLC-1	RUNNING	PLC-1	8930A1160N002.DWG
AUX2	712	DI	PLC-1	OL	PLC-1	8930A1160N002.DWG
HSAR	712	DI	PLC-1	REMOTE	PLC-1	8930A1160N002.DWG
YB	716	DI	PLC-1	BACKWASH	PLC-1	8930A1160N003.DWG
AUX1	720	DI	PLC-1	RUNNING	PLC-1	8930A1170N001.DWG
AUX2	720	DI	PLC-1	FAILED	PLC-1	8930A1170N001.DWG
IS1	720	DI	PLC-1	PHASE LOSS	PLC-1	8930A1170N001.DWG
IS2	720	DI	PLC-1	PHASE REVERSAL	PLC-1	8930A1170N001.DWG
ZSE	720	DI	PLC-1	TRANSFER SWITCH EMERGENCY	PLC-1	8930A1170N001.DWG
ZSN	720	DI	PLC-1	TRANSFER SWITCH NORMAL	PLC-1	8930A1170N001.DWG
AUX1	721	DI	PLC-1	RUNNING	PLC-1	8930A1170N001.DWG
AUX1	721	DI	PLC-1	RUNNING	PLC-1	8930A1170N003.DWG
AUX2	721	DI	PLC-1	FAILED	PLC-1	8930A1170N001.DWG
AUX1	731	DI	PLC-1	RUNNING	PLC-1	8930A1160N004.DWG
AUX2	731	DI	PLC-1	OL	PLC-1	8930A1160N004.DWG
HSAR	731	DI	PLC-1	REMOTE	PLC-1	8930A1160N004.DWG
PSH	731	DI	PLC-1		PLC-1	8930A1160N004.DWG
TSH	731	DI	PLC-1		PLC-1	8930A1160N004.DWG
AUX1	732	DI	PLC-1	RUNNING	PLC-1	8930A1160N004.DWG
AUX2	732	DI	PLC-1	OL	PLC-1	8930A1160N004.DWG
HSAR	732	DI	PLC-1	REMOTE	PLC-1	8930A1160N004.DWG
PSH	732	DI	PLC-1		PLC-1	8930A1160N004.DWG
TSH	732	DI	PLC-1		PLC-1	8930A1160N004.DWG

PLC I/O Listing for PLC-1

Tag	Loop	I/O	Location	Description 1	Description 2	Drawing #
AUX1	733	DI	PLC-1	RUNNING	PLC-1	8930A1160N004.DWG
AUX2	733	DI	PLC-1	OL	PLC-1	8930A1160N004.DWG
HSAR	733	DI	PLC-1	REMOTE	PLC-1	8930A1160N004.DWG
PSH	733	DI	PLC-1		PLC-1	8930A1160N004.DWG
TSH	733	DI	PLC-1		PLC-1	8930A1160N004.DWG
AUX1	761	DI	PLC-1	RUNNING	PLC-1	8930A1160N007.DWG
AUX2	761	DI	PLC-1	OL	PLC-1	8930A1160N007.DWG
HSAR	761	DI	PLC-1	REMOTE	PLC-1	8930A1160N007.DWG
PSH	761	DI	PLC-1		PLC-1	8930A1160N007.DWG
TSH	761	DI	PLC-1		PLC-1	8930A1160N007.DWG
AUX1	762	DI	PLC-1	RUNNING	PLC-1	8930A1160N007.DWG
AUX2	762	DI	PLC-1	OL	PLC-1	8930A1160N007.DWG
HSAR	762	DI	PLC-1	REMOTE	PLC-1	8930A1160N007.DWG
PSH	762	DI	PLC-1		PLC-1	8930A1160N007.DWG
TSH	762	DI	PLC-1		PLC-1	8930A1160N007.DWG
AUX1	763	DI	PLC-1	RUNNING	PLC-1	8930A1160N007.DWG
AUX2	763	DI	PLC-1	OL	PLC-1	8930A1160N007.DWG
HSAR	763	DI	PLC-1	REMOTE	PLC-1	8930A1160N007.DWG
PSH	763	DI	PLC-1		PLC-1	8930A1160N007.DWG
TSH	763	DI	PLC-1		PLC-1	8930A1160N007.DWG
FSH	769C	DI	PLC-1		PLC-1	8930A1132N010.DWG
FSH	769D	DI	PLC-1		PLC-1	8930A1132N010.DWG
FSH	769E	DI	PLC-1		PLC-1	8930A1132N010.DWG
FSH	769H	DI	PLC-1		PLC-1	8930A1121N001.DWG
FSH	769J	DI	PLC-1		PLC-1	8930A1121N002.DWG
AUX1	800	DI	PLC-1	RUNNING	PLC-1	8930A1170N003.DWG
AUX2	800	DI	PLC-1	FAIL	PLC-1	8930A1170N003.DWG

PLC I/O Listing for PLC-1

Tag	Loop	I/O	Location	Description 1	Description 2	Drawing #
XSH	800	DI	PLC-1	SMOKE	PLC-1	8930A1170N003.DWG
AUX1	801	DI	PLC-1	RUNNING	PLC-1	8930A1170N003.DWG
AUX1	802	DI	PLC-1	RUNNING	PLC-1	8930A1170N003.DWG
ESL	802	DI	PLC-1	PWR FAIL	PLC-1	8930A1170N002.DWG
ZSA	802	DI	PLC-1	AUTO	PLC-1	8930A1170N002.DWG
ZSE	802	DI	PLC-1	EMERGENCY	PLC-1	8930A1170N002.DWG
ZSN	802	DI	PLC-1	NORMAL	PLC-1	8930A1170N002.DWG
ZST	802	DI	PLC-1	TEST	PLC-1	8930A1170N002.DWG
Total DI Points = 179						
MS	111	DO	PLC-1	RUN	PLC-1	8930A1121N001.DWG
SV	111	DO	PLC-1	SCUM SPRAY	PLC-1	8930A1121N001.DWG
MS	112	DO	PLC-1	RUN	PLC-1	8930A1121N002.DWG
SV	112	DO	PLC-1	SCUM SPRAY	PLC-1	8930A1121N002.DWG
MSC	130	DO	PLC-1	CLOSE	PLC-1	8930A1123N001.DWG
MSO	130	DO	PLC-1	OPEN	PLC-1	8930A1123N001.DWG
MS	131	DO	PLC-1	RUN	PLC-1	8930A1123N001.DWG
MS	132	DO	PLC-1	RUN	PLC-1	8930A1123N001.DWG
MS	181	DO	PLC-1	RUN	PLC-1	8930A1128N001.DWG
MS	182	DO	PLC-1	RUN	PLC-1	8930A1128N001.DWG
MS	183	DO	PLC-1	RUN	PLC-1	8930A1128N002.DWG
MS	184	DO	PLC-1	RUN	PLC-1	8930A1128N002.DWG
MS	185	DO	PLC-1	RUN	PLC-1	8930A1128N003.DWG
MS	186	DO	PLC-1	RUN	PLC-1	8930A1128N003.DWG
MSC	211	DO	PLC-1	CLOSE	PLC-1	8930A1130N002.DWG
MSO	211	DO	PLC-1	OPEN	PLC-1	8930A1130N002.DWG
MSC	221	DO	PLC-1	CLOSE	PLC-1	8930A1130N003.DWG

PLC I/O Listing for PLC-1

Tag	Loop	I/O	Location	Description 1	Description 2	Drawing #
MSO	221	DO	PLC-1	OPEN	PLC-1	8930A1130N003.DWG
MSC	240	DO	PLC-1	CLOSE	PLC-1	8930A1131N001.DWG
MSO	240	DO	PLC-1	OPEN	PLC-1	8930A1131N001.DWG
MSC	247	DO	PLC-1	CLOSE	PLC-1	8930A1131N001.DWG
MSO	247	DO	PLC-1	OPEN	PLC-1	8930A1131N001.DWG
MSC	248	DO	PLC-1	CLOSE	PLC-1	8930A1131N002.DWG
MSO	248	DO	PLC-1	OPEN	PLC-1	8930A1131N002.DWG
MSC	249	DO	PLC-1	CLOSE	PLC-1	8930A1131N003.DWG
MSO	249	DO	PLC-1	OPEN	PLC-1	8930A1131N003.DWG
XST	271	DO	PLC-1	START/STOP	PLC-1	8930A1132N002.DWG
XST	272	DO	PLC-1	START/STOP	PLC-1	8930A1132N003.DWG
XST	281	DO	PLC-1	START/STOP	PLC-1	8930A1132N005.DWG
MSC	281B	DO	PLC-1	CLOSE	PLC-1	8930A1132N005.DWG
MSO	281B	DO	PLC-1	OPEN	PLC-1	8930A1132N005.DWG
MSC	281C	DO	PLC-1	CLOSE	PLC-1	8930A1132N005.DWG
MSO	281C	DO	PLC-1	OPEN	PLC-1	8930A1132N005.DWG
MSC	281D	DO	PLC-1	CLOSE	PLC-1	8930A1132N005.DWG
MSO	281D	DO	PLC-1	OPEN	PLC-1	8930A1132N005.DWG
XST	282	DO	PLC-1	START/STOP	PLC-1	8930A1132N006.DWG
XST	283	DO	PLC-1	START/STOP	PLC-1	8930A1132N007.DWG
XST	284	DO	PLC-1	START/STOP	PLC-1	8930A1132N008.DWG
XST	285	DO	PLC-1	START/STOP	PLC-1	8930A1132N009.DWG
MS	711	DO	PLC-1	RUN	PLC-1	8930A1160N001.DWG
MS	712	DO	PLC-1	RUN	PLC-1	8930A1160N002.DWG
MS	714	DO	PLC-1	RUN	PLC-1	8930A1160N003.DWG
MS	731	DO	PLC-1	RUN	PLC-1	8930A1160N004.DWG
MS	732	DO	PLC-1	RUN	PLC-1	8930A1160N004.DWG

PLC I/O Listing for PLC-1

Tag	Loop	I/O	Location	Description 1	Description 2	Drawing #
MS	733	DO	PLC-1	RUN	PLC-1	8930A1160N004.DWG
SV	752A	DO	PLC-1	PLANT WATER	PLC-1	8930A1121N001.DWG
SV	752B	DO	PLC-1	PLANT WATER	PLC-1	8930A1121N002.DWG
MS	761	DO	PLC-1	RUN	PLC-1	8930A1160N007.DWG
MS	762	DO	PLC-1	RUN	PLC-1	8930A1160N007.DWG
MS	763	DO	PLC-1	RUN	PLC-1	8930A1160N007.DWG

Total DO Points = 50

PLC I/O Listing for PLC-2

Tag	Loop	I/O	Location	Description 1	Description 2	Drawing #
F	010	AI	PLC-2		PLC-2	8930A1110N001.DWG
L	012	AI	PLC-2		PLC-2	8930A1110N001.DWG
L	041	AI	PLC-2		PLC-2	8930A1110N001.DWG
L	042	AI	PLC-2		PLC-2	8930A1110N004.DWG
L	051	AI	PLC-2		PLC-2	8930A1110N001.DWG
L	052	AI	PLC-2		PLC-2	8930A1110N004.DWG
SB	091	AI	PLC-2	SPEED IN	PLC-2	8930A1120N001.DWG
SB	092	AI	PLC-2	SPEED IN	PLC-2	8930A1120N001.DWG
Z	094	AI	PLC-2	POSITION	PLC-2	8930A1120N001.DWG
A	095	AI	PLC-2	DO	PLC-2	8930A1120N001.DWG
SB	101	AI	PLC-2	SPEED IN	PLC-2	8930A1120N002.DWG
SB	102	AI	PLC-2	SPEED IN	PLC-2	8930A1120N002.DWG
Z	104	AI	PLC-2	POSITION	PLC-2	8930A1120N002.DWG
A	105	AI	PLC-2	DO	PLC-2	8930A1120N002.DWG
SB	121	AI	PLC-2	SPEED IN	PLC-2	8930A1150N002.DWG
SB	122	AI	PLC-2	SPEED IN	PLC-2	8930A1150N002.DWG
SB	123	AI	PLC-2	SPEED IN	PLC-2	8930A1150N002A.DWG
F	124	AI	PLC-2		PLC-2	8930A1150N001.DWG
Z1	124	AI	PLC-2	POSITION	PLC-2	8930A1150N001.DWG
F	125	AI	PLC-2		PLC-2	8930A1150N001.DWG
Z1	125	AI	PLC-2	POSITION	PLC-2	8930A1150N001.DWG
F	126	AI	PLC-2		PLC-2	8930A1150N003.DWG
F	127	AI	PLC-2		PLC-2	8930A1150N003.DWG
Z1	127	AI	PLC-2	POSITION	PLC-2	8930A1150N003.DWG
P	306	AI	PLC-2		PLC-2	8930A1140N003.DWG
F	307	AI	PLC-2		PLC-2	8930A1140N003.DWG
A	308	AI	PLC-2	CL2	PLC-2	8930A1140N003.DWG

PLC I/O Listing for PLC-2

Tag	Loop	I/O	Location	Description 1	Description 2	Drawing #
F	309	AI	PLC-2		PLC-2	8930A1150N012.DWG
L	326	AI	PLC-2		PLC-2	8930A1103N001.DWG
L	327	AI	PLC-2		PLC-2	8930A1103N001.DWG
PD	411	AI	PLC-2		PLC-2	8930A1150N008.DWG
PD	412	AI	PLC-2		PLC-2	8930A1150N009.DWG
Z	413	AI	PLC-2	POSITION	PLC-2	8930A1150N008.DWG
Z	414	AI	PLC-2	POSITION	PLC-2	8930A1150N008.DWG
Z	415	AI	PLC-2	POSITION	PLC-2	8930A1150N009.DWG
Z	416	AI	PLC-2	POSITION	PLC-2	8930A1150N009.DWG
SB	423	AI	PLC-2	SPEED IN	PLC-2	8930A1150N010.DWG
F	425	AI	PLC-2		PLC-2	8930A1150N010.DWG
SB	427	AI	PLC-2	SPEED IN	PLC-2	8930A1150N011.DWG
F	429	AI	PLC-2		PLC-2	8930A1150N011.DWG
W	441	AI	PLC-2		PLC-2	8930A1151N004.DWG
W	442	AI	PLC-2		PLC-2	8930A1151N004.DWG
W	443	AI	PLC-2		PLC-2	8930A1151N004.DWG
SI	451	AI	PLC-2	SPEED IN	PLC-2	8930A1151N005.DWG
SI	452	AI	PLC-2	SPEED IN	PLC-2	8930A1151N005.DWG
SI	453	AI	PLC-2	SPEED IN	PLC-2	8930A1151N006.DWG
SB	501	AI	PLC-2	SPEED IN	PLC-2	8930A1104N001.DWG
SB	502	AI	PLC-2	SPEED IN	PLC-2	8930A1104N001.DWG
F	503	AI	PLC-2		PLC-2	8930A1104N001.DWG
L	504	AI	PLC-2		PLC-2	8930A1104N001.DWG
L	600	AI	PLC-2		PLC-2	8930A1104N002.DWG
F	603	AI	PLC-2		PLC-2	8930A1104N002.DWG

Total AI Points = 52

PLC I/O Listing for PLC-2

Tag	Loop	I/O	Location	Description 1	Description 2	Drawing #
F	011	AO	PLC-2		PLC-2	8930A1110N001.DWG
SS	091	AO	PLC-2	SPEED OUT	PLC-2	8930A1120N001.DWG
SS	092	AO	PLC-2	SPEED OUT	PLC-2	8930A1120N001.DWG
SS	101	AO	PLC-2	SPEED OUT	PLC-2	8930A1120N002.DWG
SS	102	AO	PLC-2	SPEED OUT	PLC-2	8930A1120N002.DWG
SS	121	AO	PLC-2	SPEED OUT	PLC-2	8930A1150N002.DWG
SS	122	AO	PLC-2	SPEED OUT	PLC-2	8930A1150N002.DWG
SS	123	AO	PLC-2	SPEED OUT	PLC-2	8930A1150N002A.DWG
Z2	124	AO	PLC-2	POSITION	PLC-2	8930A1150N001.DWG
Z2	125	AO	PLC-2	POSITION	PLC-2	8930A1150N001.DWG
F	126	AO	PLC-2		PLC-2	8930A1150N003.DWG
Z2	127	AO	PLC-2	POSITION	PLC-2	8930A1150N003.DWG
SS	423	AO	PLC-2	SPEED OUT	PLC-2	8930A1150N010.DWG
SS	427	AO	PLC-2	SPEED OUT	PLC-2	8930A1150N011.DWG
SS	451	AO	PLC-2	SPEED OUT	PLC-2	8930A1151N005.DWG
SS	452	AO	PLC-2	SPEED OUT	PLC-2	8930A1151N005.DWG
SS	453	AO	PLC-2	SPEED OUT	PLC-2	8930A1151N006.DWG
SS	501	AO	PLC-2	SPEED OUT	PLC-2	8930A1104N001.DWG
SS	502	AO	PLC-2	SPEED OUT	PLC-2	8930A1104N001.DWG
Total AO Points = 19						
JS1	002	DI	PLC-2	24V PWR SUP FAIL	PLC-2	8930A1151N007.DWG
JS2	002	DI	PLC-2	24V PWR SUP FAIL	PLC-2	8930A1151N007.DWG
JS3	002	DI	PLC-2	DIODE BRIDGE FAIL	PLC-2	8930A1151N007.DWG
TSH	002	DI	PLC-2	PLC TEMP	PLC-2	8930A1151N007.DWG
ZS	002	DI	PLC-2	INTRUSION	PLC-2	8930A1151N007.DWG
AUX2	011	DI	PLC-2	FAILED	PLC-2	8930A1110N001.DWG

PLC I/O Listing for PLC-2

Tag	Loop	I/O	Location	Description 1	Description 2	Drawing #
HSAR	041	DI	PLC-2	REMOTE	PLC-2	8930A1110N001.DWG
ZSC	041	DI	PLC-2	CLOSED	PLC-2	8930A1110N001.DWG
ZSO	041	DI	PLC-2	OPENED	PLC-2	8930A1110N001.DWG
HSAR	042	DI	PLC-2	REMOTE	PLC-2	8930A1110N004.DWG
ZSC	042	DI	PLC-2	CLOSED	PLC-2	8930A1110N004.DWG
ZSO	042	DI	PLC-2	OPENED	PLC-2	8930A1110N004.DWG
HSAR	051	DI	PLC-2	REMOTE	PLC-2	8930A1110N001.DWG
ZSC	051	DI	PLC-2	CLOSED	PLC-2	8930A1110N001.DWG
ZSO	051	DI	PLC-2	OPENED	PLC-2	8930A1110N001.DWG
HSAR	052	DI	PLC-2	REMOTE	PLC-2	8930A1110N004.DWG
ZSC	052	DI	PLC-2	CLOSED	PLC-2	8930A1110N004.DWG
ZSO	052	DI	PLC-2	OPENED	PLC-2	8930A1110N004.DWG
AUX2	070	DI	PLC-2	FAILED	PLC-2	8930A1111N002.DWG
AUX1	071	DI	PLC-2	RUNNING	PLC-2	8930A1111N001.DWG
AUX2	071	DI	PLC-2	OL	PLC-2	8930A1111N001.DWG
HSAR	071	DI	PLC-2	REMOTE	PLC-2	8930A1111N001.DWG
TSH	071	DI	PLC-2	HIGH TEMP	PLC-2	8930A1111N001.DWG
AUX1	072	DI	PLC-2	RUNNING	PLC-2	8930A1111N001.DWG
AUX2	072	DI	PLC-2	OL	PLC-2	8930A1111N001.DWG
HSAR	072	DI	PLC-2	REMOTE	PLC-2	8930A1111N001.DWG
TSH	072	DI	PLC-2	HIGH TEMP	PLC-2	8930A1111N001.DWG
AUX1	090	DI	PLC-2	RUNNING	PLC-2	8930A1120N001.DWG
AUX2	090	DI	PLC-2	OL	PLC-2	8930A1120N001.DWG
HSAR	090	DI	PLC-2	REMOTE	PLC-2	8930A1120N001.DWG
LSL	090	DI	PLC-2	LOW OIL	PLC-2	8930A1120N001.DWG
TSH	090	DI	PLC-2		PLC-2	8930A1120N001.DWG
AUX1	091	DI	PLC-2	RUNNING	PLC-2	8930A1120N001.DWG

PLC I/O Listing for PLC-2

Tag	Loop	I/O	Location	Description 1	Description 2	Drawing #
AUX2	091	DI	PLC-2	FAILED	PLC-2	8930A1120N001.DWG
HSAR	091	DI	PLC-2	REMOTE	PLC-2	8930A1120N001.DWG
LSL	091	DI	PLC-2	LOW OIL	PLC-2	8930A1120N001.DWG
TSH	091	DI	PLC-2		PLC-2	8930A1120N001.DWG
AUX1	092	DI	PLC-2	RUNNING	PLC-2	8930A1120N001.DWG
AUX2	092	DI	PLC-2	FAILED	PLC-2	8930A1120N001.DWG
HSAR	092	DI	PLC-2	REMOTE	PLC-2	8930A1120N001.DWG
LSL	092	DI	PLC-2	LOW OIL	PLC-2	8930A1120N001.DWG
TSH	092	DI	PLC-2		PLC-2	8930A1120N001.DWG
HSAR	094	DI	PLC-2	REMOTE	PLC-2	8930A1120N001.DWG
ZSC	094	DI	PLC-2	CLOSED	PLC-2	8930A1120N001.DWG
ZSO	094	DI	PLC-2	OPENED	PLC-2	8930A1120N001.DWG
AUX1	100	DI	PLC-2	RUNNING	PLC-2	8930A1120N002.DWG
AUX2	100	DI	PLC-2	OL	PLC-2	8930A1120N002.DWG
HSAR	100	DI	PLC-2	REMOTE	PLC-2	8930A1120N002.DWG
LSL	100	DI	PLC-2	LOW OIL	PLC-2	8930A1120N002.DWG
TSH	100	DI	PLC-2		PLC-2	8930A1120N002.DWG
AUX1	101	DI	PLC-2	RUNNING	PLC-2	8930A1120N002.DWG
AUX2	101	DI	PLC-2	FAILED	PLC-2	8930A1120N002.DWG
HSAR	101	DI	PLC-2	REMOTE	PLC-2	8930A1120N002.DWG
LSL	101	DI	PLC-2	LOW OIL	PLC-2	8930A1120N002.DWG
TSH	101	DI	PLC-2		PLC-2	8930A1120N002.DWG
AUX1	102	DI	PLC-2	RUNNING	PLC-2	8930A1120N002.DWG
AUX2	102	DI	PLC-2	FAILED	PLC-2	8930A1120N002.DWG
HSAR	102	DI	PLC-2	REMOTE	PLC-2	8930A1120N002.DWG
LSL	102	DI	PLC-2	LOW OIL	PLC-2	8930A1120N002.DWG
TSH	102	DI	PLC-2		PLC-2	8930A1120N002.DWG

PLC I/O Listing for PLC-2

Tag	Loop	I/O	Location	Description 1	Description 2	Drawing #
HSAR	104	DI	PLC-2	REMOTE	PLC-2	8930A1120N002.DWG
ZSC	104	DI	PLC-2	CLOSED	PLC-2	8930A1120N002.DWG
ZSO	104	DI	PLC-2	OPENED	PLC-2	8930A1120N002.DWG
AUX1	121	DI	PLC-2	RUNNING	PLC-2	8930A1150N002.DWG
AUX2	121	DI	PLC-2	FAILED	PLC-2	8930A1150N002.DWG
FSL	121	DI	PLC-2	SEAL WATER FAIL	PLC-2	8930A1150N002.DWG
HSAR	121	DI	PLC-2	REMOTE	PLC-2	8930A1150N002.DWG
PSH	121	DI	PLC-2		PLC-2	8930A1150N002.DWG
TSH	121	DI	PLC-2		PLC-2	8930A1150N002.DWG
AUX1	122	DI	PLC-2	RUNNING	PLC-2	8930A1150N002.DWG
AUX2	122	DI	PLC-2	FAILED	PLC-2	8930A1150N002.DWG
FSL	122	DI	PLC-2	SEAL WATER FAIL	PLC-2	8930A1150N002.DWG
HSAR	122	DI	PLC-2	REMOTE	PLC-2	8930A1150N002.DWG
PSH	122	DI	PLC-2		PLC-2	8930A1150N002.DWG
TSH	122	DI	PLC-2		PLC-2	8930A1150N002.DWG
AUX1	123	DI	PLC-2	RUNNING	PLC-2	8930A1150N002A.DWG
AUX2	123	DI	PLC-2	FAILED	PLC-2	8930A1150N002A.DWG
FSL	123	DI	PLC-2	SEAL WATER FAIL	PLC-2	8930A1150N002A.DWG
HSAR	123	DI	PLC-2	REMOTE	PLC-2	8930A1150N002A.DWG
PSH	123	DI	PLC-2		PLC-2	8930A1150N002A.DWG
TSH	123	DI	PLC-2		PLC-2	8930A1150N002A.DWG
HSAR	124	DI	PLC-2	REMOTE	PLC-2	8930A1150N001.DWG
ZSC	124	DI	PLC-2	CLOSED	PLC-2	8930A1150N001.DWG
ZSO	124	DI	PLC-2	OPENED	PLC-2	8930A1150N001.DWG
HSAR	125	DI	PLC-2	REMOTE	PLC-2	8930A1150N001.DWG
ZSC	125	DI	PLC-2	CLOSED	PLC-2	8930A1150N001.DWG
ZSO	125	DI	PLC-2	OPENED	PLC-2	8930A1150N001.DWG

PLC I/O Listing for PLC-2

Tag	Loop	I/O	Location	Description 1	Description 2	Drawing #
AUX2	126	DI	PLC-2	FAILED	PLC-2	8930A1150N003.DWG
HSAR	127	DI	PLC-2	REMOTE	PLC-2	8930A1150N003.DWG
ZSC	127	DI	PLC-2	CLOSED	PLC-2	8930A1150N003.DWG
ZSO	127	DI	PLC-2	OPENED	PLC-2	8930A1150N003.DWG
HSAR	128	DI	PLC-2	REMOTE	PLC-2	8930A1150N003.DWG
ZSC	128	DI	PLC-2	CLOSED	PLC-2	8930A1150N003.DWG
ZSO	128	DI	PLC-2	OPENED	PLC-2	8930A1150N003.DWG
HSAR	129	DI	PLC-2	REMOTE	PLC-2	8930A1150N003.DWG
ZSC	129	DI	PLC-2	CLOSED	PLC-2	8930A1150N003.DWG
ZSO	129	DI	PLC-2	OPENED	PLC-2	8930A1150N003.DWG
AUX1	301	DI	PLC-2	RUNNING	PLC-2	8930A1140N001.DWG
AUX2	301	DI	PLC-2	FAILED	PLC-2	8930A1140N001.DWG
HSAR	301	DI	PLC-2	REMOTE	PLC-2	8930A1140N001.DWG
PSH	301	DI	PLC-2		PLC-2	8930A1140N001.DWG
TSH	301	DI	PLC-2	TEMP	PLC-2	8930A1140N001.DWG
AUX1	302	DI	PLC-2	RUNNING	PLC-2	8930A1140N001.DWG
AUX2	302	DI	PLC-2	FAILED	PLC-2	8930A1140N001.DWG
HSAR	302	DI	PLC-2	REMOTE	PLC-2	8930A1140N001.DWG
PSH	302	DI	PLC-2		PLC-2	8930A1140N001.DWG
TSH	302	DI	PLC-2	TEMP	PLC-2	8930A1140N001.DWG
AUX1	303	DI	PLC-2	RUNNING	PLC-2	8930A1140N002.DWG
AUX2	303	DI	PLC-2	FAILED	PLC-2	8930A1140N002.DWG
HSAR	303	DI	PLC-2	REMOTE	PLC-2	8930A1140N002.DWG
PSH	303	DI	PLC-2		PLC-2	8930A1140N002.DWG
TSH	303	DI	PLC-2	TEMP	PLC-2	8930A1140N002.DWG
AUX1	304	DI	PLC-2	RUNNING	PLC-2	8930A1140N002.DWG
AUX2	304	DI	PLC-2	FAILED	PLC-2	8930A1140N002.DWG

PLC I/O Listing for PLC-2

Tag	Loop	I/O	Location	Description 1	Description 2	Drawing #
HSAR	304	DI	PLC-2	REMOTE	PLC-2	8930A1140N002.DWG
PSH	304	DI	PLC-2		PLC-2	8930A1140N002.DWG
TSH	304	DI	PLC-2	TEMP	PLC-2	8930A1140N002.DWG
HSAR	321	DI	PLC-2	REMOTE	PLC-2	8930A1103N001.DWG
ZSC	321	DI	PLC-2	CLOSED	PLC-2	8930A1103N001.DWG
ZSO	321	DI	PLC-2	OPENED	PLC-2	8930A1103N001.DWG
HSAR	322	DI	PLC-2	REMOTE	PLC-2	8930A1103N001.DWG
ZSC	322	DI	PLC-2	CLOSED	PLC-2	8930A1103N001.DWG
ZSO	322	DI	PLC-2	OPENED	PLC-2	8930A1103N001.DWG
HSAR	323	DI	PLC-2	REMOTE	PLC-2	8930A1103N001.DWG
ZSC	323	DI	PLC-2	CLOSED	PLC-2	8930A1103N001.DWG
ZSO	323	DI	PLC-2	OPENED	PLC-2	8930A1103N001.DWG
HSAR	324	DI	PLC-2	REMOTE	PLC-2	8930A1103N001.DWG
ZSC	324	DI	PLC-2	CLOSED	PLC-2	8930A1103N001.DWG
ZSO	324	DI	PLC-2	OPENED	PLC-2	8930A1103N001.DWG
HSAR	325	DI	PLC-2	REMOTE	PLC-2	8930A1103N001.DWG
ZSC	325	DI	PLC-2	CLOSED	PLC-2	8930A1103N001.DWG
ZSO	325	DI	PLC-2	OPENED	PLC-2	8930A1103N001.DWG
AUX1	401	DI	PLC-2	RUNNING	PLC-2	8930A1150N004.DWG
AUX2	401	DI	PLC-2	FAILED	PLC-2	8930A1150N004.DWG
HSAR	401	DI	PLC-2	REMOTE	PLC-2	8930A1150N004.DWG
TSH	401	DI	PLC-2		PLC-2	8930A1150N004.DWG
PSH	401A	DI	PLC-2		PLC-2	8930A1150N004.DWG
TSH	401A	DI	PLC-2	TEMP	PLC-2	8930A1150N004.DWG
PSH	401B	DI	PLC-2		PLC-2	8930A1150N004.DWG
AUX1	402	DI	PLC-2	RUNNING	PLC-2	8930A1150N005.DWG
AUX2	402	DI	PLC-2	FAILED	PLC-2	8930A1150N005.DWG

PLC I/O Listing for PLC-2

Tag	Loop	I/O	Location	Description 1	Description 2	Drawing #
HSAR	402	DI	PLC-2	REMOTE	PLC-2	8930A1150N005.DWG
TSH	402	DI	PLC-2		PLC-2	8930A1150N005.DWG
PSH	402A	DI	PLC-2		PLC-2	8930A1150N005.DWG
TSH	402A	DI	PLC-2	TEMP	PLC-2	8930A1150N005.DWG
PSH	402B	DI	PLC-2		PLC-2	8930A1150N005.DWG
AUX1	403	DI	PLC-2	RUNNING	PLC-2	8930A1150N006.DWG
AUX2	403	DI	PLC-2	FAILED	PLC-2	8930A1150N006.DWG
HSAR	403	DI	PLC-2	REMOTE	PLC-2	8930A1150N006.DWG
TSH	403	DI	PLC-2		PLC-2	8930A1150N006.DWG
PSH	403A	DI	PLC-2		PLC-2	8930A1150N006.DWG
TSH	403A	DI	PLC-2	TEMP	PLC-2	8930A1150N006.DWG
PSH	403B	DI	PLC-2		PLC-2	8930A1150N006.DWG
HSAR	404	DI	PLC-2	REMOTE	PLC-2	8930A1150N007.DWG
ZSC	404	DI	PLC-2	CLOSED	PLC-2	8930A1150N007.DWG
ZSO	404	DI	PLC-2	OPENED	PLC-2	8930A1150N007.DWG
HSAR	405	DI	PLC-2	REMOTE	PLC-2	8930A1150N007.DWG
ZSC	405	DI	PLC-2	CLOSED	PLC-2	8930A1150N007.DWG
ZSO	405	DI	PLC-2	OPENED	PLC-2	8930A1150N007.DWG
HSAR	406	DI	PLC-2	REMOTE	PLC-2	8930A1150N007.DWG
ZSC	406	DI	PLC-2	CLOSED	PLC-2	8930A1150N007.DWG
ZSO	406	DI	PLC-2	OPENED	PLC-2	8930A1150N007.DWG
HSAR	407	DI	PLC-2	REMOTE	PLC-2	8930A1150N007.DWG
ZSC	407	DI	PLC-2	CLOSED	PLC-2	8930A1150N007.DWG
ZSO	407	DI	PLC-2	OPENED	PLC-2	8930A1150N007.DWG
HSAR	408	DI	PLC-2	REMOTE	PLC-2	8930A1150N007.DWG
ZSC	408	DI	PLC-2	CLOSED	PLC-2	8930A1150N007.DWG
ZSO	408	DI	PLC-2	OPENED	PLC-2	8930A1150N007.DWG

PLC I/O Listing for PLC-2

Tag	Loop	I/O	Location	Description 1	Description 2	Drawing #
HSAR	411	DI	PLC-2	REMOTE	PLC-2	8930A1150N008.DWG
ZSC	411	DI	PLC-2	CLOSED	PLC-2	8930A1150N008.DWG
ZSO	411	DI	PLC-2	OPENED	PLC-2	8930A1150N008.DWG
HSAR	412	DI	PLC-2	REMOTE	PLC-2	8930A1150N009.DWG
ZSC	412	DI	PLC-2	CLOSED	PLC-2	8930A1150N009.DWG
ZSO	412	DI	PLC-2	OPENED	PLC-2	8930A1150N009.DWG
HSAR	413	DI	PLC-2	REMOTE	PLC-2	8930A1150N008.DWG
ZSC	413	DI	PLC-2	CLOSED	PLC-2	8930A1150N008.DWG
ZSO	413	DI	PLC-2	OPENED	PLC-2	8930A1150N008.DWG
HSAR	414	DI	PLC-2	REMOTE	PLC-2	8930A1150N008.DWG
ZSC	414	DI	PLC-2	CLOSED	PLC-2	8930A1150N008.DWG
ZSO	414	DI	PLC-2	OPENED	PLC-2	8930A1150N008.DWG
HSAR	415	DI	PLC-2	REMOTE	PLC-2	8930A1150N009.DWG
ZSC	415	DI	PLC-2	CLOSED	PLC-2	8930A1150N009.DWG
ZSO	415	DI	PLC-2	OPENED	PLC-2	8930A1150N009.DWG
HSAR	416	DI	PLC-2	REMOTE	PLC-2	8930A1150N009.DWG
ZSC	416	DI	PLC-2	CLOSED	PLC-2	8930A1150N009.DWG
ZSO	416	DI	PLC-2	OPENED	PLC-2	8930A1150N009.DWG
HSAR	417	DI	PLC-2	REMOTE	PLC-2	8930A1150N008.DWG
ZSC	417	DI	PLC-2	CLOSED	PLC-2	8930A1150N008.DWG
ZSO	417	DI	PLC-2	OPENED	PLC-2	8930A1150N008.DWG
HSAR	418	DI	PLC-2	REMOTE	PLC-2	8930A1150N009.DWG
ZSC	418	DI	PLC-2	CLOSED	PLC-2	8930A1150N009.DWG
ZSO	418	DI	PLC-2	OPENED	PLC-2	8930A1150N009.DWG
LSHH	419	DI	PLC-2		PLC-2	8930A1150N013.DWG
LSLL	419	DI	PLC-2		PLC-2	8930A1150N013.DWG
AUX1	419A	DI	PLC-2	RUNNING	PLC-2	8930A1150N013.DWG

PLC I/O Listing for PLC-2

Tag	Loop	I/O	Location	Description 1	Description 2	Drawing #
X1	419A	DI	PLC-2	FAULT	PLC-2	8930A1150N013.DWG
AUX1	419B	DI	PLC-2	RUNNING	PLC-2	8930A1150N013.DWG
X1	419B	DI	PLC-2	FAULT	PLC-2	8930A1150N013.DWG
HSAR	421	DI	PLC-2	REMOTE	PLC-2	8930A1150N010.DWG
ZSC	421	DI	PLC-2	CLOSED	PLC-2	8930A1150N010.DWG
ZSO	421	DI	PLC-2	OPENED	PLC-2	8930A1150N010.DWG
AUX1	422	DI	PLC-2	RUNNING	PLC-2	8930A1150N010.DWG
AUX2	422	DI	PLC-2	FAILED	PLC-2	8930A1150N010.DWG
AUX1	423	DI	PLC-2	RUNNING	PLC-2	8930A1150N010.DWG
AUX2	423	DI	PLC-2	VFD FAIL	PLC-2	8930A1150N010.DWG
FSL	423	DI	PLC-2		PLC-2	8930A1150N012.DWG
HSAR	423	DI	PLC-2	REMOTE	PLC-2	8930A1150N010.DWG
PSH	423	DI	PLC-2		PLC-2	8930A1150N010.DWG
TSH	423	DI	PLC-2	TEMP	PLC-2	8930A1150N010.DWG
TSH	423A	DI	PLC-2	STATOR TEMP	PLC-2	8930A1150N010.DWG
HSAR	424	DI	PLC-2	REMOTE	PLC-2	8930A1150N010.DWG
XSH	424	DI	PLC-2	SMOKE	PLC-2	8930A1151N008.DWG
ZSC	424	DI	PLC-2	CLOSED	PLC-2	8930A1150N010.DWG
ZSO	424	DI	PLC-2	OPENED	PLC-2	8930A1150N010.DWG
HSAR	425	DI	PLC-2	REMOTE	PLC-2	8930A1150N011.DWG
ZSC	425	DI	PLC-2	CLOSED	PLC-2	8930A1150N011.DWG
ZSO	425	DI	PLC-2	OPENED	PLC-2	8930A1150N011.DWG
AUX1	426	DI	PLC-2	RUNNING	PLC-2	8930A1150N011.DWG
AUX2	426	DI	PLC-2	FAILED	PLC-2	8930A1150N011.DWG
AUX1	427	DI	PLC-2	RUNNING	PLC-2	8930A1150N011.DWG
AUX2	427	DI	PLC-2	VFD FAIL	PLC-2	8930A1150N011.DWG
FSL	427	DI	PLC-2		PLC-2	8930A1150N012.DWG

PLC I/O Listing for PLC-2

Tag	Loop	I/O	Location	Description 1	Description 2	Drawing #
HSAR	427	DI	PLC-2	REMOTE	PLC-2	8930A1150N011.DWG
PSH	427	DI	PLC-2		PLC-2	8930A1150N011.DWG
TSH	427	DI	PLC-2	TEMP	PLC-2	8930A1150N011.DWG
TSH	427A	DI	PLC-2	STATOR TEMP	PLC-2	8930A1150N011.DWG
HSAR	428	DI	PLC-2	REMOTE	PLC-2	8930A1150N011.DWG
ZSC	428	DI	PLC-2	CLOSED	PLC-2	8930A1150N011.DWG
ZSO	428	DI	PLC-2	OPENED	PLC-2	8930A1150N011.DWG
AUX1	433	DI	PLC-2	RUN	PLC-2	8930A1151N003.DWG
AUX2	433	DI	PLC-2	OL	PLC-2	8930A1151N003.DWG
HSAR	433	DI	PLC-2	REMOTE	PLC-2	8930A1151N003.DWG
SSL	433	DI	PLC-2		PLC-2	8930A1151N003.DWG
TSH	433	DI	PLC-2	HIGH TEMP	PLC-2	8930A1151N003.DWG
AUX1	434	DI	PLC-2	RUN	PLC-2	8930A1151N003.DWG
AUX2	434	DI	PLC-2	OL	PLC-2	8930A1151N003.DWG
HSAR	434	DI	PLC-2	REMOTE	PLC-2	8930A1151N003.DWG
SSL	434	DI	PLC-2		PLC-2	8930A1151N003.DWG
TSH	434	DI	PLC-2	HIGH TEMP	PLC-2	8930A1151N003.DWG
LSH	440	DI	PLC-2		PLC-2	8930A1151N004.DWG
AUX1	451	DI	PLC-2	RUNNING	PLC-2	8930A1151N005.DWG
AUX2	451	DI	PLC-2	FAILED	PLC-2	8930A1151N005.DWG
FSL	451	DI	PLC-2	LOW FLOW	PLC-2	8930A1151N005.DWG
HSAR	451	DI	PLC-2	REMOTE	PLC-2	8930A1151N005.DWG
PSH	451	DI	PLC-2	HIGH PRESS	PLC-2	8930A1151N005.DWG
AUX1	452	DI	PLC-2	RUNNING	PLC-2	8930A1151N005.DWG
AUX2	452	DI	PLC-2	FAILED	PLC-2	8930A1151N005.DWG
FSL	452	DI	PLC-2	LOW FLOW	PLC-2	8930A1151N005.DWG
HSAR	452	DI	PLC-2	REMOTE	PLC-2	8930A1151N005.DWG

PLC I/O Listing for PLC-2

Tag	Loop	I/O	Location	Description 1	Description 2	Drawing #
PSH	452	DI	PLC-2	HIGH PRESS	PLC-2	8930A1151N005.DWG
AUX1	453	DI	PLC-2	RUNNING	PLC-2	8930A1151N006.DWG
AUX2	453	DI	PLC-2	FAILED	PLC-2	8930A1151N006.DWG
HSAR	453	DI	PLC-2	REMOTE	PLC-2	8930A1151N006.DWG
AUX1	470	DI	PLC-2	RUNNING	PLC-2	8930A1151N007.DWG
AUX2	470	DI	PLC-2	FAIL	PLC-2	8930A1151N007.DWG
XSH	470	DI	PLC-2	SMOKE	PLC-2	8930A1151N007.DWG
AUX1	471	DI	PLC-2	RUNNING	PLC-2	8930A1151N008.DWG
AUX1	472	DI	PLC-2	RUNNING	PLC-2	8930A1151N008.DWG
AUX1	473	DI	PLC-2	RUNNING	PLC-2	8930A1151N008.DWG
AUX2	473	DI	PLC-2	OL	PLC-2	8930A1151N008.DWG
XSH	473	DI	PLC-2	SMOKE	PLC-2	8930A1151N008.DWG
AUX1	474	DI	PLC-2	RUNNING	PLC-2	8930A1151N008.DWG
AUX2	474	DI	PLC-2	OL	PLC-2	8930A1151N008.DWG
AUX1	475	DI	PLC-2	RUNNING	PLC-2	8930A1151N008.DWG
AUX2	475	DI	PLC-2	OL	PLC-2	8930A1151N008.DWG
XSH	475	DI	PLC-2	SMOKE	PLC-2	8930A1151N008.DWG
AUX1	476	DI	PLC-2	RUNNING	PLC-2	8930A1151N009.DWG
AUX2	476	DI	PLC-2	OL	PLC-2	8930A1151N009.DWG
XSH	476	DI	PLC-2	SMOKE	PLC-2	8930A1151N009.DWG
AUX2	477	DI	PLC-2	OL	PLC-2	8930A1151N009.DWG
AUXH1	477	DI	PLC-2	RUN-HIGH	PLC-2	8930A1151N009.DWG
AUXL1	477	DI	PLC-2	RUN-LOW	PLC-2	8930A1151N009.DWG
XSH	477	DI	PLC-2	SMOKE	PLC-2	8930A1151N009.DWG
LSH	500	DI	PLC-2		PLC-2	8930A1104N001.DWG
LSLL	500	DI	PLC-2		PLC-2	8930A1104N001.DWG
AUX1	501	DI	PLC-2	RUNNING	PLC-2	8930A1104N001.DWG

PLC I/O Listing for PLC-2

Tag	Loop	I/O	Location	Description 1	Description 2	Drawing #
AUX2	501	DI	PLC-2	FAILED	PLC-2	8930A1104N001.DWG
HSAR	501	DI	PLC-2	REMOTE	PLC-2	8930A1104N001.DWG
MSH	501	DI	PLC-2	MOISTURE	PLC-2	8930A1104N001.DWG
TSH	501	DI	PLC-2		PLC-2	8930A1104N001.DWG
AUX1	502	DI	PLC-2	RUNNING	PLC-2	8930A1104N001.DWG
AUX2	502	DI	PLC-2	FAILED	PLC-2	8930A1104N001.DWG
HSAR	502	DI	PLC-2	REMOTE	PLC-2	8930A1104N001.DWG
MSH	502	DI	PLC-2	MOISTURE	PLC-2	8930A1104N001.DWG
TSH	502	DI	PLC-2		PLC-2	8930A1104N001.DWG
AUX1	601	DI	PLC-2	RUNNING	PLC-2	8930A1104N002.DWG
AUX2	601	DI	PLC-2	OL	PLC-2	8930A1104N002.DWG
HSAR	601	DI	PLC-2	REMOTE	PLC-2	8930A1104N002.DWG
MSH	601	DI	PLC-2		PLC-2	8930A1104N002.DWG
TSH	601	DI	PLC-2		PLC-2	8930A1104N002.DWG
AUX1	602	DI	PLC-2	RUNNING	PLC-2	8930A1104N002.DWG
AUX2	602	DI	PLC-2	OL	PLC-2	8930A1104N002.DWG
HSAR	602	DI	PLC-2	REMOTE	PLC-2	8930A1104N002.DWG
MSH	602	DI	PLC-2		PLC-2	8930A1104N002.DWG
TSH	602	DI	PLC-2		PLC-2	8930A1104N002.DWG
LSH	603	DI	PLC-2		PLC-2	8930A1104N002.DWG
LSLL	603	DI	PLC-2		PLC-2	8930A1104N002.DWG
FSH	769A	DI	PLC-2		PLC-2	8930A1151N004.DWG
FSH	769B	DI	PLC-2		PLC-2	8930A1151N004.DWG
FSH	769F	DI	PLC-2		PLC-2	8930A1120N003.DWG
FSH	769G	DI	PLC-2		PLC-2	8930A1120N003.DWG
FSH	769K	DI	PLC-2		PLC-2	8930A1110N004.DWG
FSH	769M	DI	PLC-2		PLC-2	8930A1131N003.DWG

PLC I/O Listing for PLC-2

Tag	Loop	I/O	Location	Description 1	Description 2	Drawing #
Total DI Points = 303						
MSC	041	DO	PLC-2	CLOSE	PLC-2	8930A1110N001.DWG
MSO	041	DO	PLC-2	OPEN	PLC-2	8930A1110N001.DWG
MSC	042	DO	PLC-2	CLOSE	PLC-2	8930A1110N004.DWG
MSO	042	DO	PLC-2	OPEN	PLC-2	8930A1110N004.DWG
MSC	051	DO	PLC-2	CLOSE	PLC-2	8930A1110N001.DWG
MSO	051	DO	PLC-2	OPEN	PLC-2	8930A1110N001.DWG
MSC	052	DO	PLC-2	CLOSE	PLC-2	8930A1110N004.DWG
MSO	052	DO	PLC-2	OPEN	PLC-2	8930A1110N004.DWG
MS	071	DO	PLC-2	RUN	PLC-2	8930A1111N001.DWG
MS	072	DO	PLC-2	RUN	PLC-2	8930A1111N001.DWG
MS	090	DO	PLC-2	RUN	PLC-2	8930A1120N001.DWG
MS	091	DO	PLC-2	RUN	PLC-2	8930A1120N001.DWG
MS	092	DO	PLC-2	RUN	PLC-2	8930A1120N001.DWG
MSC	094	DO	PLC-2	CLOSE	PLC-2	8930A1120N001.DWG
MSO	094	DO	PLC-2	OPEN	PLC-2	8930A1120N001.DWG
MS	100	DO	PLC-2	RUN	PLC-2	8930A1120N002.DWG
MS	101	DO	PLC-2	RUN	PLC-2	8930A1120N002.DWG
MS	102	DO	PLC-2	RUN	PLC-2	8930A1120N002.DWG
MSC	104	DO	PLC-2	CLOSE	PLC-2	8930A1120N002.DWG
MSO	104	DO	PLC-2	OPEN	PLC-2	8930A1120N002.DWG
MS	121	DO	PLC-2	RUN	PLC-2	8930A1150N002.DWG
MS	122	DO	PLC-2	RUN	PLC-2	8930A1150N002.DWG
MS	123	DO	PLC-2	RUN	PLC-2	8930A1150N002A.DWG
MSC	124	DO	PLC-2	CLOSE	PLC-2	8930A1150N001.DWG
MSC	125	DO	PLC-2	CLOSE	PLC-2	8930A1150N001.DWG

PLC I/O Listing for PLC-2

Tag	Loop	I/O	Location	Description 1	Description 2	Drawing #
MSC	127	DO	PLC-2	CLOSE	PLC-2	8930A1150N003.DWG
MSC	128	DO	PLC-2	CLOSE	PLC-2	8930A1150N003.DWG
MSO	128	DO	PLC-2	OPEN	PLC-2	8930A1150N003.DWG
MSC	129	DO	PLC-2	CLOSE	PLC-2	8930A1150N003.DWG
MSO	129	DO	PLC-2	OPEN	PLC-2	8930A1150N003.DWG
MS	301	DO	PLC-2	RUN	PLC-2	8930A1140N001.DWG
MS	302	DO	PLC-2	RUN	PLC-2	8930A1140N001.DWG
MS	303	DO	PLC-2	RUN	PLC-2	8930A1140N002.DWG
MS	304	DO	PLC-2	RUN	PLC-2	8930A1140N002.DWG
MSC	321	DO	PLC-2	CLOSE	PLC-2	8930A1103N001.DWG
MSO	321	DO	PLC-2	OPEN	PLC-2	8930A1103N001.DWG
MSC	322	DO	PLC-2	CLOSE	PLC-2	8930A1103N001.DWG
MSO	322	DO	PLC-2	OPEN	PLC-2	8930A1103N001.DWG
MSC	323	DO	PLC-2	CLOSE	PLC-2	8930A1103N001.DWG
MSO	323	DO	PLC-2	OPEN	PLC-2	8930A1103N001.DWG
MSC	324	DO	PLC-2	CLOSE	PLC-2	8930A1103N001.DWG
MSO	324	DO	PLC-2	OPEN	PLC-2	8930A1103N001.DWG
MSC	325	DO	PLC-2	CLOSE	PLC-2	8930A1103N001.DWG
MSO	325	DO	PLC-2	OPEN	PLC-2	8930A1103N001.DWG
MS	401	DO	PLC-2	RUN	PLC-2	8930A1150N004.DWG
MS	402	DO	PLC-2	RUN	PLC-2	8930A1150N005.DWG
MS	403	DO	PLC-2	RUN	PLC-2	8930A1150N006.DWG
MSC	404	DO	PLC-2	CLOSE	PLC-2	8930A1150N007.DWG
MSO	404	DO	PLC-2	OPEN	PLC-2	8930A1150N007.DWG
MSC	405	DO	PLC-2	CLOSE	PLC-2	8930A1150N007.DWG
MSO	405	DO	PLC-2	OPEN	PLC-2	8930A1150N007.DWG
MSC	406	DO	PLC-2	CLOSE	PLC-2	8930A1150N007.DWG

PLC I/O Listing for PLC-2

Tag	Loop	I/O	Location	Description 1	Description 2	Drawing #
MSO	406	DO	PLC-2	OPEN	PLC-2	8930A1150N007.DWG
MSC	407	DO	PLC-2	CLOSE	PLC-2	8930A1150N007.DWG
MSO	407	DO	PLC-2	OPEN	PLC-2	8930A1150N007.DWG
MSC	408	DO	PLC-2	CLOSE	PLC-2	8930A1150N007.DWG
MSO	408	DO	PLC-2	OPEN	PLC-2	8930A1150N007.DWG
MSC	411	DO	PLC-2	CLOSE	PLC-2	8930A1150N008.DWG
MSO	411	DO	PLC-2	OPEN	PLC-2	8930A1150N008.DWG
MSC	412	DO	PLC-2	CLOSE	PLC-2	8930A1150N009.DWG
MSO	412	DO	PLC-2	OPEN	PLC-2	8930A1150N009.DWG
MSC	413	DO	PLC-2	CLOSE	PLC-2	8930A1150N008.DWG
MSO	413	DO	PLC-2	OPEN	PLC-2	8930A1150N008.DWG
MSC	414	DO	PLC-2	CLOSE	PLC-2	8930A1150N008.DWG
MSO	414	DO	PLC-2	OPEN	PLC-2	8930A1150N008.DWG
MSC	415	DO	PLC-2	CLOSE	PLC-2	8930A1150N009.DWG
MSO	415	DO	PLC-2	OPEN	PLC-2	8930A1150N009.DWG
MSC	416	DO	PLC-2	CLOSE	PLC-2	8930A1150N009.DWG
MSO	416	DO	PLC-2	OPEN	PLC-2	8930A1150N009.DWG
MSC	417	DO	PLC-2	CLOSE	PLC-2	8930A1150N008.DWG
MSO	417	DO	PLC-2	OPEN	PLC-2	8930A1150N008.DWG
MSC	418	DO	PLC-2	CLOSE	PLC-2	8930A1150N009.DWG
MSO	418	DO	PLC-2	OPEN	PLC-2	8930A1150N009.DWG
MSC	421	DO	PLC-2	CLOSE	PLC-2	8930A1150N010.DWG
MSO	421	DO	PLC-2	OPEN	PLC-2	8930A1150N010.DWG
MS	423	DO	PLC-2	RUN	PLC-2	8930A1150N010.DWG
MSC	424	DO	PLC-2	CLOSE	PLC-2	8930A1150N010.DWG
MSO	424	DO	PLC-2	OPEN	PLC-2	8930A1150N010.DWG
MSC	425	DO	PLC-2	CLOSE	PLC-2	8930A1150N011.DWG

PLC I/O Listing for PLC-2

Tag	Loop	I/O	Location	Description 1	Description 2	Drawing #
MSO	425	DO	PLC-2	OPEN	PLC-2	8930A1150N011.DWG
MS	427	DO	PLC-2	RUN	PLC-2	8930A1150N011.DWG
MSC	428	DO	PLC-2	CLOSE	PLC-2	8930A1150N011.DWG
MSO	428	DO	PLC-2	OPEN	PLC-2	8930A1150N011.DWG
MS	433	DO	PLC-2	RUN	PLC-2	8930A1151N003.DWG
MS	434	DO	PLC-2	RUN	PLC-2	8930A1151N003.DWG
MS	451	DO	PLC-2	RUN	PLC-2	8930A1151N005.DWG
MS	452	DO	PLC-2	RUN	PLC-2	8930A1151N005.DWG
MS	453	DO	PLC-2	RUN	PLC-2	8930A1151N006.DWG
MS	501	DO	PLC-2	RUN	PLC-2	8930A1104N001.DWG
MS	502	DO	PLC-2	RUN	PLC-2	8930A1104N001.DWG
MS	601	DO	PLC-2	RUN	PLC-2	8930A1104N002.DWG
MS	602	DO	PLC-2	RUN	PLC-2	8930A1104N002.DWG

Total DO Points = 92

SECTION 17905

SCHEDULES - SCADA LIST

PART 1 GENERAL

1.01 SUMMARY

A. The SCADA list is not a take-off list. Additional information is 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 SCADA List are defined on the Drawings.

PART 2 PRODUCTS

Not used.

PART 3 EXECUTION

3.01 SCADA LIST

A. SCADA list attached.

END OF SECTION

Engineers...Working Wonders With Water™

SCADA Listing

Tag	Loop	Equipment	Function	Description 1	Description 2	Drawing #
Q2		Q2-SP	SP	% POLYMER		8930A1151N006.DWG
JA1	001	JS-001	ALARM	24V PWR SUP FAIL		8930A1170N002.DWG
JA2	001	JS-001	ALARM	24V PWR SUP FAIL		8930A1170N002.DWG
JA3	001	JS-001	ALARM	DIODE BRIDGE FAIL		8930A1170N002.DWG
TAH	001	TE-001	ALARM			8930A1170N002.DWG
XA3	001	UPS-001	ALARM	LO BATT.		8930A1170N002.DWG
XA4	001	UPS-001	ALARM	UPS FAIL		8930A1170N002.DWG
Y1	001	UPS-001	STATUS	ON UPS POWER		8930A1170N002.DWG
ZA	001	ZS-001	ALARM	INTRUSION		8930A1170N002.DWG
JA1	002	JS-002	ALARM	24V PWR SUP FAIL		8930A1151N007.DWG
JA2	002	JS-002	ALARM	24V PWR SUP FAIL		8930A1151N007.DWG
JA3	002	JS-002	ALARM	DIODE BRIDGE FAIL		8930A1151N007.DWG
TAH	002	TE-002	ALARM			8930A1151N007.DWG
XA3	002	UPS-002	ALARM	LO BATT.		8930A1151N007.DWG
XA4	002	UPS-002	ALARM	UPS FAIL		8930A1151N007.DWG
Y1	002	UPS-002	STATUS	ON UPS POWER		8930A1151N007.DWG
ZA	002	ZS-002	ALARM	INTRUSION		8930A1151N007.DWG
FAH	010	FE-010	ALARM			8930A1110N001.DWG
FAL	010	FE-010	ALARM			8930A1110N001.DWG
FI	010	FE-010	NUM			8930A1110N001.DWG
FR	010	FE-010	TREND			8930A1110N001.DWG
QFH	010	FE-010	SP			8930A1110N001.DWG
QFL	010	FE-010	SP			8930A1110N001.DWG

Tag	Loop	Equipment	Function	Description 1	Description 2	Drawing #
Y2	011	COS-011	ALARM	FAILED		8930A1110N001.DWG
LAH	012	LE-012	ALARM			8930A1110N001.DWG
LAHH	012	LE-012	ALARM	BYPASS		8930A1110N001.DWG
LAL	012	LE-012	ALARM			8930A1110N001.DWG
LD3A	012	LE-012	ALARM	HI DIFF LVL		8930A1110N001.DWG
LD4A	012	LE-012	ALARM	HI DIFF LVL		8930A1110N001.DWG
LDI3	012	LE-012	NUM	DIFF LVL		8930A1110N001.DWG
LDI4	012	LE-012	NUM	DIFF LVL		8930A1110N001.DWG
LI	012	LE-012	NUM			8930A1110N001.DWG
LR	012	LE-012	TREND			8930A1110N001.DWG
QLHH	012	LE-012	SP			8930A1110N001.DWG
QLL	012	LE-012	SP			8930A1110N001.DWG
HAD	041	EDR-041	ACTION	HOA		8930A1110N001.DWG
HAO	041	EDR-041	ACTION	OC		8930A1110N001.DWG
LAH	041	LE-041	ALARM			8930A1110N001.DWG
LAL	041	LE-041	ALARM			8930A1110N001.DWG
LD1A	041	LE-041	ALARM	HI DIFF LVL		8930A1110N001.DWG
LDI1	041	LE-041	NUM	DIFF LVL		8930A1110N001.DWG
LI	041	LE-041	NUM			8930A1110N001.DWG
LR	041	LE-041	TREND			8930A1110N001.DWG
QLH	041	LE-041	SP			8930A1110N001.DWG
QLL	041	LE-041	SP			8930A1110N001.DWG
YOC	041	EDR-041	STATUS	OC		8930A1110N001.DWG
YR	041	EDR-041	STATUS	REMOTE		8930A1110N001.DWG
HAD	042	EDR-042	ACTION	HOA		8930A1110N004.DWG
HAO	042	EDR-042	ACTION	OC		8930A1110N004.DWG
LAH	042	LE-042	ALARM			8930A1110N004.DWG

Tag	Loop	Equipment	Function	Description 1	Description 2	Drawing #
LAL	042	LE-042	ALARM			8930A1110N004.DWG
LI	042	LE-042	NUM			8930A1110N004.DWG
LR	042	LE-042	TREND			8930A1110N004.DWG
QLH	042	LE-042	SP			8930A1110N004.DWG
QLL	042	LE-042	SP			8930A1110N004.DWG
YOC	042	EDR-042	STATUS	OC		8930A1110N004.DWG
YR	042	EDR-042	STATUS	REMOTE		8930A1110N004.DWG
HAR	043	MBS-043	ACTION	RESET ETM		8930A1110N002.DWG
IAH	043	MBS-043	ALARM	HIGH CURRENT		8930A1110N002.DWG
KI	043	MBS-043	NUM	ETM		8930A1110N002.DWG
TAH	043	MBS-043	ALARM	TEMP		8930A1110N002.DWG
Y1	043	MBS-043	STATUS	RUNNING		8930A1110N002.DWG
Y2	043	MBS-043	ALARM	FAILED		8930A1110N002.DWG
YE	043	MBS-043	STATUS	ESTOP		8930A1110N002.DWG
YH	043	MBS-043	STATUS	HAND		8930A1110N002.DWG
YR	043	MBS-043	STATUS	AUTO		8930A1110N002.DWG
HAR	044	CMP-044	ACTION	RESET ETM		8930A1110N002.DWG
IAH	044	CMP-044	ALARM	HIGH CURRENT		8930A1110N002.DWG
KI	044	CMP-044	NUM	ETM		8930A1110N002.DWG
TAH	044	CMP-044	ALARM	TEMP		8930A1110N002.DWG
Y1	044	CMP-044	STATUS	RUNNING		8930A1110N002.DWG
Y2	044	CMP-044	ALARM	FAILED		8930A1110N002.DWG
YE	044	CMP-044	STATUS	ESTOP		8930A1110N002.DWG
YH	044	CMP-044	STATUS	HAND		8930A1110N002.DWG
YR	044	CMP-044	STATUS	AUTO		8930A1110N002.DWG
HAD	051	EDR-051	ACTION	HOA		8930A1110N001.DWG
HAO	051	EDR-051	ACTION	OC		8930A1110N001.DWG

SCADA Listing

Tag	Loop	Equipment	Function	Description 1	Description 2	Drawing #
LAH	051	LE-051	ALARM			8930A1110N001.DWG
LAL	051	LE-051	ALARM			8930A1110N001.DWG
LD2A	051	LE-051	ALARM	HI DIFF LVL		8930A1110N001.DWG
LDI2	051	LE-051	NUM	DIFF LVL		8930A1110N001.DWG
LI	051	LE-051	NUM			8930A1110N001.DWG
LR	051	LE-051	TREND			8930A1110N001.DWG
QLH	051	LE-051	SP			8930A1110N001.DWG
QLL	051	LE-051	SP			8930A1110N001.DWG
YOC	051	EDR-051	STATUS	OC		8930A1110N001.DWG
YR	051	EDR-051	STATUS	REMOTE		8930A1110N001.DWG
HAD	052	EDR-052	ACTION	HOA		8930A1110N004.DWG
HAO	052	EDR-052	ACTION	OC		8930A1110N004.DWG
LAH	052	LE-052	ALARM			8930A1110N004.DWG
LAL	052	LE-052	ALARM			8930A1110N004.DWG
LI	052	LE-052	NUM			8930A1110N004.DWG
LR	052	LE-052	TREND			8930A1110N004.DWG
QLH	052	LE-052	SP			8930A1110N004.DWG
QLL	052	LE-052	SP			8930A1110N004.DWG
YOC	052	EDR-052	STATUS	OC		8930A1110N004.DWG
YR	052	EDR-052	STATUS	REMOTE		8930A1110N004.DWG
HAR	053	MBS-053	ACTION	RESET ETM		8930A1110N003.DWG
IAH	053	MBS-053	ALARM	HIGH CURRENT		8930A1110N003.DWG
KI	053	MBS-053	NUM	ETM		8930A1110N003.DWG
TAH	053	MBS-053	ALARM	TEMP		8930A1110N003.DWG
Y1	053	MBS-053	STATUS	RUNNING		8930A1110N003.DWG
Y2	053	MBS-053	ALARM	FAILED		8930A1110N003.DWG
YE	053	MBS-053	STATUS	ESTOP		8930A1110N003.DWG

Tag	Loop	Equipment	Function	Description 1	Description 2	Drawing #
YH	053	MBS-053	STATUS	HAND		8930A1110N003.DWG
YR	053	MBS-053	STATUS	AUTO		8930A1110N003.DWG
HAR	054	CMP-054	ACTION	RESET ETM		8930A1110N003.DWG
IAH	054	CMP-054	ALARM	HIGH CURRENT		8930A1110N003.DWG
KI	054	CMP-054	NUM	ETM		8930A1110N003.DWG
TAH	054	CMP-054	ALARM	TEMP		8930A1110N003.DWG
Y1	054	CMP-054	STATUS	RUNNING		8930A1110N003.DWG
Y2	054	CMP-054	ALARM	FAILED		8930A1110N003.DWG
YE	054	CMP-054	STATUS	ESTOP		8930A1110N003.DWG
YH	054	CMP-054	STATUS	HAND		8930A1110N003.DWG
YR	054	CMP-054	STATUS	AUTO		8930A1110N003.DWG
HAJ	070	HAJ-070	ACTION	LS		8930A1111N001.DWG
Y2	070	VCP-070	ALARM	FAILED		8930A1111N002.DWG
HAD	071	FAN-071	ACTION	HOA		8930A1111N001.DWG
HAR	071	FAN-071	ACTION	RESET ETM		8930A1111N001.DWG
HAT	071	FAN-071	ACTION	SS		8930A1111N001.DWG
KI	071	FAN-071	NUM	ETM		8930A1111N001.DWG
TAH	071	FAN-071	ALARM	HIGH TEMP		8930A1111N001.DWG
Y1	071	FAN-071	STATUS	RUNNING		8930A1111N001.DWG
Y2	071	FAN-071	ALARM	FAILED		8930A1111N001.DWG
YR	071	FAN-071	STATUS	REMOTE		8930A1111N001.DWG
HAD	072	FAN-072	ACTION	HOA		8930A1111N001.DWG
HAR	072	FAN-072	ACTION	RESET ETM		8930A1111N001.DWG
HAT	072	FAN-072	ACTION	SS		8930A1111N001.DWG
KI	072	FAN-072	NUM	ETM		8930A1111N001.DWG
TAH	072	FAN-072	ALARM	HIGH TEMP		8930A1111N001.DWG
Y1	072	FAN-072	STATUS	RUNNING		8930A1111N001.DWG

Tag	Loop	Equipment	Function	Description 1	Description 2	Drawing #
Y2	072	FAN-072	ALARM	FAILED		8930A1111N001.DWG
YR	072	FAN-072	STATUS	REMOTE		8930A1111N001.DWG
HAD	090	MIX-090	ACTION	HOA		8930A1120N001.DWG
HAR	090	MIX-090	ACTION	RESET ETM		8930A1120N001.DWG
HAT	090	MIX-090	ACTION	SS		8930A1120N001.DWG
KI	090	MIX-090	NUM	ETM		8930A1120N001.DWG
TAH	090	MIX-090	ALARM			8930A1120N001.DWG
Y1	090	MIX-090	STATUS	RUNNING		8930A1120N001.DWG
Y2	090	MIX-090	ALARM	FAILED		8930A1120N001.DWG
YR	090	MIX-090	STATUS	REMOTE		8930A1120N001.DWG
HAD	091	AER-091	ACTION	HOA		8930A1120N001.DWG
HAR	091	AER-091	ACTION	RESET ETM		8930A1120N001.DWG
HAT	091	AER-091	ACTION	SS		8930A1120N001.DWG
KI	091	AER-091	NUM	ETM		8930A1120N001.DWG
QS	091	AER-091	SP	SPEED		8930A1120N001.DWG
SIB	091	AER-091	NUM	SPEED		8930A1120N001.DWG
TAH	091	AER-091	ALARM			8930A1120N001.DWG
Y1	091	AER-091	STATUS	RUNNING		8930A1120N001.DWG
Y2	091	AER-091	ALARM	FAILED		8930A1120N001.DWG
YR	091	AER-091	STATUS	REMOTE		8930A1120N001.DWG
HAD	092	AER-092	ACTION	HOA		8930A1120N001.DWG
HAR	092	AER-092	ACTION	RESET ETM		8930A1120N001.DWG
HAT	092	AER-092	ACTION	SS		8930A1120N001.DWG
KI	092	AER-092	NUM	ETM		8930A1120N001.DWG
QS	092	AER-092	SP	SPEED		8930A1120N001.DWG
SIB	092	AER-092	NUM	SPEED		8930A1120N001.DWG
TAH	092	AER-092	ALARM			8930A1120N001.DWG

Tag	Loop	Equipment	Function	Description 1	Description 2	Drawing #
Y1	092	AER-092	STATUS	RUNNING		8930A1120N001.DWG
Y2	092	AER-092	ALARM	FAILED		8930A1120N001.DWG
YR	092	AER-092	STATUS	REMOTE		8930A1120N001.DWG
HAD	094	EDM-094	ACTION	HOA		8930A1120N001.DWG
HAK	094	EDM-094	ACTION	JOJC		8930A1120N001.DWG
YOC	094	EDM-094	STATUS	OC		8930A1120N001.DWG
YR	094	EDM-094	STATUS	REMOTE		8930A1120N001.DWG
ZI	094	EDM-094	NUM	POSITION		8930A1120N001.DWG
AAH	095	AE-095	ALARM	DO		8930A1120N001.DWG
AAL	095	AE-095	ALARM	DO		8930A1120N001.DWG
AI	095	AE-095	NUM	DO		8930A1120N001.DWG
AR	095	AE-095	TREND	DO		8930A1120N001.DWG
QAH	095	AE-095	SP	DO		8930A1120N001.DWG
QAL	095	AE-095	SP	DO		8930A1120N001.DWG
HAD	100	MIX-100	ACTION	HOA		8930A1120N002.DWG
HAR	100	MIX-100	ACTION	RESET ETM		8930A1120N002.DWG
HAT	100	MIX-100	ACTION	SS		8930A1120N002.DWG
KI	100	MIX-100	NUM	ETM		8930A1120N002.DWG
TAH	100	MIX-100	ALARM			8930A1120N002.DWG
Y1	100	MIX-100	STATUS	RUNNING		8930A1120N002.DWG
Y2	100	MIX-100	ALARM	FAILED		8930A1120N002.DWG
YR	100	MIX-100	STATUS	REMOTE		8930A1120N002.DWG
HAD	101	AER-101	ACTION	HOA		8930A1120N002.DWG
HAR	101	AER-101	ACTION	RESET ETM		8930A1120N002.DWG
HAT	101	AER-101	ACTION	SS		8930A1120N002.DWG
KI	101	AER-101	NUM	ETM		8930A1120N002.DWG
QS	101	AER-101	SP	SPEED		8930A1120N002.DWG

Tag	Loop	Equipment	Function	Description 1	Description 2	Drawing #
SIB	101	AER-101	NUM	SPEED		8930A1120N002.DWG
TAH	101	AER-101	ALARM			8930A1120N002.DWG
Y1	101	AER-101	STATUS	RUNNING		8930A1120N002.DWG
Y2	101	AER-101	ALARM	FAILED		8930A1120N002.DWG
YR	101	AER-101	STATUS	REMOTE		8930A1120N002.DWG
HAD	102	AER-102	ACTION	HOA		8930A1120N002.DWG
HAR	102	AER-102	ACTION	RESET ETM		8930A1120N002.DWG
HAT	102	AER-102	ACTION	SS		8930A1120N002.DWG
KI	102	AER-102	NUM	ETM		8930A1120N002.DWG
QS	102	AER-102	SP	SPEED		8930A1120N002.DWG
SIB	102	AER-102	NUM	SPEED		8930A1120N002.DWG
TAH	102	AER-102	ALARM			8930A1120N002.DWG
Y1	102	AER-102	STATUS	RUNNING		8930A1120N002.DWG
Y2	102	AER-102	ALARM	FAILED		8930A1120N002.DWG
YR	102	AER-102	STATUS	REMOTE		8930A1120N002.DWG
HAD	104	EDM-104	ACTION	HOA		8930A1120N002.DWG
HAK	104	EDM-104	ACTION	JOJC		8930A1120N002.DWG
YOC	104	EDM-104	STATUS	OC		8930A1120N002.DWG
YR	104	EDM-104	STATUS	REMOTE		8930A1120N002.DWG
ZI	104	EDM-104	NUM	POSITION		8930A1120N002.DWG
AAH	105	AE-105	ALARM	DO		8930A1120N002.DWG
AAL	105	AE-105	ALARM	DO		8930A1120N002.DWG
AI	105	AE-105	NUM	DO		8930A1120N002.DWG
AR	105	AE-105	TREND	DO		8930A1120N002.DWG
QAH	105	AE-105	SP	DO		8930A1120N002.DWG
QAL	105	AE-105	SP	DO		8930A1120N002.DWG
HAR	111	CLR-111	ACTION	RESET ETM		8930A1121N001.DWG

Tag	Loop	Equipment	Function	Description 1	Description 2	Drawing #
HAT	111	CLR-111	ACTION	SS		8930A1121N001.DWG
KI	111	CLR-111	NUM	ETM		8930A1121N001.DWG
TAH	111	CLR-111	ALARM			8930A1121N001.DWG
XA	111	CLR-111	ALARM	SHEAR PIN		8930A1121N001.DWG
XAH	111	CLR-111	ALARM	HI TORQUE		8930A1121N001.DWG
XAHH	111	CLR-111	ALARM	HI HI TORQUE		8930A1121N001.DWG
Y1	111	CLR-111	STATUS	RUNNING		8930A1121N001.DWG
Y2	111	CLR-111	ALARM	FAILED		8930A1121N001.DWG
YR	111	CLR-111	STATUS	REMOTE		8930A1121N001.DWG
HAR	112	CLR-112	ACTION	RESET ETM		8930A1121N002.DWG
HAT	112	CLR-112	ACTION	SS		8930A1121N002.DWG
KI	112	CLR-112	NUM	ETM		8930A1121N002.DWG
TAH	112	CLR-112	ALARM			8930A1121N002.DWG
XA	112	CLR-112	ALARM	SHEAR PIN		8930A1121N002.DWG
XAH	112	CLR-112	ALARM	HI TORQUE		8930A1121N002.DWG
XAHH	112	CLR-112	ALARM	HI HI TORQUE		8930A1121N002.DWG
Y1	112	CLR-112	STATUS	RUNNING		8930A1121N002.DWG
Y2	112	CLR-112	ALARM	FAILED		8930A1121N002.DWG
YR	112	CLR-112	STATUS	REMOTE		8930A1121N002.DWG
FAL	121	FE-121	ALARM	SEAL WATER FAIL		8930A1150N002.DWG
HAD	121	PMP-121	ACTION	HOA		8930A1150N002.DWG
HAR	121	PMP-121	ACTION	RESET ETM		8930A1150N002.DWG
HAT	121	PMP-121	ACTION	SS		8930A1150N002.DWG
KI	121	PMP-121	NUM	ETM		8930A1150N002.DWG
PAH	121	PSH-121	ALARM			8930A1150N002.DWG
QS	121	PMP-121	SP	SPEED		8930A1150N002.DWG
SIB	121	PMP-121	NUM	SPEED		8930A1150N002.DWG

Tag	Loop	Equipment	Function	Description 1	Description 2	Drawing #
TAH	121	PMP-121	ALARM			8930A1150N002.DWG
Y1	121	PMP-121	STATUS	RUNNING		8930A1150N002.DWG
Y2	121	PMP-121	ALARM	FAILED		8930A1150N002.DWG
YR	121	PMP-121	STATUS	REMOTE		8930A1150N002.DWG
FAL	122	FE-122	ALARM	SEAL WATER FAIL		8930A1150N002.DWG
HAD	122	PMP-122	ACTION	HOA		8930A1150N002.DWG
HAR	122	PMP-122	ACTION	RESET ETM		8930A1150N002.DWG
HAT	122	PMP-122	ACTION	SS		8930A1150N002.DWG
KI	122	PMP-122	NUM	ETM		8930A1150N002.DWG
PAH	122	PSH-122	ALARM			8930A1150N002.DWG
QS	122	PMP-122	SP	SPEED		8930A1150N002.DWG
SIB	122	PMP-122	NUM	SPEED		8930A1150N002.DWG
TAH	122	PMP-122	ALARM			8930A1150N002.DWG
Y1	122	PMP-122	STATUS	RUNNING		8930A1150N002.DWG
Y2	122	PMP-122	ALARM	FAILED		8930A1150N002.DWG
YR	122	PMP-122	STATUS	REMOTE		8930A1150N002.DWG
FAL	123	FE-123	ALARM	SEAL WATER FAIL		8930A1150N002A.DWG
HAD	123	PMP-123	ACTION	HOA		8930A1150N002A.DWG
HAR	123	PMP-123	ACTION	RESET ETM		8930A1150N002A.DWG
HAT	123	PMP-123	ACTION	SS		8930A1150N002A.DWG
KI	123	PMP-123	NUM	ETM		8930A1150N002A.DWG
PAH	123	PSH-123	ALARM			8930A1150N002A.DWG
QS	123	PMP-123	SP	SPEED		8930A1150N002A.DWG
SIB	123	PMP-123	NUM	SPEED		8930A1150N002A.DWG
TAH	123	PMP-123	ALARM			8930A1150N002A.DWG
Y1	123	PMP-123	STATUS	RUNNING		8930A1150N002A.DWG
Y2	123	PMP-123	ALARM	FAILED		8930A1150N002A.DWG

Tag	Loop	Equipment	Function	Description 1	Description 2	Drawing #
YR	123	PMP-123	STATUS	REMOTE		8930A1150N002A.DWG
FAH	124	FE-124	ALARM			8930A1150N001.DWG
FAL	124	FE-124	ALARM			8930A1150N001.DWG
FI	124	FE-124	NUM			8930A1150N001.DWG
FQI	124	FE-124	NUM			8930A1150N001.DWG
FR	124	FE-124	TREND			8930A1150N001.DWG
HAD	124	EAM-124	ACTION	HOA		8930A1150N001.DWG
HAK	124	EAM-124	ACTION	MODULATE		8930A1150N001.DWG
QFH	124	FE-124	SP			8930A1150N001.DWG
QFL	124	FE-124	SP			8930A1150N001.DWG
YOC	124	EAM-124	STATUS	OC		8930A1150N001.DWG
YR	124	EAM-124	STATUS	REMOTE		8930A1150N001.DWG
ZI	124	EAM-124	NUM	POSITION		8930A1150N001.DWG
FAH	125	FE-125	ALARM			8930A1150N001.DWG
FAL	125	FE-125	ALARM			8930A1150N001.DWG
FI	125	FE-125	NUM			8930A1150N001.DWG
FQI	125	FE-125	NUM			8930A1150N001.DWG
FR	125	FE-125	TREND			8930A1150N001.DWG
HAD	125	EAM-125	ACTION	HOA		8930A1150N001.DWG
HAK	125	EAM-125	ACTION	MODULATE		8930A1150N001.DWG
QFH	125	FE-125	SP			8930A1150N001.DWG
QFL	125	FE-125	SP			8930A1150N001.DWG
YOC	125	EAM-125	STATUS	OC		8930A1150N001.DWG
YR	125	EAM-125	STATUS	REMOTE		8930A1150N001.DWG
ZI	125	EAM-125	NUM	POSITION		8930A1150N001.DWG
FAH	126	FE-126	ALARM			8930A1150N003.DWG
FAL	126	FE-126	ALARM			8930A1150N003.DWG

Tag	Loop	Equipment	Function	Description 1	Description 2	Drawing #
FI	126	FE-126	NUM			8930A1150N003.DWG
FR	126	FE-126	TREND			8930A1150N003.DWG
QFH	126	FE-126	SP			8930A1150N003.DWG
QFL	126	FE-126	SP			8930A1150N003.DWG
Y2	126	COS-126				8930A1150N003.DWG
FAH	127	FE-127	ALARM			8930A1150N003.DWG
FAL	127	FE-127	ALARM			8930A1150N003.DWG
FI	127	FE-127	NUM			8930A1150N003.DWG
FR	127	FE-127	TREND			8930A1150N003.DWG
HAD	127	EAM-127	ACTION	HOA		8930A1150N003.DWG
HAK	127	EAM-127	ACTION	MODULATE		8930A1150N003.DWG
QFH	127	FE-127	SP			8930A1150N003.DWG
QFI	127	FE-127	SP	WAS FLOW		8930A1150N003.DWG
QFL	127	FE-127	SP			8930A1150N003.DWG
QFQ	127	FE-127	SP	WAS TOTAL		8930A1150N003.DWG
YOC	127	EAM-127	STATUS	OC		8930A1150N003.DWG
YR	127	EAM-127	STATUS	REMOTE		8930A1150N003.DWG
ZI	127	EAM-127	NUM	POSITION		8930A1150N003.DWG
HAD	128	EDR-128	ACTION	HOA		8930A1150N003.DWG
HAO	128	EDR-128	ACTION	OC		8930A1150N003.DWG
YOC	128	EDR-128	STATUS	OC		8930A1150N003.DWG
YR	128	EDR-128	STATUS	REMOTE		8930A1150N003.DWG
HAD	129	EDR-129	ACTION	HOA		8930A1150N003.DWG
HAO	129	EDR-129	ACTION	OC		8930A1150N003.DWG
YOC	129	EDR-129	STATUS	OC		8930A1150N003.DWG
YR	129	EDR-129	STATUS	REMOTE		8930A1150N003.DWG
HAD	130	EDR-130	ACTION	HOA		8930A1123N001.DWG

Tag	Loop	Equipment	Function	Description 1	Description 2	Drawing #
LAH	130	LE-130	ALARM			8930A1123N001.DWG
LAL	130	LE-130	ALARM			8930A1123N001.DWG
LI	130	LE-130	NUM			8930A1123N001.DWG
LR	130	LE-130	TREND			8930A1123N001.DWG
QLH	130	LE-130	SP			8930A1123N001.DWG
QLL	130	LE-130	SP			8930A1123N001.DWG
YOC	130	EDR-130	STATUS	OC		8930A1123N001.DWG
YR	130	EDR-130	STATUS	REMOTE		8930A1123N001.DWG
HAD	131	PMP-131	ACTION	HOA		8930A1123N001.DWG
HAR	131	PMP-131	ACTION	RESET ETM		8930A1123N001.DWG
HAT	131	PMP-131	ACTION	SS		8930A1123N001.DWG
KI	131	PMP-131	NUM	ETM		8930A1123N001.DWG
MAH	131	PMP-131	ALARM			8930A1123N001.DWG
TAH	131	PMP-131	ALARM			8930A1123N001.DWG
Y1	131	PMP-131	STATUS	RUNNING		8930A1123N001.DWG
Y2	131	PMP-131	ALARM	FAILED		8930A1123N001.DWG
YR	131	PMP-131	STATUS	REMOTE		8930A1123N001.DWG
HAD	132	PMP-132	ACTION	HOA		8930A1123N001.DWG
HAR	132	PMP-132	ACTION	RESET ETM		8930A1123N001.DWG
HAT	132	PMP-132	ACTION	SS		8930A1123N001.DWG
KI	132	PMP-132	NUM	ETM		8930A1123N001.DWG
MAH	132	PMP-132	ALARM			8930A1123N001.DWG
TAH	132	PMP-132	ALARM			8930A1123N001.DWG
Y1	132	PMP-132	STATUS	RUNNING		8930A1123N001.DWG
Y2	132	PMP-132	ALARM	FAILED		8930A1123N001.DWG
YR	132	PMP-132	STATUS	REMOTE		8930A1123N001.DWG
LAH	180	LE-180	ALARM	OVERFLOW		8930A1128N001.DWG

Tag	Loop	Equipment	Function	Description 1	Description 2	Drawing #
LAL	180	LE-180	ALARM			8930A1128N001.DWG
LI	180	LE-180	NUM			8930A1128N001.DWG
LR	180	LE-180	TREND			8930A1128N001.DWG
QL1	180	QL1-180	SP			8930A1128N001.DWG
QL2	180	QL2-180	SP			8930A1128N001.DWG
QL3	180	QL3-180	SP			8930A1128N001.DWG
QLH	180	LE-180	SP			8930A1128N001.DWG
QLL	180	LE-180	SP			8930A1128N001.DWG
AAH	181	AE-181	ALARM	HIGH TURB		8930A1128N001.DWG
AAHH	181	AAHH-181	ALARM	HIGH HIGH TURB		8930A1128N001.DWG
AI	181	AE-181	NUM	TURB		8930A1128N001.DWG
AR	181	AE-181	TREND	TURB		8930A1128N001.DWG
HAD	181	PMP-181	ACTION	HOA		8930A1128N001.DWG
HAR	181	PMP-181	ACTION	RESET ETM		8930A1128N001.DWG
HAT	181	PMP-181	ACTION	SS		8930A1128N001.DWG
HAY	181	HAY-181	ACTION	EABLE/DISABLE		8930A1128N001.DWG
KI	181	PMP-181	NUM	ETM		8930A1128N001.DWG
MAH	181	PMP-181	ALARM	MOISTURE		8930A1128N001.DWG
QAH	181	AE-181	SP	TURB		8930A1128N001.DWG
QAHH	181	QAHH-181	SP	TURB		8930A1128N001.DWG
QKI	181	QKI-181	SP	HIGH TURB TIME		8930A1128N001.DWG
QS	181	PMP-181	SP	SPEED		8930A1128N001.DWG
SIB	181	PMP-181	NUM	SPEED		8930A1128N001.DWG
TAH	181	PMP-181	ALARM			8930A1128N001.DWG
Y1	181	PMP-181	STATUS	RUNNING		8930A1128N001.DWG
Y2	181	PMP-181	ALARM	FAILED		8930A1128N001.DWG
YR	181	PMP-181	STATUS	REMOTE		8930A1128N001.DWG

Tag	Loop	Equipment	Function	Description 1	Description 2	Drawing #
HAD	182	PMP-182	ACTION	HOA		8930A1128N001.DWG
HAR	182	PMP-182	ACTION	RESET ETM		8930A1128N001.DWG
HAT	182	PMP-182	ACTION	SS		8930A1128N001.DWG
KI	182	PMP-182	NUM	ETM		8930A1128N001.DWG
MAH	182	PMP-182	ALARM	MOISTURE		8930A1128N001.DWG
QS	182	PMP-182	SP	SPEED		8930A1128N001.DWG
SIB	182	PMP-182	NUM	SPEED		8930A1128N001.DWG
TAH	182	PMP-182	ALARM			8930A1128N001.DWG
Y1	182	PMP-182	STATUS	RUNNING		8930A1128N001.DWG
Y2	182	PMP-182	ALARM	FAILED		8930A1128N001.DWG
YR	182	PMP-182	STATUS	REMOTE		8930A1128N001.DWG
HAD	183	PMP-183	ACTION	HOA		8930A1128N002.DWG
HAR	183	PMP-183	ACTION	RESET ETM		8930A1128N002.DWG
HAT	183	PMP-183	ACTION	SS		8930A1128N002.DWG
KI	183	PMP-183	NUM	ETM		8930A1128N002.DWG
MAH	183	PMP-183	ALARM	MOISTURE		8930A1128N002.DWG
QS	183	PMP-183	SP	SPEED		8930A1128N002.DWG
SIB	183	PMP-183	NUM	SPEED		8930A1128N002.DWG
TAH	183	PMP-183	ALARM			8930A1128N002.DWG
Y1	183	PMP-183	STATUS	RUNNING		8930A1128N002.DWG
Y2	183	PMP-183	ALARM	FAILED		8930A1128N002.DWG
YR	183	PMP-183	STATUS	REMOTE		8930A1128N002.DWG
HAD	184	PMP-184	ACTION	HOA		8930A1128N002.DWG
HAR	184	PMP-184	ACTION	RESET ETM		8930A1128N002.DWG
HAT	184	PMP-184	ACTION	SS		8930A1128N002.DWG
KI	184	PMP-184	NUM	ETM		8930A1128N002.DWG
MAH	184	PMP-184	ALARM	MOISTURE		8930A1128N002.DWG

Tag	Loop	Equipment	Function	Description 1	Description 2	Drawing #
QS	184	PMP-184	SP	SPEED		8930A1128N002.DWG
SIB	184	PMP-184	NUM	SPEED		8930A1128N002.DWG
TAH	184	PMP-184	ALARM			8930A1128N002.DWG
Y1	184	PMP-184	STATUS	RUNNING		8930A1128N002.DWG
Y2	184	PMP-184	ALARM	FAILED		8930A1128N002.DWG
YR	184	PMP-184	STATUS	REMOTE		8930A1128N002.DWG
HAD	185	PMP-185	ACTION	HOA		8930A1128N003.DWG
HAR	185	PMP-185	ACTION	RESET ETM		8930A1128N003.DWG
HAT	185	PMP-185	ACTION	SS		8930A1128N003.DWG
KI	185	PMP-185	NUM	ETM		8930A1128N003.DWG
PAH	185	PE-185	ALARM	PRESS		8930A1128N003.DWG
TAH	185	PMP-185	ALARM			8930A1128N003.DWG
Y1	185	PMP-185	STATUS	RUNNING		8930A1128N003.DWG
Y2	185	PMP-185	ALARM	FAILED		8930A1128N003.DWG
YR	185	PMP-185	STATUS	REMOTE		8930A1128N003.DWG
FAH	186	FE-186	ALARM			8930A1128N003.DWG
FAL	186	FE-186	ALARM			8930A1128N003.DWG
FI	186	FE-186	NUM			8930A1128N003.DWG
FR	186	FE-186	TREND			8930A1128N003.DWG
HAD	186	PMP-186	ACTION	HOA		8930A1128N003.DWG
HAR	186	PMP-186	ACTION	RESET ETM		8930A1128N003.DWG
HAT	186	PMP-186	ACTION	SS		8930A1128N003.DWG
KI	186	PMP-186	NUM	ETM		8930A1128N003.DWG
PAH	186	PE-186	ALARM	PRESS		8930A1128N003.DWG
QFH	186	FE-186	SP			8930A1128N003.DWG
QFL	186	FE-186	SP			8930A1128N003.DWG
TAH	186	PMP-186	ALARM			8930A1128N003.DWG

Tag	Loop	Equipment	Function	Description 1	Description 2	Drawing #
Y1	186	PMP-186	STATUS	RUNNING		8930A1128N003.DWG
Y2	186	PMP-186	ALARM	FAILED		8930A1128N003.DWG
YR	186	PMP-186	STATUS	REMOTE		8930A1128N003.DWG
HAD	188	EAM-188	ACTION	HOA		8930A1128N002.DWG
HAK	188	EAM-188	ACTION	MODULATE		8930A1128N002.DWG
YOC	188	EAM-188	STATUS	OC		8930A1128N002.DWG
YR	188	EAM-188	STATUS	REMOTE		8930A1128N002.DWG
ZI	188	EAM-188	NUM	POSITION		8930A1128N002.DWG
LAH	189	LE-189	ALARM			8930A1128N001.DWG
LALL	189	LE-189	ALARM			8930A1128N001.DWG
LAH	210	LSH-210	ALARM	HI LVL		8930A1130N002.DWG
PI	210	PE-210	NUM			8930A1130N002.DWG
HAD	211	EDR-211	ACTION	HOA		8930A1130N002.DWG
HAO	211	EDR-211	ACTION	OC		8930A1130N002.DWG
YOC	211	EDR-211	STATUS	OC		8930A1130N002.DWG
YR	211	EDR-211	STATUS	REMOTE		8930A1130N002.DWG
Y2	212	VAL-212	ALARM	FAILED		8930A1130N002.DWG
ZLC	212	VAL-212	STATUS	CLOSED		8930A1130N002.DWG
ZLO	212	VAL-212	STATUS	OPENED		8930A1130N002.DWG
Y2	213A	VAL-213A	ALARM	FAILED		8930A1130N002.DWG
ZLC	213A	VAL-213A	STATUS	CLOSED		8930A1130N002.DWG
ZLO	213A	VAL-213A	STATUS	OPENED		8930A1130N002.DWG
Y2	213B	VAL-213B	ALARM	FAILED		8930A1130N002.DWG
ZLC	213B	VAL-213B	STATUS	CLOSED		8930A1130N002.DWG
ZLO	213B	VAL-213B	STATUS	OPENED		8930A1130N002.DWG
Y2	213C	VAL-213C	ALARM	FAILED		8930A1130N002.DWG
ZLC	213C	VAL-213C	STATUS	CLOSED		8930A1130N002.DWG

Tag	Loop	Equipment	Function	Description 1	Description 2	Drawing #
ZLO	213C	VAL-213C	STATUS	OPENED		8930A1130N002.DWG
Y2	213D	VAL-213D	ALARM	FAILED		8930A1130N002.DWG
ZLC	213D	VAL-213D	STATUS	CLOSED		8930A1130N002.DWG
ZLO	213D	VAL-213D	STATUS	OPENED		8930A1130N002.DWG
Y2	213E	VAL-213E	ALARM	FAILED		8930A1130N002.DWG
ZLC	213E	VAL-213E	STATUS	CLOSED		8930A1130N002.DWG
ZLO	213E	VAL-213E	STATUS	OPENED		8930A1130N002.DWG
TAH	214	PMP-214	ALARM			8930A1130N002.DWG
Y1	214	PMP-214	STATUS	RUNNING		8930A1130N002.DWG
Y2	214	PMP-214	ALARM	FAILED		8930A1130N002.DWG
TAH	215	PMP-215	ALARM			8930A1130N002.DWG
Y1	215	PMP-215	STATUS	RUNNING		8930A1130N002.DWG
Y2	215	PMP-215	ALARM	FAILED		8930A1130N002.DWG
TAH	216	MTR-216	ALARM			8930A1130N002.DWG
Y1	216	MTR-216	STATUS	RUNNING		8930A1130N002.DWG
Y2	216	MTR-216	ALARM	FAILED		8930A1130N002.DWG
LAH	220	LSH-220	ALARM	HI LVL		8930A1130N003.DWG
PI	220	PE-220	NUM			8930A1130N003.DWG
HAD	221	EDR-221	ACTION	HOA		8930A1130N003.DWG
HAO	221	EDR-221	ACTION	OC		8930A1130N003.DWG
YOC	221	EDR-221	STATUS	OC		8930A1130N003.DWG
YR	221	EDR-221	STATUS	REMOTE		8930A1130N003.DWG
Y2	222	VAL-222	ALARM	FAILED		8930A1130N003.DWG
ZLC	222	VAL-222	STATUS	CLOSED		8930A1130N003.DWG
ZLO	222	VAL-222	STATUS	OPENED		8930A1130N003.DWG
Y2	223A	VAL-223A	ALARM	FAILED		8930A1130N003.DWG
ZLC	223A	VAL-223A	STATUS	CLOSED		8930A1130N003.DWG

Tag	Loop	Equipment	Function	Description 1	Description 2	Drawing #
ZLO	223A	VAL-223A	STATUS	OPENED		8930A1130N003.DWG
Y2	223B	VAL-223B	ALARM	FAILED		8930A1130N003.DWG
ZLC	223B	VAL-223B	STATUS	CLOSED		8930A1130N003.DWG
ZLO	223B	VAL-223B	STATUS	OPENED		8930A1130N003.DWG
Y2	223C	VAL-223C	ALARM	FAILED		8930A1130N003.DWG
ZLC	223C	VAL-223C	STATUS	CLOSED		8930A1130N003.DWG
ZLO	223C	VAL-223C	STATUS	OPENED		8930A1130N003.DWG
Y2	223D	VAL-223D	ALARM	FAILED		8930A1130N003.DWG
ZLC	223D	VAL-223D	STATUS	CLOSED		8930A1130N003.DWG
ZLO	223D	VAL-223D	STATUS	OPENED		8930A1130N003.DWG
Y2	223E	VAL-223E	ALARM	FAILED		8930A1130N003.DWG
ZLC	223E	VAL-223E	STATUS	CLOSED		8930A1130N003.DWG
ZLO	223E	VAL-223E	STATUS	OPENED		8930A1130N003.DWG
TAH	224	PMP-224	ALARM			8930A1130N003.DWG
Y1	224	PMP-224	STATUS	RUNNING		8930A1130N003.DWG
Y2	224	PMP-224	ALARM	FAILED		8930A1130N003.DWG
TAH	225	PMP-225	ALARM			8930A1130N003.DWG
Y1	225	PMP-225	STATUS	RUNNING		8930A1130N003.DWG
Y2	225	PMP-225	ALARM	FAILED		8930A1130N003.DWG
TAH	226	MTR-226	ALARM			8930A1130N003.DWG
Y1	226	MTR-226	STATUS	RUNNING		8930A1130N003.DWG
Y2	226	MTR-226	ALARM	FAILED		8930A1130N003.DWG
31-AAH	230	31-AE-230	ALARM	HIGH TURB		8930A1130N001.DWG
31-AAHH	230	31-AE-230	ALARM	HIGH HIGH		8930A1130N001.DWG
31-AI	230	31-AE-230	NUM	TURB		8930A1130N001.DWG
31-AR	230	31-AE-230	TREND	TURB		8930A1130N001.DWG
31-QAH1	230	31-AE-230	SP	TURB		8930A1130N001.DWG

Tag	Loop	Equipment	Function	Description 1	Description 2	Drawing #
AAL	240	AE-240	ALARM	UVT		8930A1131N001.DWG
AALL	240	AE-240	ALARM	UVT		8930A1131N001.DWG
AI	240	AE-240	NUM	UVT		8930A1131N001.DWG
HAD	240	EDR-240	ACTION	HOA		8930A1131N001.DWG
HAO	240	EDR-240	ACTION	OC		8930A1131N001.DWG
YOC	240	EDR-240	STATUS	OC		8930A1131N001.DWG
YR	240	EDR-240	STATUS	REMOTE		8930A1131N001.DWG
FAH	241	FE-241	ALARM			8930A1131N001.DWG
FAL	241	FE-241	ALARM			8930A1131N001.DWG
FI	241	FE-241	NUM			8930A1131N001.DWG
FR	241	FR-241	TREND			8930A1131N001.DWG
LAH	241	LE-241	ALARM	CHANNEL LEVEL		8930A1131N001.DWG
LAL	241	LE-241				8930A1131N001.DWG
LI	241	LE-241	NUM			8930A1131N001.DWG
LR	241	LE-241	TREND			8930A1131N001.DWG
QFH	241	QFH-241	SP			8930A1131N001.DWG
QFL	241	QFL-241	SP			8930A1131N001.DWG
QLH	241	LE-241	SP			8930A1131N001.DWG
QLL	241	LE-241	SP			8930A1131N001.DWG
AAL	241A	AE-241A	ALARM	UV		8930A1131N001.DWG
AALL	241A	AE-241A	ALARM	UV		8930A1131N001.DWG
AC	241A	AE-241A	SP	UV DOSE		8930A1131N001.DWG
AI	241A	AE-241A	NUM	UV		8930A1131N001.DWG
JC	241A	JC-241A	SP	BANK POWER		8930A1131N001.DWG
LAL	241A	LE-241A	ALARM			8930A1131N001.DWG
Y1	241A	Y1-241A	STATUS	BANK ON		8930A1131N001.DWG
Y1	241A	Y1-241A	STATUS	LAMP ON		8930A1131N001.DWG

Tag	Loop	Equipment	Function	Description 1	Description 2	Drawing #
YAH1	241A	YAH1-241A	ALARM	BANK 1 FAILED		8930A1131N001.DWG
YAH2	241A	YAH2-241A	ALARM	LAMP COUNT LOW		8930A1131N001.DWG
YAH3	241A	YAH3-241A	ALARM	MULTILAMP FAIL		8930A1131N001.DWG
YAH4	241A	YAH4-241A	ALARM	ADJ LAMP FAIL		8930A1131N001.DWG
YAW	241A	YAW-241A	ALARM	LAMP WIPER FAIL		8930A1131N001.DWG
AAL	241B	AE-241B	ALARM	UV		8930A1131N001.DWG
AALL	241B	AE-241B	ALARM	UV		8930A1131N001.DWG
AC	241B	AE-241B	SP	UV DOSE		8930A1131N001.DWG
AI	241B	AE-241B	NUM	UV		8930A1131N001.DWG
JC	241B	JC-241B	SP	BANK POWER		8930A1131N001.DWG
LAL	241B	LE-241B	ALARM			8930A1131N001.DWG
Y1	241B	Y1-241B	STATUS	BANK ON		8930A1131N001.DWG
Y1	241B	Y1-241B	STATUS	LAMP ON		8930A1131N001.DWG
YAH1	241B	YAH1-241B	ALARM	BANK 1 FAILED		8930A1131N001.DWG
YAH2	241B	YAH2-241B	ALARM	LAMP COUNT LOW		8930A1131N001.DWG
YAH3	241B	YAH3-241B	ALARM	MULTILAMP FAIL		8930A1131N001.DWG
YAH4	241B	YAH4-241B	ALARM	ADJ LAMP FAIL		8930A1131N001.DWG
YAW	241B	YAW-241B	ALARM	LAMP WIPER FAIL		8930A1131N001.DWG
AAL	241C	AE-241C	ALARM	UV		8930A1131N001.DWG
AALL	241C	AE-241C	ALARM	UV		8930A1131N001.DWG
AC	241C	AE-241C	SP	UV DOSE		8930A1131N001.DWG
AI	241C	AE-241C	NUM	UV		8930A1131N001.DWG
JC	241C	JC-241C	SP	BANK POWER		8930A1131N001.DWG
LAL	241C	LE-241C	ALARM			8930A1131N001.DWG
Y1	241C	Y1-241C	STATUS	LAMP ON		8930A1131N001.DWG
Y1	241C	Y1-241C	STATUS	BANK ON		8930A1131N001.DWG
YAH1	241C	YAH1-241C	ALARM	BANK 1 FAILED		8930A1131N001.DWG

Tag	Loop	Equipment	Function	Description 1	Description 2	Drawing #
YAH2	241C	YAH2-241C	ALARM	LAMP COUNT LOW		8930A1131N001.DWG
YAH3	241C	YAH3-241C	ALARM	MULTILAMP FAIL		8930A1131N001.DWG
YAH4	241C	YAH4-241C	ALARM	ADJ LAMP FAIL		8930A1131N001.DWG
YAW	241C	YAW-241C	ALARM	LAMP WIPER FAIL		8930A1131N001.DWG
AAL	242	LE-242	ALARM	UV		8930A1131N002.DWG
AALL	242	LE-242	ALARM	UV		8930A1131N002.DWG
AC	242	LE-242	SP	UV DOSE		8930A1131N002.DWG
AI	242	LE-242	NUM	UV		8930A1131N002.DWG
FAH	242	FE-242	ALARM			8930A1131N002.DWG
FAL	242	FE-242	ALARM			8930A1131N002.DWG
FI	242	FE-242	NUM			8930A1131N002.DWG
FR	242	FE-242	TREND			8930A1131N002.DWG
JC	242	LE-242	SP	BANK POWER		8930A1131N002.DWG
LAH	242	LE-242	ALARM	CHANNEL LEVEL		8930A1131N002.DWG
LAL	242	LE-242	ALARM			8930A1131N002.DWG
LAL	242	LE-242				8930A1131N002.DWG
LI	242	LE-242	NUM			8930A1131N002.DWG
LR	242	LE-242	TREND			8930A1131N002.DWG
QFH	242	FE-242	SP			8930A1131N002.DWG
QFL	242	FE-242	SP			8930A1131N002.DWG
QLH	242	LE-242	SP			8930A1131N002.DWG
QLL	242	LE-242	SP			8930A1131N002.DWG
Y1	242	LE-242	STATUS	LAMP ON		8930A1131N002.DWG
Y1	242	LE-242	STATUS	BANK ON		8930A1131N002.DWG
YAH1	242	LE-242	ALARM	BANK 1 FAILED		8930A1131N002.DWG
YAH2	242	LE-242	ALARM	LAMP COUNT LOW		8930A1131N002.DWG
YAH3	242	LE-242	ALARM	MULTILAMP FAIL		8930A1131N002.DWG

Tag	Loop	Equipment	Function	Description 1	Description 2	Drawing #
YAH4	242	LE-242	ALARM	ADJ LAMP FAIL		8930A1131N002.DWG
YAW	242	LE-242	ALARM	LAMP WIPER FAIL		8930A1131N002.DWG
AAL	242B	LE-242B	ALARM	UV		8930A1131N002.DWG
AALL	242B	LE-242B	ALARM	UV		8930A1131N002.DWG
AC	242B	LE-242B	SP	UV DOSE		8930A1131N002.DWG
AI	242B	LE-242B	NUM	UV		8930A1131N002.DWG
JC	242B	LE-242B	SP	BANK POWER		8930A1131N002.DWG
LAL	242B	LE-242B	ALARM			8930A1131N002.DWG
Y1	242B	LE-242B	STATUS	LAMP ON		8930A1131N002.DWG
Y1	242B	LE-242B	STATUS	BANK ON		8930A1131N002.DWG
YAH1	242B	LE-242B	ALARM	BANK 1 FAILED		8930A1131N002.DWG
YAH2	242B	LE-242B	ALARM	LAMP COUNT LOW		8930A1131N002.DWG
YAH3	242B	LE-242B	ALARM	MULTILAMP FAIL		8930A1131N002.DWG
YAH4	242B	LE-242B	ALARM	ADJ LAMP FAIL		8930A1131N002.DWG
YAW	242B	LE-242B	ALARM	LAMP WIPER FAIL		8930A1131N002.DWG
AAL	242C	LE-242C	ALARM	UV		8930A1131N002.DWG
AALL	242C	LE-242C	ALARM	UV		8930A1131N002.DWG
AC	242C	LE-242C	SP	UV DOSE		8930A1131N002.DWG
AI	242C	LE-242C	NUM	UV		8930A1131N002.DWG
JC	242C	LE-242C	SP	BANK POWER		8930A1131N002.DWG
LAL	242C	LE-242C	ALARM			8930A1131N002.DWG
Y1	242C	LE-242C	STATUS	LAMP ON		8930A1131N002.DWG
Y1	242C	LE-242C	STATUS	BANK ON		8930A1131N002.DWG
YAH1	242C	LE-242C	ALARM	BANK 1 FAILED		8930A1131N002.DWG
YAH2	242C	LE-242C	ALARM	LAMP COUNT LOW		8930A1131N002.DWG
YAH3	242C	LE-242C	ALARM	MULTILAMP FAIL		8930A1131N002.DWG
YAH4	242C	LE-242C	ALARM	ADJ LAMP FAIL		8930A1131N002.DWG

Tag	Loop	Equipment	Function	Description 1	Description 2	Drawing #
YAW	242C	LE-242C	ALARM	LAMP WIPER FAIL		8930A1131N002.DWG
FAH	243	FE-243	ALARM			8930A1131N003.DWG
FAL	243	FE-243	ALARM			8930A1131N003.DWG
FI	243	FE-243	NUM			8930A1131N003.DWG
FR	243	FE-243	TREND			8930A1131N003.DWG
LAH	243	LE-243	ALARM	CHANNEL LEVEL		8930A1131N003.DWG
LAL	243	LE-243				8930A1131N003.DWG
LI	243	LE-243	NUM			8930A1131N003.DWG
LR	243	LE-243	TREND			8930A1131N003.DWG
QFH	243	FE-243	SP			8930A1131N003.DWG
QFL	243	FE-243	SP			8930A1131N003.DWG
QLH	243	LE-243	SP			8930A1131N003.DWG
QLL	243	LE-243	SP			8930A1131N003.DWG
AAL	243A	LE-243A	ALARM	UV		8930A1131N003.DWG
AALL	243A	LE-243A	ALARM	UV		8930A1131N003.DWG
AC	243A	LE-243A	SP	UV DOSE		8930A1131N003.DWG
AI	243A	LE-243A	NUM	UV		8930A1131N003.DWG
JC	243A	LE-243A	SP	BANK POWER		8930A1131N003.DWG
LAL	243A	LE-243A	ALARM			8930A1131N003.DWG
Y1	243A	LE-243A	STATUS	BANK ON		8930A1131N003.DWG
Y1	243A	LE-243A	STATUS	LAMP ON		8930A1131N003.DWG
YAH1	243A	LE-243A	ALARM	BANK 1 FAILED		8930A1131N003.DWG
YAH2	243A	LE-243A	ALARM	LAMP COUNT LOW		8930A1131N003.DWG
YAH3	243A	LE-243A	ALARM	MULTILAMP FAIL		8930A1131N003.DWG
YAH4	243A	LE-243A	ALARM	ADJ LAMP FAIL		8930A1131N003.DWG
YAW	243A	LE-243A	ALARM	LAMP WIPER FAIL		8930A1131N003.DWG
AAL	243B	LE-243B	ALARM	UV		8930A1131N003.DWG

Tag	Loop	Equipment	Function	Description 1	Description 2	Drawing #
AALL	243B	LE-243B	ALARM	UV		8930A1131N003.DWG
AC	243B	LE-243B	SP	UV DOSE		8930A1131N003.DWG
AI	243B	LE-243B	NUM	UV		8930A1131N003.DWG
JC	243B	LE-243B	SP	BANK POWER		8930A1131N003.DWG
LAL	243B	LE-243B	ALARM			8930A1131N003.DWG
Y1	243B	LE-243B	STATUS	BANK ON		8930A1131N003.DWG
Y1	243B	LE-243B	STATUS	LAMP ON		8930A1131N003.DWG
YAH1	243B	LE-243B	ALARM	BANK 1 FAILED		8930A1131N003.DWG
YAH2	243B	LE-243B	ALARM	LAMP COUNT LOW		8930A1131N003.DWG
YAH3	243B	LE-243B	ALARM	MULTILAMP FAIL		8930A1131N003.DWG
YAH4	243B	LE-243B	ALARM	ADJ LAMP FAIL		8930A1131N003.DWG
YAW	243B	LE-243B	ALARM	LAMP WIPER FAIL		8930A1131N003.DWG
AAL	243C	LE-243C	ALARM	UV		8930A1131N003.DWG
AALL	243C	LE-243C	ALARM	UV		8930A1131N003.DWG
AC	243C	LE-243C	SP	UV DOSE		8930A1131N003.DWG
AI	243C	LE-243C	NUM	UV		8930A1131N003.DWG
JC	243C	LE-243C	SP	BANK POWER		8930A1131N003.DWG
LAL	243C	LE-243C	ALARM			8930A1131N003.DWG
Y1	243C	LE-243C	STATUS	LAMP ON		8930A1131N003.DWG
Y1	243C	LE-243C	STATUS	BANK ON		8930A1131N003.DWG
YAH1	243C	LE-243C	ALARM	BANK 1 FAILED		8930A1131N003.DWG
YAH2	243C	LE-243C	ALARM	LAMP COUNT LOW		8930A1131N003.DWG
YAH3	243C	LE-243C	ALARM	MULTILAMP FAIL		8930A1131N003.DWG
YAH4	243C	LE-243C	ALARM	ADJ LAMP FAIL		8930A1131N003.DWG
YAW	243C	LE-243C	ALARM	LAMP WIPER FAIL		8930A1131N003.DWG
HAD	244	EDM-244	ACTION	HOA		8930A1131N001.DWG
HAK	244	EDM-244	ACTION	JOJC		8930A1131N001.DWG

Tag	Loop	Equipment	Function	Description 1	Description 2	Drawing #
YOC	244	EDM-244	STATUS	OC		8930A1131N001.DWG
YR	244	EDM-244	STATUS	REMOTE		8930A1131N001.DWG
ZI	244	EDM-244	NUM	POSITION		8930A1131N001.DWG
HAD	245	EDM-245	ACTION	HOA		8930A1131N002.DWG
HAK	245	EDM-245	ACTION	JOJC		8930A1131N002.DWG
YOC	245	EDM-245	STATUS	OC		8930A1131N002.DWG
YR	245	EDM-245	STATUS	REMOTE		8930A1131N002.DWG
ZI	245	EDM-245	NUM	POSITION		8930A1131N002.DWG
HAD	246	EDM-246	ACTION	HOA		8930A1131N003.DWG
HAK	246	EDM-246	ACTION	JOJC		8930A1131N003.DWG
YOC	246	EDM-246	STATUS	OC		8930A1131N003.DWG
YR	246	EDM-246	STATUS	REMOTE		8930A1131N003.DWG
ZI	246	EDM-246	NUM	POSITION		8930A1131N003.DWG
HAD	247	EDR-247	ACTION	HOA		8930A1131N001.DWG
HAO	247	EDR-247	ACTION	OC		8930A1131N001.DWG
Y2	247	COS-247	ALARM	FAILED		8930A1131N002.DWG
YOC	247	EDR-247	STATUS	OC		8930A1131N001.DWG
YR	247	EDR-247	STATUS	REMOTE		8930A1131N001.DWG
HAD	248	EDR-248	ACTION	HOA		8930A1131N002.DWG
HAO	248	EDR-248	ACTION	OC		8930A1131N002.DWG
YOC	248	EDR-248	STATUS	OC		8930A1131N002.DWG
YR	248	EDR-248	STATUS	REMOTE		8930A1131N002.DWG
HAD	249	EDR-249	ACTION	HOA		8930A1131N003.DWG
HAO	249	EDR-249	ACTION	OC		8930A1131N003.DWG
YOC	249	EDR-249	STATUS	OC		8930A1131N003.DWG
YR	249	EDR-249	STATUS	REMOTE		8930A1131N003.DWG
LAL	270	WE-270	ALARM	LEVEL		8930A1132N001.DWG

Tag	Loop	Equipment	Function	Description 1	Description 2	Drawing #
LR	270	WE-270	TREND	LEVEL		8930A1132N001.DWG
QC	270	WE-270	SP	CONC		8930A1132N001.DWG
QLL	270	WE-270	SP	LEVEL		8930A1132N001.DWG
WI	270	WE-270	NUM	WEIGHT		8930A1132N001.DWG
HAD	271	PMP-271	ACTION	HOA		8930A1132N002.DWG
HAS	271	PMP-271	ACTION	SPEED-HAND		8930A1132N002.DWG
HAT	271	PMP-271	ACTION	SS		8930A1132N002.DWG
KI	271	PMP-271	NUM	ETM		8930A1132N002.DWG
LAH	271	PMP-271	ALARM	LEAK		8930A1132N002.DWG
QC	271	PMP-271	SP	CONC Mg/L		8930A1132N002.DWG
QD	271	PMP-271	SP	DOSE Mg/L		8930A1132N002.DWG
Y1	271	PMP-271	STATUS	RUNNING		8930A1132N002.DWG
YR	271	PMP-271	STATUS	REMOTE		8930A1132N002.DWG
HAD	272	PMP-272	ACTION	HOA		8930A1132N003.DWG
HAS	272	PMP-272	ACTION	SPEED-HAND		8930A1132N003.DWG
HAT	272	PMP-272	ACTION	SS		8930A1132N003.DWG
KI	272	PMP-272	NUM	ETM		8930A1132N003.DWG
LAH	272	PMP-272	ALARM	LEAK		8930A1132N003.DWG
QC	272	PMP-272	SP	CONC Mg/L		8930A1132N003.DWG
QD	272	PMP-272	SP	DOSE Mg/L		8930A1132N003.DWG
Y1	272	PMP-272	STATUS	RUNNING		8930A1132N003.DWG
YR	272	PMP-272	STATUS	REMOTE		8930A1132N003.DWG
LAH	273	LE-273	ALARM			8930A1132N003.DWG
LAH	280	LE-280	ALARM			8930A1132N004.DWG
LAH	280	LE-280	ALARM			8930A1132N004.DWG
LAHH	280	LE-280	ALARM			8930A1132N004.DWG
LAL	280	LE-280	ALARM			8930A1132N004.DWG

Tag	Loop	Equipment	Function	Description 1	Description 2	Drawing #
LALL	280	LE-280	ALARM			8930A1132N004.DWG
LI	280	LE-280	NUM			8930A1132N004.DWG
LR	280	LE-280	TREND			8930A1132N004.DWG
QLH	280	LE-280	SP			8930A1132N004.DWG
QLHH	280	LE-280	SP			8930A1132N004.DWG
QLL	280	LE-280	SP			8930A1132N004.DWG
QLLL	280	LE-280	SP			8930A1132N004.DWG
HAD	281	PMP-281	ACTION	HOA		8930A1132N005.DWG
HAS	281	PMP-281	ACTION	SPEED-HAND		8930A1132N005.DWG
HAT	281	PMP-281	ACTION	SS		8930A1132N005.DWG
KI	281	PMP-281	NUM	ETM		8930A1132N005.DWG
LAH	281	PMP-281	ALARM	LEAK		8930A1132N005.DWG
Y1	281	PMP-281	STATUS	RUNNING		8930A1132N005.DWG
YR	281	PMP-281	STATUS	REMOTE		8930A1132N005.DWG
HAD	283	PMP-283	ACTION	HOA		8930A1132N007.DWG
HAS	283	PMP-283	ACTION	SPEED-HAND		8930A1132N007.DWG
HAT	283	PMP-283	ACTION	SS		8930A1132N007.DWG
KI	283	PMP-283	NUM	ETM		8930A1132N007.DWG
LAH	283	PMP-283	ALARM	LEAK		8930A1132N007.DWG
QC	283	PMP-283	SP	CONC Mg/L		8930A1132N007.DWG
QD	283	PMP-283	SP	DOSE Mg/L		8930A1132N007.DWG
Y1	283	PMP-283	STATUS	RUNNING		8930A1132N007.DWG
YR	283	PMP-283	STATUS	REMOTE		8930A1132N007.DWG
HAD	284	PMP-284	ACTION	HOA		8930A1132N008.DWG
HAS	284	PMP-284	ACTION	SPEED-HAND		8930A1132N008.DWG
HAT	284	PMP-284	ACTION	SS		8930A1132N008.DWG
KI	284	PMP-284	NUM	ETM		8930A1132N008.DWG

Tag	Loop	Equipment	Function	Description 1	Description 2	Drawing #
LAH	284	PMP-284	ALARM	LEAK		8930A1132N008.DWG
QC	284	PMP-284	SP	CONC Mg/L		8930A1132N008.DWG
QD	284	PMP-284	SP	DOSE Mg/L		8930A1132N008.DWG
Y1	284	PMP-284	STATUS	RUNNING		8930A1132N008.DWG
YR	284	PMP-284	STATUS	REMOTE		8930A1132N008.DWG
HAD	285	PMP-285	ACTION	HOA		8930A1132N009.DWG
HAS	285	PMP-285	ACTION	SPEED-HAND		8930A1132N009.DWG
HAT	285	PMP-285	ACTION	SS		8930A1132N009.DWG
KI	285	PMP-285	NUM	ETM		8930A1132N009.DWG
LAH	285	PMP-285	ALARM	LEAK		8930A1132N009.DWG
QC	285	PMP-285	SP	CONC Mg/L		8930A1132N009.DWG
QD	285	PMP-285	SP	DOSE Mg/L		8930A1132N009.DWG
Y1	285	PMP-285	STATUS	RUNNING		8930A1132N009.DWG
YR	285	PMP-285	STATUS	REMOTE		8930A1132N009.DWG
HAD	301	PMP-301	ACTION	HOA		8930A1140N001.DWG
HAR	301	PMP-301	ACTION	RESET ETM		8930A1140N001.DWG
HAT	301	PMP-301	ACTION	SS		8930A1140N001.DWG
KI	301	PMP-301	NUM	ETM		8930A1140N001.DWG
PAH	301	PE-301	ALARM			8930A1140N001.DWG
TAH	301	PMP-301	ALARM			8930A1140N001.DWG
Y1	301	PMP-301	STATUS	RUNNING		8930A1140N001.DWG
Y2	301	PMP-301	ALARM	FAILED		8930A1140N001.DWG
YR	301	PMP-301	STATUS	REMOTE		8930A1140N001.DWG
HAD	302	PMP-302	ACTION	HOA		8930A1140N001.DWG
HAR	302	PMP-302	ACTION	RESET ETM		8930A1140N001.DWG
HAT	302	PMP-302	ACTION	SS		8930A1140N001.DWG
KI	302	PMP-302	NUM	ETM		8930A1140N001.DWG

Tag	Loop	Equipment	Function	Description 1	Description 2	Drawing #
PAH	302	PE-302	ALARM			8930A1140N001.DWG
TAH	302	PMP-302	ALARM			8930A1140N001.DWG
Y1	302	PMP-302	STATUS	RUNNING		8930A1140N001.DWG
Y2	302	PMP-302	ALARM	FAILED		8930A1140N001.DWG
YR	302	PMP-302	STATUS	REMOTE		8930A1140N001.DWG
HAD	303	PMP-303	ACTION	HOA		8930A1140N002.DWG
HAR	303	PMP-303	ACTION	RESET ETM		8930A1140N002.DWG
HAT	303	PMP-303	ACTION	SS		8930A1140N002.DWG
KI	303	PMP-303	NUM	ETM		8930A1140N002.DWG
PAH	303	PE-303	ALARM			8930A1140N002.DWG
TAH	303	PMP-303	ALARM			8930A1140N002.DWG
Y1	303	PMP-303	STATUS	RUNNING		8930A1140N002.DWG
Y2	303	PMP-303	ALARM	FAILED		8930A1140N002.DWG
YR	303	PMP-303	STATUS	REMOTE		8930A1140N002.DWG
HAD	304	PMP-304	ACTION	HOA		8930A1140N002.DWG
HAR	304	PMP-304	ACTION	RESET ETM		8930A1140N002.DWG
HAT	304	PMP-304	ACTION	SS		8930A1140N002.DWG
KI	304	PMP-304	NUM	ETM		8930A1140N002.DWG
PAH	304	PE-304	ALARM			8930A1140N002.DWG
TAH	304	PMP-304	ALARM			8930A1140N002.DWG
Y1	304	PMP-304	STATUS	RUNNING		8930A1140N002.DWG
Y2	304	PMP-304	ALARM	FAILED		8930A1140N002.DWG
YR	304	PMP-304	STATUS	REMOTE		8930A1140N002.DWG
PAH	306	PE-306	ALARM			8930A1140N003.DWG
PAL	306	PE-306	ALARM			8930A1140N003.DWG
PI	306	PE-306	NUM			8930A1140N003.DWG
PR	306	PE-306	TREND			8930A1140N003.DWG

Tag	Loop	Equipment	Function	Description 1	Description 2	Drawing #
QP1	306	PE-306	SP	LEAD		8930A1140N003.DWG
QP2	306	PE-306	SP	LAG-1		8930A1140N003.DWG
QP3	306	PE-306	SP	LAG-2		8930A1140N003.DWG
QP4	306	PE-306	SP	LAG-3		8930A1140N003.DWG
QP5	306	PE-306	SP	LEAD		8930A1140N003.DWG
QP6	306	PE-306	SP	LAG-1		8930A1140N003.DWG
QP7	306	PE-306	SP	LAG-2		8930A1140N003.DWG
QP8	306	PE-306	SP	LAG-3		8930A1140N003.DWG
QPH	306	PE-306	SP			8930A1140N003.DWG
QPL	306	PE-306	SP			8930A1140N003.DWG
FAH	307	FE-307	ALARM			8930A1140N003.DWG
FAL	307	FE-307	ALARM			8930A1140N003.DWG
FI	307	FE-307	NUM			8930A1140N003.DWG
FR	307	FE-307	TREND			8930A1140N003.DWG
QFH	307	FE-307	SP			8930A1140N003.DWG
QFL	307	FE-307	SP			8930A1140N003.DWG
AAH	308	AE-308	ALARM	CL2		8930A1140N003.DWG
AAL	308	AE-308	ALARM	CL2		8930A1140N003.DWG
AI	308	AE-308	NUM	CL2		8930A1140N003.DWG
AR	308	AE-308	TREND	CL2		8930A1140N003.DWG
QAH	308	AE-308	SP	CL2		8930A1140N003.DWG
QAL	308	AE-308	SP	CL2		8930A1140N003.DWG
FAH	309	FE-309	ALARM			8930A1150N012.DWG
FAL	309	FE-309	ALARM			8930A1150N012.DWG
FI	309	FE-309	NUM			8930A1150N012.DWG
FR	309	FE-309	TREND			8930A1150N012.DWG
QFH	309	FE-309	SP			8930A1150N012.DWG

Tag	Loop	Equipment	Function	Description 1	Description 2	Drawing #
QFL	309	FE-309	SP			8930A1150N012.DWG
HAO	324	EDR-324	ACTION	OC		8930A1103N001.DWG
YOC	324	EDR-324	STATUS	OC		8930A1103N001.DWG
YR	324	EDR-324	STATUS	REMOTE		8930A1103N001.DWG
LAH	327	LE-327	ALARM			8930A1103N001.DWG
LAL	327	LE-327	ALARM			8930A1103N001.DWG
LI	327	LE-327	NUM			8930A1103N001.DWG
LR	327	LE-327	TREND			8930A1103N001.DWG
QLH	327	LE-327	SP			8930A1103N001.DWG
QLL	327	LE-327	SP			8930A1103N001.DWG
HAD	401	BLO-401	ACTION	HOA		8930A1150N004.DWG
HAJ	401	HAJ-401	ACTION	LS		8930A1150N004.DWG
HAR	401	BLO-401	ACTION	RESET ETM		8930A1150N004.DWG
HAT	401	BLO-401	ACTION	SS		8930A1150N004.DWG
KI	401	BLO-401	NUM	ETM		8930A1150N004.DWG
TAH	401	TE-401	ALARM	DISCH HIGH TEMP		8930A1150N004.DWG
Y1	401	BLO-401	STATUS	RUNNING		8930A1150N004.DWG
Y2	401	BLO-401	ALARM	FAILED		8930A1150N004.DWG
YR	401	BLO-401	STATUS	REMOTE		8930A1150N004.DWG
PAH	401A	PE-401A	ALARM	INLET FILTER CLOGGED		8930A1150N004.DWG
TAH	401A	BLO-401	ALARM			8930A1150N004.DWG
PAH	401B	PE-401B	ALARM	DISCH HIGH PRESS		8930A1150N004.DWG
HAD	402	BLO-402	ACTION	HOA		8930A1150N005.DWG
HAJ	402	HAJ-402	ACTION	LS		8930A1150N005.DWG
HAR	402	BLO-402	ACTION	RESET ETM		8930A1150N005.DWG
HAT	402	BLO-402	ACTION	SS		8930A1150N005.DWG
HAY	402	HAY-402	ACTION	TANK 1/TANK 2		8930A1150N005.DWG

Tag	Loop	Equipment	Function	Description 1	Description 2	Drawing #
KI	402	BLO-402	NUM	ETM		8930A1150N005.DWG
TAH	402	TE-402	ALARM	DISCH HIGH TEMP		8930A1150N005.DWG
Y1	402	BLO-402	STATUS	RUNNING		8930A1150N005.DWG
Y2	402	BLO-402	ALARM	FAILED		8930A1150N005.DWG
YR	402	BLO-402	STATUS	REMOTE		8930A1150N005.DWG
PAH	402A	PE-402A	ALARM	INLET FILTER CLOGGED		8930A1150N005.DWG
TAH	402A	BLO-402	ALARM			8930A1150N005.DWG
PAH	402B	PE-402B	ALARM	DISCH HIGH PRESS		8930A1150N005.DWG
HAD	403	BLO-403	ACTION	HOA		8930A1150N006.DWG
HAJ	403	HAJ-403	ACTION	LS		8930A1150N006.DWG
HAR	403	BLO-403	ACTION	RESET ETM		8930A1150N006.DWG
HAT	403	BLO-403	ACTION	SS		8930A1150N006.DWG
KI	403	BLO-403	NUM	ETM		8930A1150N006.DWG
TAH	403	TE-403	ALARM	DISCH HIGH TEMP		8930A1150N006.DWG
Y1	403	BLO-403	STATUS	RUNNING		8930A1150N006.DWG
Y2	403	BLO-403	ALARM	FAILED		8930A1150N006.DWG
YR	403	BLO-403	STATUS	REMOTE		8930A1150N006.DWG
PAH	403A	PE-403A	ALARM	INLET FILTER CLOGGED		8930A1150N006.DWG
TAH	403A	BLO-403	ALARM			8930A1150N006.DWG
PAH	403B	PE-403B	ALARM	DISCH HIGH PRESS		8930A1150N006.DWG
HAD	404	EDR-404	ACTION	HOA		8930A1150N007.DWG
HAO	404	EDR-404	ACTION	OC		8930A1150N007.DWG
YOC	404	EDR-404	STATUS	OC		8930A1150N007.DWG
YR	404	EDR-404	STATUS	REMOTE		8930A1150N007.DWG
HAD	405	EDR-405	ACTION	HOA		8930A1150N007.DWG
HAO	405	EDR-405	ACTION	OC		8930A1150N007.DWG
YOC	405	EDR-405	STATUS	OC		8930A1150N007.DWG

Tag	Loop	Equipment	Function	Description 1	Description 2	Drawing #
YR	405	EDR-405	STATUS	REMOTE		8930A1150N007.DWG
HAD	406	EDR-406	ACTION	HOA		8930A1150N007.DWG
HAO	406	EDR-406	ACTION	OC		8930A1150N007.DWG
YOC	406	EDR-406	STATUS	OC		8930A1150N007.DWG
YR	406	EDR-406	STATUS	REMOTE		8930A1150N007.DWG
HAD	407	EDR-407	ACTION	HOA		8930A1150N007.DWG
HAO	407	EDR-407	ACTION	OC		8930A1150N007.DWG
YOC	407	EDR-407	STATUS	OC		8930A1150N007.DWG
YR	407	EDR-407	STATUS	REMOTE		8930A1150N007.DWG
HAD	408	EDR-408	ACTION	HOA		8930A1150N007.DWG
HAO	408	EDR-408	ACTION	OC		8930A1150N007.DWG
YOC	408	EDR-408	STATUS	OC		8930A1150N007.DWG
YR	408	EDR-408	STATUS	REMOTE		8930A1150N007.DWG
HAD	411	EDR-411	ACTION	HOA		8930A1150N008.DWG
HAO	411	EDR-411	ACTION	OC		8930A1150N008.DWG
LAH	411	PE-411	ALARM			8930A1150N008.DWG
LAL	411	PE-411	ALARM			8930A1150N008.DWG
LI	411	PE-411	NUM	LEVEL		8930A1150N008.DWG
LR	411	PE-411	TREND			8930A1150N008.DWG
QLAH	411	PE-411	SP			8930A1150N008.DWG
QLAL	411	PE-411	SP			8930A1150N008.DWG
YOC	411	EDR-411	STATUS	OC		8930A1150N008.DWG
YR	411	EDR-411	STATUS	REMOTE		8930A1150N008.DWG
HAD	412	EDR-412	ACTION	HOA		8930A1150N009.DWG
HAO	412	EDR-412	ACTION	OC		8930A1150N009.DWG
LAH	412	PE-412	ALARM			8930A1150N009.DWG
LAL	412	PE-412	ALARM			8930A1150N009.DWG

Tag	Loop	Equipment	Function	Description 1	Description 2	Drawing #
LI	412	PE-412	NUM	LEVEL		8930A1150N009.DWG
LR	412	PE-412	TREND			8930A1150N009.DWG
QLAH	412	PE-412	SP			8930A1150N009.DWG
QLAL	412	PE-412	SP			8930A1150N009.DWG
YOC	412	EDR-412	STATUS	OC		8930A1150N009.DWG
YR	412	EDR-412	STATUS	REMOTE		8930A1150N009.DWG
HAD	413	EDM-413	ACTION	HOA		8930A1150N008.DWG
HAK	413	EDM-413	ACTION	JOJC		8930A1150N008.DWG
YOC	413	EDM-413	STATUS	OC		8930A1150N008.DWG
YR	413	EDM-413	STATUS	REMOTE		8930A1150N008.DWG
ZI	413	EDM-413	NUM	POSITION		8930A1150N008.DWG
HAD	414	EDM-414	ACTION	HOA		8930A1150N008.DWG
HAK	414	EDM-414	ACTION	JOJC		8930A1150N008.DWG
YOC	414	EDM-414	STATUS	OC		8930A1150N008.DWG
YR	414	EDM-414	STATUS	REMOTE		8930A1150N008.DWG
ZI	414	EDM-414	NUM	POSITION		8930A1150N008.DWG
HAD	415	EDM-415	ACTION	HOA		8930A1150N009.DWG
YOC	415	EDM-415	STATUS	OC		8930A1150N009.DWG
YR	415	EDM-415	STATUS	REMOTE		8930A1150N009.DWG
HAD	416	EDM-416	ACTION	HOA		8930A1150N009.DWG
YOC	416	EDM-416	STATUS	OC		8930A1150N009.DWG
YR	416	EDM-416	STATUS	REMOTE		8930A1150N009.DWG
HAD	417	EDR-417	ACTION	HOA		8930A1150N008.DWG
HAO	417	EDR-417	ACTION	OC		8930A1150N008.DWG
YOC	417	EDR-417	STATUS	OC		8930A1150N008.DWG
YR	417	EDR-417	STATUS	REMOTE		8930A1150N008.DWG
HAD	418	EDR-418	ACTION	HOA		8930A1150N009.DWG

Tag	Loop	Equipment	Function	Description 1	Description 2	Drawing #
HAO	418	EDR-418	ACTION	OC		8930A1150N009.DWG
YOC	418	EDR-418	STATUS	OC		8930A1150N009.DWG
YR	418	EDR-418	STATUS	REMOTE		8930A1150N009.DWG
LAHH	419	LE-419	ALARM			8930A1150N013.DWG
LALL	419	LE-419	ALARM			8930A1150N013.DWG
HAR	419A	PMP-419A	ACTION	RESET ETM		8930A1150N013.DWG
KI	419A	PMP-419A	NUM	ETM		8930A1150N013.DWG
X1	419A	PMP-419A	ALARM	FAULT		8930A1150N013.DWG
Y1	419A	PMP-419A	STATUS	RUNNING		8930A1150N013.DWG
HAR	419B	PMP-419B	ACTION	RESET ETM		8930A1150N013.DWG
KI	419B	PMP-419B	NUM	ETM		8930A1150N013.DWG
X1	419B	PMP-419B	ALARM	FAULT		8930A1150N013.DWG
Y1	419B	PMP-419B	STATUS	RUNNING		8930A1150N013.DWG
HAD	421	EDR-421	ACTION	HOA		8930A1150N010.DWG
HAO	421	EDR-421	ACTION	OC		8930A1150N010.DWG
YOC	421	EDR-421	STATUS	OC		8930A1150N010.DWG
YR	421	EDR-421	STATUS	REMOTE		8930A1150N010.DWG
HAR	422	GRI-422	ACTION	RESET ETM		8930A1150N010.DWG
KI	422	GRI-422	NUM	ETM		8930A1150N010.DWG
Y1	422	GRI-422	STATUS	RUNNING		8930A1150N010.DWG
Y2	422	GRI-422	ALARM	FAILED		8930A1150N010.DWG
FAL	423	FE-423	ALARM			8930A1150N012.DWG
HAD	423	PMP-423	ACTION	HOA		8930A1150N010.DWG
HAR	423	PMP-423	ACTION	RESET ETM		8930A1150N010.DWG
HAT	423	PMP-423	ACTION	SS		8930A1150N010.DWG
KI	423	PMP-423	NUM	ETM		8930A1150N010.DWG
PAH	423	PE-423	ALARM			8930A1150N010.DWG

Tag	Loop	Equipment	Function	Description 1	Description 2	Drawing #
QS	423	PMP-423	SP	SPEED		8930A1150N010.DWG
SIB	423	PMP-423	NUM	SPEED		8930A1150N010.DWG
TAH	423	PMP-423	ALARM	HIGH TEMP		8930A1150N010.DWG
Y1	423	PMP-423	STATUS	RUNNING		8930A1150N010.DWG
Y2	423	PMP-423	ALARM	FAILED		8930A1150N010.DWG
YR	423	PMP-423	STATUS	REMOTE		8930A1150N010.DWG
TAH	423A	TE-423A	ALARM	STATOR TEMP		8930A1150N010.DWG
HAD	424	EDR-424	ACTION	HOA		8930A1150N010.DWG
HAO	424	EDR-424	ACTION	OC		8930A1150N010.DWG
XAH	424	XAH-424	ALARM	SMOKE		8930A1151N008.DWG
YOC	424	EDR-424	STATUS	OC		8930A1150N010.DWG
YR	424	EDR-424	STATUS	REMOTE		8930A1150N010.DWG
FAH	425	FE-425	ALARM			8930A1150N010.DWG
FAL	425	FE-425	ALARM			8930A1150N010.DWG
FI	425	FE-425	NUM			8930A1150N010.DWG
FQI	425	FE-425	NUM			8930A1150N010.DWG
FR	425	FE-425	TREND			8930A1150N010.DWG
HAD	425	EDR-425	ACTION	HOA		8930A1150N011.DWG
HAO	425	EDR-425	ACTION	OC		8930A1150N011.DWG
QFH	425	FE-425	SP			8930A1150N010.DWG
YOC	425	EDR-425	STATUS	OC		8930A1150N011.DWG
YR	425	EDR-425	STATUS	REMOTE		8930A1150N011.DWG
HAR	426	GRI-426	ACTION	RESET ETM		8930A1150N011.DWG
KI	426	GRI-426	NUM	ETM		8930A1150N011.DWG
Y1	426	GRI-426	STATUS	RUNNING		8930A1150N011.DWG
Y2	426	GRI-426	ALARM	FAILED		8930A1150N011.DWG
FAL	427	FE-427	ALARM			8930A1150N012.DWG

Tag	Loop	Equipment	Function	Description 1	Description 2	Drawing #
HAD	427	PMP-427	ACTION	HOA		8930A1150N011.DWG
HAR	427	PMP-427	ACTION	RESET ETM		8930A1150N011.DWG
HAT	427	PMP-427	ACTION	SS		8930A1150N011.DWG
KI	427	PMP-427	NUM	ETM		8930A1150N011.DWG
PAH	427	PE-427	ALARM			8930A1150N011.DWG
QS	427	PMP-427	SP	SPEED		8930A1150N011.DWG
SIB	427	PMP-427	NUM	SPEED		8930A1150N011.DWG
Y1	427	PMP-427	STATUS	RUNNING		8930A1150N011.DWG
Y2	427	PMP-427	ALARM	FAILED		8930A1150N011.DWG
YR	427	PMP-427	STATUS	REMOTE		8930A1150N011.DWG
HAD	428	EDR-428	ACTION	HOA		8930A1150N011.DWG
HAO	428	EDR-428	ACTION	OC		8930A1150N011.DWG
YOC	428	EDR-428	STATUS	OC		8930A1150N011.DWG
YR	428	EDR-428	STATUS	REMOTE		8930A1150N011.DWG
FAH	429	FE-429	ALARM			8930A1150N011.DWG
FAL	429	FE-429	ALARM			8930A1150N011.DWG
FI	429	FE-429	NUM			8930A1150N011.DWG
FQI	429	FE-429	NUM			8930A1150N011.DWG
FR	429	FE-429	TREND			8930A1150N011.DWG
QFH	429	FE-429	SP			8930A1150N011.DWG
KI	431	PE-431	NUM	ETM		8930A1151N001.DWG
PAH	431	PE-431	ALARM	SYSTEM PRESS HIGH		8930A1151N001.DWG
PAL	431	PE-431	ALARM	AIR PRESS LOW		8930A1151N001.DWG
PI	431	PE-431	NUM	PRESS SYSTEM		8930A1151N001.DWG
SI	431	PE-431	NUM	SPEED		8930A1151N001.DWG
Y1	431	PE-431	STATUS	RUNNING		8930A1151N001.DWG
Y2	431	PE-431	ALARM	FAILED		8930A1151N001.DWG

Tag	Loop	Equipment	Function	Description 1	Description 2	Drawing #
YR	431	PE-431	STATUS	REMOTE		8930A1151N001.DWG
HAD	433	CNV-433	ACTION	HOA		8930A1151N003.DWG
HAR	433	CNV-433	ACTION	RESET-ETM		8930A1151N003.DWG
KI	433	CNV-433	NUM	ETM		8930A1151N003.DWG
SAL	433	CNV-433	ALARM			8930A1151N003.DWG
Y2	433	CNV-433	ALARM	FAILED		8930A1151N003.DWG
YR	433	CNV-433	STATUS	REMOTE		8930A1151N003.DWG
HAD	434	CNV-434	ACTION	HOA		8930A1151N003.DWG
HAR	434	CNV-434	ACTION	RESET-ETM		8930A1151N003.DWG
KI	434	CNV-434	NUM	ETM		8930A1151N003.DWG
SAL	434	CNV-434	ALARM			8930A1151N003.DWG
Y2	434	CNV-434	ALARM	FAILED		8930A1151N003.DWG
YR	434	CNV-434	STATUS	REMOTE		8930A1151N003.DWG
LAL	441	WE-441	ALARM	LEVEL		8930A1151N004.DWG
LI	441	WE-441	NUM	LEVEL		8930A1151N004.DWG
LR	441	WE-441	TREND	LEVEL		8930A1151N004.DWG
QLL	441	WE-441	SP	LEVEL		8930A1151N004.DWG
WI	441	WE-441	NUM	WEIGHT		8930A1151N004.DWG
LAL	442	WE-442	ALARM	LEVEL		8930A1151N004.DWG
LI	442	WE-442	NUM	LEVEL		8930A1151N004.DWG
LR	442	WE-442	TREND	LEVEL		8930A1151N004.DWG
QLL	442	WE-442	SP	LEVEL		8930A1151N004.DWG
WI	442	WE-442	NUM	WEIGHT		8930A1151N004.DWG
LAL	443	WE-443	ALARM	LEVEL		8930A1151N004.DWG
LI	443	WE-443	NUM	LEVEL		8930A1151N004.DWG
LR	443	WE-443	TREND	LEVEL		8930A1151N004.DWG
QLL	443	WE-443	SP	LEVEL		8930A1151N004.DWG

Tag	Loop	Equipment	Function	Description 1	Description 2	Drawing #
WI	443	WE-443	NUM	WEIGHT		8930A1151N004.DWG
FAL	451	PBU-451	ALARM	LOW FLOW		8930A1151N005.DWG
HAT	451	PBU-451	ACTION	SS		8930A1151N005.DWG
PAH	451	PBU-451	ALARM			8930A1151N005.DWG
Q1	451	PBU-451	SP	DOSE		8930A1151N005.DWG
Q2	451	PBU-451	SP	CONC		8930A1151N005.DWG
Q3	451	PBU-451	SP	% POLYMER		8930A1151N005.DWG
Q4	451	PBU-451	SP	DENSITY		8930A1151N005.DWG
Q5	451	PBU-451	SP	QMAX GPH		8930A1151N005.DWG
QS	451	PBU-451	SP	SPEED		8930A1151N005.DWG
SI	451	PBU-451	NUM	SPEED		8930A1151N005.DWG
Y1	451	PBU-451	STATUS	RUNNING		8930A1151N005.DWG
Y2	451	PBU-451	ALARM	FAILED		8930A1151N005.DWG
YR	451	PBU-451	STATUS	REMOTE		8930A1151N005.DWG
FAL	452	PBU-452	ALARM	LOW FLOW		8930A1151N005.DWG
HAT	452	PBU-452	ACTION	SS		8930A1151N005.DWG
PAH	452	PBU-452	ALARM			8930A1151N005.DWG
Q1	452	PBU-452	SP	DOSE		8930A1151N005.DWG
Q2	452	PBU-452	SP	CONC		8930A1151N005.DWG
Q3	452	PBU-452	SP	% POLYMER		8930A1151N005.DWG
Q4	452	PBU-452	SP	DENSITY		8930A1151N005.DWG
QS	452	PBU-452	SP	SPEED		8930A1151N005.DWG
SI	452	PBU-452	NUM	SPEED		8930A1151N005.DWG
Y1	452	PBU-452	STATUS	RUNNING		8930A1151N005.DWG
Y2	452	PBU-452	ALARM	FAILED		8930A1151N005.DWG
YR	452	PBU-452	STATUS	REMOTE		8930A1151N005.DWG
HAT	453	HAT-453	ACTION	SS		8930A1151N006.DWG

Tag	Loop	Equipment	Function	Description 1	Description 2	Drawing #
Q1	453	Q1-453	SP	DOSE		8930A1151N006.DWG
Q3	453	Q3-453	SP	DENSITY		8930A1151N006.DWG
Q4	453	Q4-453	SP	QMAX GPH		8930A1151N006.DWG
QS	453	QS-453	SP	SPEED		8930A1151N006.DWG
SI	453	SI-453	NUM	SPEED		8930A1151N006.DWG
Y1	453	Y1-453	STATUS	RUNNING		8930A1151N006.DWG
Y2	453	Y2-453	ALARM	FAILED		8930A1151N006.DWG
YR	453	YR-453	STATUS	REMOTE		8930A1151N006.DWG
HAY	460	HAY-460	ACTION	ENABLE / DISABLE		8930A1150N008.DWG
HAR	471	HAR-471	ALARM	RESET ETM		8930A1151N008.DWG
KI	471	KI-471	NUM	ETM		8930A1151N008.DWG
Y1	471	Y1-471	STATUS	RUNNING		8930A1151N008.DWG
HAR	472	EF-472	ALARM	RESET ETM		8930A1151N008.DWG
KI	472	EF-472	NUM	ETM		8930A1151N008.DWG
Y1	472	EF-472	STATUS	RUNNING		8930A1151N008.DWG
HAR	473	EF-473	ALARM	RESET ETM		8930A1151N008.DWG
KI	473	EF-473	NUM	ETM		8930A1151N008.DWG
XAH	473	EF-473	ALARM	SMOKE		8930A1151N008.DWG
Y1	473	EF-473	STATUS	RUNNING		8930A1151N008.DWG
Y2	473	EF-473	ALARM	FAILED		8930A1151N008.DWG
HAR	474	HAR-474	ALARM	RESET ETM		8930A1151N008.DWG
KI	474	KI-474	NUM	ETM		8930A1151N008.DWG
Y1	474	Y1-474	STATUS	RUNNING		8930A1151N008.DWG
Y2	474	Y2-474	ALARM	FAILED		8930A1151N008.DWG
HAR	475	EF-475	ALARM	RESET ETM		8930A1151N008.DWG
KI	475	EF-475	NUM	ETM		8930A1151N008.DWG
XAH	475	EF-475	ALARM	SMOKE		8930A1151N008.DWG

Tag	Loop	Equipment	Function	Description 1	Description 2	Drawing #
Y1	475	EF-475	STATUS	RUNNING		8930A1151N008.DWG
Y2	475	EF-475	ALARM	FAILED		8930A1151N008.DWG
HAR	476	EF-476	ALARM	RESET ETM		8930A1151N009.DWG
KI	476	EF-476	NUM	ETM		8930A1151N009.DWG
XAH	476	EF-476	ALARM	SMOKE		8930A1151N009.DWG
Y1	476	EF-476	STATUS	RUNNING		8930A1151N009.DWG
Y2	476	EF-476	ALARM	FAILED		8930A1151N009.DWG
HAR	477	SF-477	ACTION	RESET-ETM		8930A1151N009.DWG
KI	477	SF-477	NUM	ETM		8930A1151N009.DWG
XAH	477	SF-477	ALARM	SMOKE		8930A1151N009.DWG
Y1H	477	SF-477	STATUS	RUN-HIGH		8930A1151N009.DWG
Y1L	477	SF-477	STATUS	RUN-LOW		8930A1151N009.DWG
Y2	477	SF-477	ALARM	FAILED		8930A1151N009.DWG
HAW	500	HAW-500	ACTION	LEAD/LAG		8930A1104N001.DWG
LAH	500	LE-500	ALARM			8930A1104N001.DWG
LALL	500	LE-500	ALARM			8930A1104N001.DWG
HAD	501	PMP-501	ACTION	HOA		8930A1104N001.DWG
HAR	501	PMP-501	ACTION	RESET ETM		8930A1104N001.DWG
HAT	501	PMP-501	ACTION	SS		8930A1104N001.DWG
KI	501	PMP-501	NUM	ETM		8930A1104N001.DWG
MAH	501	PMP-501	ALARM	MOISTURE		8930A1104N001.DWG
QS	501	PMP-501	SP	SPEED		8930A1104N001.DWG
SIB	501	PMP-501	NUM	SPEED		8930A1104N001.DWG
TAH	501	PMP-501	ALARM			8930A1104N001.DWG
Y1	501	PMP-501	STATUS	RUNNING		8930A1104N001.DWG
Y2	501	PMP-501	ALARM	FAILED		8930A1104N001.DWG
YR	501	PMP-501	STATUS	REMOTE		8930A1104N001.DWG

Tag	Loop	Equipment	Function	Description 1	Description 2	Drawing #
HAD	502	PMP-502	ACTION	HOA		8930A1104N001.DWG
HAR	502	PMP-502	ACTION	RESET ETM		8930A1104N001.DWG
HAT	502	PMP-502	ACTION	SS		8930A1104N001.DWG
KI	502	PMP-502	NUM	ETM		8930A1104N001.DWG
MAH	502	PMP-502	ALARM	MOISTURE		8930A1104N001.DWG
QS	502	PMP-502	SP	SPEED		8930A1104N001.DWG
SIB	502	PMP-502	NUM	SPEED		8930A1104N001.DWG
TAH	502	PMP-502	ALARM			8930A1104N001.DWG
Y1	502	PMP-502	STATUS	RUNNING		8930A1104N001.DWG
Y2	502	PMP-502	ALARM	FAILED		8930A1104N001.DWG
YR	502	PMP-502	STATUS	REMOTE		8930A1104N001.DWG
FAH	503	FIT-503	ALARM			8930A1104N001.DWG
FAL	503	FIT-503	ALARM			8930A1104N001.DWG
FI	503	FIT-503	NUM			8930A1104N001.DWG
FQI	503	FIT-503	NUM			8930A1104N001.DWG
FR	503	FIT-503	TREND			8930A1104N001.DWG
QFH	503	FIT-503	SP			8930A1104N001.DWG
QFL	503	FIT-503	SP			8930A1104N001.DWG
LAH	504	LE-504	ALARM			8930A1104N001.DWG
LAL	504	LE-504	ALARM			8930A1104N001.DWG
LI	504	LE-504	NUM			8930A1104N001.DWG
LR	504	LE-504	TREND			8930A1104N001.DWG
QL1	504	LE-504	SP	START LEAD		8930A1104N001.DWG
QL2	504	LE-504	SP	START LAG		8930A1104N001.DWG
QL3	504	LE-504	SP	STOP PUMPS		8930A1104N001.DWG
QLH	504	LE-504	SP			8930A1104N001.DWG
QLL	504	LE-504	SP			8930A1104N001.DWG

Tag	Loop	Equipment	Function	Description 1	Description 2	Drawing #
HAJ	600	HAJ-600	ACTION	LS		8930A1104N002.DWG
LAH	600	LE-600	ALARM			8930A1104N002.DWG
LAL	600	LE-600	ALARM			8930A1104N002.DWG
LI	600	LE-600	NUM			8930A1104N002.DWG
LR	600	LE-600	TREND			8930A1104N002.DWG
QLH	600	LE-600	SP			8930A1104N002.DWG
QLL	600	LE-600	SP			8930A1104N002.DWG
HAD	601	PMP-601	ACTION	HO		8930A1104N002.DWG
HAR	601	PMP-601	ACTION	RESET ETM		8930A1104N002.DWG
HAT	601	PMP-601	ACTION	SS		8930A1104N002.DWG
KI	601	PMP-601	NUM	ETM		8930A1104N002.DWG
MAH	601	PMP-601	ALARM			8930A1104N002.DWG
TAH	601	PMP-601	ALARM			8930A1104N002.DWG
Y1	601	PMP-601	STATUS	RUNNING		8930A1104N002.DWG
Y2	601	PMP-601	ALARM	FAILED		8930A1104N002.DWG
YR	601	PMP-601	STATUS	REMOTE		8930A1104N002.DWG
HAD	602	PMP-602	ACTION	HO		8930A1104N002.DWG
HAR	602	PMP-602	ACTION	RESET ETM		8930A1104N002.DWG
HAT	602	PMP-602	ACTION	SS		8930A1104N002.DWG
KI	602	PMP-602	NUM	ETM		8930A1104N002.DWG
MAH	602	PMP-602	ALARM			8930A1104N002.DWG
TAH	602	PMP-602	ALARM			8930A1104N002.DWG
Y1	602	PMP-602	STATUS	RUNNING		8930A1104N002.DWG
Y2	602	PMP-602	ALARM	FAILED		8930A1104N002.DWG
YR	602	PMP-602	STATUS	REMOTE		8930A1104N002.DWG
FAH	603	FE-603	ALARM			8930A1104N002.DWG
FAL	603	FE-603	ALARM			8930A1104N002.DWG

Tag	Loop	Equipment	Function	Description 1	Description 2	Drawing #
FI	603	FE-603	NUM			8930A1104N002.DWG
FQI	603	FE-603	NUM			8930A1104N002.DWG
FR	603	FE-603	TREND			8930A1104N002.DWG
LAH	603	LE-603	ALARM			8930A1104N002.DWG
LALL	603	LE-603	ALARM			8930A1104N002.DWG
QFH	603	FE-603	SP			8930A1104N002.DWG
QFL	603	FE-603	SP			8930A1104N002.DWG
FAH	710	FE-710	ALARM			8930A1160N001.DWG
FAL	710	FE-710	ALARM			8930A1160N001.DWG
FI	710	FE-710	NUM			8930A1160N001.DWG
FQI	710	FE-710	NUM			8930A1160N001.DWG
FR	710	FE-710	TREND			8930A1160N001.DWG
QFH	710	FE-710	SP			8930A1160N001.DWG
QFL	710	FE-710	SP			8930A1160N001.DWG
HAD	711	PMP-711	ACTION	HOA		8930A1160N001.DWG
HAJ	711	LE-711	ACTION	LS		8930A1160N001.DWG
HAR	711	PMP-711	ACTION	RESET ETM		8930A1160N001.DWG
HAT	711	PMP-711	ACTION	SS		8930A1160N001.DWG
KI	711	PMP-711	NUM	ETM		8930A1160N001.DWG
LAH	711	LE-711	ALARM			8930A1160N001.DWG
LAL	711	LE-711	ALARM			8930A1160N001.DWG
LI	711	LE-711	NUM			8930A1160N001.DWG
LR	711	LE-711	TREND			8930A1160N001.DWG
QL1	711	LE-711	SP	STOP		8930A1160N001.DWG
QLH	711	LE-711	SP			8930A1160N001.DWG
QLL	711	LE-711	SP			8930A1160N001.DWG
Y1	711	PMP-711	STATUS	RUNNING		8930A1160N001.DWG

Tag	Loop	Equipment	Function	Description 1	Description 2	Drawing #
Y2	711	PMP-711	ALARM	FAILED		8930A1160N001.DWG
YR	711	PMP-711	STATUS	REMOTE		8930A1160N001.DWG
HAD	712	PMP-712	ACTION	HOA		8930A1160N002.DWG
HAR	712	PMP-712	ACTION	RESET ETM		8930A1160N002.DWG
HAT	712	PMP-712	ACTION	SS		8930A1160N002.DWG
KI	712	PMP-712	NUM	ETM		8930A1160N002.DWG
LAH	712	LE-712	ALARM			8930A1160N002.DWG
LAL	712	LE-712	ALARM			8930A1160N002.DWG
LI	712	LE-712	NUM			8930A1160N002.DWG
LR	712	LE-712	TREND			8930A1160N002.DWG
QL1	712	LE-712	SP	STOP		8930A1160N002.DWG
QLH	712	LE-712	SP			8930A1160N002.DWG
QLL	712	LE-712	SP			8930A1160N002.DWG
Y1	712	PMP-712	STATUS	RUNNING		8930A1160N002.DWG
Y2	712	PMP-712	ALARM	FAILED		8930A1160N002.DWG
YR	712	PMP-712	STATUS	REMOTE		8930A1160N002.DWG
AAH	713	AE-713	ALARM	CL		8930A1160N003.DWG
AAL	713	AE-713	ALARM	CL		8930A1160N003.DWG
AI	713	AE-713	NUM	CL		8930A1160N003.DWG
AR	713	AE-713	TREND	CL		8930A1160N003.DWG
HAD	713	EDR-713	ACTION	HOA		8930A1160N003.DWG
HAO	713	EDR-713	ACTION	OC		8930A1160N003.DWG
QAH	713	AE-713	SP	CL		8930A1160N003.DWG
QAL	713	AE-713	SP	CL		8930A1160N003.DWG
YOC	713	EDR-713	STATUS	OC		8930A1160N003.DWG
HAR	714	MIX-714	ACTION	RESET ETM		8930A1160N003.DWG
HAT	714	MIX-714	ACTION	SS		8930A1160N003.DWG

Tag	Loop	Equipment	Function	Description 1	Description 2	Drawing #
IAH	714	MIX-714	ALARM			8930A1160N003.DWG
IAL	714	MIX-714	ALARM			8930A1160N003.DWG
II	714	MIX-714	NUM			8930A1160N003.DWG
IR	714	MIX-714	TREND			8930A1160N003.DWG
KI	714	MIX-714	NUM	ETM		8930A1160N003.DWG
QIH	714	MIX-714	SP			8930A1160N003.DWG
QIL	714	MIX-714	SP			8930A1160N003.DWG
Y1	714	MIX-714	STATUS	RUNNING		8930A1160N003.DWG
AAH	715	AE-715	ALARM	CL		8930A1160N003.DWG
AAL	715	AE-715	ALARM	CL		8930A1160N003.DWG
AI	715	AE-715	NUM	CL		8930A1160N003.DWG
AR	715	AE-715	TREND	CL		8930A1160N003.DWG
LAH	715	LE-715	ALARM			8930A1160N003.DWG
LAL	715	LE-715	ALARM			8930A1160N003.DWG
LI	715	LE-715	NUM			8930A1160N003.DWG
LR	715	LE-715	TREND			8930A1160N003.DWG
QAH	715	AE-715	SP	CL		8930A1160N003.DWG
QAL	715	AE-715	SP	CL		8930A1160N003.DWG
QL1	715	LE-715	SP	STOP MIXER		8930A1160N003.DWG
QL2	715	LE-715	SP	START WELL PUMP		8930A1160N003.DWG
QL3	715	LE-715	SP	STOP WELL PUMP		8930A1160N003.DWG
QLH	715	LE-715	SP			8930A1160N003.DWG
QLL	715	LE-715	SP			8930A1160N003.DWG
FAH	720	FE-720	ALARM			8930A1170N001.DWG
FAL	720	FE-720	ALARM			8930A1170N001.DWG
FI	720	FE-720	NUM			8930A1170N001.DWG
FQI	720	FE-720	NUM			8930A1170N001.DWG

Tag	Loop	Equipment	Function	Description 1	Description 2	Drawing #
FR	720	FE-720	TREND			8930A1170N001.DWG
IA1	720	PMP-720	ALARM	PHASE LOSS		8930A1170N001.DWG
IA2	720	PMP-720	ALARM	PHASE REVERSAL		8930A1170N001.DWG
QFH	720	FE-720	SP			8930A1170N001.DWG
QFL	720	FE-720	SP			8930A1170N001.DWG
Y1	720	PMP-720	STATUS	RUNNING		8930A1170N001.DWG
Y2	720	PMP-720	STATUS	FAILED		8930A1170N001.DWG
YSE	720	PMP-720	STATUS	TRANSFER SWITCH EMERGENCY		8930A1170N001.DWG
YSN	720	PMP-720	STATUS	TRANSFER SWITCH NORMAL		8930A1170N001.DWG
HAR	721	70-EF-721	ACTION	RESET ETM		8930A1170N003.DWG
KI	721	70-EF-721	NUM	ETM		8930A1170N003.DWG
Y1	721	PMP-721	STATUS	RUNNING		8930A1170N001.DWG
Y1	721	70-EF-721	STATUS	RUNNING		8930A1170N003.DWG
Y2	721	PMP-721	STATUS	FAILED		8930A1170N001.DWG
HAD	731	PMP-731	ACTION	HOA		8930A1160N004.DWG
HAR	731	PMP-731	ACTION	RESET ETM		8930A1160N004.DWG
HAT	731	PMP-731	ACTION	SS		8930A1160N004.DWG
KI	731	PMP-731	NUM	ETM		8930A1160N004.DWG
PAH	731	PE-731	ALARM			8930A1160N004.DWG
TAH	731	PMP-731	ALARM			8930A1160N004.DWG
Y1	731	PMP-731	STATUS	RUNNING		8930A1160N004.DWG
Y2	731	PMP-731	ALARM	FAILED		8930A1160N004.DWG
YR	731	PMP-731	STATUS	REMOTE		8930A1160N004.DWG
HAD	732	PMP-732	ACTION	HOA		8930A1160N004.DWG
HAR	732	PMP-732	ACTION	RESET ETM		8930A1160N004.DWG
HAT	732	PMP-732	ACTION	SS		8930A1160N004.DWG
KI	732	PMP-732	NUM	ETM		8930A1160N004.DWG

Tag	Loop	Equipment	Function	Description 1	Description 2	Drawing #
PAH	732	PE-732	ALARM			8930A1160N004.DWG
TAH	732	PMP-732	ALARM			8930A1160N004.DWG
Y1	732	PMP-732	STATUS	RUNNING		8930A1160N004.DWG
Y2	732	PMP-732	ALARM	FAILED		8930A1160N004.DWG
YR	732	PMP-732	STATUS	REMOTE		8930A1160N004.DWG
HAD	733	PMP-733	ACTION	HOA		8930A1160N004.DWG
HAR	733	PMP-733	ACTION	RESET ETM		8930A1160N004.DWG
HAT	733	PMP-733	ACTION	SS		8930A1160N004.DWG
KI	733	PMP-733	NUM	ETM		8930A1160N004.DWG
PAH	733	PE-733	ALARM			8930A1160N004.DWG
TAH	733	PMP-733	ALARM			8930A1160N004.DWG
Y1	733	PMP-733	STATUS	RUNNING		8930A1160N004.DWG
Y2	733	PMP-733	ALARM	FAILED		8930A1160N004.DWG
YR	733	PMP-733	STATUS	REMOTE		8930A1160N004.DWG
FAH	734	FE-734	ALARM			8930A1160N005.DWG
FAL	734	FE-734	ALARM			8930A1160N005.DWG
FI	734	FE-734	NUM			8930A1160N005.DWG
FR	734	FE-734	TREND			8930A1160N005.DWG
PAH	734	PE-734	ALARM			8930A1160N005.DWG
PAL	734	PE-734	ALARM			8930A1160N005.DWG
PI	734	PE-734	NUM			8930A1160N005.DWG
PR	734	PE-734	TREND			8930A1160N005.DWG
QFH	734	FE-734	SP			8930A1160N005.DWG
QFL	734	FE-734	SP			8930A1160N005.DWG
QPH	734	PE-734	SP			8930A1160N005.DWG
QPL	734	PE-734	SP			8930A1160N005.DWG
HAD	752A	SV-752A	ACTION	HOA		8930A1121N001.DWG

Tag	Loop	Equipment	Function	Description 1	Description 2	Drawing #
HAO	752A	SV-752A	ACTION	OC		8930A1121N001.DWG
HAD	752B	SV-752B	ACTION	HOA		8930A1121N002.DWG
HAO	752B	SV-752B	ACTION	OC		8930A1121N002.DWG
HAD	760	EDR-760	ACTION	HOA		8930A1160N006.DWG
HAO	760	EDR-760	ACTION	OC		8930A1160N006.DWG
LAH	760	LE-760	ALARM			8930A1160N006.DWG
LAL	760	LE-760	ALARM			8930A1160N006.DWG
LI	760	LE-760	NUM			8930A1160N006.DWG
LR	760	LE-760	TREND			8930A1160N006.DWG
QL1	760	LE-760	SP	STOP MIXER		8930A1160N006.DWG
QL2	760	LE-760	SP	START WELL PUMP		8930A1160N006.DWG
QL3	760	LE-760	SP	STOP WELL PUMP		8930A1160N006.DWG
QLH	760	LE-760	SP			8930A1160N006.DWG
QLL	760	LE-760	SP			8930A1160N006.DWG
YOC	760	EDR-760	STATUS	OC		8930A1160N006.DWG
HAD	761	PMP-761	ACTION	HOA		8930A1160N007.DWG
HAR	761	PMP-761	ACTION	RESET ETM		8930A1160N007.DWG
HAT	761	PMP-761	ACTION	SS		8930A1160N007.DWG
KI	761	PMP-761	NUM	ETM		8930A1160N007.DWG
PAH	761	PE-761	ALARM			8930A1160N007.DWG
TAH	761	PMP-761	ALARM			8930A1160N007.DWG
Y1	761	PMP-761	STATUS	RUNNING		8930A1160N007.DWG
Y2	761	PMP-761	ALARM	FAILED		8930A1160N007.DWG
YR	761	PMP-761	STATUS	REMOTE		8930A1160N007.DWG
HAD	762	PMP-762	ACTION	HOA		8930A1160N007.DWG
HAR	762	PMP-762	ACTION	RESET ETM		8930A1160N007.DWG
HAT	762	PMP-762	ACTION	SS		8930A1160N007.DWG

Tag	Loop	Equipment	Function	Description 1	Description 2	Drawing #
KI	762	PMP-762	NUM	ETM		8930A1160N007.DWG
PAH	762	PE-762	ALARM			8930A1160N007.DWG
TAH	762	PMP-762	ALARM			8930A1160N007.DWG
Y1	762	PMP-762	STATUS	RUNNING		8930A1160N007.DWG
Y2	762	PMP-762	ALARM	FAILED		8930A1160N007.DWG
YR	762	PMP-762	STATUS	REMOTE		8930A1160N007.DWG
HAD	763	PMP-763	ACTION	HOA		8930A1160N007.DWG
HAR	763	PMP-763	ACTION	RESET ETM		8930A1160N007.DWG
HAT	763	PMP-763	ACTION	SS		8930A1160N007.DWG
KI	763	PMP-763	NUM	ETM		8930A1160N007.DWG
PAH	763	PE-763	ALARM			8930A1160N007.DWG
TAH	763	PMP-763	ALARM			8930A1160N007.DWG
Y1	763	PMP-763	STATUS	RUNNING		8930A1160N007.DWG
Y2	763	PMP-763	ALARM	FAILED		8930A1160N007.DWG
YR	763	PMP-763	STATUS	REMOTE		8930A1160N007.DWG
FAH	764	FE-764	ALARM			8930A1160N008.DWG
FAL	764	FE-764	ALARM			8930A1160N008.DWG
FI	764	FE-764	NUM			8930A1160N008.DWG
FR	764	FE-764	TREND			8930A1160N008.DWG
PAH	764	PE-764	ALARM			8930A1160N008.DWG
PAL	764	PE-764	ALARM			8930A1160N008.DWG
PI	764	PE-764	NUM			8930A1160N008.DWG
PR	764	PE-764	TREND			8930A1160N008.DWG
QFH	764	FE-764	SP			8930A1160N008.DWG
QFL	764	FE-764	SP			8930A1160N008.DWG
QPH	764	PE-764	SP			8930A1160N008.DWG
QPL	764	PE-764	SP			8930A1160N008.DWG

Tag	Loop	Equipment	Function	Description 1	Description 2	Drawing #
FAH	769A	FE-769A	ALARM			8930A1151N004.DWG
FAH	769B	FE-769B	ALARM			8930A1151N004.DWG
FAH	769F	FE-769F	ALARM			8930A1120N003.DWG
FAH	769G	FE-769G	ALARM			8930A1120N003.DWG
FAH	769H	FE-769H	ALARM			8930A1121N001.DWG
FAH	769J	FE-769J	ALARM			8930A1121N002.DWG
FAH	769K	FE-769K	ALARM			8930A1110N004.DWG
XAH	800	ACU-800	ALARM	SMOKE		8930A1170N003.DWG
Y1	800	ACU-800	STATUS	RUNNING		8930A1170N003.DWG
Y2	800	ACU-800	ALARM	FAIL		8930A1170N003.DWG
HAR	801	70-EF-801	ACTION	RESET ETM		8930A1170N003.DWG
KI	801	70-EF-801	NUM	ETM		8930A1170N003.DWG
Y1	801	70-EF-801	STATUS	RUNNING		8930A1170N003.DWG
EAL1	802	SSM-802	ALARM	POWER FAIL		8930A1170N002.DWG
HAR	802	70-EF-802	ACTION	RESET ETM		8930A1170N003.DWG
KI	802	70-EF-802	NUM	ETM		8930A1170N003.DWG
Y1	802	70-EF-802	STATUS	RUNNING		8930A1170N003.DWG
ZSA	802	SSM-802	STATUS	AUTO		8930A1170N002.DWG
ZSE	802	SSM-802	STATUS	EMERGENCY		8930A1170N002.DWG
ZSN	802	SSM-802	STATUS	NORMAL		8930A1170N002.DWG
ZST	802	SSM-802	STATUS	TEST		8930A1170N002.DWG
LAH	803	TNK-803	ALARM	PIPE LEAK SUMP		8930A1170N004.DWG
LAL	803	TNK-803	ALARM	FUEL LEVEL		8930A1170N004.DWG
LI	803	TNK-803	NUM	FUEL LEVEL		8930A1170N004.DWG
XAH	803	TNK-803	ALARM	INTERSTITIAL LEAK		8930A1170N004.DWG
LAH	804	TNK-804	ALARM	FUEL LEVEL		8930A1170N004.DWG
LAL	804	TNK-804	ALARM	FUEL LEVEL		8930A1170N004.DWG

Tag	Loop	Equipment	Function	Description 1	Description 2	Drawing #
XAH	804	TNK-804	ALARM	RUPTURE		8930A1170N004.DWG
JAH	805	GEN-805	ALARM	LOAD		8930A1170N004.DWG
JI1	805	GEN-805	NUM	KW		8930A1170N004.DWG
JI2	805	GEN-805	NUM	KW AVAIL		8930A1170N004.DWG
KI	805	GEN-805	NUM	ETM		8930A1170N004.DWG
SAH	805	GEN-805	ALARM	HIGH FREQ		8930A1170N004.DWG
SAL	805	GEN-805	ALARM	LOW FREQ		8930A1170N004.DWG
SI	805	GEN-805	NUM	FREQ		8930A1170N004.DWG
XAH	805	GEN-805	ALARM	GROUD FAULT		8930A1170N004.DWG
Y1	805	GEN-805	STATUS	GEN RUNNING		8930A1170N004.DWG
Y1A	805	GEN-805	STATUS	LOAD BANK RUNNING		8930A1170N004.DWG
Y2	805	GEN-805	ALARM	GEN FAIL		8930A1170N004.DWG
Y2A	805	GEN-805	STATUS	LOAD BANK FAILED		8930A1170N004.DWG
Y3	805	GEN-805	ALARM	SPD FAIL		8930A1170N004.DWG
ZA	805	GEN-805	STATUS	COMM		8930A1170N004.DWG

Tag	Loop	Equipment	Function	Description 1	Description 2	Drawing #
QB	<...>	PMP-271	SP	SG		8930A1132N003.DWG
SIB	<...>	PMP-271	NUM	SPEED		8930A1132N003.DWG
31-HAY	230	31-AE-230	ACTION	ENABLE/DISABLE		8930A1130N001.DWG
31-QAH2	230	31-AE-230	SP	TURB		8930A1130N001.DWG
31-QAHH	230	31-AE-230	SP	TURB		8930A1130N001.DWG
31-QK1	230	31-QK1-230	SP	HIGH TURB TIME		8930A1130N001.DWG
31-QK2	230	31-QK2-230	SP	HIGH TURB TIME		8930A1130N001.DWG
QB	271	PMP-271	SP	SG		8930A1132N002.DWG
SIB	271	PMP-271	NUM	SPEED		8930A1132N002.DWG
Y2	271	PMP-271	ALARM	FAILED		8930A1132N002.DWG
Y2	272	PMP-272	ALARM	FAILED		8930A1132N003.DWG
Y2	281	PMP-281	ALARM	FAILED		8930A1132N005.DWG
HAD	281B	EDR-281B	ACTION	HOA		8930A1132N005.DWG
HAO	281B	EDR-281B	ACTION	OC		8930A1132N005.DWG
HAY	281B	EDR-281B	ACTION	ENABLE / DISABLE		8930A1132N005.DWG
YOC	281B	EDR-281B	STATUS	OC		8930A1132N005.DWG
HAD	281C	EDR-281C	ACTION	HOA		8930A1132N005.DWG
HAO	281C	EDR-281C	ACTION	OC		8930A1132N005.DWG
YOC	281C	EDR-281C	STATUS	OC		8930A1132N005.DWG
HAD	281D	EDR-281D	ACTION	HOA		8930A1132N005.DWG
HAO	281D	EDR-281D	ACTION	OC		8930A1132N005.DWG
YOC	281D	EDR-281D	STATUS	OC		8930A1132N005.DWG
HAD	282	PMP-282	ACTION	HOA		8930A1132N006.DWG
HAS	282	PMP-282	ACTION	SPEED-HAND		8930A1132N006.DWG
HAT	282	PMP-282	ACTION	SS		8930A1132N006.DWG
KI	282	PMP-282	NUM	ETM		8930A1132N006.DWG
LAH	282	PMP-282	ALARM	LEAK		8930A1132N006.DWG

Tag	Loop	Equipment	Function	Description 1	Description 2	Drawing #
Y1	282	PMP-282	STATUS	RUNNING		8930A1132N006.DWG
Y2	282	PMP-282	ALARM	FAILED		8930A1132N006.DWG
YR	282	PMP-282	STATUS	REMOTE		8930A1132N006.DWG
QB	283	PMP-283	SP	SG		8930A1132N007.DWG
QB	284	PMP-284	SP	SG		8930A1132N008.DWG
QB	285	PMP-285	SP	SG		8930A1132N009.DWG
HAO	321	EDR-321	ACTION	OC		8930A1103N001.DWG
YOC	321	EDR-321	STATUS	OC		8930A1103N001.DWG
YR	321	EDR-321	STATUS	REMOTE		8930A1103N001.DWG
HAO	322	EDR-322	ACTION	OC		8930A1103N001.DWG
YOC	322	EDR-322	STATUS	OC		8930A1103N001.DWG
YR	322	EDR-322	STATUS	REMOTE		8930A1103N001.DWG
HAO	323	EDR-323	ACTION	OC		8930A1103N001.DWG
YOC	323	EDR-323	STATUS	OC		8930A1103N001.DWG
YR	323	EDR-323	STATUS	REMOTE		8930A1103N001.DWG
HAO	325	EDR-325	ACTION	OC		8930A1103N001.DWG
YOC	325	EDR-325	STATUS	OC		8930A1103N001.DWG
YR	325	EDR-325	STATUS	REMOTE		8930A1103N001.DWG
LAH	326	LE-326	ALARM			8930A1103N001.DWG
LAL	326	LE-326	ALARM			8930A1103N001.DWG
LI	326	LE-326	NUM			8930A1103N001.DWG
LR	326	LE-326	TREND			8930A1103N001.DWG
QLH	326	LE-326	SP			8930A1103N001.DWG
QLL	326	LE-326	SP			8930A1103N001.DWG
HAK	415	EDM-415	ACTION	JOJC		8930A1150N009.DWG
ZI	415	EDM-415	NUM	POSITION		8930A1150N009.DWG
HAK	416	EDM-416	ACTION	JOJC		8930A1150N009.DWG

Tag	Loop	Equipment	Function	Description 1	Description 2	Drawing #
ZI	416	EDM-416	NUM	POSITION		8930A1150N009.DWG
QF1	425	FE-425	SP	FEED RATE		8930A1150N010.DWG
QFL	425	FE-425	SP	STOP		8930A1150N010.DWG
QKL	425	FE-425	SP	STOP		8930A1150N010.DWG
TAH	427	PMP-427	ALARM	HIGH TEMP		8930A1150N011.DWG
TAH	427A	TE-427A	ALARM	STATOR TEMP		8930A1150N011.DWG
QF1	429	FE-429	SP	FEED RATE		8930A1150N011.DWG
QFL	429	FE-429	SP	STOP		8930A1150N011.DWG
QKL	429	FE-429	SP	STOP		8930A1150N011.DWG
IAH	431	PE-431	ALARM	HIGH CURRENT		8930A1151N001.DWG
TAH	431	PE-431	ALARM	TEMP		8930A1151N001.DWG
YE	431	PE-431	STATUS	E-STOP		8930A1151N001.DWG
IAH	432	PE-432	ALARM	HIGH CURRENT		8930A1151N002.DWG
KI	432	PE-432	NUM	ETM		8930A1151N002.DWG
PAH	432	PE-432	ALARM	SYSTEM PRESS HIGH		8930A1151N002.DWG
PAL	432	PE-432	ALARM	AIR PRESS LOW		8930A1151N002.DWG
PI	432	PE-432	NUM	PRESS SYSTEM		8930A1151N002.DWG
SI	432	PE-432	NUM	SPEED		8930A1151N002.DWG
TAH	432	PE-432	ALARM	TEMP		8930A1151N002.DWG
Y1	432	PE-432	STATUS	RUNNING		8930A1151N002.DWG
Y2	432	PE-432	ALARM	FAILED		8930A1151N002.DWG
YE	432	PE-432	STATUS	E-STOP		8930A1151N002.DWG
YR	432	PE-432	STATUS	REMOTE		8930A1151N002.DWG
HAT	433	CNV-433	ACTION	SS		8930A1151N003.DWG
TAH	433	CNV-433	ALARM			8930A1151N003.DWG
Y1	433	CNV-433	STATUS	RUN		8930A1151N003.DWG
HAT	434	CNV-434	ACTION	SS		8930A1151N003.DWG

SCADA Listing

Tag	Loop	Equipment	Function	Description 1	Description 2	Drawing #
TAH	434	CNV-434	ALARM			8930A1151N003.DWG
Y1	434	CNV-434	STATUS	RUN		8930A1151N003.DWG
Q5	452	PBU-452	SP	QMAX GPH		8930A1151N005.DWG
YB	716	FLT-716	STATUS	BACKWASH		8930A1160N003.DWG
FAH	769C	FE-769C	ALARM	EYEWASH IN USE		8930A1132N010.DWG
FAH	769D	FE-769D	ALARM	EYEWASH IN USE		8930A1132N010.DWG
FAH	769E	FE-769E	ALARM	EYEWASH IN USE		8930A1132N010.DWG
FAH	769M	FE-769M	ALARM			8930A1131N003.DWG

Tag	Loop	Equipment	Function	Description 1	Description 2	Drawing #
HAJ	271	HAJ-271	SEL	LEAD/STANDBY		8930A1132N002.DWG

Tag	Loop	Equipment	Function	Description 1	Description 2	Drawing #
HAJ	281	HAJ-281	SEL	LEAD/STANDBY		8930A1132N005.DWG

Tag	Loop	Equipment	Function	Description 1	Description 2	Drawing #
HAJ	283	HAJ-283	SEL	LEAD/STANDBY		8930A1132N007.DWG

SCADA Listing

Tag	Loop	Equipment	Function	Description 1	Description 2	Drawing #
JI1	802	SSM-802	NUM	KW		8930A1170N002.DWG
JI2	802	SSM-802	NUM	KVAR		8930A1170N002.DWG
JI3	802	SSM-802	NUM	KVA		8930A1170N002.DWG
JR1	802	SSM-802	TREND	KW		8930A1170N002.DWG
JR2	802	SSM-802	TREND	KVAR		8930A1170N002.DWG
JR3	802	SSM-802	TREND	KVA		8930A1170N002.DWG

Tag	Loop	Equipment	Function	Description 1	Description 2	Drawing #
Y3	431	PE-431	STATUS	WASH CYCLE		8930A1151N001.DWG
Y6	431	PE-431	STATUS	SEWATERING MODE		8930A1151N001.DWG
Y3	432	PE-432	STATUS	WASH CYCLE		8930A1151N002.DWG
Y6	432	PE-432	STATUS	SEWATERING MODE		8930A1151N002.DWG

SCADA Listing

Tag	Loop	Equipment	Function	Description 1	Description 2	Drawing #
QL1	411	PE-411	SP	STOP		8930A1150N008.DWG
QL2	411	PE-411	SP	START		8930A1150N008.DWG
QL3	412	PE-412	SP	STOP		8930A1150N009.DWG
QL4	412	PE-412	SP	START		8930A1150N009.DWG

Tag	Loop	Equipment	Function	Description 1	Description 2	Drawing #
HAL	040	HAL-040	ACTION	OLOL		8930A1110N001.DWG
HAW	040	HAW-040	ACTION	LEAD/LAG		8930A1110N001.DWG

Tag	Loop	Equipment	Function	Description 1	Description 2	Drawing #
HAL	050	HAL-050	ACTION	OLOL		8930A1110N001.DWG
HAW	050	HAW-050	ACTION	LEAD/LAG		8930A1110N001.DWG

Tag	Loop	Equipment	Function	Description 1	Description 2	Drawing #
HAD2	111	CLR-111	ACTION	HOA		8930A1121N001.DWG
HAD2	112	CLR-112	ACTION	HOA		8930A1121N002.DWG

Tag	Loop	Equipment	Function	Description 1	Description 2	Drawing #
QF1	281	PMP-281	SP	FEED RATE		8930A1132N005.DWG
QF1	282	PMP-282	SP	FEED RATE		8930A1132N006.DWG

Tag	Loop	Equipment	Function	Description 1	Description 2	Drawing #
QF2	281	QF2-281	SP	FEED RATE		8930A1132N005.DWG
QF2	282	PMP-282	SP	FEED RATE		8930A1132N006.DWG

Tag	Loop	Equipment	Function	Description 1	Description 2	Drawing #
KI3	460	KI1-460	SP	START DELAY		8930A1151N001.DWG
KI5	460	KI1-460	NUM	STOP DELAY		8930A1151N001.DWG
QK3	460	KI1-460	SP	START DELAY		8930A1151N001.DWG

Tag	Loop	Equipment	Function	Description 1	Description 2	Drawing #
QL1	411	PE-411	SP	STOP		8930A1150N008.DWG
QL2	411	PE-411	SP	START		8930A1150N008.DWG
QL1	412	PE-412	SP	STOP		8930A1150N009.DWG
QL2	412	PE-412	SP	START		8930A1150N009.DWG

Tag	Loop	Equipment	Function	Description 1	Description 2	Drawing #
QL1	326	LE-326	SP	STOP		8930A1103N001.DWG
QL1	327	LE-327	SP	STOP		8930A1103N001.DWG

Tag	Loop	Equipment	Function	Description 1	Description 2	Drawing #
KI2	460	KI1-460	NUM	START DELAY		8930A1151N001.DWG
QK2	460	KI1-460	SP	START DELAY		8930A1151N001.DWG

SCADA Listing

Tag	Loop	Equipment	Function	Description 1	Description 2	Drawing #
LI	270	WE-270	NUM	LEVEL		8930A1132N001.DWG

Tag	Loop	Equipment	Function	Description 1	Description 2	Drawing #
QK	130	QK-130	SP			8930A1123N001.DWG

Tag	Loop	Equipment	Function	Description 1	Description 2	Drawing #
HAO	130	EDR-130	ACTION	OC		8930A1123N001.DWG

Tag	Loop	Equipment	Function	Description 1	Description 2	Drawing #
QLD3	012	LE-012	SP	HI DIFF LVL		8930A1110N001.DWG
QLD4	012	LE-012	SP	HI DIFF LVL		8930A1110N001.DWG
QLH	012	LE-012	SP			8930A1110N001.DWG
QLD1	041	LE-041	SP	HI DIFF LVL		8930A1110N001.DWG
QLD2	051	LE-051	SP	HI DIFF LVL		8930A1110N001.DWG

SCADA Listing

Tag	Loop	Equipment	Function	Description 1	Description 2	Drawing #
KI1	460	KI1-460	NUM	START DELAY		8930A1151N001.DWG
KI6	460	KI1-460	NUM	STOP DELAY		8930A1151N001.DWG
QK1	460	KI1-460	SP	START DELAY		8930A1151N001.DWG
QK5	460	KI1-460	SP	STOP DELAY		8930A1151N001.DWG

Tag	Loop	Equipment	Function	Description 1	Description 2	Drawing #
IIA	802	SSM-802	NUM	AMPS		8930A1170N002.DWG
IRA	802	SSM-802	TREND	AMPS		8930A1170N002.DWG

Tag	Loop	Equipment	Function	Description 1	Description 2	Drawing #
EIA	802	SSM-802	NUM	VOLTS		8930A1170N002.DWG
ERA	802	SSM-802	TREND	VOLTS		8930A1170N002.DWG

SCADA Listing

Tag	Loop	Equipment	Function	Description 1	Description 2	Drawing #
IRB	802	SSM-802	TREND	AMPS		8930A1170N002.DWG

Tag	Loop	Equipment	Function	Description 1	Description 2	Drawing #
EIB	802	SSM-802	NUM	VOLTS		8930A1170N002.DWG
ERB	802	SSM-802	TREND	VOLTS		8930A1170N002.DWG

SCADA Listing

Tag	Loop	Equipment	Function	Description 1	Description 2	Drawing #
IRC	802	SSM-802	TREND	AMPS		8930A1170N002.DWG

Tag	Loop	Equipment	Function	Description 1	Description 2	Drawing #
EIC	802	SSM-802	NUM	VOLTS		8930A1170N002.DWG
ERC	802	SSM-802	TREND	VOLTS		8930A1170N002.DWG

Tag	Loop	Equipment	Function	Description 1	Description 2	Drawing #
IIB	802	SSM-802	NUM	AMPS		8930A1170N002.DWG

Tag	Loop	Equipment	Function	Description 1	Description 2	Drawing #
IIC	802	SSM-802	NUM	AMPS		8930A1170N002.DWG

SCADA Listing

Tag	Loop	Equipment	Function	Description 1	Description 2	Drawing #
LAH	440	LE-440	ALARM			8930A1151N004.DWG

Tag	Loop	Equipment	Function	Description 1	Description 2	Drawing #
QF3	281	QF3-281	SP	FEED RATE		8930A1132N005.DWG
QF3	282	PMP-282	SP	FEED RATE		8930A1132N006.DWG

SCADA Listing

Tag	Loop	Equipment	Function	Description 1	Description 2	Drawing #
QK1	306	PE-306	SP	PUMP START		8930A1140N003.DWG
QK2	306	PE-306	SP	PUMP STOP		8930A1140N003.DWG

SCADA Listing

Tag	Loop	Equipment	Function	Description 1	Description 2	Drawing #
HAJ	133	HAJ-133	ACTION	LS		8930A1123N001.DWG

Tag	Loop	Equipment	Function	Description 1	Description 2	Drawing #
Y4	431	PE-431	STATUS	WASH CYCLE		8930A1151N001.DWG
Y5	431	PE-431	STATUS	SEWATERING MODE		8930A1151N001.DWG
Y4	432	PE-432	STATUS	WASH CYCLE		8930A1151N002.DWG
Y5	432	PE-432	STATUS	SEWATERING MODE		8930A1151N002.DWG

Tag	Loop	Equipment	Function	Description 1	Description 2	Drawing #
KI4	460	KI1-460	NUM	STOP DELAY		8930A1151N001.DWG
QK4	460	KI1-460	SP	STOP DELAY		8930A1151N001.DWG

Tag	Loop	Equipment	Function	Description 1	Description 2	Drawing #
HAD1	111	CLR-111	ACTION	HOA		8930A1121N001.DWG
HAD1	112	CLR-112	ACTION	HOA		8930A1121N002.DWG

Tag	Loop	Equipment	Function	Description 1	Description 2	Drawing #
QK1	111	CLR-111	SP	TIME		8930A1121N001.DWG
QK1	112	CLR-112	SP	TIME		8930A1121N002.DWG

Tag	Loop	Equipment	Function	Description 1	Description 2	Drawing #
QL1	600	LE-600	SP			8930A1104N002.DWG

Tag	Loop	Equipment	Function	Description 1	Description 2	Drawing #
QP2	734	PE-734	SP			8930A1160N005.DWG
QP2	764	PE-764	SP			8930A1160N008.DWG

SCADA Listing

Tag	Loop	Equipment	Function	Description 1	Description 2	Drawing #
QP1	734	PE-734	SP			8930A1160N005.DWG
QP1	764	PE-764	SP			8930A1160N008.DWG

SCADA Listing

Tag	Loop	Equipment	Function	Description 1	Description 2	Drawing #
QL1	130	LE-130	SP			8930A1123N001.DWG

Tag	Loop	Equipment	Function	Description 1	Description 2	Drawing #
QL2	600	LE-600	SP			8930A1104N002.DWG
QP3	734	PE-734	SP			8930A1160N005.DWG
QP3	764	PE-764	SP			8930A1160N008.DWG

Tag	Loop	Equipment	Function	Description 1	Description 2	Drawing #
QL2	130	LE-130	SP			8930A1123N001.DWG

SCADA Listing

Tag	Loop	Equipment	Function	Description 1	Description 2	Drawing #
HAM	461	HAM-461	ACTION	AM		8930A1151N001.DWG
HAT	461	HAM-461	ACTION	SS		8930A1151N001.DWG
KI1	461	HAM-461	NUM	DURATION TIMER		8930A1151N001.DWG
QK1	461	HAM-461	SP	START TIME		8930A1151N001.DWG
QK2	461	HAM-461	SP	DURATION		8930A1151N001.DWG

SCADA Listing

Tag	Loop	Equipment	Function	Description 1	Description 2	Drawing #
HAM	412	HAM-412	ACTION	AM		8930A1151N002.DWG
HAT	412	HAM-412	ACTION	SS		8930A1151N002.DWG
KI2	412	HAM-412	NUM	DURATION TIMER		8930A1151N002.DWG
QK1	412	HAM-412	SP	START TIME		8930A1151N002.DWG
QK2	412	HAM-412	SP	DURATION		8930A1151N002.DWG

SECTION 17950

TESTING, CALIBRATION, AND COMMISSIONING

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Testing requirements that apply to all process control and instrumentation systems for the entire Project.

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 01660 - Testing, Training, and Commissioning.
      c. Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
      d. Section 17100 - Control Strategies.

1.02 REFERENCES

A. As specified in Section 17050.

1.03 DEFINITIONS

A. As specified in Section 17050.

B. Specific definitions:
   1. PTO: Profibus Trade Organization.

1.04 SYSTEM DESCRIPTION (NOT USED)

1.05 SUBMITTALS

A. Furnish submittals as specified in Section 01330.

B. General:
   1. Reference additional detailed test submittal scheduling and prerequisite requirements as specified in the Sequencing article of Section 17050.
   2. For each test described in Parts 2 and 3 of this Section, and described in other sections of the Instrumentation and Control Specifications, prepare and submit

complete test plans, test procedures, test forms, test binders, test reports, and other submittals, as specified below.

3. Submit manufacturer's certifications and manufacturer's field reports where required.
4. Submit test plans, procedures, forms, and binders for approval by the Engineer before scheduling or performing tests.
5. Develop the PCIS system test submittals in consultation and cooperation with all applicable subcontractors.
6. Additional test form and test procedure requirements are specified with individual test requirements.

C. Overall test plan:
   1. Develop and submit an overall testing plan for the PCIS. The overall test plan to be reviewed and approved by the Engineer before detailed test plans, procedures, and forms will be reviewed.
   2. Describe the test phases as they apply specifically to this Project and each process system.
   3. Provide a preliminary testing schedule to show the sequence of tests and commissioning as they apply to each process system and each PLC.
   4. Provide a description of factory tests. Describe what equipment will be included, what testing equipment will be used, and the simulator that will be used.
   5. Provide examples of proposed forms and checklists.
   6. Overall test plan will call out test procedures that must be witnessed by the Owner or representative.

D. Test procedures:
   1. Develop and submit detailed test procedures to show that the integrated SCADA system hardware and software is fully operational and in compliance with the requirements specified in the Contract Documents.
   2. Provide a statement of test objectives for each test.
   3. Prepare specific procedures for each process system.
   4. Describe sequentially the steps to be followed in verifying the correct operation of each process system, including all features described in the loop descriptions, control strategies, and shown in the P&IDs. Implied or generic test procedures are not acceptable.
   5. Specify who will perform the tests, specifically what testing equipment will be used (including serial numbers and NIST-traceable calibration), and how the testing equipment will be used.
   6. Describe the expected role of the Engineer, as well as any requirements for assistance from Owner's staff.
   7. Provide the forms and checklists to be used.

E. Test forms:
   1. Provide test and calibration forms and checklists for each of the following:
      a. Calibration.
      b. Factory acceptance tests.
      c. Loop validation tests.
      d. Pre-commissioning test.
      e. Performance test.
   2. Test forms shall include the detailed test procedures, or shall include clear references to separate pages containing the complete test procedure

applicable to each form. If references to procedures are used, the complete procedure shall be included with each test binder.

3. Every page of each test form shall include project name, date, time, name of person conducting the test, signature of person conducting the test, and for witnessed tests, place for signature of person (Engineer and Owner) witnessing the test.
4. Some sample test forms are included at the end of this Section. These test forms show the minimum required test form content. They are not complete, and have not been customized for this Project. The Contractor is to develop and submit test forms customized for the Project and meeting all of the specified test and submittal requirements.

F. Testing binders:
1. Sub-system to be tested, provide and submit a test binder containing all test procedures and individual test forms for the test. References to other documents for test procedures and requirements are not acceptable.
2. Fill out in advance headings and all other information known before the test.
3. Include applicable test plan information, as well as a list of all test prerequisites, test personnel, and equipment.
4. Include or list reference material and provide separately at the time of the test.
5. Record test results and verify that all test requirements and conditions have been met.

G. Factory acceptance test procedure additional minimal requirements:
1. Prepare and submit a factory acceptance test procedure which includes:
   a. Control system testing block diagram.
   b. Estimated test duration.
   c. Details on the simulator construction, components, and operation.

H. Test reports:
1. At the conclusion of each test, submit a complete test report, including all test results and certifications.
2. Include all completed test binders, forms, and checklists.
3. Submission, review, and acceptance of each test report is generally required before the start of the sub-system.

1.06 QUALITY ASSURANCE

A. Test personnel:
1. Furnish qualified technical personnel to perform all calibration, testing, and verification. The test personnel are required to be familiar with this Project and the equipment, software, and systems before being assigned to the test program.

1.07 DELIVERY, STORAGE, AND HANDLING (NOT USED)

1.08 PROJECT OR SITE CONDITIONS (NOT USED)

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING

A. As specified in Section 17050.

1.11 WARRANTY (NOT USED)

1.12 SYSTEM START-UP (NOT USED)

1.13 OWNERS INSTRUCTIONS (NOT USED)

1.14 COMMISSIONING (NOT USED)

1.15 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS (NOT USED)

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS (NOT USED)

2.04 MANUFACTURED UNITS (NOT USED)

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS (NOT USED)

2.07 ACCESSORIES (NOT USED)

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL

A. Factory acceptance test - general:
   1. Before shipment to the Project Site, the complete PCIS system including all operator stations, servers, network equipment, printers, PCMs, PLCs, RTUs, LCPs, CCS, peripherals, communications equipment, and other SCADA equipment, shall be assembled, connected, and all software loaded for a fully functional factory acceptance test (FAT) of the integrated system.
   2. Perform tests to show that the integrated system hardware and software is fully operational and in compliance with the requirements specified in the Contract Documents.
   3. Additional factory tests are specified in other sections of the Instrumentation and Control Specifications.
   4. The Contractor’s test personnel shall be responsible for performing tests and recording results.
   5. The FAT will be witnessed by the Engineer and/or other representatives of the Owner.
   6. Right of observation: The Owner retains the right to observe all factory test activities including any and all subsystem preparation, pretests, troubleshooting, retests, warm-up, and software modification and/or update.

7. The Owner reserves the right to test any specified function, whether or not explicitly stated in the test submittal.
8. Costs for repeating testing: The Contractor shall pay for Engineer's and other Owner's representatives' travel, subsistence, for witnessing the repetition of failed tests.
9. Correction of deficiencies: Any deficiencies observed during the test shall be corrected and retested before completion of the test.
10. Any changes and/or corrections shall be noted on the test forms. Engineer shall witness the revisions and/or corrections prior to leaving the test site.
11. If the corrections and/or revisions are too extensive to be made while the Engineer is scheduled to be at the FAT test site, the FAT shall be, at the Engineer's sole discretion, considered failed, and the test shall be restarted at a later date. All costs for the re-test shall be borne by the Contractor.

B. Testing simulation:
1. The FAT shall make use of hardware simulators that contain switches, pilot lights, variable analog signal generators, and analog signal level displays, which shall be connected to the I/O points within the SCADA system. All inputs and outputs shall be simulated and proper control and system operation shall be validated.
2. The use of jumper wires, terminal block mounted pilot lights, and loose meters to act as or supply the functionality of a simulator shall not be allowed.
3. The hardware simulator may consist of a PLC, operating under a SCADA software package, or other approved software that has its I/O points wired to PLC's I/O points. Software operating on a PC may then act as the switches, pilot lights, variable analog signal generators, and analog signal level displays.

C. Preliminary factory acceptance test:
1. A complete preliminary factory acceptance test (pre-FAT) shall be conducted utilizing test procedures approved by the Engineer. The pre-FAT test procedure shall be a subset of the full FAT.
2. The purpose of the pre-FAT is to provide assurance to the Engineer that the SCADA system is ready for the full, witnessed factory acceptance test, in terms of both stability and functionality. Debugging of software and troubleshooting of hardware shall occur during and before the pre-FAT, not during the FAT. The Contractor shall fully test the SCADA system and fix all deficiencies found before the full FAT.
3. The Owner shall have the right to witness any or all of the pre-FAT testing and shall be notified in writing 20 days before the start of the pre-FAT.
4. The pre-FAT test results submittal shall include a letter, signed by the Contractor's project manager or company officer, certifying that the system is complete, has been tested successfully, and is fully ready for the full, witnessed FAT. The submittal shall include completed pre-FAT test forms, signed by the Contractor's staff, and shall be submitted for review before the start of the FAT.

D. Panel inspections:
1. The Engineer will inspect each control panel for completeness, workmanship, fit and finish, and compliance with the Contract Documents and the approved shop drawings.

2. Provide panel inspection forms as part of the factory acceptance test procedures submittal.
3. Inspection to include, as a minimum: Layout, mounting, wire and data cable routing, wire tags, power supply, components and wiring, I/O components layout (including terminals, wiring and relays), device layout on doors and front panels, and proper ventilation operation.

E. I/O test:
1. Verify that I/O is properly wired to field terminals and is properly mapped into the PLC and the rest of the SCADA system, including all operator interface devices.
2. Test methodology:
   a. Discrete inputs: Apply appropriate input at panel terminal, observe input card indicator, observe data value at each indicated data address, observe data received on all operator interface displays (SCADA workstations and local operator interface (LOI) displays).
   b. Discrete outputs: Issue commands from operator interface screen, verify output card indicator light and measure response at field wiring terminals. [Repeat for each operator interface screen.
   c. Analog inputs: Apply appropriate analog input signal at panel terminals, observe data value at each indicated data address, and observe data properly received at each operator screen. Check each point at 0 percent, 50 percent, and 100 percent of scale.
   d. Analog outputs: Enter scaled values in the output buffer file, observe the output data file value, and measure appropriate response at panel wiring terminals.
3. Test forms to include, but not be limited to:
   a. PLC and panel number.
   b. I/O type.
   c. I/O tag name.
   d. Panel terminal block numbers.
   e. Rack/slot/number of I/O point.
   f. Check-off for correct response for each I/O point.
   g. Space for comments.
   h. Initials of individual performing test.
   i. Date test was performed.
   j. Witness' signature lines.

F. System configuration test:
1. Demonstrate and test the setup and configuration of all operator stations, servers, development stations, and peripherals.
2. Demonstrate all utility software and functions, such as virus protection, backup, optical drive burning, network monitoring, etc.
3. Demonstrate the proper operation of all peripheral hardware.
4. Demonstrate all general SCADA functions.
5. Demonstrate proper operation of log-on and other access security functions.
6. Demonstrate the proper operation of all historical data storage, trend, display, backup, and report functions.
7. Test automatic fail over of redundant equipment.

8. Demonstrate the proper operation of the alarm display and acknowledgement functions.
9. Test forms:
    a. For each test, list the specification page and paragraph of the function demonstrated, and provide a description of the function.
    b. List the specific tests and steps to be conducted.
    c. For each function, list all of the different sub-functions or ways the function can be used, and provide a test check-off for each:
        1) Include signature and date lines.

G. Control logic test:
1. The purpose of this test is to verify that all software functions and logic work as specified, along with any hardwired logic or functions in the tested control panels.
2. Testing requirements:
    a. Demonstrate each function described in Section 17100. Demonstrate in detail how each function operates under a variety of operating scenarios. Test to verify the application of each general control strategy function to each specific control strategy or loop description.
    b. Demonstrate the proper operation of the programming and configuration for each control strategy or loop description. Test each strategy or loop description on a sentence by sentence and function by function basis. Loops with similar or identical logic must each be tested individually.
    c. Demonstrate the proper operation of all digital communication links and networks. Verify each digital communication I/O point.
    d. Failure testing: In addition to demonstrating correct operation of all specified features, special effort shall be made to demonstrate how the system responds to and recovers from abnormal conditions including, but not limited to: equipment failure, operator error, communications subsystem error, communications failures, simulated/forced software lockups, power failure (both utility power and power to SCADA hardware), process equipment failure, and high system loading conditions.
3. Test forms:
    a. Include the fully revised and approved control strategy for the loop being tested.
    b. Identify the cause and effect as each I/O point is toggled through the simulator. Check boxes shall be provided to track proper and/or improper operation of the loop.
    c. Any deficiencies or operational changes shall be noted on the forms for correction and documentation:
        1) Include signature and date lines.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 17050.

B. Installation supervision:
   1. Provide as specified in Section 17050.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 FIELD QUALITY CONTROL

A. General:
   1. The Owner reserves the right to test any specified function, whether or not explicitly stated in the test submittals.
   2. Failure testing:
      a. In addition to demonstrating correct operation of all specified features, demonstrate how the system reacts and recovers from abnormal conditions including, but not limited to:
         1) Equipment failure.
         2) Operator error.
         3) Communications sub-system error.
         4) Power failure.
         5) Process equipment failure.
         6) High system loading conditions.
   3. Conduct testing Monday through Friday during normal working hours for no more than 8 hours per day. Testing at other times requires approval of the Engineer.

B. Manufacturer services:
   1. Provide as specified in Section 17050.

C. Sequencing:
   1. See additional requirements specified in the Sequencing article of Section 17050.

D. Calibration:
   1. After installation but before starting other tests, calibrate and adjust all instruments, devices, valves, and systems, in conformance with the component manufacturer's instructions and as specified in these Contract Documents.
   2. Components having adjustable features are to be set carefully for the specific conditions and applications of this installation. Test and verify that components and/or systems are within the specified limits of accuracy.
   3. Replace either individually or within a system, defective elements that cannot achieve proper calibration or accuracy.
   4. Calibration points:
      a. Calibrate each analog instrument at 0 percent, 25 percent, 50 percent, 75 percent, and 100 percent of span, using test instruments with

accuracies traceable to National Institute of Standards and Technology (NIST).

5. Field verify calibration of instruments that have been factory-calibrated to determine whether any of the calibrations are in need of adjustment.
6. Analyzer calibration:
   a. Calibrate and test each analyzer system as a workable system after installation. Follow the testing procedures directed by the manufacturers' technical representatives.
7. Complete instrument calibration sheets for every field instrument and analyzer.
8. Calibration tags:
   a. Attach a calibration and testing tag to each instrument, piece of equipment, or system.
   b. Sign the tag when calibration is complete.

E. LAN cable post-testing:
1. After installing the cable and connectors, test all cables using the LAN certification to confirm the installation meets the requirements of the specification.
2. Provide test documentation that includes the cable number, total length of cable, a permanent hard copy, as well as an ASCII-formatted diskette copy of all traces.
3. After installing connectors:
   a. Perform cable end-to-end testing on all installed cables from both ends of the cable. Test shall include cable system performance tests and confirm the absence of wiring errors.
   b. Submit a signed test report presenting the results of the cable testing.
   c. Repair or replace any portions of the system not meeting TIA standards for a Category 6A installation. Repaired sections shall be retested.
4. Submit 3 copies of all final documentation (including traces), using the approved test form, to the Engineer upon successful completion of the testing.

F. Data and Voice Cable Testing:
1. Test in accordance with County Standards
   a. Refer to Appendix J.

A. Ultrasonic and radar check out:
1. Check response under all operating conditions.
2. Track all responses through trend charts in the SCADA system.
3. Provide Echo Transmission and signal quality on all level transmitters including guided and unguided units.
   a. Provide printout of the actual transmission and all parameters.

B. Loop check/validation:
1. Shall be completed prior to operational testing specified in Section 01660.
2. Owner reserves the right to witness this testing.
3. Check all control loops under simulated operating conditions by causing a range of input signals at the primary control elements and observing appropriate responses of the respective control and monitoring elements, final control elements, and the graphic displays associated with the SCADA system. Issue commands from the SCADA system and verify proper responses of field devices. Use actual process inputs wherever available.

4. Provide “end-to-end” tests:
    a. Test SCADA system inputs from field device to SCADA system operator workstations.
    b. Test SCADA system outputs from SCADA operator workstations to field devices and equipment.
    c. Observe and record responses at all intermediate devices.
    d. Test and record operator commands and signal readouts to each operator device where there is more than one operator interface point.
    e. For each signal, perform separate tests for SCADA computer screens, local operator interface (LOI) screens, and local control panels.
5. Retest any loop following any necessary corrections.
6. Apply simulated sensor inputs corresponding to 0 percent, 25 percent, 50 percent, 75 percent, and 100 percent of span for networks that incorporate analog elements, and monitor the resulting outputs to verify compliance to accuracy tolerance requirements.
7. Apply continuously variable up and down analog inputs to verify the proper operation and setting of discrete devices (signal trips, etc.).
8. Apply provisional settings on controllers and alarm setpoints.
9. Record all analog loop test data on test forms.
10. Exercise each field device requiring an analog command signal, through the SCADA system. Vary, during the validation process, the output from the PLC SCADA system and measure the end device position, speed, etc. to confirm the proper operation of the device for the supplied analog signal. Manually set the output from the SCADA screen at 0 percent, 25 percent, 50 percent, 75 percent, and 100 percent and measure the response at the final device and at any intermediate devices.
11. Exercise each field device providing a discrete input to the SCADA system in the field and observe the proper operation shall be observed at the operator workstation:
    a. Test limit switches, set limits mechanically, and observe proper operation at the operator workstation.
    b. Exercise starters, relay contacts, switch contacts, and observe proper operation.
    c. Calibrate and test instruments supplying discrete inputs, and observe proper operation.
12. Test each device accepting a discrete output signal from the SCADA. Perform the appropriate operator action at the SCADA operator stations (including LOIs, if present) and confirm the proper operation of the field device:
    a. Stroke valves through outputs from the SCADA system, and confirm proper directional operation. Confirm travel limits and any feedback signals to the SCADA system.
    b. Exercise motors starters from the SCADA system and verify proper operation through direct field observation.
    c. Exercise solenoids and other field devices from the SCADA system and verify proper operation through direct field observation.
13. Include in the test forms:
    a. Analog input devices:
        1) Calibration range.
        2) Calibration data: Input, output, and error at each test value.
        3) Analog input associated PLC register address.

4) Value in PLC register at each test point.
5) Value displayed at each operator interface station (local operator interface displays and SCADA workstations).

b. Analog output devices:
1) Calibration range.
2) Test value at each test point.
3) Analog output associated PLC register address.
4) Control variable value at field device at each test point.
5) Physical device response at each test point:
a) Response to be actual valve position, or motor speed, etc.

c. Discrete instrument input devices:
1) Switch setting, contact action, and dead band.
2) Valve position switches:
a) Response in the PLC as the valve is stroked from the PLC.
b) Field observed actual valve position, and valve indicator position as the valve is stroked from the PLC.
3) Operator interface switches (control stations and other pilot devices) and associated response.
4) Starter and drive auxiliary device contact response.
5) Response of all other discrete inputs to the PLC.

d. Discrete output devices:
1) Observed response of field device to the discrete output from the PLC.
2) Observe the proper operation of Open, Close, Start, Stop, On, Off, etc.

e. Test equipment used and associated serial numbers.

C. Pre-commissioning (functional) test:
1. General:
a. Commence pre-commissioning tests after completion of all loop check/validation tests:
1) As specified in Section 17050, Sequencing and Scheduling article.
b. Pre-commissioning to demonstrate proper operation of all systems with process equipment operating over full operating ranges under conditions as closely resembling actual operating conditions as possible.
c. Pre-commissioning testing to generally occur in conjunction with System Testing phase specified in Section 01660.
d. Additional tests are specified in other Instrumentation and Control Sections.
e. Follow approved detailed test procedures and check lists for all pre-commissioning and test activities.
2. Control logic operational validation:
a. Shall be completed prior to operational testing specified in Section 01660.
b. The purpose of control logic validation is to field test the operation of the complete control system, including all parts of the SCADA system, all control panels (including vendor control panels), all control circuits, all control stations, all monitored/controlled equipment, and final control elements.
c. Demonstrate all control functionality shown on the P&IDs, control schematics, and other drawings, and specified in the loop descriptions, control strategies, Electrical Specifications, and Mechanical Equipment Specifications.

d. Test in detail on a function-by-function and sentence-by-sentence basis.
e. Thoroughly test all hardware and software functions:
   1) Including all hardwired and software control circuit interlocks and alarms.
f. Test final control elements, controlled equipment, control panels, and ancillary equipment under startup, shut down, and steady-state operating conditions to verify all logic and control is achieved.
g. Control logic validation tests to include, but not limited to: a repeat of all control logic tests from the factory acceptance tests, modified and expanded to include all field instruments, control panels, circuits, and equipment.

3. Loop tuning:
   a. Optimally tune all electronic control stations and software control logic incorporating proportional, integral, or derivative control. Apply control signal disturbances at various process variable levels and adjusting the gain, reset, or rate settings as required to achieve proper response.
   b. Verify the transient stability of final control elements operating over the full range of operating conditions, by applying control signal disturbances, monitoring the amplitude and decay rate of control parameter oscillations and making necessary controller adjustments as required to eliminate excessive oscillatory amplitudes and decay rates. As a minimum, achieve 1/4 wave amplitude decay ratio damping (subsidence ratio of 4) under the full range of operating conditions.
   c. If excessive oscillations or system instability occur, as determined by the Engineer, continue tuning and parameter adjustments, or develop and implement any additional control algorithms needed to achieve satisfactory control loop operation.
   d. Loop Tuning during the 10-day Operational Phase Test Specified in Section 01660 is not allowed or and will be considered as a Major Failure.
4. Pre-commissioning validation sheets:
   a. Document each pre-commissioning test on an approved test form.
   b. Document loop tuning with a report for each loop, including two-pen chart recordings showing the responses to step disturbance at a minimum of 3 setpoints or process rates approved by the Engineer. Show tuning parameters on the charts, along with time, date, and sign-off by Contractor and Engineer.
   c. Include on the form, functions which can be demonstrated on a loop-by-loop basis:
      1) Loop number and P&ID number.
      2) Control strategy, or reference to specification tested.
      3) Test procedures: Where applicable, use the FAT function-by-function, sentence-by-sentence loop test checklist forms modified to meet the requirements of the pre-commissioning test. Otherwise, create new forms.
   d. For functions that cannot be demonstrated on a loop-by-loop basis (such as overall plant power failure), include on the test form a listing of the specific steps and tests to be conducted. Include with each test description the following information:
      1) Specification page and paragraph of function demonstrated.
      2) Description of function and/or text from specification.
      3) Test procedures: use the FAT loop test checklist forms modified to meet the specific testing conditions of the pre-commissioning test.

5. Pre-commissioning certification:
    a. Document via a certified report the completion of all pre-commissioning and test activities:
        1) Including all test forms with test data entered, submitted to the Engineer with a clear and unequivocal statement that all pre-commissioning test requirements have been satisfied.

3.08 ADJUSTING (NOT USED)

3.09 CLEANING (NOT USED)

3.10 DEMONSTRATION AND TRAINING

A. Performance/reliability/operational tests:
    1. After successful completion of the pre-commissioning test as accepted by the Engineer and Owner, the performance test can proceed.
    2. Complete training and instruction of the Owner's personnel as specified in the Sequencing and Scheduling article of Section 17050.

B. The performance test may be performed concurrently with the 10-day operational test specified in Section 01660.

C. General:
    1. The performance test is part of the Work that must be completed as a condition of substantial completion for the entire Project.
    2. The complete PLC control and SCADA system must run continuously for the duration of the performance test. During this period, exercise all system functions, and log for cause of failure, any system interruption and accompanying component, subsystem, or program failure:
        a. Include time of occurrence and duration of each failure.
    3. Provide a competently trained technician or programmer on call for the Project Site during all normal working days and hours from the start of the performance test until final acceptance of the system. Response time to the Project Site:
        a. 24 hours or less, for a major failure.
    4. The performance test duration:
        a. 10 days.
    5. Test and use the entire process control system under standard operating conditions.

D. SCADA system testing:
    1. Exercise each system function, e.g., status report, alarms, logs, and displays several times at a minimum, and in a manner that approximates "normal" system operation.
    2. Failure of the SCADA system during testing shall be considered as indicating that the programs and operating system do not meet the requirements of the specifications.
        a. Corrective action is required before restarting the acceptance test.

E. Failures:
   1. Classify failures as either major or minor.
      a. Minor failure:
         1) A small and non-critical component failure or software problem that can be corrected by the Owner's operators.
         2) Log this occurrence but this is not a reason for stopping the test and is not grounds for non-acceptance.
         3) Should the same or similar component failure occur repeatedly, this may be considered as grounds for non-acceptance.
         4) Failure of one printer or operator station is considered a minor failure providing all functions can be provided by backup equipment, i.e., alternate printers and operator station, and repairs can be made and equipment returned to service within 3 working days.
      b. Major failure:
         1) Considered to have occurred when a component, subsystem, software control, or program fault causes a halt in or improper operation of the system and/or when a technician's work is required to make a repair or to re-initiate operation of the system.
         2) Cause termination of the performance test.
         3) Start a new acceptance test when the causes of a major failure have been corrected.
         4) A failure is also considered major when failure of any control system that results in an overflow, underflow, overdose, or underdose condition occurs.

F. Technician report:
   1. Each time a technician is required to respond to a system malfunction, he or she must complete a report, which includes details concerning the nature of the complaint or malfunction and the resulting repair action required and taken.
   2. If a malfunction occurs which clears itself or which the operator on duty is able to correct, no report is required or logged as specified above.
   3. If a technician has performed work but no report is written, then a major failure is considered to have occurred.
   4. Each report shall be submitted within 24 hours to the Engineer and the Owner, or its representative.

3.11 PROTECTION (NOT USED)

3.12 SCHEDULES

A. Example test forms:
   1. Example test forms are attached at the end of this Section. They may be used as a starting point for the development of Project-specific test forms for this Project.
   2. The example test forms are not intended to be complete or comprehensive. Edit and supplement the forms to meet the requirements for testing and test forms specified in this Section and other Contract Documents.

END OF SECTION

	INSTALLATION AND CERTIFICATION CHECKLIST DOCUMENTATION	

INSTRUMENT LOOP NO. _____

SERVICE DESCRIPTION _____

A COPY OF LATEST ISSUE OF THE FOLLOWING DOCUMENTS ARE INCLUDED IN THIS INSTRUMENT INSTALLATION CERTIFICATION FILE:

- ☐ INSTRUMENT SPECIFICATION SHEETS (FOR ALL INSTRUMENTS IN THE LOOP)
- ☐ INSTRUMENT INSTALLATION DETAILS (FOR ALL INSTRUMENTS IN THE LOOP)
- ☐ INSTRUMENT LOOP WIRING DIAGRAMS
- ☐ INSTRUMENT INSTALLATION CERTIFICATION CHECKLIST
- ☐ SIZING CALCULATIONS
- ☐ INSTRUMENT INSTALLATION SCHEDULE (APPLICABLE PART)
- ☐ NAMEPLATE SCHEDULE (APPLICABLE PART)
- ☐ VENDOR LITERATURE CALIBRATION INFORMATION

	No	Yes
INSTRUMENT LOOP IS PART OF AN EQUIPMENT START UP/SHUTDOWN INTERLOCKS?	☐	☐

REMARKS: _____

CHECKED BY (COMPANY) _____ ACCEPTED BY (COMPANY) _____

SIGNATURE _____ SIGNATURE _____

DATE _____ DATE _____

	SWITCHES INSTALLATION AND CALIBRATION CHECKLIST	

INSTRUMENT LOOP NO. _____

SERVICE DESCRIPTION _____

CHECK BELOW, WHEN COMPLETED:

- ☐ BENCH CALIBRATED PER SPEC SHEET
- ☐ VERIFIED PER P&ID NO
- ☐ CORRESPONDS TO SPECIFICATION SHEET NO.
- ☐ WIRING CORRECT PER INSTRUMENT LOOP DRAWING NO.
- ☐ INSTALLATION CORRECT PER DETAIL NO.
- ☐ ACCESSORIES ARE PRESENT AND PROPERLY INSTALLED
- ☐ INSTRUMENT IS ACCESSIBLE FOR MAINTENANCE OR REMOVAL
- ☐ ENGRAVED LAMINATED NAMEPLATE (NO SPELLING ERRORS) PERMANENTLY INSTALLED

INSTRUMENT LOOP IS PART OF AN EQUIPMENT START UP/SHUTDOWN INTERLOCKS? ☐ No ☐ Yes

FIELD CALIBRATION CHECK

CONTACT NO.	FUNCTION	FOR SIGNAL	CONTACT IS TO	AT SPECIFIED VALUE FOR		ACTUAL TRIP POINT WAS…	
1	☐ ALARM	☐ INCR	☐ OPEN	SET PT =		SET PT =	
	☐ S/D PERM	☐ DECR	☐ CLOSE	RESET =		RESET =	
2	☐ ALARM	☐ INCR	☐ OPEN	SET PT =		SET PT =	
	☐ S/D PERM	☐ DECR	☐ CLOSE	RESET =		RESET =	
3	☐ ALARM	☐ INCR	☐ OPEN	SET PT =		SET PT =	
	☐ S/D PERM	☐ DECR	☐ CLOSE	RESET =		RESET =	
4	☐ ALARM	☐ INCR	☐ OPEN	SET PT =		SET PT =	
	☐ S/D PERM	☐ DECR	☐ CLOSE	RESET =		RESET =	

NOTE: PERM IS ABBREVIATED FOR PERMISSIVE

	SWITCHES **INSTALLATION AND CALIBRATION CHECKLIST**	

REMARKS: _____

CHECKED BY (COMPANY) _____ ACCEPTED BY (COMPANY) _____

SIGNATURE _____ SIGNATURE _____

DATE _____ DATE _____

	TRANSMITTER/CONTROLLER/INDICATOR INSTALLATION AND CALIBRATION CHECKLIST	

☐ No ☐ Yes

INSTRUMENT LOOP IS PART OF AN EQUIPMENT START UP/SHUTDOWN INTERLOCKS?

INSTRUMENT TYPE INDICATOR ☐ TRANSMITTER ☐ CONTROLLER ☐

☐ OTHER DESCRIPTION _____

INSTRUMENT TAG NO. _____ SERIAL NO. _____

SERVICE DESCRIPTION _____

BENCH CALIBRATION CHECK

INPUT RANGE = _____ OUTPUT RANGE = _____

HEAD CORRECTION = _____ ☐ LINEAR

CALIBRATED SPAN = _____ ☐ SQUARE ROOT

% CALIB SPAN	DESIRED VALUE	ACTUAL VALUE	EXPECTED VALUE	ACTUAL VALUE
0				
50				
100				

CHECK BELOW, WHEN COMPLETED:

☐ BENCH CALIBRATED PER SPECIFICATION SHEET _____

☐ VERIFIED PER P&ID NO _____

☐ CORRESPONDS TO SPECIFICATION SHEET NO. _____

☐ WIRING CORRECT PER INSTRUMENT LOOP DRAWING NO. _____

☐ INSTALLATION CORRECT PER DETAIL NO. _____

☐ ACCESSORIES ARE PRESENT AND PROPERLY INSTALLED

☐ INSTRUMENT IS ACCESSIBLE FOR MAINTENANCE OR REMOVAL

☐ ENGRAVED LAMINATED NAMEPLATE (NO SPELLING ERRORS) PERMANENTLY INSTALLED

FIELD CALIBRATION CHECK

INPUT RANGE = _____ OUTPUT RANGE = _____

% CALIB SPAN	DESIRED VALUE	ACTUAL VALUE	EXPECTED VALUE	ACTUAL VALUE
0				
50				
100				

	TRANSMITTER/CONTROLLER/INDICATOR INSTALLATION AND CALIBRATION CHECKLIST	

☐ DIRECT ☐ REVERSE

☐ ACTION VERIFIED AT 50% SPAN

☐ ACTION VERIFIED AT _____ SPAN

CONTROLLER SETTINGS								
SETTING	**GAIN**	**PB**	**RESET (INTEGRAL)**	**DERIV. (RATE)**	**HIGH LIMIT**	**LOW LIMIT**	**ELEV. ZERO**	**ZERO SUPP**
PRE-TUNE								
POST-TUNE								

PRE-TUNE SETTINGS					
	GAIN	**PB**	**RESET (REPEAT/MIN)**	**RESET (MIN/REPEAT)**	**DERIVATION (MINUTES)**
FLOW:	1.0	100	10	0.1	N/A
LEVEL	1.0	100	MIN.	MAX.	N/A
PRESSURE	2.0	50	2.0	0.5	N/A
TEMP.	4.0	25	0.1	10	OFF

REMARKS _____

_____

_____

_____

_____

_____

_____

_____

CHECKED BY (COMPANY) _____ ACCEPTED BY (COMPANY) _____

SIGNATURE _____ SIGNATURE _____

DATE _____ DATE _____

	ANALYZERS INSTALLATION AND CALIBRATION CHECKLIST	

☐ No ☐ Yes

INSTRUMENT LOOP IS PART OF AN EQUIPMENT START UP/SHUTDOWN INTERLOCKS?

TYPE OF INSTRUMENT _____

INSTRUMENT TAG NO. _____ SERIAL NO. _____

SERVICE DESCRIPTION _____

CHECK BELOW, IF TRUE

- ☐ BENCH CALIBRATED PER SPECIFICATION SHEET _____
- ☐ VERIFIED PER P&ID NO _____
- ☐ CORRESPONDS TO SPECIFICATION SHEET NO. _____
- ☐ WIRING CORRECT PER INSTRUMENT LOOP DRAWING NO. _____
- ☐ INSTALLATION CORRECT PER DETAIL NO. _____
- ☐ ACCESSORIES ARE PRESENT AND PROPERLY INSTALLED
- ☐ INSTRUMENT IS ACCESSIBLE FOR MAINTENANCE OR REMOVAL
- ☐ ENGRAVED LAMINATED NAMEPLATE (NO SPELLING ERRORS) PERMANENTLY INSTALLED

REMARKS _____

CHECKED BY (COMPANY) _____ ACCEPTED BY (COMPANY) _____

SIGNATURE _____ SIGNATURE _____

DATE _____ DATE _____

	CONTROL VALVES INSTALLATION AND CALIBRATION CHECKLIST	

☐ No ☐ Yes

INSTRUMENT LOOP IS PART OF AN EQUIPMENT START UP/SHUTDOWN INTERLOCKS?

VALVE TAG NO. _____ SERIAL NO. _____

☐ TRANSDUCER TAG NO. _____ SERIAL NO. _____

☐ SOLENOID TAG NO. _____ SERIAL NO. _____

☐ VOLUME BOOSTER TAG NO. _____ SERIAL NO. _____

☐ POSITIONER _____ SERIAL NO. _____

SERVICE DESCRIPTION _____

TRANSDUCER CHECK					
INPUT RANGE =			OUTPUT RANGE =		
CALIBRATED SPAN =			CALIBRATED SPAN =		
BENCH					
SPAN	DESIRED	ACTUAL	SPAN	EXPECTED	ACTUAL
0%			0%		
50%			50%		
100%			100%		
FIELD					
SPAN	DESIRED	ACTUAL	SPAN	EXPECTED	ACTUAL
0%			0%		
50%			50%		
100%			100%		

CHECK BELOW, IF TRUE:

☐ BENCH CALIBRATED PER ABOVE _____

☐ VERIFIED PER P&ID NO. _____

☐ CORRESPONDS TO SPECIFICATION SHEET NO. _____

- ☐ VALVE SPECIFICATION NO. _____
- ☐ TRANSDUCER SPECIFICATION NO. _____
- ☐ SOLENOID SPECIFICATION NO. _____

☐ WIRING CORRECT PER INSTRUMENT LOOP DRAWING NO. _____

☐ INSTALLATION CORRECT PER INSTRUMENT INSTALLATION DETAILS _____

- ☐ VALVE DETAIL NO. _____
- ☐ TRANSDUCER DETAIL NO. _____
- ☐ SOLENOID DETAIL NO. _____

	CONTROL VALVES **INSTALLATION AND CALIBRATION CHECKLIST**	

☐ ACCESSORIES ARE PRESENT AND PROPERLY INSTALLED

☐ INSTRUMENT IS ACCESSIBLE FOR MAINTENANCE OR REMOVAL

☐ ENGRAVED LAMINATED NAMEPLATE (NO SPELLING ERRORS) PERMANENTLY INSTALLED

VALVE CHECK			
FLOW CHECK	☐ PROCESS FLOW DIRECTION THRU THE VALVE IS CORRECT		
SAFETY CHECK	ON LOSS OF AIR VALVE FAILS ☐ OPEN ☐ CLOSE	ON LOSS OF POWER SOLENOID FAILS ☐ TO VENT ☐ TO VALVE	
TRAVEL CHECK	FULL OPEN AT _____ PSI	FULL CLOSED AT _____ PSI	MEASURED TRAVEL _____ INCHES
SEATING CHECK	☐ ON BENCH ☐ IN-LINE	RESULTS	ACTUATOR BENCH SET

POSITIONER CHECK
VALVE FULL OPEN AT _____ PSI TO POSITIONER
VALVE FULL CLOSED AT _____ PSI TO POSITIONER

VOLUME BOOSTER CHECK
BYPASS VALVE (GAIN) ADJUSTING SCREW BACKED OUT _____ TURNS FROM CLOSED TO ENSURE QUICK BUT STABLE OPERATION (TYPICALLY 1-1/2 TO 2 TURNS)

REMARKS _____

_____

_____

_____

_____

_____

_____

CHECKED BY (COMPANY) _____ ACCEPTED BY (COMPANY) _____

SIGNATURE _____ SIGNATURE _____

DATE _____ DATE _____

	DEVICENET INSTALLATION TESTING	

Devicenet Network _____

Network Installation Characteristics

Architecture	Baud Rate	Trunk Media	Drop Media
☐ Single Master	☐ 125 kBaud	☐ Thick Round	☐ Thick Round, Unshielded
or			
☐ Multi Master	☐ 250 kBaud	☐ Thin Round	☐ Thin Round, Shielded
☐ Redundant Power Supplies	☐ 500 kBaud		☐ Thick Round, Shielded
☐ Per Network			

Installed Node List

☐ 0 ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10 ☐ 11 ☐ 12 ☐ 13 ☐ 14 ☐ 15
☐ 16 ☐ 17 ☐ 18 ☐ 19 ☐ 20 ☐ 21 ☐ 22 ☐ 23 ☐ 24 ☐ 25 ☐ 26 ☐ 27 ☐ 28 ☐ 29 ☐ 30 ☐ 31
☐ 32 ☐ 33 ☐ 34 ☐ 35 ☐ 36 ☐ 37 ☐ 38 ☐ 39 ☐ 40 ☐ 41 ☐ 42 ☐ 43 ☐ 44 ☐ 45 ☐ 46 ☐ 47
☐ 48 ☐ 49 ☐ 50 ☐ 51 ☐ 52 ☐ 53 ☐ 54 ☐ 55 ☐ 56 ☐ 57 ☐ 58 ☐ 59 ☐ 60 ☐ 61 ☐ 62 ☐ 63

☐ All nodes present and in accordance with network drawings/specifications ☐ ODVA approved devices
☐ Nodes/devices accessible for inspection and maintenance ☐ Nodes/devices properly addressed

Comments: _____

Media Inspection

Trunk Cable	Drop Cable	Installation
☐ ODVA approved	☐ ODVA approved	☐ No evidence of physical damage
☐ Labeling complete	☐ Labeling complete	☐ Installed in protective raceway
☐ Cable/conductor terminations	☐ Cable/conductor terminations	☐ Bending radius not exceeded
☐ Terminating resistors at ends	☐ Max drop length < 20'	☐ Cable supports in place
		☐ V- and shield are grounded
		☐ Clearance from high temperature/voltage sources
		☐ No installation subject to vibration

Comments: _____

Network Power Supplies

Power Supply Equipment	Supply Source (120 VAC)	Network Power Tap (24 VDC)
☐ ODVA compliant	☐ Overcurrent protection	☐ Overcurrent protection
☐ Quantity and ratings	☐ Conductor size	☐ Conductor size

Comments: _____