5. Provide service factor of 2.5 for electric motor drives and 3.5 for engine drives.
6. Do not allow metal-to-metal contact between driver and driven equipment.
7. 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. Falk, WA Torus.
      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 preloaded neoprene cylinder type couplings.
   4. Provide flexible connecting element of rubber and reinforcement fibers.
   5. Connect stub shafts through collars or round flanges, firmly keyed to their shafts with neoprene cylinders held to individual flanges by through pins.

D. Spacer Couplings: 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 mountings 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 cartridge 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. Provide and route leakage drain line to nearest equipment floor drain indicated on the Drawings.
   5. For pumps with packing, design packing gland to allow adjustment and repacking without dismantling pump except to open up packing box.

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 Food and Drug Administration (FDA) or National Sanitation Foundation (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 herein.
   1. Provide seal types meeting the following requirements:
      a. Balanced hydraulically.
      b. Spring: Stationary, out of pumping fluid, Hastelloy C; Type 316 stainless steel for split seals.
      c. O-Ring: Viton 747.
      d. Gland: Type 316L stainless steel.
      e. Set Screws: Type 316L stainless steel.
      f. Hard Face: Reaction bonded, Silicon Carbide.
      g. Soft Face: Carbon, Union Carbide 658 RC.
      h. Seal designed to withstand 125 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. Double cartridge type mechanical plus spare rebuild kit for each size and type of pump.
   3. Manufacturers: The following, no equal:
      a. Chesterton, 180.
      b. No other manufacturer will be accepted. This item is being sole sourced per NRS 338.140 to match equipment in use at the project site either completed or in the course of completion.

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 operate 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, Super-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 ambient temperature 15 degrees Fahrenheit above the maximum ambient temperature specified elsewhere in this Section.
   2. Provide an external oil cooler when required to satisfy the specified operating conditions. Provide air cooled system if a water cooling source is not indicated on the Drawings. 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 for L10 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; 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 one 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 transmissability to 10 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: 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: Paint 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 and remove concrete spatter after concrete is placed.

B. Concrete Surfaces Designated to Receive Grout:
   1. Give surfaces heavy sandblasting treatment.
   2. Clean surfaces of sandblasting sand, grease, oil, dirt, and other foreign material that may reduce bonding of grout.
   3. Concrete Saturation: Saturate concrete with water. Concrete surface shall be damp concrete at time grout is placed.
   4. Prior to grouting, the existing surface shall be in a (SSD) saturated surface dry condition. This condition shall be accomplished using clean, potable water within normal tap water temperature range.

C. Field Measurements:
   1. Prior to fabrication of equipment, take measurements for installation of equipment and verify dimensions indicated on the Drawings. 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 Hydraulic Institute Standards, 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 to be sufficient to read angular and radial misalignment at 10 percent or less of the manufacturer's recommended acceptable misalignment.
4. Alignment and calculations to 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, tighten anchor bolts and grout between base and foundation. Allow minimum 48 hours for grout to harden. After grout hardens, remove jacking screws, fully tighten anchor bolts, and recheck alignment. Correct alignment as required.
6. After operational testing is complete, dowel motor or drivers and driven equipment. Comply with manufacturer's instructions.

D. Grouting Equipment Bases:
1. Comply with manufacturer's installation instructions for grouting spaces, type of grout, and tolerances for level and alignments, both vertical and horizontal.
2. Grout base when piping connections are complete and in alignment with no strain transmitted to equipment.
3. Grout base when equipment is leveled and in alignment.
4. Place grout, filling voids under equipment bases including recesses between anchor bolts and sleeves.
   a. Extend grout to edge of bases or bedplates and bevel at 45 degrees around units.
   b. Finish surfaces with slope that prevents ponding water within grouted areas.
5. Grout: As specified in Section 03600.

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

F. Tolerances:
   1. Completed Equipment Installations: Comply with requirements for intended use and specified vibration and noise tolerances.

G. Warning Signs: Mount securely with stainless fasteners at equipment which 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 01756.

3.05 MANUFACTURER'S REPRESENTATIVE

A. Field Check-out: 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 manufacturers 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 01756.

END OF SECTION

SECTION 15052

BASIC PIPING MATERIALS AND METHODS

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes: Basic piping materials and methods.

1.02 REFERENCES

A. American Society of Testing and Materials (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. D 2240 - Standard Test Method for Rubber Property - Durometer Hardness.

B. Carson City Adopted Codes:
   1. 2006 International Building Code (IBC)
   2. 2006 Uniform Plumbing Code (UPC)
   3. 2006 Uniform Mechanical Code (UMC)

1.03 DEFINITIONS

A. Aboveground Piping: Piping within buildings, tunnels, or other structures without regard to elevation of piping, or exposed piping outside buildings and structures.

B. Underground Piping: Piping actually buried in soil or cast in concrete.

C. Underwater Piping: Piping below tops of walls in basins or concrete tanks containing water.

D. Wet Wall: Wall with water on at least one side.

1.04 INTENT OF DRAWINGS AND SPECIFICATIONS

A. Except in details, piping is indicated diagrammatically. Sizes and locations are indicated on the Drawings. Not every offset and fitting, or structural difficulty that may be encountered has been indicated on the Drawings.

B. Perform minor modifications to piping alignment where necessary to avoid structural, mechanical, electrical 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 Schedule.

1.05 SYSTEM DESCRIPTION

A. Performance Requirements:
   1. Venting Piping Under Pressure:
      a. Lay piping under pressure flat or at a continuous slope without air traps, unless otherwise indicated on the Drawings.
      b. Install plug valves as air bleeder cocks at high points in piping. Provide one-inch plug valves for water lines, and 2-inch plug valves for sewage and sludge lines, unless otherwise indicated on the Drawings.
      c. Provide additional pipe taps with plug cocks and riser pipes along piping as required for venting during initial filling, disinfecting, and sampling.
      d. Before piping is placed into service, close plug valves and install plugs. Protect plugs and plug valves from corrosion in accordance with Section 09960.
   2. Restraining Piping:
      a. Restrain piping at valves and at fittings where piping changes direction, changes sizes, and at ends.
         1) When piping is underground, use concrete thrust block or mechanical restraints.
         2) When piping is aboveground or under water, use mechanical or structural restraints.
         3) Determine thrust forces by multiplying the nominal cross sectional area of the piping by design test pressure of the piping.
      b. Provide restraints with ample size to withstand thrust forces resulting from test pressures.
         1) During testing, provide suitable temporary restraints where piping does not require permanent restraints.
      c. Place concrete thrust blocks against undisturbed soil. Place concrete so piping joints, fittings, and other appurtenances are accessible for assembly and disassembly.
      d. Provide underground mechanical restraints where specified in the Piping Schedule.
   3. Connections to Existing Piping:
      a. Expose existing piping to which connections are to be made with sufficient time to permit, where necessary, field adjustments in line, grade, or fittings.
         1) Protect domestic water supplies from contamination.
            a) Make connections between domestic water supply and other water systems in accordance with requirements of public health authorities.
            b) Provide devices approved by OWNER of domestic water supply system to prevent flow from other sources into the domestic supply system.
      b. Make connections to existing piping and valves after sections of new piping to be connected have been tested and found satisfactory.
      c. 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. Connections to In-service Piping:
      a. Shutdown in-service piping in accordance with Section 01140.
         1) Establish procedures and timing in a conference attended by CONTRACTOR, ENGINEER, and OWNER of the in-service piping.

b. Where operation and maintenance of existing facilities require that a shutdown be made during hours other than normal working hours, perform the related work in coordination with the hours of actual shutdown.
c. Additional provisions regarding shutdown of existing facilities are specified in Section 01140.

5. Connections Between Ferrous and Nonferrous Metals:
   a. Connect ferrous and nonferrous metal piping, tubing, and fittings with dielectric couplings especially designed for the prevention of chemical reactions between dissimilar metals.
   b. Nonferrous metals include aluminum, copper, and copper alloys.
6. Flanged Connections Between Dissimilar Metals Such as Ductile Iron Pipe and Steel Pipe:
   a. Provide stainless steel bolts with isolation bushings and washers, and full-face flange gaskets.

1.06 SUBMITTALS

A. CONTRACTOR shall provide submittals as specified in Sections 01330 and 15050.

PART 2 PRODUCTS

2.01 ESCUTCHEONS

A. Manufacturers: One of the following or equal:
   1. Dearborn Brass Company, Model Number 5358.
   2. Keeney Manufacturing Company, Model Number 102 or Number 105.
   3. Beaton and Corbin, Model Number 1 or Number 13.

B. Material: Chrome-plated steel plate.

2.02 LINK TYPE SEALS

A. Manufacturers: One of the following or equal:
   1. Calpico, Incorporated.
   2. Thunderline Corporation, Link-Seal.

B. 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 stainless steel or glass reinforced nylon pressure plate under each bolt head and nut. Isolate pressure plate from contact with wall sleeve.

2.03 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 and less than 100 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 20 inches in diameter and larger:
      1) Garlock, Style 8798.
      2) John Crane, similar product.
   b. Pipe less than 20 inches in diameter:
      1) Garlock, Style 7797.
      2) John Crane, similar product.

B. Gaskets for Flanged Joints in Polyvinyl Chloride and Polyethylene Piping:
1. Suitable for pressures equal and less than 150 pounds per square inch gauge, with low flange bolt loadings, temperatures equal and less than 120 degrees Fahrenheit, polymer, chlorine, caustic solutions, and other chemicals, except chemicals which liberate free fluorine including fluorochemicals and gaseous fluorine.
2. Material: Viton Rubber; 0.125-inch thick.
3. Manufacturers: One of the following or equal:
   a. Garlock.
   b. John Crane, similar product.

C. Gaskets for Flanged Joints in Ductile Iron, or Steel Water Piping:
1. Suitable for hot or cold water, pressures equal and less than 150 pounds per square inch gauge, and temperatures equal and less than 160 degrees Fahrenheit.
2. Material:
   a. Neoprene elastomer, compressed, non-asbestos fiber reinforcement.
   b. Teflon ring; or teflon envelope with nonasbestos filler.
3. Manufacturers: One of the following or equal:
   a. Garlock, Bluegard 3300.
   b. John Crane, similar product.

D. Gaskets for any other fluids or any other pressure or temperature conditions shall be suitable for the specific fluids and pressure and temperature conditions.

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 WALL AND SLAB PENETRATIONS

A. Provide sleeves for piping penetrations through aboveground masonry and concrete walls, floors, ceilings, roofs, pilasters, columns, piers, and beams unless specified or otherwise indicated on the Drawings.

B. 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.
   1. Arrange sleeves and adjacent joints so piping can be pulled out of sleeves and replaced without disturbing the structure.
   2. Cut ends of sleeves flush with surfaces of concrete, masonry, or plaster.
   3. Conceal ends of sleeves with escutcheons where piping runs through floors, walls, or ceilings of finished spaces within buildings.
   4. Seal spaces between pipes and sleeves with link-type seals when not otherwise specified or indicated on the Drawings.

C. Cast couplings or wall pieces in walls for penetrations of buried rigid piping including cast iron, ductile iron, reinforced concrete, and vitrified clay through structures.
   1. Provide couplings or wall pieces with mechanical push-ons, or similar flexible joints at outside faces of walls.
   2. Provide additional similar joints in piping at transition points between trenches and structure excavations.
   3. For steel piping, single joints may be used in lieu of 2 joints. Locate single joints outside within 2 feet from outside faces of walls. Link Seal: Use 2 link seals where seal is used to seal at wet wall sleeves. Mount one seal on the inside face of the wall and the other on the outside face of the wall. Coordinate the inside diameter of the wall sleeve with the size of the seal to provide watertight sealing.

D. Link Seal: Use 2 link seals where seal is used to seal at wet wall sleeves. Mount one seal on the inside face of the wall and the other on the outside face of the wall. Coordinate the inside diameter of the wall sleeve with the size of the seal to provide watertight sealing.

E. Where not indicated on the Drawings, penetrations for conditions other than those specified under the preceding subparagraphs shall be 1 of the 3 types specified in such subparagraphs found by ENGINEER to be the most suitable for the particular conditions.

3.03 EXPOSED PIPING

A. Install exposed piping in straight runs parallel to the axes of structures, unless indicated otherwise.
   1. Install piping runs plumb and level, unless otherwise indicated on the Drawings. Slope plumbing drain piping with 1/4 inch per foot downward in the direction of flow.

B. Install exposed piping after installing equipment and after piping and fitting locations have been determined.

C. Support piping in accordance with Section 15061 and Section 15062.
   1. Do not transfer pipe loads and strain to equipment.

D. 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.

E. Assemble piping without distortion or stresses caused by misalignment.
   1. Match and properly orient flanges, unions, flexible couplings, and other connections.
   2. Do not subject piping to bending or other undue stresses when fitting piping. Do not correct defective orientation or alignment by distorting flanged joints or subjecting flange bolts to bending or other undue stresses.
   3. Flange bolts, union halves, flexible connectors, and other connection elements shall slip freely into place.
   4. Alter piping assembly to fit when proper fit is not obtained.
   5. Install eccentric reducers or increasers with the top horizontal for pump suction piping.

3.04 BURIED PIPING

A. Bury piping with minimum 3-foot cover without air traps, unless otherwise indicated on the Drawings.

B. Where 2 similar services run parallel to each other, piping for such services may be laid in the same trench. Lay piping with sufficient room for assembly and disassembly of joints, for thrust blocks, for other structures, and to meet separation requirements of public health authorities having jurisdiction.

C. At the interface of concrete encasement and polyethylene wrap, the polyethylene wrap shall extend a minimum of 1 foot into the concrete encasement.

D. Laying Piping:
   1. Lay piping in finished trenches free from water or debris. Begin at the lowest point with bell ends up slope.
   2. Place piping with top or bottom markings with markings in proper position.
   3. Lay piping on an unyielding foundation with uniform bearing under the full length of barrels.
   4. 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.
   5. At the end of each day's construction, plug open ends of piping temporarily to prevent entrance of debris or animals.

E. Concrete encase all buried pipe installed under concrete slabs or structures.

3.05 PIPING ALTERNATIVES

A. Provide piping in accordance with this Section, unless indicated on the Drawings or specified otherwise.

B. Alternative Pipe Ratings: Piping with greater pressure rating than specified may be substituted in lieu of specified piping without changes to the Contract Price. Piping of different material may not be substituted in lieu of specified piping.

C. Alternative Joint Types: Ductile iron piping with mechanical joints or push-on joints may be substituted in lieu of bell and spigot joints.

D. Valves in Piping Sections: Capable of withstanding specified test pressures for piping sections and fabricated with ends to fit piping.

E. For flanged joints, where one of the joining flanges is raised face type, provide a matching raised face type flange for the other joining flange.

3.06 CLEANING

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

B. Cleaning Potable Water Piping:
   1. Flush and disinfect potable water piping in accordance with Section 15142.

3.07 PIPING SCHEDULE

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

AM	Air method
GR	Gravity method
HH	High head method
LH	Low head method
SC	Special case

   2. Abbreviations to designate piping include the following:

BL	Bituminous Lining
BSP	Black Steel Pipe
CI	Cast Iron
CISP	Cast Iron Soil Pipe
Cl	Class, followed by the designation
CM	Cement Mortar
CPVC	Chlorinated Polyvinyl Chloride
DIP	Ductile Iron Piping
DR	Diameter Ratio
Flg	Flanged Joint
FRMP	Fiberglass Reinforced Mortar Pipe

Ga	Gauge, preceded by the designation
GC	Gel Coat
GE	Grooved End Joint
GI	Glass
GSP	Galvanized Steel Pipe
MI	Malleable Iron
MJ	Mechanical Joint
NPS	Nominal Pipe Size, followed by the number in inches, pounds per square inch, or pounds per square inch, gauge.
P	Painted
PSIG	Pounds per Square Inch, Gauge
PVC	Polyvinyl Chloride
PE	Polyethylene Wrapped – Double Wrapped
PU	Polyurethane Lining or Coating
RCP	Reinforced Concrete Pipe
RMJ	Restrained Mechanical Joint
RPO	Restrained Push-On Joint
Sc	Screwed
Sch.	Schedule, followed by the designation
SN	Stiffness Number
SS	Stainless Steel
SW	Solvent Weld
VCP	Vitrified Clay Piping
W	Welded
WT	Warning Tape

(The PIPING SCHEDULE follows in the next pages.)

Identifier For All Piping	Diameter (Inches)	Material	Thickness or Schedule	Test Pressure (psig)	Test Method	Joints	Lining	Protective Coating	Remarks
Drain (D)									
Aboveground	All	DIP	Cl 53	20 ft	GR	Flg	Per Section 15251	Per Section 15251	--
Submerged	All	DIP	Cl 53	20 ft	GR	Flg	Per Section 15251	Per Section 15251	--
Underground	All	DIP	Cl 51	20 ft	GR	MJ C-150	Per Section 15251	Per Section 15251	Encase in concrete under slabs.
Under Slab	All	Acid Resist. CISP	Standard	20 ft	GR	Bell & Spigot	BL	--	Encase in concrete under structures.
Foul Air (FA)	All	316L St	Sch 10S	5	AM	Flg	--	--	--
Aboveground, exposed		Stl.							
No. 2 Water (2W)									
Aboveground	All	GSP	Sch 40	150	HH	SW	PU	P	Insulated where outdoors.
Underground	All	PVC	Sch 80	150	HH	SW	--	P	WT; Encase in concrete under slabs.
No. 3 Water (3W)									
Aboveground	All	GSP	Sch 40	150	HH	Sc	PU	--	Insulated where exposed outdoors; heat-traced where indicated on the drawings.
Underground	All	PVC	Sch 80	150	HH	SW	--	P	Encase in concrete under structures. Use purple reclaimed water pipe.

Identifier For All Piping	Diameter (Inches)	Material	Thickness or Schedule	Test Pressure (psig)	Test Method	Joints	Lining	Protective Coating	Remarks
Raw Water (RW)									
Exposed (pressure)	All	DIP	Cl 53	125	HH	Flg	Per Section 15251	Per Section 15251	--
Underground (pressure)	24” and under	DIP	Cl 51	125	HH	RMJ	Per Section 15251	Per Section 15251	WT
Underground (gravity)	36” and over	PVC	DR 35	20	LH	RPO	--	--	WT
Underground (gravity)	Greater than 36”	FRMP	Per Section 15269	20	LH	Per Section 15269	--	--	WT
Sanitary Sewer (SS)									
Exposed	All	DIP	Cl 53	20 ft	GR	Flg	Per Section 15251	Per Section 15251	--
Underground	All	Acid Resist. CISP	Standard per ASTM A74	25 ft	GR	No Hub	Per Section 15251	Per Section 15251	WT; Encase in concrete under slabs.
Secondary Scum (SSC)									
Underground	All	DIP	Cl 51	100	HH	RPO	Per Section 15251	Per Section 15251	Encase in concrete under slabs.

END OF SECTION

SECTION 15061

PIPE SUPPORTS

PART 1 GENERAL

1.01 SUMMARY

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

1.02 REFERENCES

A. American National Standard Institute or 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 SUBMITTALS

A. Shop Drawings: Include schedule, indicating where supports will be installed, and drawings of pipe support system components.

B. Calculations and other information to substantiate supports meet minimum design strength requirements and can withstand seismic loads as specified in Section 01612.

PART 2 PRODUCTS

2.01 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. 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.

L. 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.

M. 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.

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

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

P. 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.

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

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

S. 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.

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

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

2.02 MATERIALS

A. Pipe Supports:
   1. Stainless Steel (Type 316): Use in all submerged locations, above water level but below top of wall inside water bearing structures and where specifically indicated on the Drawings.
   2. Hot-dip Galvanized Steel: Use in areas other than above and where specifically indicated on the Drawings. Hot-dip galvanize pipe support after fabrication.
   3. Plastic, Aluminum, and Other Miscellaneous Materials: Use where specifically indicated on the Drawings.

B. Fasteners:
   1. As specified in Section 05120.

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.

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

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

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

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

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

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

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

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

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

K. 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.

L. 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.

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

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

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

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

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

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

S. Support plumbing drainage and vents in accordance with the Plumbing Code adopted by the OWNER.

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

U. Where pipe is insulated, install over-sized supports and hangers.

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

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

X. Paint or Coat support system components as specified in Section 09960.

END OF SECTION

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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.

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 Responsibility:
   1. The manufacturer of the preformed channel pipe support system shall be considered the designer of the support system.
   2. Prepare design calculations utilizing the design criteria included in these Specifications.
   3. Prepare detailed Shop Drawings illustrating the layout of the support system and identifying the components of the support system.

B. Design Criteria:
   1. Include live, dead, and seismic loads associated with piping, valves, and appurtenances. Consider the content of the pipes in load calculations.
   2. Minimum Gauge Thickness: 12 gauge.
   3. Allowable Stress of Channels:
      a. Steel Channels: The lesser of 25,000 pounds per square inch, or 0.66 times yield stress of steel.
      b. Stainless Steel Channels: 0.66 times the yield stress of the stainless steel alloy.
   4. Maximum Deflection: 1/240 of span.
   5. Allowable Column Loads: As recommended by manufacturer in published instruction for column's unsupported height and "K" value for calculating effective column length of not less than 1.0.

6. Future Loads:
   a. Support systems indicated on the Drawings may include spaces intended to accommodate future pipes.
   b. Assume such spaces are occupied by 6-inch diameter ductile iron pipes. Only the number of pipes that would physically fit into the space need be considered.
   c. Include the weight of the pipe contents in determining future loads. Assume pipe contents are water.
7. Seismic Design Criteria: As specified in Section 01612 as specified for mechanical equipment.
8. Spacing of Supports: As required to comply with design requirements but not more than 5 feet.

C. Supports submerged and below the Top of Walls of Water Bearing Structures: Use Type 316 stainless steel for support system components.
   1. Supports in Other Locations: Use hot-dipped galvanized components unless other materials are specifically indicated on the Drawings.

1.04 SUBMITTALS

A. Shop Drawings: Include layout of support system including pipe loads, selected channel size, fittings, and appurtenances.

B. Structural Design Calculations. Detailed calculations stamped and signed by a Professional Engineer registered in the State where the project is located.

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 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 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.

2.03 FABRICATION

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

B. Do not galvanize or paint stainless steel components.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install preformed channel concrete inserts for vertical support, quantity based on manufacturer's structural design calculations.

B. Fasten preformed channel pipe supports to existing walls using Z-fittings and concrete anchors as indicated on the Drawings.

C. Fasten preformed channel pipe supports to preformed channel concrete inserts embedded in ceiling using U-shaped fittings.

D. Suspend threaded rods from concrete inserts embedded in ceiling. Support preformed channel pipe supports with threaded rods.

E. Touchup cut or damaged galvanized surfaces.

F. Prevent contact between pipes and support components of dissimilar metals. Utilize rubber coated, plastic coated, or vinyl coated components, stainless steel components, or wrap pipe with PVC or polyethylene tape.

G. Install support as near as possible to concentrated loads.

H. Install support within 2 feet of horizontal and vertical changes in pipe alignment.

I. Adjust supports or install shims to obtain specified slope or elevation.

END OF SECTION

SECTION 15075

MECHANICAL IDENTIFICATION

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes: Mechanical Identification including the following:
   1. Pipe identification by color and legend
   2. Special Items.
   3. Identification of equipment and components of systems with paint, brands, tags, and signboards.

1.02 REFERENCES

A. American National Standards Institute (ANSI):
   1. A13.1 - Scheme for the Identification of Piping Systems.

1.03 SUBMITTALS

A. Submit Following:
   1. Product data.
   2. Samples.
      a. Provide color panel for all proposed color schemes.
   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 MANUFACTURERS

A. One of the following or approved equal:
   1. Seton, Opti Code Pipe Markers.
   2. Lab Safety Supply.

2.02 MATERIALS

A. Pipe Markers: Self-adhesive vinyl, suitable for outdoor application from -40 to 180 degrees Fahrenheit; meet ANSI A13.1 requirements.

1. Lettering:

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

2. 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, CO2, halon)	White	Red

B. Coatings: As specified in Section 09960.

C. Pipe Identification Tags: Aluminum or stainless steel with stamped-in 1/4 inch high identifying lettering.

D. Pipe Identification Tag Chains: Aluminum or stainless steel.

E. 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:
   1. Brady Bradysnap-On B-915.
   2. Seton Setmark.

2.03 SPECIAL ITEMS

A. In addition, special coating in accordance with Section 09960 of the following items is required:

Item	Color
Valve handwheels and levers	Red
Hoist hooks and blocks	Yellow and black stripes
Steel guard posts	Yellow

B. Paint minimum 2-inches high numbers on or adjacent to accessible valves, pumps, flow meters, and other items of equipment that are identified on Drawings or in specifications by tag number.

PART 3 EXECUTION

3.01 EXAMINATION

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

3.02 PREPARATION AND COATING APPLICATIONS

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

B. Prepare all surfaces in accordance with product manufacturer's instructions.

3.03 PIPING IDENTIFICATION

A. Pipe, miscellaneous pipe fittings, and valve operators shall be coated as specified in the following.
   1. Pipe identification markers indicating piping service shall be provided for all exposed interior and exterior piping. Pipe markers shall be color coded with color field conforming to ANSI A13.1 latest edition for the pipe service listed on the Piping Schedule and Plans. Letter size spelling the service and length of color field shall conform with ANSI.
   2. Markers shall be manufactured of outdoor grade acrylic plastic with UV inhibitors. Markers shall be provided with integral flow directional arrows and shall give 360 degrees of visibility.
   3. Markers for pipes up to 6-inches outside diameter shall snap on and completely encircle the pipe. No tapes, banding, or adhesives shall be allowed. For pipes larger than 6-inches outside diameter, the markers shall be attached by stainless steel spring fasteners.
   4. Pipe markers shall be supplied at pipe origin and termination, on each side of all walls, above and below all floors and ceilings, at points of entering or leaving pipe or cable trays, at all valves and fittings, and at no greater than 25-foot intervals interior and 50-foot exterior between such markings.
   5. Where two or more pipes run parallel, markings shall be applied in the same relative location on each so as to be in vertical or horizontal linearity as the case may be and present a neat appearance. Where numerous fittings occur close together as in manifolds and around equipment, the above Specifications as to location of banding shall be modified as indicated by good judgment to prevent a cluttered appearance.
   6. Loose handles, wrenches, operating keys, etc. for valves shall be painted along with the valves.

7. In addition to the pipe markers, the following exposed piping shall be color coded in its entirety as listed below.

PIPE COLOR CODE CHART		
Pipe Contents	**Color of Bands**	**Color of Letters**
Drain (Equipment, Roof, Basin, Dewatering)	None	White
Drain (Septage Receiving)	Brown	Black
Raw Wastewater (RW)	Brown	Black
No. 2 Water	Red	White
No. 3 Water	Red	None

8. ANSI colors shall be in accordance with ANSI Z53.1, latest revision.

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

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

D. 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 PIPING COLOR CODE AND LETTERING SCHEDULE

A. Match existing within plant. Submit colors for approval by the ENGINEER.

3.05 SPECIAL COLOR AND PAINTING REQUIREMENTS

A. Items specified in the following shall be finish color coated as specified. ANSI colors shall conform with ANSI Z535.1, latest revision. Color coating shall be within the system specified for the equipment.
1. Red:
   a. Items listed in ANSI Z535.1, Section 6.1 shall be painted ANSI Safety Red. In general, these items shall include fire protection equipment and apparatus, danger signs and locations, and stop bars, buttons, or switches. In addition, all hose valves and riser pipes, fire protection piping and sprinkler systems, and electrical stop switches shall be painted ANSI Red.
2. Orange:
   a. Items listed in ANSI Z535.1, Section 6.2 shall be painted ANSI Safety Orange. ANSI Safety Orange shall be used as a basic color for designating dangerous parts of machines or energized equipment which may cut, crush, shock, or otherwise injure, and to emphasize such hazards when enclosure doors are open or when gear belt or other guards around moving equipment are open or removed, exposing

unguarded hazards. In addition, moving machinery having a linear or peripheral speed in excess of 10 feet per minute, which is either inadequately guarded due to physical problems or may be operated with the guard removed, rims of sprocket, gears, pulleys, etc.; crossheads of large engines and compressors; and flywheels shall be coated ANSI Orange.

3. Yellow:
   a. Items listed in ANSI Z535.1, Section 6.3 shall be painted ANSI Safety Yellow. Safety Yellow shall be the basic color for designating caution and for marking physical hazards such as striking against, stumbling, falling, tripping, and “caught-in-between”. In addition, an 8-inch wide strip on the top and bottom of tread stairways shall be coated.
4. Green:
   a. Items listed in ANSI Z535.1, Section 6.4 shall be painted ANSI Safety Green. Safety Green shall be the basic color for designating safety and the location of first-aid equipment. In general, gas masks, first-aid kits, eye wash facilities, and safety deluge showers shall be coated ANSI Safety Green.
5. Purple:
   a. Items listed in ANSI Z535.1, Section 6.6 shall be painted ANSI Safety Purple. In general atomic sludge density meters shall be coated ANSI Safety Purple.

3.06 ELECTRICAL CONDUIT AND VENT LINES

A. Paint electrical conduit to match adjacent ceiling or wall surfaces as directed. Paint vent lines to match surfaces they adjoin.

B. Identify electrical conduit as specified in Section 16075.

END OF SECTION

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SECTION 15082

PIPING INSULATION

PART 1 GENERAL

1.01 SUMMARY

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

1.02 REFERENCES

A. American Society for Testing and Materials (ASTM):
1. A 53 - Specification for Pipe, Steel, Black and Hot-dipped, Zinc-Coated, Welded and Seamless.
2. C 168 - Terminology Relating to Thermal Insulating Materials.
3. C 177 - Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded-Hot-Plate Apparatus.
4. C 335 - Test Method for Steady-state Heat Transfer Properties of Horizontal Pipe Insulation.
5. C 518 - Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus.
6. C 533 - Specification for Calcium Silicate Block and Pipe Thermal Insulation.
7. C 534 - Specification for Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form.
8. C 547 - Specification for Mineral Fiber Pipe Insulation.
9. C 552 - Specification for Cellular Glass Thermal Insulation.
10. C 585 - Practice for Inner and Outer Diameters of Rigid Thermal Insulation for Nominal Sizes of Pipe and Tubing (NPS System).
11. C 591 - Specification for Unfaced Preformed Rigid Cellular Polyisocyanurate Thermal Insulation.
12. C 795 - Specification for Thermal Insulation for Use in Contact with Austenitic Stainless Steel.
13. C 929 - Practice for Handling, Transporting, Shipping, Storage, Receiving and Application of Thermal Insulation Materials for Use in Contact with Austenitic Stainless Steel.
14. C 1136 - Specification for Flexible, Low Permeance Vapor Retarders for Thermal Insulation.
15. D 2310 - Classification of Machine-Made "Fiberglass" (Glass-Fiber-Reinforced-Thermosetting-Resin) Pipe.
16. E 84 - Test Method for Surface Burning Characteristics of Building Materials.
17. E 96 - 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 not concealed or buried.

D. Flame Spread and Smoke Density: Burning characteristics determined in accordance with ASTM E 84. No units apply to value.

E. K Factor: Thermal conductivity determined in accordance with ASTM C 177 or C 518 and expressed in units of Btu-inch/hour-feet^2- degrees Fahrenheit.

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

G. 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 per 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 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.

1.06 PROJECT CONDITIONS

A. As specified in Section 15050.

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:

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**
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

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 in tubular form.
   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 Fahrenheit to plus 220 degrees Fahrenheit.
   4. K Factor at 75 Degrees Fahrenheit: Not more than 0.27 BTU-in/hr-sq ft-degree Fahrenheit.
   5. Fire Ratings:
      a. Flame Spread: 25 or less.
      b. Smoke Density: 50 or less for insulation thicknesses up to 1.5 inches.
   6. Joints: Seal with 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. Conform to ASTM C 547, Class 1.

b. Provide with factory installed vapor barrier.
   1) Material: White kraft paper bound to aluminum foil meeting 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 Fahrenheit to plus 850 degrees Fahrenheit.
3. K Factor at 75 degrees Fahrenheit: Not more than 0.23 BTU-in/hr-sq ft-degree Fahrenheit.
4. Average Insulation Density: 3.3 pounds per cubic foot.
5. Maximum Moisture Absorption, Volume Percent: 0.2.
6. Manufacturers: One of the following or equal:
   a. Owens-Corning Fiberglas Corp., Fiberglas SSL-II.
   b. Johns Manville, Micro-Lok Fiber Glass Insulation.
   c. Knauf Fiber Glass, 1000° Pipe Insulation.

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: One-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, Thermazip TMZ300.

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: One-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 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.

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. Pipe Testing: Test piping as specified in Section 15052 or 15956 as applicable. Test before installing insulation except where pre-insulated pipe is used.

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

C. 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.

D. Butt longitudinal and circumferential insulation joints firmly together.

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

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

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

H. 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.

I. 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.

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

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

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

M. 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.

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

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

3.03 REPAIR

A. Restore existing insulation and surfaces disturbed or damaged by application of new pipe insulation.

3.04 INSULATION SCHEDULE

Service Designation[1]	Location[2]	Insulation Type[3]	Jacket Type[3]	Service Temp. °F[4]	Vapor Barrier
Potable Water (PW)	Exterior or Concealed	1 or 2	3	30-70	Install on Type 2 insulation
No. 3 Water (3W)	Exterior or Concealed	1 or 2	3	30-70	Install on Type 2 insulation
No. 2 Water (2W)	Exterior or Concealed	1 or 2	3	30-70	Install on Type 2 insulation
Raw Water (RW)	Exterior or Concealed	1 or 2	3	30-70	Install on Type 2 insulation
Heat Traced Pipes[6]	Exterior or Concealed	1 or 2	3	Use thickness established in Table in paragraph 2.01	Install on Type 2 insulation

Notes:

1. Refer to Piping Schedule in Section 15052 for service designations.
2. Insulation jackets are not required where indicated on the Drawings.
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 Paragraph 2.01A.
5. Insulate all piping systems that are specified to be heat traced.

END OF SECTION

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SECTION 15110

VALVES

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes: Basic requirements for valves.

1.02 REFERENCES

A. American National Standards Institute/American Society of Mechanical Engineers (ANSI/ ASME):
   1. B16.21 - Nonmetallic Flat Gaskets for Pipe Flanges.
   2. B16.34 - Valves - Flanged, Threaded, and Welding End.

B. American Society for Testing and Materials (ASTM):
   1. A 126 - Specification for Gray Iron Casting for Valves, Flanges, and Pipe Fittings.
   2. A 167 - Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip.
   3. A 536 - Specification for Ductile Iron Castings.
   4. E 527 - Practice for Numbering Metals and Alloys (UNS).

C. American National Standards Institute/American Water Works Association (ANSI/AWWA):
   1. C 111/A21.11 - Standard for Rubber-Gasket Joints for Ductile-Iron Pressure Pipe Fittings.

D. American Water Works Association (AWWA):
   1. C 504 - Standard for Rubber-Seated Butterfly Valves.

E. SSPC – Society for Protective Coatings:
   1. SSPC SP 2 - Surface Preparation Specification for Hand Tool Cleaning.
   2. SSPC SP7 - Brush-Off Blast Cleaning.
   3. SSPC SP10 - Surface Preparation Specification for 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 in accordance with Section 01330.

B. Submittals Prior to Installation:
   1. Product Data: Submit detailed technical information relating to the valve including description of component parts, materials of construction, performance, dimensions, and weights.

C. Operation and Maintenance Data:
   1. Furnish bound sets of installation, operation, and maintenance instructions for each type of valve 4-inch in nominal size and larger. 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: ASTM A 167, Type 316, UNS Alloy S31600 or S30400.

B. Valve, Gate, 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 C 111/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 minimums unless specified otherwise.

2.02 INTERIOR PROTECTIVE COATING

A. Provide valves with type of protective coating specified in the particular valve specification.

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

C. Coating 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 to meet SSPC SP-7 or SP-10, as recommended by epoxy manufacturer.
      c. Apply in accordance with manufacturer's published instructions.
      d. Coating Thickness: 0.010 to 0.012 inches except that:
         1) Coating Thickness in Grooves for Gaskets: 0.005 inches.
         2) Do not coat seat grooves in valves with bonded seat.
      e. Quality Control:
         1) Coating Thickness: Measured with a non-destructive magnetic type thickness gauge.
         2) Verify coating integrity with a wet sponge-testing unit operating at approximately 60 volts, or as recommended by the coating manufacturer.
         3) Consider tests successful when coating thickness meets specified requirements and when no pinholes are found.
         4) Correct defective coating disclosed by unsuccessful tests, and repeat test.
         5) Repair pinholes with liquid epoxy recommended by manufacturer of the epoxy used for coating.
   2. High Solids Epoxy:
      a. Product: As specified in Section 09960.
         1) Certified to NSF 61 for drinking water use.
      b. Clean surfaces to meet SP-7 or SP-10, or as recommended by coating manufacturer.
      c. Apply coating in accordance with Section 09960 and coating manufacturer’s recommendations.
      d. 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. Prior to installation, coat buried valves with 2 coats of protective coal tar in accordance with AWWA C 504.
   2. After installation, encase valves with 2 layers of polyethylene wrap as specified for ductile iron piping in Section 15251.
      a. Ascertain that polyethylene wrapping does not affect operation of valve.

2.04 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. Two-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.

2.05 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 and gates 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 finish 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: Required Information 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.
   3. Valves to be installed with appropriate fittings and coordinated with supports to facilitate removal.

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. Buried plug valves with geared operators shall be installed 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 finish 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 and 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.

3.03 MANUFACTURER'S FIELD SERVICES

A. Coordinate field service work with the manufacturer's representative, OWNER, and ENGINEER at least 14 calendar days prior to initiating such work.

B. Require manufacturer's representative to perform the following services as described below and as specified in Section 01756.
   1. Installation Inspection: One man-day.
      a. Check and verify that installation of the valves 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 Section 01756.

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.

1.02 REFERENCES

A. American Water Works Association (AWWA):
   1. C 507 - Standard for Ball Valves 6 Inch Through 48 Inch.

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.

1.04 SUBMITTALS

A. Submit as specified in Section 15110.

B. Certifications:
   1. Metal Body Ball Valves: Submit affidavit of compliance with AWWA C 507.

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.

B. General:
   1. Type: Non-lubricated 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. Flanges shall conform to ANSI/ASME B16.1 standards.
   3. Stem Packing: Manually adjustable while valve is under pressure.
   4. Shafts: Rigidly connected to the ball by a positive means. The connection shall be designed 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 bodies.
   3. Ball: Type 304 or 316 stainless steel.
   4. Seats: TFE.
   5. Stem Seals: TFE or Viton.
   6. Bearings: Self-lubricated, corrosion resistant material that will not contaminate potable water.

2.02 PLASTIC BODY BALL VALVES

A. Manufacturers: One of the following or equal:
   1. Asahi America.
   2. Chemtrol Division, NIBCO, 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.

C. Materials:
   1. Body: Polyvinyl chloride (PVC).
   2. Ball: Polyvinyl chloride (PVC).
   3. Seats: TFE (Teflon).
   4. O-rings: EPDM.

PART 3 EXECUTION

3.01 INSTALLATION

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

3.02 MANUFACTURER’S FIELD SERVICES

A. See section 15110.

END OF SECTION

SECTION 15116

PLUG VALVES

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes: Non-lubricated plug valves.

1.02 REFERENCES

A. American Society for Testing and Materials (ASTM):
   1. A 126 - Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings.

1.03 GENERAL REQUIREMENTS

A. Meet all requirements specified in Section 15110 and Section 13446.

B. In case of conflict between Section 15110 or Section 13446 and this Section, the requirements of this Section shall govern.

1.04 SUBMITTALS

A. Submit as specified in Section 15110.

B. Design Calculations:
   1. Submit calculations and design data substantiating conformance with the Drawings and Specifications.
   2. Calculations for torque required to open and close the valve including maximum torque at any point along valve travel, breakaway from seat, etc.

C. Quality assurance certifications per part 1.05 of this Section.

1.05 QUALITY ASSURANCE

A. The valve manufacturer shall have a minimum of 7-years experience in the manufacture of cylindrical eccentric plug valves for wastewater service. The manufacturer shall be ISO 9000 certified.

B. Submit information and certifications to verify quality assurance requirements.

PART 2 PRODUCTS

2.01 NON-LUBRICATED ECCENTRIC PLUG VALVES

A. Manufacturers: One of the following or equal:
   1. DeZurik, "PEC".

B. Design:
   1. Type: Non-lubricated eccentric type with rectangular port.
   2. Suitable for service under minimum working pressure of 150 pounds per square inch.
   3. Plug: One-piece construction.
   4. Plug Face: Resilient material which operates satisfactorily at a temperature of 180 degrees Fahrenheit continuous and 215 degrees Fahrenheit intermittent.
   5. Compression Washer: Provide flat compression washer made of Teflon, or of a material having equal physical characteristics on valve stem between plug and bonnet.
   6. Stem Seals: Provide v-ring stem seals serviceable and externally adjustable with the valve under rated pressure without unbolting the valve bonnet assembly.
   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 and at least 70 percent for valves 24 inches and greater.
   10. Valve and Gear actuators:
      a. Valve 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 have gasket seals on all units.
      d. Worm gear actuators shall be Limitorque Model HBC-4 Series or DeZurik G series, or equal.
      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 bearing. 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 of 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 line 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 shall be Type 316 stainless steel.

C. Materials:
   1. Body and Plug: ASTM A 126, Class B, cast-iron with plug face of neoprene, Buna N material suitable for the intended service as specified under paragraph 2.01 of this Section.
   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: Stainless steel Type 316.
   4. Internal Parts, Except the Body and Plug: Type 316 stainless steel, Monel, or nickel.
   5. Exposed Nuts, Bolts, and Washers: Type 316 stainless steel.

2.02 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 as follows:
      a. Gear sectors shall be one-piece construction made of ductile iron ASTM A536 Grade 80-55-06 with a tensile strength of 80,000 psi.
      b. Operator shaft and the gear quadrant shall be supported on bronze bearings. Operators shall clearly indicate valve position and an adjustable stop shall be provided to set closing torque. Operators shall be designed to hold the valve in any intermediate position without creeping or vibrating (self-locking gearing).
      c. Handwheel: Maximum 40 pounds pull at most adverse design condition.
      d. Actuator shall be isolated from service media and outside elements by metal encased spring loaded seals on the top and bottom of gear sector. There shall be a window between the valve and actuator to access packing adjustment without removing the actuator from the valve.
   3. Unless otherwise specified, size operators for the valve design working pressure and bidirectional valve service.
   4. Fit valves located more than 6 feet above operating level with chain operated valve wheels.
      a. Chains: Smooth welded link type made of galvanized steel; sufficient length to reach approximately 4 feet above the operating level.
      b. Where chains constitute a nuisance or hazard to operating personnel, provide hold-backs or other means for keeping the chains out of the way.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install valves in accordance with Section 15110 and the manufacturer’s instructions.

B. Install valves so that in the closed position the pressure in the pipeline applies a seating head on the valves.

C. Install valve so that valve stem is in horizontal position.

D. 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 exceeds 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.

3.02 SOURCE QUALITY CONTROL

A. Factory test all valves with the specified operator under specified conditions and pressure ratings.

3.03 MANUFACTURER'S 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 in a minimum of two separate trips as described below and as specified in Section 01756.
   1. Installation inspection: One 8-hour day onsite.
   2. Manufacturer's representative shall verify the installation of the plug valves is in accordance with the Drawings and the manufacturer's installation instructions.
   3. Manufacturer's representative shall certify the installation and complete forms in Section 01756.

END OF SECTION

SECTION 15117

SPECIALTY VALVES

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Backflow Preventers.
   2. Solenoid Valves.
   3. Corporation Stops.
   4. Curb Stops.
   5. Cocks.

1.02 REFERENCES

A. American Society for Testing and Materials (ASTM):
   1. A 126 - Specification for Gray Iron Casting for Valves, Flanges, and Pipe Fittings.
   2. A 276 - Specification for Stainless Steel and Heat-Resisting Steel Bars and Shapes.
   3. B 584 - Specification for Copper Alloy Sand Castings for General Application.
   4. D 2000 - Classification System for Rubber Products in Automotive Applications.

B. American Water Works Association (AWWA):
   1. C 511 - Reduced Pressure Principle Backflow Prevention Assembly.

C. National Electrical Manufacturers Association (NEMA).

1.03 SUBMITTALS

A. Furnish submittals as specified in Section 15110.

B. Submittals Prior to Installation:
   1. Product Data: Submit detailed technical information relating to each type of valve including description of component parts, materials of construction, performance, dimensions, and weights.

C. Operation and Maintenance Data:
   1. Furnish bound sets of installation, operation, and maintenance instructions for each type of valve. Include information on valve operators in operation and maintenance instruction manual.

1.04 QUALITY ASSURANCE

A. Manufacturer Qualifications: Manufactured by manufacturers whose valves have had successful operational experience in comparable service.

1.05 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 larger than 2 inch.
   3. Watts Regulator: Series 909.

B. Design: Reduced pressure chamber type in accordance with AWWA C 511.

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 SOLENOID VALVES

A. Two-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. Three-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. Four-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: Water.
      b. Temperature of Fluid: 50 to 85 degrees Fahrenheit.
      c. Piping Test Pressure: 100 pounds per square inch gauge.

2. Unless otherwise indicated on the Drawings, provide valves that:
   a. Have NEMA 4 enclosure.
   b. Are for 120 volt ac operation.
   c. Are suitable for use indicated on the Drawings.
   d. Have Class F molded coils.
3. 2-way Valves: Furnish with openings of size equal to or larger than the nominal size designation of the valve.
4. Furnish 2-way and 3-way valves with manual operator.

E. Materials:
   1. Body: Brass or bronze.
   2. Seats: Resilient material.

2.03 CORPORATION STOPS

A. Type: In accordance with AWWA C 800.
   1. Manufacturers: One of the following or equal:
      a. Ford.
      b. Mueller Company.

2.04 CURB STOPS

A. Manufacturers: One of the following or equal:
   1. Ford.
   2. Mueller Company.

B. Description: Round way solid tee head stops.

2.05 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, Section 13445, and 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.

END OF SECTION

SECTION 15120

PIPING SPECIALTIES

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes: Piping specialties including:
   1. Expansion joints.
   2. Pipe saddles.
   3. Tapping sleeves.
   4. Pressure gauges.

1.02 REFERENCES

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

B. American National Standards Institute/American Water Works Association (ANSI/AWWA):
   1. ANSI/AWWA C153/A21.53 - Ductile-Iron Compact Fittings.
   2. ANSI/AWWA C111/A21.11 - Rubber Gasket Joints for Ductile-Iron and Gray-Iron Pressure Pipe and Fittings.
   3. ANSI/AWWA C110/A21.10 - Ductile-Iron and Gray-Iron Fittings.
   4. ANSI/AWWA C213 - Fusion-Bonded Epoxy Coatings and Linings for Steel Water Pipelines.
   5. ANSI/AWWA C151/A21.51 - Ductile-Iron Pipe, Centrifugally Cast.

C. American Society for Testing and Materials (ASTM).
   1. ASTM A148 - Specification for Steel Castings, High-Strength, for Structural Purposes.
   2. ASTM A536 - Specification for Ductile Iron Castings.

D. Society of Automotive Engineers (SAE).

1.03 SUBMITTALS

A. Submit in accordance with Section 01330.

B. 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 ball type flexible expansion joint used on the project.
   3. Manufacturer's published installation instructions.
   4. Operation and maintenance manuals.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Expansion Joints and Vibration Control Joints:
   1. Protect joints against damage during packing, shipping, 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 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 Pipesupport 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 ANSI flanges, or plain suitable for welding connections, as required for piping in which installed.

B. Split Sleeve Couplings:
   1. Manufacturers:
      a. Brico Industries, Inc., Style FxE Type 2 or equal.
   2. Material:
      a. Housing: 304 L stainless steel.
      b. Gasket: Viton® or other elastomer suitable for air service up to 300 degrees Fahrenheit.
      c. Bolts: 316 stainless steel.
      d. End Rings: 304 L stainless steel.
   3. Design:
      a. Housing: Two-piece split-sleeve coupling with a double arch cross section. Provide a Teflon® shoulder at the expansion end of the coupling to allow smooth expansion of the pipe.
      b. Axial expansion allowance: 2 inches, minimum.

c. End Rings: Fix two end rings to one section of the pipe being joined to keep the coupling in the proper location.
d. Coupling Spacing: As indicated on the Drawings

2.02 PIPE SADDLES

A. Manufacturers: One of the following or equal:
1. BTR Inc./Smith-Blair, Inc., Style 317.
2. Romac Industries, Inc., Style 202S.

B. Materials:
1. Pipe Saddles: Ductile iron.
2. Straps, Bolts, and Nuts: Type 304 stainless steel with Teflon coating on nuts.
3. Gaskets: Rubber.

2.03 TAPPING SLEEVES

A. Manufacturers: One of the following or equal:
1. BTR Inc./Smith-Blair, Inc., Style 622.
2. Romac Industries, Inc., Style FTS 420.

B. Materials:
1. Tapping Sleeves:
   a. Ductile iron construction.
   b. Considered an integral part of a tapping sleeve and valve assembly with openings the same as the valve.
   c. Extra heavy-duty construction to provide resistance to line pressure (90 psi).
   d. Constructed in two halves for assembly around main to be tapped.
   e. Outlet Branch: Flanged, Class 125, ANSI B16.1, for bolting to tapping valve. Size as indicated on the Drawings. Inside diameter sufficiently larger than nominal size to provide clearance for full size cutters of tapping machine.
   f. Castings Wall: Extra heavy and reinforced for extra strength.
   g. Rated for 200 psi working pressure.
2. Bolts and Nuts: Type 304 stainless steel.
3. Nuts: Teflon coated.
4. Gaskets: Rubber.
5. Tapping Valves:
   a. Type: Gate valve as specified in Section 15115.
   b. Seat Rings: Bronze. Sufficient size to permit use of full size cutters of specified manufacturer tapping machines. Inside diameter at least 3/16-inch larger than nominal size of valve. Minimum seating surface area equal to that of standard gate valve.
   c. Ends: One end flanged to fit tapping sleeve and the other hub-end or mechanical joint.
   d. Discs: Proportionately larger to match seat ring minimum seating surface area as specified in (b) above.

2.04 PRESSURE GAUGES

A. Design:
   1. Provide dual-range, liquid-filled gauges with ranges as indicated on the Drawings.
   2. Size: As follows, unless otherwise indicated on the Drawings or specified:
      a. For 1-Inch Pipe and Larger: 4-1/2 inch diameter.
      b. For Smaller than 1-Inch Pipe: 2-1/2 inch diameter.
   3. Provide gauges with back flanged aluminum cases with threaded ring, except for panel mounting, in which case provide gauge with front flanged aluminum case with threaded ring. Apply black epoxy coating to cases.
   4. Provide case fitted with a rupture disc which shall relieve out the back of the case.
   5. Window: Shatterproof glass or high temperature acrylic.
   6. Provide gauges with Type 316 stainless steel socket and bellows or bourdon tube, depending on pressure range.
      a. Where the maximum pressure is less than or equal to 15 pounds per square inch the gauge shall use bellows as the measuring element.
      b. Where the maximum pressure is greater than 15 pounds per square inch, the measuring element shall be a bourdon tube.
   7. Socket Tips:
      a. Socket Tips for Bellows and Bourdon Tube: Type 316 Stainless steel.
      b. Size: 1/2 inch for 4-1/2 inch diameter gauges, 1/4 inch for 2-1/2 inch diameter gauges.
   8. Mount gauges on diaphragm seals where indicated on the Drawings.
      a. Provide diaphragm seals with Type 316 stainless steel top housing, bottom housing, and bolt assemblies.
         1) Bottom housing shall be fitted with a 1/4-inch flushing connection.
         2) This flushing connection shall be fitted with a Type 316 stainless steel close nipple and a brass shutoff cock.
         3) Diaphragm Seal: Removable.
            a) For pressure less than or equal to 15 pounds per square inch, provide Viton diaphragm seal.
            b) For pressures greater than 15 pounds per square inch, provide Type 316 stainless steel diaphragm seal.
      b. For Ferric Chloride service, provide diaphragm seals with Teflon diaphragm and PVC housing.
      c. Fit diaphragm seal gauge assembly with a snubber.
         1) Snubber shall have porous metal disc sized to dampen pressure fluctuations in the filled system.
         2) Snubber: Stainless steel.
         3) Snubber filter disc shall be sized to prevent the gauge from pulsating.
      d. Provide diaphragm seal gauge assemblies filled with silicon.
   9. Pressure gauges, except gauges with diaphragm seals, shall have pulsation dampeners installed between the gauge and the shut-off valve.
      a. Pulsation Dampeners: Stainless steel.

B. Manufacturers:
   1. Pressure Gauges: One of the following or equal:
      a. U.S. Gauge Division of Ametek, Inc., Solfrunt Gauges, Figure Number 1931T.
      b. Dresser Industries, Inc., Ashcroft Figure Number 1379.

2. Pressure Gauges for Digester Gas Systems: One of the following or equal:
   a. Dresser Industries, Inc., Ashcroft, Figure 1179 compound gauge.
3. Diaphragm Seal: One of the following or equal:
   a. For pressure less than or equal to 15 pounds per square inch:
      1) Ashcroft, Type 301.
      2) Mansfield and Green, Type LG.
   b. For pressures greater than 15 pounds per square inch:
      1) Ashcroft, Type 101.
      2) Mansfield and Green, Type RG.
4. Snubber: One of the following or equal:
   a. Chemiquip, Ashcroft.
5. Pulsation Dampeners: One of the following or equal:
   a. Dresser Industries, Inc., Ashcroft Figure Number 1106S.
   b. Operation and Maintenance Specialties, Charlotte, N.C., Ray Pressure Snubbers.

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 one 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. Pipe Saddles:
   1. Coat threads on bolts with anti-gall coating prior to installation.

C. Tapping Sleeves:
   1. Coat threads on bolts with anti-gall coating prior to installation.

D. Pressure gauges:
   1. Install pressure and compound gauges as indicated on the Drawings and as specified.
   2. Install gauges as recommended by the manufacturer’s published instructions.

3.02 FIELD QUALITY CONTROL

A. Testing: Field test gauges with a calibrated test gauge, in the presence of ENGINEER.

END OF SECTION

SECTION 15121

FLEXIBLE COUPLINGS

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes: Flexible couplings, flanged coupling adapters.

1.02 REFERENCES

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

B. American Society for Testing and Materials (ASTM):
   1. A 36 - Specification for Structural Steel.
   2. A 53 - Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless.
   3. A 325 - Specification for High-Strength Bolts for Structural Steel Joints.

C. Society of Automotive Engineers (SAE).

1.03 SUBMITTALS

A. Submit in accordance with Section 01330.

B. Shop drawings detailing dimensions and materials.

C. Piping Layout Drawings: Coordinate preparation of required piping layout drawings such that coupling center sleeve sizes are clearly identified on drawings.

D. Manufacturer's published installation instructions.

PART 2 PRODUCTS

2.01 PIPE COUPLINGS IN 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 C 111.
   2) Buried and Submerged: 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: Polyurethane lined and coated per Section 09960.

B. Flexible Couplings:
1. Manufacturers: One of the following or equal:
   a. Dresser Industries, Style 153.
   b. Romac Industries, Inc., Style 501.
   c. Smith-Blair, Inc., Series 441.
2. Materials:
   a. Center Sleeve: Ductile iron, ASTM A536.
   b. Follower Flanges: Ductile iron, ASTM A536.
   c. Bolts and Hex Nuts:
      1) Aboveground: High strength, low alloy steel.
      2) Buried and Underwater: Type 316 stainless steel.
3. Coating and Lining: Provide product with shop-applied primer, which is compatible with finish coating to be applied in the field.
4. Center Sleeve Dimensions: Provide center sleeves with lengths in accordance with following table:

Nominal Pipe Size, Inches	**Buried Condition**	**Aboveground Condition**
3 inch and smaller	Manufacturer's standard	Manufacturer's standard
4 inch to 8 inch, inclusive	7 inches	5 inches
10 inch to 14 inch, inclusive	12 inches	6 inches
Greater than 16 inch	Use steel flexible coupling per Paragraph 2.02	Use steel flexible coupling per Paragraph 2.02

C. Flanged Coupling Adapters, 12-inch size and smaller:
1. Manufacturers: One of the following or equal:
   a. Dresser Industries, Style 127.
   b. Romac Industries, Inc., Style FCA501.
   c. Smith-Blair, Inc., Series 912.

2. Materials:
   a. Flanged Body: Ductile iron, ASTM A126 or ASTM A536.
   b. Follower Ring: Ductile iron, ASTM A536.
   c. Bolts and Hex Nuts:
      1) Aboveground: High strength, low alloy steel.
      2) Buried and Underwater: Type 316 stainless steel bolts.
3. Flange Design: In accordance with AWWA Class D with ANSI 150 pound drilling.
4. Coating and Lining: Provide product with shop-applied primer which is compatible with finish coating to be applied in the field.

D. Flanged Coupling Adapters, greater than 12-inch size:
1. Manufacturers: One of the following or equal:
   a. Dresser Industries, Style 128-W.
   b. Romac Industries, Inc., Style FC400.
   c. Smith-Blair, Inc., Series 913.
2. Materials:
   a. Flange and Flanged Body: Steel, ASTM A53 or ASTM A512.
   b. Follower Ring: Rolled steel.
   c. Bolts and Hex Nuts:
      1) Aboveground: High strength, low alloy steel.
      2) Buried and Underwater: Type 316 stainless steel bolts.
3. Flange Design: In accordance with AWWA Class D with ANSI 150 pound drilling.
4. Coating and Lining: Provide product with shop-applied primer that is compatible with finish coating to be applied in the field.

2.02 PIPE COUPLINGS IN STEEL PIPING

A. Flexible Couplings:
1. Manufacturers: One of the following or equal:
   a. Dresser Industries, 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 steel.
   b. Bolts and Hex Nuts:
      1) Aboveground: High strength, low alloy steel.
      2) Buried and Underwater: Type 316 stainless steel bolts.
3. Coating and Lining:
   a. Buried Installations and Underwater:
      1) When ductile iron coupling components are provided, provide product with shop-applied primer, which is compatible with finish coating to be applied in the field.
      2) When steel coupling components are provided, line and coat sleeve and flanges with fusion-bonded epoxy in accordance with AWWA C213. Epoxy coating shall be a minimum 0.012 inches thickness.
   b. Aboveground Installations: Provide product with shop-applied primer which is compatible with finish coating to be applied in the field.

4. Center Sleeve Dimensions: Provide center sleeves with lengths in accordance with following table:

Nominal Pipe Size, Inches	Buried Condition	Aboveground Condition
2-1/2 inch and smaller	Manufacturer's standard	Manufacturer's standard
3 inch to 6 inch, inclusive	7 inches	4 inches
8 inch to 14 inch, inclusive	7 inches	5 inches
Greater than 14"	10 inches	7 inches

B. Flanged Coupling Adapters:
   1. Manufacturers: One of the following or equal:
      a. Dresser Industries, 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: Steel, ASTM A53 or ASTM A512.
      b. Follower Ring: Rolled steel.
      c. Bolts and Hex Nuts:
         1) Aboveground: High strength, low alloy steel.
         2) Buried and Underwater: Type 316 stainless steel bolts.
   3. Flange Design: In accordance with AWWA Class D with ANSI 150 pound drilling.
   4. Coating and Lining: Provide product with shop-applied primer that is compatible with finish coating to be applied in the field.

2.03 SPLIT-SLEEVE TYPE COUPLING

A. General: As an alternate for flexible couplings or where shown on the Drawings, provide split-sleeve type couplings. Where thrust restraint is required or where shown on the Drawings, provide end rings for attachment to the pipe.

B. Construction: Couplings selected shall be designed for the type, size, and working pressure of the pipe with which they are to be used.
   1. Couplings are bolted, split-sleeve type and consist of these basic components:
      a. One or two-piece housing.
      b. Gasket assembly
      c. Bolts, nuts, and end rings required for pipe restraint.
   2. Coupling shall be manufactured from ASTM A 36 Carbon Steel. The coupling shall be of a double arch cross section, which closes around pipe ends (with steel end rings for thrust restraint as required). As the coupling closes, it confines the elastomeric gasket beneath the arches of the sleeve to create the radial seal. The axial seal is affected at the closure plates as the bolts pull the coupling snug around the pipe. The coupling shall permit a degree of angular pipe deflection, flexibility, contraction, and expansion (limited by the thrust rings when required). Couplings shall be epoxy-coated on the inner diameter and outer diameter prior to delivery. Buried couplings shall receive additional

protection against corrosion that matches the pipe as given in Section 09960. Bolts and nuts shall conform to the requirements of Section 05500.

C. Pipe Preparation: Pipe ends shall be smooth for expansion or contraction requirements. Where thrust restraint is required or shown on the Drawings, pipe ends shall include end rings affixed for pipe end restraint requirements. The coupling manufacturer will provide end rings that are to be welded to the pipe per the manufacturer's requirements in lieu of other types of M-11 restraint systems. Follow coupling manufacturer's recommendation for size and amount of welding required to attach the end rings to the pipe.

D. Gaskets: The sealing members are comprised of two "O" ring gaskets and an elastomeric sealing pad bonded to the integral sealing plate. Internal pressure is not required to affect the seal. For water service, the gasket supplied may be Isoprene or Buna-N conforming to ASTM D-2000 for the design pressure within the temperature range of minus 20 to 180 degrees Fahrenheit. Elastomers shall have properties as designated by ASTM D-2000.

E. Restrained Joint: When required for thrust restraint or as shown on the Drawings, end rings shall be furnished with the couplings and shall be of the same material as the coupling housings. The coupling shall provide a fully restrained pipe joint. One end ring is welded to each of the pipe ends (as required). The ring fits beneath the coupling and is protected by the coupling. All pipe restraint shall be within the coupling house, requiring no external thrust restraint components.

F. Manufacturer: The following or equal:
   1. Victaulic Company of America, DEPEND-O-LOK.

2.04 FLEXIBLE COUPLINGS FOR FIBERLGASS REINFORCED MORTAR PIPE (FRMP)

A. All flexible couplings for FRMP shall be provided by the FRMP supplier.

B. Unless indicated otherwise on the Drawings, flexible couplings shall be double gasketed type and constructed of fiberglass reinforced polymer mortar resin in accordance with Section 15269.

2.05 TRANSITION COUPLINGS

A. Application: Use transition couplings with function and design similar to flexible couplings and flanged coupling adapters for connecting piping having different outside diameters.

B. Provide and install transition-coupling products specifically designed and manufactured for that application and suitable for the upstream and downstream outside pipe diameters.

C. All hardware shall be Type 316 stainless steel for buried, submerged, and buried vault service.

D. Manufacturer: The following or equal:
   1. JCM Industries, Inc.
   2. Romac Industries, Inc.

2.06 GASKETS FOR FLEXIBLE COUPLINGS AND FLANGED COUPLING ADAPTERS

A. Provide gasket materials for process piping applications as follows:
   1. Low Pressure and High Pressure Air, Steam, Hot Water: EPDM.
   2. All Other Process Piping Applications: Neoprene rubber or Buna-N.

2.07 EXTERIOR COATINGS - UNDERGROUND AND SUBMERSED APPLICATIONS

A. Manufacturers: One of the following or equal:
   1. Tapecoat Company, Inc., T.C. Mastic.
   2. Kop-Coat Company, Inc., Bitumastic Number 50.
   3. Thickness: Minimum 0.040 inch.

PART 3 EXECUTION

3.01 INSTALLATION

A. In underground and underwater installations, coat the coupling exterior after installation with a protective coating.

B. Install pipe couplings with gap between pipe ends in accordance with the following table. Install flexible coupling with pipe gap located in middle of center sleeve. Install flanged coupling adapter with end of plain end pipe in middle of flanged coupling body. Maximum gap tolerance shall be plus or minus 1/8 inch.

Center Ring Length	Gap Dimension and Tolerance
4 inch through 6 inch	3/8 inch plus or minus 1/8 inch
7 inch	5/8 inch plus or minus 1/8 inch
10 inch and greater	7/8 inch plus or minus 1/4 inch.

C. Provide joint harnesses for flexible couplings unless otherwise indicated on the Drawings with a written note.
   1. Design joint harnesses on steel and stainless steel piping for the test pressures specified with the Piping Schedule in Section 15052.
   2. Joint harnesses may be eliminated if alternative coupling design using “fixed x expansion” or “fixed x fixed” configurations are utilized.

END OF SECTION

SECTION 15142

DISINFECTION OF DOMESTIC WATER LINES

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes: Disinfection of water lines, bacteriological testing, and flushing of lines at completion of treatment.

1.02 REFERENCES

A. American Water Works Association(AWWA):
   1. AWWA C 651 - Standard for Disinfecting Water Mains.

B. American Public Health Association/American Waterworks Association/Water Environment Federation (APHA/AWWA/WEF):
   1. Standard Methods for Examination of Water and Wastewater.

1.03 SUBMITTALS

A. Submit Disinfection Test Plan Which Details Procedure to be Utilized to Disinfect Water Lines Including:
   1. Method and locations of disinfectant application.
   2. Locations of sampling points.
   3. Method of flushing and location of flushing ports.
   4. Method of dechlorination.
   5. Disposal location for dechlorinated water.

B. Submit Disinfection Reports and Include the Following:
   1. Date issued.
   2. Project name and location.
   3. Treatment subcontractor's name, address, and phone number.
   4. Type and form of disinfectant used.
   5. Time and date of disinfectant injection start.
   6. Time and date of disinfectant injection completion.
   7. Test locations.
   8. Initial and 24 hour disinfectant residuals in parts per million for each outlet tested.
   9. Time and date of flushing start.
   10. Time and date of flushing completion.
   11. Disinfectant residual after flushing in parts per million for each outlet tested.

C. Submit Bacteriological Reports and Include the Following:
   1. Date issued.
   2. Project name and location.
   3. Laboratory's name, certification number, address, and phone number.
   4. Time and date of water sample collection.
   5. Name of person collecting samples.
   6. Test locations.

7. Time and date of laboratory test start.
8. Coliform bacteria test results for each outlet tested.
9. Certification that water conforms or fails to conform to bacterial standards of Federal Safe Drinking Water Act.
10. Bacteriologist's signature and bacteriological laboratory's evidence of certification.

1.04 QUALITY ASSURANCE

A. Bacteriological Laboratory: Certified by state in which Project is located.

1.05 PRODUCT DELIVERY, STORAGE, AND HANDLING

A. Protect against damage and contamination.

B. Maintain caution labels on hazardous materials.

C. Maintain storage room dry and with temperatures as uniform as possible between 60 degrees Fahrenheit and 80 degrees Fahrenheit.

1.06 PROTECTION

A. Provide necessary signs, barricades, and notices to prevent persons from accidentally consuming water or disturbing system being treated.

PART 2 PRODUCTS

2.01 MATERIALS

A. Disinfectant: Free chlorine in liquid, powder, tablet, or gas form.

PART 3 EXECUTION

3.01 CLEANING WATER LINES

A. Prior to chlorination, remove by flushing or other means, soil, and debris from the water lines.

3.02 INSPECTION

A. Verify that water line system is completed and cleaned.

B. Start disinfection of water lines when conditions are satisfactory.

3.03 SYSTEM TREATMENT

A. Perform disinfection of water lines in accordance with AWWA C 651 and as specified in this Section.

B. Starting at outlet closest to water source, bleed water from each outlet until water produces odor of disinfectant. Repeat process at each outlet throughout system.

C. Test for disinfectant residual at each of following locations and other locations in accordance with submitted disinfection test plan:
   1. Ends of piping runs.
   2. Remote outlets.
   3. Tanks.
   4. At least 2 outlets on each building floor where directed.

D. Maintain disinfectant in system for 24 hours.

E. When disinfectant residual is less than 25 parts per million after 24 hours, repeat system treatment.

3.04 FLUSHING

A. Remove disinfectant from water lines.

B. Flush water lines with potable water containing no more disinfectant residual than the active distribution system or 1.0 parts per million, whichever is greater.

C. Continue flushing until water at designated flushing ports contains disinfectant residual equal to concentration specified above.

3.05 DISPOSAL OF CHLORINATED WATER

A. Dispose of chlorinated water in accordance with the submitted disinfection test plan and applicable requirements of federal, state, county, and city having jurisdiction over disposal of hazardous wastes in location of the Project and disposal site.

3.06 BACTERIOLOGICAL TEST

A. Instruct bacteriological laboratory to take water samples no sooner than 24 hours after flushing system.

B. At the end of 24 hours and before the water main is placed in service, collect bacteriological quality samples at each of following locations and other locations in accordance with the submitted disinfection test plan and Standard Methods for the Examination of Water and Wastewater:
   1. Where water enters system.
   2. Ends of piping runs.
   3. Remote outlets.
   4. Tanks.
   5. At least 2 outlets on each building floor.

C. Analyze water samples in accordance with Standard Methods for Examination of Water and Wastewater.

D. When bacteriological test proves water quality to be unacceptable, repeat disinfection treatment.

END OF SECTION

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SECTION 15251

DUCTILE IRON PIPING

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes: Ductile iron piping, joints, fittings, gaskets, and pipe lining and coating.

1.02 REFERENCES

A. American National Standards Institute/American Society of Mechanical Engineers (ANSI/ASME):
   1. B 16.1 - Cast Iron Pipe Flanges and Flanged Fittings.

B. American Society for Testing and Materials (ASTM):
   1. A 47 - Specifications for Ferritic Malleable Iron Castings.
   2. A 183 - Specifications for Carbon Steel Tank Bolts and Nuts.
   3. A 283 - Specifications for Low and Intermediate Tensile Strength Carbon Steel Plates.
   4. A 536 - Ductile Iron Castings.
   5. A 674 - Practice for Polyethylene Encasement for Ductile Iron Pipe for Water or Other Liquids.
   6. D 792 - Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement.

C. American Water Works Association (AWWA):
   1. C 104 - Cement-Mortar Lining for Ductile-Iron Pipe and Fittings for Water.
   2. C 105 - Polyethylene Encasement for Ductile-Iron Pipe Systems.
   3. C 110 - Ductile-Iron and Gray-Iron Fittings, 3 Inches Through 48 Inches, for Water and Other Liquids.
   4. C 111 - Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings.
   5. C 115 - Flanged Ductile-Iron Pipe with Ductile-Iron or Gray-Iron Threaded Flanges.
   6. C 150 - Thickness Design of Ductile-Iron Pipe.
   7. C 151 - Ductile-Iron Pipe, Centrifugally Cast, for Water or Other Liquids.
   8. C 153 - Ductile-Iron Compact Fittings, 3 Inches Through 24 Inches, and 54 Inches Through 64 Inches, for Water Service.
   9. C 600 - Installation of Ductile-Iron Water Mains and Their Appurtenances.
   10. C 606 - Grooved and Shouldered Joints.

D. American Welding Society (AWS):
   1. D11.2 - Guide for Welding Iron Castings.

E. Ductile Iron Pipe Research Association (DIPRA):
   1. Thrust Restraint Design Manual.

F. NACE International, The Corrosion Society (NACE):
   1. RP0188-99 - 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. Steel Structures Painting Council (SSPC):
   1. PA-2 - Measurement of Dry Coating Thickness With Magnetic Gauges.

1.03 SUBMITTALS

A. 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: Layouts and supporting calculations for restrained joint thrust restraint systems.

B. Pipe Design Calculations:
   1. Calculations for required wall thickness in accordance with AWWA C 150.
   2. Calculations for thrust restraint system design.

C. Product Data: Photographs, drawings, and descriptions of fittings, gaskets, couplings, grooving of pipe and fittings, pipe linings, and coatings.

D. Test Reports:
   1. Manufacturer's test reports for polyurethane lining certifying successful performance of the wet sponge spark tests.
   2. Manufacturer’s test results for glass lined pipe certifying compliance with specified material requirements for glass lining.

E. Certificates: Submit certified documentation of holiday detection testing results with all glass lined pipe shipments. 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. Acceptance criteria shall be as specified under Field Quality Control.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Block piping material for shipment, prevent damage to castings and linings.

B. Carefully handle piping material during loading, unloading, and installation. Do not drop piping material from cars or trucks. Lower piping material by mechanical means. Do not drop or pound pipe to fit grade.

C. Polyurethane lined pipe and fittings must be handled only from the outside. No forks, chains, straps, hooks, or other lifting device shall be placed inside the pipe or fittings for lifting, positioning, or laying.

D. Repair damaged cement mortar lining to match quality, thickness, and bonding of original lining in accordance with AWWA C 104. When lining cannot be repaired or repairs are defective, replace defective piping with undamaged piping.

E. Protect gaskets and polyethylene encasement from long term exposure to sunlight.

F. Store fittings and other accessories such that they do not accumulate and hold rainwater, dirt, and debris.

1.05 QUALITY ASSURANCE

A. Qualifications of Lining Manufacturers: For piping specified to receive glass lining or polyurethane lining use only a manufacturer having a minimum of 5 years experience supplying this type of product to the wastewater and water treatment industry.

B. Welding 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.

C. Regulatory Requirements: Install work of this Section in accordance with local, state, and federal regulations.

1.06 THRUST RESTRAINT SYSTEM DESIGN

A. Assume responsibility for the restrained joint thrust restraint system design.

B. 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 latest version of the Ductile Iron Pipe Research Association (DIPRA) Thrust Restraint Design Manual and the following additional criteria:
   1. Design Pressure: Test pressure scheduled in Section 15052 or 100 pounds per square inch, whichever is greater.
   2. Laying Condition: Type 3 as defined by AWWA C150.
   3. Soil Type: Silt 1 as defined by DIPRA.
   4. Unit Friction Resistance: Based upon polyethylene encasement of pipe.
   5. Safety Factor: 1.5 (for thrust restraint calculations only).

PART 2 PRODUCTS

2.01 MATERIALS

A. Ductile Iron Piping:
   1. Type, Typical: AWWA C 150 and AWWA C 151 with minimum pressure class wall thickness that meets project pressure and structural requirements, unless otherwise specified or indicated on the Drawings.
   2. Type with Screw-on Flanges: AWWA C 115 with minimum special thickness Class 53 wall thickness that meets project pressure and structural requirements, unless otherwise specified in Section 15052.
   3. Laying Condition: Type 3 as defined by AWWA C 150.

B. Joints:
   1. Flanged Joints:
      a. Flanges, Screw-on: Comply with the diameter, thickness, drilling, and other characteristics in accordance with ANSI B 16.1. 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 ANSI/ASME B 16.1 except when connecting flanges underground, in concrete pipe valve boxes, or underwater, use Type 316 stainless steel. Cut and finish bolts to project a maximum of 1/4 inch beyond nut when joints are assembled.
      e. Gaskets: As specified in Section 15052.
   2. Mechanical Joints: In accordance with AWWA C 111/ANSI A 21.11 with Type 316 stainless steel hardware.
   3. Restrained Mechanical Joints:
      a. Design: Integral retainer weldment type or lugged type joint with Type 316 stainless steel rods and nuts. Restrained mechanical joints of the configuration which utilizes a gripping or friction force for restraint are not acceptable.
      b. Manufacturers: One of the following or equal:
         1) Pacific States Cast Iron Pipe Company, Lock Mechanical Joint.
         2) American Cast Iron Pipe Company, MJ Coupled Joint.
   4. Push-on Rubber Gasket Joints: AWWA C 111/ANSI A 21.11.
   5. Restrained Push-on Joints:
      a. Design:
         1) Restrained push-on joints of the configuration that utilizes a gripping or friction force for restraint are not acceptable.
         2) Suitable for 350 pounds per square inch gauge (psig) as well as test pressures scheduled in Section 15052.
      b. 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.
      c. Angular deflection: shall be limited to half the manufacturer's published allowable for buried joints.
   6. Grooved Joints: AWWA C 606, 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 with Type 316 stainless steel hardware where submerged or buried.
      c. Gaskets: Capable of being applied on surface of piping with cavities to provide for an improved seal with the internal piping pressure; material for following services:
         1) For Liquid Service: Halogenated butyl.

d. Fittings: AWWA C 606, rigid radius-cut groove.
   1) Center-to-center Dimensions: AWWA C 110/ANSI A 21.10.
   2) Wall Thickness and Other Characteristics: AWWA C 153.
e. Flanged Unit Connections: Flanged to grooved joint adapters or a long enough spool with 1 end flanged and the other grooved to prevent interference with the operation of adjacent valves, pumps, or other items.

2.02 FITTINGS

A. Fittings: Ductile iron conforming with AWWA C 110/ANSI A 21.10 or AWWA C 153/ANSI A 21.53.

B. Joint Type: Same as that of the associated piping as specified in Section 15052.

C. Plain end-to-flanged joint connectors using set screws are not acceptable.

2.03 PIPE LININGS AND COATINGS

A. Pipe linings and coatings: Provide linings and coatings as follows.
   1. Ceramic Epoxy lining:
      a. Protecto 401.
      b. Minimum lining thickness: 40 mils or as recommended by manufacturer.
   2. Asphaltic base coating:
      a. Apply over cement mortar linings and to outside surface of pipes that will not receive another coating.
      b. Apply in accordance with AWWA C151.

B. Coat the exterior of all exposed piping with the high solids epoxy and polyurethane coating system per Section 09960.

2.04 POLYETHYLENE ENCASEMENT

A. Provide 2 layers of linear low-density polyethylene (LLDPE) film for all buried service.

B. Polyethylene Encasement Sheets or Tubes:
   1. 8 mil thickness low density polyethylene, or
   2. 4-mil thickness high density, cross laminated polyethylene in accordance with AWWA C105.

PART 3 EXECUTION

3.01 INSTALLATION

A. General:
   1. Install ductile iron piping in accordance with AWWA C 600, modified as specified in Section 15052.
   2. Lay mechanical joint or bell and spigot pipe with 1/8-inch space between the spigot and shoulder of the pockets.
   3. Trenching, backfill, compaction and related earthwork shall be per Sections 02300 and 02318.

B. Polyethylene Encasement:
   1. Wrap all ductile iron pipe to be buried with polyethylene encasement in accordance with ASTM A 674 and AWWA C 105.
   2. Repair tears and make joints with two layers of plastic tape.

3.02 JOINTS

A. Install types of joints as specified in piping schedule in Section 15052.

3.03 GROOVED JOINTS

A. Install piping with grooved joints where specified 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. Install at least 1 support between consecutive couplings.

D. Grooved joints may be installed where flanged joints are scheduled, except under the following conditions:
   1. In underground and underwater installations.
   2. In piping subject to test pressure of 150 pounds per square inch gauge or more.
   3. In steam and in combustible gas piping systems.
   4. In sludge and scum piping designed to be steam cleaned as indicated on the Drawings.
   5. When wall thickness of pipe is less than the minimum recommended in published instructions by the manufacturer of the grooved end coupling.

E. Make connections to flanged valves, pumps and piping appurtenances by either:
   1. Flanged-to-grooved joint adapters.
   2. Flanged-by-grooved end pipe spool of sufficient length to prevent interference with the operation of adjacent valves, pumps or other items.
   3. Integrally cast flanged-by-grooved end pipe fittings.

3.04 FIELD QUALITY CONTROL

A. Test ductile iron piping as specified in Section 15052.
   1. Do not test sections longer than 1/2 mile in total pipe length.

B. Verify that interior surfaces of polyurethane lined pipe and fittings have continuous coverage. Repair or discard piping found to have exposed the metal substrate in accordance with manufacturer’s instructions.

END OF SECTION

SECTION 15254

CAST-IRON SOIL PIPING

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes: Cast-iron soil piping and acid resistant cast-iron soil piping.

1.02 REFERENCES

A. American Society for Testing and Materials (ASTM):
   1. A 74 - 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 - Specification for Rubber Gaskets 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 conforming to ASTM A 74.
   2. Make joints by using positive double seal compression type gaskets conforming to ASTM C 564.

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.

C. Acid resistant cast-iron piping: Manufacturers: On of the following or equal:
   1. The Duriron Company, Inc., Dayton, Ohio.
   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.
   2. Paint exposed pipe in accordance with Section 09960.

PART 3 EXECUTION

3.01 INSTALLATION

A. Cast-Iron Soil Piping:
   1. Encase in concrete underground cast-iron soil piping under structures.
   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 15255

STAINLESS STEEL PIPING AND TUBING

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes: Stainless steel piping and tubing, and alloy steel pipe.

1.02 REFERENCES

A. American National Standards Institute/American Society of Mechanical Engineers (ANSI/ASME):
   1. B16.9 Factory Made Wrought Steel Butt Welding Fittings.

B. American Society for Testing and Materials (ASTM):
   1. A 269 - Specification for Seamless and Welded Austenitic Stainless Steel Tubing for General Service.
   2. A 312 - Specification for Seamless and Welded Austenitic Stainless Steel Pipes.
   3. A 778 - Specification for Welded, Unannealed, Austenitic Stainless Steel Tubular Products.

1.03 SUBMITTALS

A. Submit in accordance with Section 01330.

B. Shop Drawings: Details of fittings and specials showing thickness and dimensions of plates, detail of welds, and materials; listing of proposed services and locations of valves, flanged joints, expansion couplings, fixed and guide supports, and tabulated layout schedules.

C. Product Data: Details of fittings and specials showing thickness and dimensions of plates, detail of welds, and materials; flanged joints, gaskets, couplings and supports.

1.04 QUALITY CONTROL

A. Qualifications:
   1. Perform welding of structural metals with welders who have current American Welding Society certificate for the type of welding to be performed. Welding shall comply with AWS D 10.4 - Recommended Practices for Welding Austenitic Chromium-Nickel Stainless Steel Piping and Tubing.
   2. Notify ENGINEER 24 hours minimum before starting shop or field welding.
   3. An independent laboratory provided by CONTRACTOR shall perform testing on all welds and shall check materials, equipment, and qualifications of welders.
   4. Remove welders performing unsatisfactory work, or require to requalify.

5. Independent laboratory shall use gamma ray, magnetic particle, dye penetrant, trepanning, or other aids to visual inspection to examine any part of welds or all welds.
6. CONTRACTOR shall bear costs of initial testing and retesting of defective welds.
7. CONTRACTOR shall also bear costs in connection with qualifying welders.

PART 2 PRODUCTS

2.01 MATERIALS

A. Stainless Steel Piping (10 psig internal operations pressure):
   1. General:
      a. Stainless steel piping 30 inches and smaller in nominal pipe size, for low-pressure applications (at or below 50 psig), minimum wall thickness corresponding to Schedule 10S.
   2. Pipe sizes specified in the Specifications and indicated on the Drawings are nominal.
   3. Supply piping 12 inches and less in diameter in 10-foot and 20-foot lengths without intermediate butt-welds.
   4. Make joints with stub ends and backing flanges, welded or flanged as indicated on the Drawings.

B. Design:
   1. Piping: Suitable for a maximum internal pressure of 80 pounds per square inch gauge, and a maximum temperature of 400 degrees Fahrenheit.

C. Materials:
   1. Low Pressure Stainless Steel Piping, (at or below 50 psig): ASTM A 778, Type 316L stainless steel.
   2. High Pressure Stainless Steel Piping, (above 50 psig): ASTM A 312, Type 316L stainless steel.
   3. Piping Stub Ends: Nonporous cast Type 316L stainless steel:
      a. Manufacturers: One of the following or equal:
         1) Alaskan Copper Works, Figure SK38P.
      b. Machine gasket and wetted surfaces of stub ends free of crevices, pits, cracks, and protrusions.
   4. Backing Flanges: Cast or forged stainless steel with stainless steel bolt sets.
   5. Flexible Couplings: Type 316 stainless steel middle ring:
      a. Manufacturers: One of the following or equal:
         1) Dresser, Style 38.
         2) Baker Industries, Style 201.

D. Fabrication:
   1. General:
      a. Provide stainless steel fabrications free from pits, cracks, crevices, oxidation, weld splatter, stains, and discoloration.
         1) Surfaces: Clean and of uniform appearance.

2. Pipe:
   a. Pipe 12 Inches and Larger in Diameter: Automatically welded using gas tungsten-arc procedures.
   b. Piping 4 Inches Through 12 Inches in Diameter: Double butt-welded.
   c. Piping less than 4 Inches in Diameter: Single butt-welded.
3. Fittings:
   a. Welded with Type 316L filler metal.
   b. Fitting Dimensions: In accordance with ANSI B 16.9.
   c. Elbows 24 Inches and Smaller in Diameter: Die formed and automatically welded, using gas tungsten-arc procedures with inert gas backing.
   d. Tees, Crosses, True Ys, and Laterals: Nozzle welded, using manual shielded metal arc procedures and double welds.
   e. Reducers: Cone type.
   f. Where not otherwise indicated on the Drawings, terminate spools with stub ends, and determine face-to-face dimensions by pipe fabricator.
4. Welding:
   a. Welding: Field welding is not allowed. Provide factory welding as needed per Section 05120.
   b. Ensure that weld seams have full penetration and be free of oxidation, crevices, pits, cracks, and protrusions.
      1) Weld seams without undercuts.
      2) Provide weld crowns of 1/16 inch with tolerance of plus 1/16 inch and minus 1/32 inch.
   c. Accomplish longitudinal welds on fittings, except elbows by the same procedures as for pipe.
   d. Manually Weld Pipe Spools with Type 316L Filler Metal:
      1) Where internal weld seams are not accessible, use gas tungsten-arc procedures with internal gas purge.
      2) Where internal weld seams are accessible, weld seams inside and outside using manual shielded metal-arc procedures.
5. Following fabrication, pickle and passivate pipe, spools, fittings, and other shop fabricated pieces by immersion in sulfuric acid solution followed by immersion in a nitric-hydrofluoric bath and subsequent wash at the proper temperature and length of time to remove free iron, weld scale, and other impurities, and to obtain a passive finished surface.

2.02 STAINLESS STEEL TUBING

A. General:
   1. Provide stainless steel tubing in sizes indicated on the Drawings.
      a. Where not indicated on the Drawings, provide stainless steel tubing of the size required to perform the function intended.
      b. Minimum Size of Stainless Steel Tubing: 1/4-inch outside diameter.

B. Tubing:
   1. Stainless Steel Tubing: Seamless tubing made of Type 316L stainless steel and conforming to ASTM A 269.
      a. Wall thickness adequate for test pressure specified on the Piping Schedule in Section 15052, but not less than 0.065 inch or Schedule 10S thicknesses.

C. Fittings:
   1. Fittings for Use with Stainless Steel Tubing: Swage ferrule design, with components made of Type 316 stainless steel.
      a. Fittings: Double acting ferrule design, providing both a primary seal and a secondary bearing force.
      b. Flare, bite, or compression type fittings are not acceptable.
   2. Manufacturers: One of the following or equal:
      a. Crawford Fitting Company, Swagelok.
      b. Hoke, Gyrolok.
      c. Parker, CPI.

D. Valves:
   1. Valves for Use with Stainless Steel Tubing: Air cocks of Type 316 stainless steel.

2.03 ALLOY STEEL PIPE

A. Alloy Steel Pipe and Fittings for Use on Condensate Return Piping:
   1. Manufacturers: One of the following or equal:
      a. U.S. Steel, Cor-Ten.
      b. Youngstown Sheet and Tube, Yoloy.

2.04 SOURCE QUALITY CONTROL

A. Test piping by air method only. Use test pressure of 15 pounds per square inch gauge.

B. Visually inspect pipe for welding defects such as crevices, pits, cracks, protrusions, and oxidation deposits.

C. Examine 3 percent of the welds by X-ray methods.
   1. For each weld found to be defective by X-ray methods, examine 3 additional welds using the same method.
   2. Provide interpretation of X-ray pictures by an independent testing laboratory acceptable to ENGINEER, and submit written report of the findings issued by the laboratory.

PART 3 EXECUTION

3.01 INSTALLATION

A. Provide stainless steel piping with flanges at valves, tees, droplegs, and safety equipment locations.

B. Provide stainless steel tubing for control and instrument air piping and for other applications indicated on the Drawings.

3.02 FIELD QUALITY CONTROL

A. Test piping by air method only. Use test pressure specified in Section 15052.

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.

END OF SECTION

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SECTION 15265

PLASTIC PIPING AND TUBING

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes: Plastic pipe, tubing, and fittings.

1.02 REFERENCES

A. American National Standards Institute (ANSI):
   1. ANSI B 16.12 - Cast Iron Threaded Screwed Drainage Fittings.

B. American Society for Testing and Materials (ASTM):
   1. D 648 - Test Method for Deflection Temperature of Plastics Under Flexural Load.
   2. D 1248 - Specification for Polyethylene Plastics Molding and Extrusion Materials.
   3. D 1784 - Specification for Rigid Poly (Vinyl Chloride) (PVC) Compounds and Chlorinated Poly (Vinyl Chloride) (CPVC) Compounds.
   4. D 1785 - Specification for Poly (Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80 and 120.
   5. D 1869 - Specification for Rubber Rings for Asbestos-Cement Pipe.
   6. D 2321 - Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity-Flow Applications.
   7. D 2412 - Test Method for Determination of External Loading Characteristics of Plastic Pipe by Parallel-Plate Loading.
   8. D 2466 - Specification for Poly (Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 40.
   9. D 2467 - Specification for Socket-Type Poly (Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80.
   10. D 2513 - Specification for Thermoplastic Gas Pressure Pipe, Tubing, and Fittings.
   11. D 2564 - Specification for Solvent Cements for Poly (Vinyl Chloride) (PVC) Plastic Piping Systems.
   12. D 2661 - Specification for Acrylonitrile-Butadiene-Styrene (ABS) Schedule 40 Plastic Drain, Waste, and Vent Pipe and Fittings.
   13. D 2665 - Specification for Poly (Vinyl Chloride) (PVC) Plastic Drain, Waste, and Vent Pipe and Fittings.
   14. D 2680 - Specification for Acrylonitrile-Butadiene-Styrene (ABS) and Poly (Vinyl Chloride) (PVC) Composite Sewer Piping.
   15. D 2751 - Standard Specification for Acrylonitrile-Butadiene-Styrene (ABS) Sewer Pipe and Fittings.
   16. D 2855 - Standard Practice for Making Solvent-cemented Joints with Poly (Vinyl Chloride) (PVC) Pipe and Fittings.
   17. D 3034 - Specification for Type PSM Poly (Vinyl Chloride) (PVC) Sewer Pipe and Fittings.

18. D 3212 - Specification for Joints for Drain and Sewer Plastic Pipes Using Flexible Elastomeric Seals.
19. D 3350 - Specification for Polyethylene Plastic Pipes and Fittings Materials.
20. D 4101 - Specification for Propylene Plastic Injection and Extrusion Materials.
21. F 439 - Specification for Socket-Type Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 80.
22. F 441 - Specification for Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe, Schedules 40 and 80.
23. F 477 - Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe.
24. F 483 - Test Method for Total Immersion Corrosion Test for Aircraft Maintenance Chemicals.
25. F 493 - Specification for Solvent Cements for Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe and Fittings.
26. F 645 - Guide for Selection, Design and Installation of Thermoplastic Water Pressure Piping Systems.
27. F 679 - Specification for Poly (Vinyl Chloride) (PVC) Large-Diameter Plastic Gravity Sewer Pipe and Fittings.
28. F 714 - Specification for Polyethylene (PE) Plastic Pipe (SDR-PR) Based on Outside Diameter.

C. American Water Works Association (AWWA):
   1. C 900 - Polyvinyl/Chloride (PVC) Pressure Pipe, 4 Inches Through 12 Inches, for Water Distribution.

D. Code of Federal Regulations:
   1. Title 49 - Transportation.

E. Plastics Pipe Institute (PPI).
   1. TR 31 - Underground Installation of Polyolefin Piping.

F. United States Department of Transportation:
   1. Materials Transportation Bureau.

1.03 ABBREVIATIONS

A. ABS: Acrylonitrile-Butadiene-Styrene.

B. CPVC: Chlorinated Polyvinyl Chloride.

C. DWV: Drain, Waste, and Vent.

D. ID: Inside Diameter of piping or tubing.

E. NPS: Nominal pipe size followed by the size designation.

F. NS: Nominal size of piping or tubing.

G. PE: Polyethylene.

H. PP: Polypropylene.

I. PVC: Polyvinyl Chloride.

J. SDR: Standard Dimension Ratio; the Outside Diameter divided by the pipe wall thickness.

1.04 SUBMITTALS

A. Submit in accordance with Section 01330.

B. Product Data: Describe PVC materials, pipe, fittings, gaskets, and solvent cement.

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: Requirements of 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. Plastic Pipe in Potable Water Applications: Provide pipe and tubing bearing NSF seal.

B. Mark plastic pipe with nominal size, type, class, schedule or pressure rating, manufacturer and all markings required by applicable 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.

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 rubber gasket.

2.02 PVC PIPING, SCHEDULE TYPE

A. Materials:
   1. PVC Schedule Type Piping: Designation PVC 1120 conforming to ASTM D 1785 and appendices thereto.
      a. Pipe and Fittings: Extruded from Type I, Grade 1, Class 12454-B material in accordance with ASTM D 1784.
      b. PVC Schedule Type Piping: Schedule 80 unless otherwise indicated 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. For CPVC or PVC pipe in sodium hypochlorite service, provide IPS Corp Type 724 cement or another cement certified by the manufacturer for high strength hypochlorite service.

2.03 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 herein.
      b. Fittings: Supplied by the pipe manufacturer.
   2. PVC Compounds: Class Number 12454-C, as specified in 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 as specified in 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: Neoprene, EPDM, or Viton as suitable for the application and conforming to 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.

2.04 POLYETHYLENE PIPING FOR DRAIN, WASTE, AND VENT PIPING SYSTEMS

A. General:
   1. Pipe and Fittings: High-density polyethylene.
   2. Dimensions of Pipe and Fittings: Based on controlled outside diameter in accordance with ASTM F 714.
      a. SDR: Maximum of 11.

B. Manufacturers: One of the following or equal:
   1. DuPont, Sclairpipe.
   2. Polaris, Duratuff; or equal.

C. Pipe, Fittings, and Adapters: Furnished by the same manufacturer, and compatible with components in the same system and with components of other systems to which connected.

D. Materials:
   1. Polyethylene: In accordance with ASTM D 1248, Type III, Class C, Category 5, Grade P34; listed by the Plastic Pipe Institute under the designation PE 3408; and have a minimum cell classification, in accordance with ASTM D 3350, of 345434C.
   2. Pipe and Fittings: Manufactured from material with the same cell classification.

2.05 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.

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 sodium hypochlorite 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 Gravity Sewer Piping.
   1. Install piping in accordance with manufacturer's published instructions, as modified and complemented herein.
   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.

D. Installation of PE Piping for Drain, Waste, and Vent:
   1. Install piping as recommended in manufacturer's published instructions.

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. Mandrel Tests for PVC Gravity Sewer 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 one 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, and 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.

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SECTION 15268

MISCELLANEOUS PIPING, TUBING, AND HOSE

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes: Hose.

1.02 SUBMITTALS

A. Product Data: Manufacturer's data indicating service type, sizes, materials, and required accessories.

PART 2 PRODUCTS

2.01 HOSE

A. Hose Material: Neoprene or EPDM for a working pressure of minimum 125 pounds per square inch, gauge.

B. Size as indicated on the Drawings fit ends with appropriate combination clamped nipples and threaded ends as indicated on the Drawings.

C. Hose Larger than 1-1/2 Inches in Size: Industrial fire hose.
   1. Manufacturers: One of the following or equal:
      a. Goodyear Rubber Products Corp.
      b. Uniroyal, Inc.
      c. Goodall Rubber Company.

D. Hose 1/2 Inch Through 1-1/2 Inch Nominal Diameter: General purpose hose.
   1. Manufacturers: One of the following or equal:
      a. Goodyear Rubber Products Corp.
      b. Uniroyal.
      c. Goodall Rubber Company.

E. Equip and fit hose ends with appropriate combination clamped nipples and threaded ends to make up the assembly indicated on the Drawings.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install hose in accordance with manufacturer's published instructions.

END OF SECTION

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SECTION 15269

FIBERGLASS REINFORCED MORTAR PIPE

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes: Fiberglass Reinforced Mortar Pipe (FRMP) and fittings.

1.02 REFERENCES

A. American Society for Testing and Materials (ASTM):
   1. D 2412 - Standard Test Method for Determination of External Loading Characteristics of plastic Pipe in Deflected Conditions.
   2. D 3262 - Standard Specification for Reinforced Plastic Mortar Sewer Pipe.
   3. D 3681 - Standard Test Method for Determining Chemical Resistance of Reinforced Thermosetting Resin Pipe in Deflected Condition.
   4. D 4161 - Standard Specification for Fiberglass (Glass-Fiber-Reinforced) Thermosetting Resin Pipe Joints Using Flexible Elastomeric Seals.
   5. F 477 - Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe.

B. American Water Works Association (AWWA):
   1. M 45 - Fiberglass Pipe Design.

1.03 SYSTEM DESCRIPTION

A. Design Requirements: Determine pipe characteristics required for adequate pipe wall strength and wall thickness needed to support the anticipated loads before, during, and after installation. The pipe must be designed for construction and service loads including pipe jacking loads where applicable.

B. All FRMP shall be supplied by the same manufacturer.

1.04 SUBMITTALS

A. Submittals shall be made in accordance with Section 01330. Provide sufficient detail to allow the ENGINEER to judge whether the proposed equipment, materials, and procedures meet the Contract requirements. All drawings shall be legible and dimensions accurately shown and clearly marked in English. Drawings and photographs transmitted by a facsimile will not be accepted. The ENGINEER's review of submitted details and data will be based on consideration for requirements for the completed work, protection for utilities and surface features, and the possibility of unnecessary delays in the execution of the work to be constructed under this Contract.

B. Shop Drawings: The CONTRACTOR shall furnish shop drawings illustrating the details of the FRMP, joint details, and miscellaneous items to be furnished and fabricated for the pipe. Dimensions, tolerances, wall thickness, properties and strengths, and other pertinent information shall be shown.

C. Calculations: Calculations shall be submitted in a neat, legible format. Assumptions used in calculations shall be consistent with information provided and applicable standards. All calculations shall be prepared, stamped, and signed by a licensed professional civil engineer.
   1. Submit calculations confirming that pipe capacity is adequate to safely support all other anticipated loads, including earth and groundwater pressures, surcharge loads, and handling loads.

D. Manufacturer's Procedures: The CONTRACTOR shall submit written descriptions of the procedures and specifications used in the manufacturing of FRMP, as specified herein.

1.05 QUALITY ASSURANCE

A. The CONTRACTOR shall furnish all labor necessary to assist the ENGINEER in inspecting pipe upon delivery. CONTRACTOR shall remove rejected pipe immediately.

B. If any part of the FRMP becomes chipped, gouged, or otherwise damaged before or during installation, it shall be rejected and removed from the site, or repaired, using methods and materials approved by the ENGINEER, in writing, at no additional cost to the OWNER. The decision to repair or replace the damaged pipe shall be at the sole discretion of the ENGINEER.

C. The ENGINEER shall be entitled to inspect pipes or witness the pipe manufacturing. The manufacturer shall provide the ENGINEER written notice of pipe and fitting manufacture dates 14 days before manufacture commences.

D. Warranty:
   1. The CONTRACTOR shall warrant and shall obtain from the manufacturer its warranty that the FRMP conforms to these specifications and will be free from defects in materials and workmanship for a period of one (1) year from the date of Substantial Completion of this Contract. Said manufacturer's warranty shall be in a form acceptable to, and for the benefit of, the OWNER, and shall be submitted by the CONTRACTOR as a condition of final payment. The CONTRACTOR shall repair or replace, at the sole option of, and at no cost to the OWNER, any work found to be defective within said warranty period. Such repair or replacement shall include the cost of removal and reinstallation, inspection, and acceptance testing.
   2. The CONTRACTOR shall also warrant to the OWNER that the materials used on this Contract, where covered by patents or license agreements, are furnished in accordance with such agreements and that the prices included herein cover all applicable royalties and fees in accordance with such license agreements. The CONTRACTOR shall defend, indemnify, and hold the OWNER harmless from and against any and all costs, loss, damage, or expense arising out of, or in any way connected, with any claim or infringement or patent, trademark, or violation of license agreement.

PART 2 PRODUCTS

2.01 MATERIALS

A. Resins: The manufacturer shall use only approved polyester or vinyl ester resin systems with a proven history of performance of in this particular application. The historical data shall have been acquired from a composite material of similar construction and composition as the proposed product.

B. Reinforcement Glass: The reinforcing glass fibers to be used to manufacture the components shall be of the highest quality commercial grade of “E” glass reinforcements or “ECR” glass filaments suitably treated with binder and sizing compatible with impregnating resins.

C. Sand: Sand shall be minimum 98 percent silica with a maximum moisture content of 0.2 percent.

D. Additives: Resin additives, such as curing agents, pigments, dyes, fillers, thixortophic agents, etc., when used, shall not detrimentally effect the performance of the product. If used they shall not visibly impair the inspection of the products.

E. Liner: The internal liner shall be suitable for service in a raw domestic sewage and industrial wastewater, and shall be highly resistant to exposure to sulfuric acid as produced by biological activity from hydrogen sulfide gases. Pipe shall meet or exceed requirements off ASTM D 3681.

2.02 FRMP PIPING

A. Manufacturers: one of the following or equal:
   1. HOBAS as manufactured by HOBAS Pipe, USA.
   2. Ameron International.
   3. Future Pipe.

B. Pipe: The pipe shall be manufactured using the method outlined below.
   1. The pipe shall be manufactured with one of the following alternative processes:
      a. By the centrifugal casting process.
      b. By the reciprocal filament winding process.
   2. The use of stiffening or reinforcing ribs is not permitted.

C. Stiffness Class: All pipe shall be a minimum pipe stiffness of 72 psi unless higher stiffness class is required for the installation, or indicated on the drawings.

D. Dimensions:
   1. Diameter:
      a. Pipes 18 through 48 inches in diameter shall be in accordance with ASTM D3262.
      b. Pipes that are larger than 48 inches shall be in accordance with the Manufacturers standard dimensions.
   2. Lengths: Laying lengths shall be supplied in nominal lengths of 10 feet, 20 feet, or 40 feet. Shorter lengths will only be allowed for specials or closure pieces unless otherwise shown on the drawings.

3. End Squareness: Pipe ends shall be square to the pipe axis within a maximum tolerance of 1/8 inch.

E. Joints:
1. The pipe shall field connected with fiberglass sleeve couplings or integral bell and spigots that utilize built-inelastomeric gaskets as the sole means to maintain joint water tightness.
2. The internal gasket arrangement shall be capable of preventing any infiltration or exfiltration through the wall pipe at the specified test conditions.
3. The joints must meet the performance requirements of ASTM D4161.
4. Joints for trenchless pipe shall be flush type with the same outside diameter as the barrel of the pipe.

F. Wall Pipes:
1. Wall pipes shall be designed, manufactured, and supplied by the pipe manufacturer.
2. The wall pipe shall be capable of maintaining true round shape to allow proper connection and fit to the connecting pipe.
3. The internal gasket arrangement shall be capable of preventing any infiltration or exfiltration through the wall pipe at the specified test conditions.
4. The wall pipe shall be designed, manufactured, and supplied with an integral seep ring to prevent water from entering and passing around the outside of the wall pipe.
5. Wall pipes shall have a flush bell end to accept the connecting pipe.
6. Wall pipes shall be of the required length to be flush on both faces of the wall through which they pass unless shown otherwise on the drawings.

G. Fittings:
1. Fittings include Base Tee Manholes, Bends, Tees, Outlets, Reducers, and similar appurtences.
2. Fittings shall be capable of withstanding all of the external loadings.
3. Fittings shall be capable of withstanding all of the internal loading and testing conditions.
4. Fittings may be molded or manufactured from mitered sections of pipe joined by glass fiber reinforced overlays.
5. Fabricated outlets on base tee manholes shall be provided as indicated on the drawings.
6. Tolerance: The tolerance of the angle of a bend or wye shall be within 1 degree. The tolerance on the laying length of a fitting shall be within 1 inch.
7. Closure Pieces: Shop fabricate and field cut as needed the minimum number of closure pieces required to complete the project.
8. Tee base manholes shall be designed and constructed at the horizontal angles, slope, and the inlet and outlet piping configurations and sizes shown in the drawings.
9. Pipe plugs shall be designed to withstand the internal test pressure and external loads. Provide plugs with hooks or other external appurtenances to allow for the easy removal of the plug in the future. Holes through the plugs are not acceptable. Where required, pipe plugs shall be held in place using thrust blocks installed per applicable typical detail(s).

H. Gaskets:
   1. Supply from pipe manufacturer approved gasket manufacturer in accordance with ASTM F477, and suitable for service intended. The pipe manufacturer shall be responsible for the quality of the gasket furnished.
   2. The gaskets shall be shipped with the pipe with proper instructions for installation.
   3. Gaskets to be designed, manufactured, and installed in such a manner so as to prevent gasket from being displaced out of position during pipe installation.
   4. Gaskets must be capable of withstanding the internal operating and test conditions.
   5. Gaskets shall be EPDM.

2.03 SOURCE QUALITY CONTROL

A. Pipe: The pipe shall be manufactured and tested in accordance with applicable standard ASTM D3262.

B. Joints: The joints shall meet the requirements of ASTM D4161.

C. Stiffness: The minimum pipe stiffness when tested in accordance with ASTM D2412 shall be 72 psi unless stiffer pipe is required for the installation.

2.04 OWNERS OBSERVATION AND TEST WITNESSING DURING MANUFACTURING

A. Owners Observe: The OWNER or OWNER's authorized representative shall have the right to inspect the manufacturing and testing of pipes, and fittings at the factory.

B. Notice: The Manufacturers shall provide the OWNER with a minimum of 14 day advance notice of when each size and type of pipe and fitting is scheduled to be manufactured.

C. Failure to Observe: The OWNER is not obligated to inspect the manufacturing or testing of pipes and fittings. If the OWNER does not observe the manufacturing or testing of pipes and fittings, it in no way implies approval of the products or test results.

PART 3 EXECUTION

3.01 DELIVERY, STORAGE, AND HANDLING

A. The Manufacturer shall package products for shipment in a manner suitable for safe transport by commercial carrier. When delivered, a receiving inspection shall be performed, and any shipping damage shall be reported to the manufacturer within 7 days. Damaged pipe shall be promptly removed from the job site.

B. Protect piping materials at the job site from scratching, scoring, distortion, and other construction and environmental damages.

C. Store and handle FRMP and fittings as recommended by the Manufacturer in published instructions.

3.02 INSTALLATION

A. Manufacturers Services:
   1. The Manufacturer shall provide a factory trained filed service representative to be present at the beginning of the project to aid the CONTRACTOR in the installation process. The trained field service representative shall be available to the CONTRACTOR and OWNER on an as needed basis.

B. Pipe Handing:
   1. Handle the pipe and fittings using textile slings or other method recommended by the pipe manufacturer. Use of chains or other equipment that may damage the surface or impair the pipe in any way shall not be permitted.

C. Installation:
   1. General: Install pipe in accordance with Section 15052 and the following.
   2. Curves: Make long radius curves by deflecting the joints of straight pipe. Deflections shall be limited to 3/4 of the manufacturers published maximum allowable deflection criteria for the size of the pipe being installed.
   3. Bends: Make bends using manufactured fittings.
   4. Closures: Make closures by using fabricated specials.
   5. Jointing:
      a. Clean ends of pipe and coupling sleeve.
      b. Check ends of pipe and couplings for damage.
      c. Apply joint lubricant approved by both the manufacturer of the pipe and gaskets to the pipe ends, coupling and gaskets.
      d. Use manufactured approved equipment such as a wire rope puller to pull pipe joints together.
      e. Do not exceed the forces recommended in the pipe manufactures written literature for jointing pipe and fittings.
   6. If the pipe is field cut or the interior lining disturbed, recoat the damaged area with resin approved by the pipe Manufacturer, with similar qualities as the original liner resin.

3.03 FIELD QUALITY CONTROL

A. Testing shall be as specified in Sections 15956 and 01450.

END OF SECTION

SECTION 15270

GALVANIZED STEEL PIPE

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.

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.

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. 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.

C. Mill certificates.

D. 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 specified in Section 15052 pipe schedule.
         2) Minimum Schedule unless otherwise specified in Section 15052 pipe schedule.
            a) Pipe 6 inches and smaller: Schedule 40.
            b) Pipe greater than 6 inch to 12 inch: Schedule 20.
            c) Pipe greater than 12-inch: 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.

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. Pipe joints:
   1. General:
      a. Use type of pipe joints as specified in Section 15052 pipe schedule.
      b. In addition to the type of pipe joints 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 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 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 Section15052.
   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.
      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.
      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 bevelled ends and no backing rings.

D. Pipe lining and coating:
1. General:
a. Lining and coating shall be 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 Section09960.
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:
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. 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 finsh 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**.**
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 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

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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 15052 – Basic Piping Materials and Methods.

1.02 REFERENCES

A. American Society of Mechanical Engineers (ASME).

B. ASTM International (ASTM).

C. Carson City Adopted Codes:
   1. 2006 International Building Code (IBC)
   2. 2006 Uniform Plumbing Code (UPC)
   3. 2006 Uniform Mechanical Code (UMC)

D. National Electrical Manufacturers Association (NEMA).

E. Plumbing and Drainage Institute (PDI):
   1. PDI-WH 201 - Water Hammer Arresters Standard.

1.03 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.

1.04 SUBMITTALS

A. Manufacturer's published recommendations for sizing and locating the unit.

B. Design and construction details of the unit.

1.05 QUALITY ASSURANCE

A. Regulatory requirements: Perform work under this Section in accordance with the City's plumbing code specified herein, 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 specified plumbing code or laws or regulations, the Code and the laws or regulations take precedence over the specified provisions and design.

PART 2 PRODUCTS

2.01 MATERIALS

A. 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.

B. Plumbing piping accessories:
   1. Cleanouts:
      a. 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, 56040-5.
            b) Zurn Industries, Inc., Z-1400-HD.
      b. Floor cleanouts (FCO) 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.
            (3) Other floor drains with no-hub outlet and nickel bronze Type B strainer:
               (a) Strainer:
               (b) Josam Company, 30000-A universal floor drain with adjustable strainer, less clamping collar.
               (c) 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, 33580.
            (2) Zurn Industries, Inc., Z-610.
4. Freezeless Yard Hydrants:
   a. For all hydrants located outdoors, provide freezeless type, complete, including galvanized steel casing, galvanized steel operating rod and graphite packing.
   b. Provide hose rack and warning sign as indicated on the Drawings.
   c. Manufacturers: One of the following or equal:
      1) IOWA ® Model Y-1.

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.

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.

3.03 FIELD QUALITY CONTROL

A. Testing:
1. Test soil, waste, drain, and vent lines as specified and in accordance with plumbing code specified herein .
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 15772

HEAT TRACING SYSTEM

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes: A complete heat tracing system for freeze prevention of exposed piping including:
   1. Heating Cables.
   2. Control Panels.
   3. Temperature Sensors.
   4. Temperature Controllers.
   5. Contactors.
   6. Enclosures.
   7. All other auxiliary equipment and controls required to complete a heat tracing system.

1.02 REFERENCES

A. American National Standards Institute (ANSI).

B. American Society of Testing and Materials (ASTM):
   1. B 193 Section 5 - Resistivity of Electrical Conductor Materials.
   2. D 2633 - Standard Test Methods for Thermoplastic Insulations and Jackets For Wire And Cable.

C. Electrical Power Research Institute (EPRI):
   1. EPRI NL 1558.

D. Factory Mutual Research Corp., (FM).

E. Institute of Electrical and Electronic Engineers (IEEE):
   1. IEEE P515 - Testing, Design, Installation, and Maintenance of Electrical Resistance Heat Tracing For Industrial Applications.
   2. IEEE 622 - Design & Installation of Electric Heat Tracing SY.

F. International Electro-Mechanical Commission (IEC).

G. National Electrical Manufacturers' Association (NEMA):
   1. 1CS1-110.

H. National Fire Protection Association (NFPA):
   1. NFPA 70 - National Electric Code (NEC).

I. Occupational Safety and Health Standards (OSHA).

J. Underwriters' Laboratories, Inc. (UL):
   1. UL 746B - Polymeric Materials - Long Term Property Evaluations.

1.03 SYSTEM DESCRIPTION

A. Design Requirements:
   1. Self-regulating heating cable shall vary its heat output relative to the temperature of the surface of the pipe or the tank allowing cable to be crossed over itself without overheating and to be cut to length in the field.
   2. Design for a useful life of 20 years or more with "power on" continuously. The criteria for life shall be to retain at least 75 percent of its original power when tested according to UL 746B.
   3. Pipe shall be insulated per Specification Section 15082 to maintain an operating temperature of 75 degrees F for a minimum ambient temperature of minus 20 degrees Fahrenheit.
   4. Provide power-connecting kits with junction boxes, end seal kits, fittings kits, electric traced labels, aluminum tapes, and line sensing thermostats or suitable electronic controllers. CONTRACTOR shall determine the quantities for the above components and the sizes of the breakers for this particular application as required and recommended per manufacturer, subject to ENGINEER acceptance, for complete operable system at no additional cost to the OWNER.

1.04 SUBMITTALS

A. Product Data:
   1. Catalog number, wattage output, voltage rating, and product data.
   2. Installation Instructions.
   3. Warranty.

B. Shop Drawings: Include isometric drawings for each heat traced pipe showing installation details, and size and type of heat tracing cable.

1.05 QUALITY ASSURANCE

A. Regulatory Requirements and Reference Standards: The electric heat tracing system shall conform to this specification and shall be designed, manufactured and tested in accordance with the minimum applicable requirements of the latest edition of the referenced codes and standards.

1.06 WARRANTY

A. Cables: All cables shall be warranted for a period of 10 years for manufacturing defects.

PART 2 PRODUCTS

2.01 HEAT TRACING CABLE

A. Manufacturers: One of the following or equal:
   1. Raychem BTX or BTU depending upon electrical classification of installation.
   2. Chromalox Type HSRL or SRL, depending upon electrical classification of installation.

B. Type: Self-regulating and self-limiting, 8 watts per foot, 208 volts, 60 hertz, flexible twin 14 AWG copper bus wires, with tinned copper braid overshield; suitable for use in electrical classification of installation location.

2.02 CONTROLLER

A. Manufacturer: One of the following or equal:
   1. Raychem Model 910.
   2. Chromalox model HTLS1D2.

B. Operating Characteristics:
   1. Controller shall provide continuous monitoring of heat tracing circuit-analyzing temperature through a hard-wired RTD.
      a. RTD: Three-wire platinum Resistance Temperature Detector.
   2. Controller shall energize system automatically if the temperature drops below a preset point. Controller shall be equipped with local alarm to alert maintenance personnel if heat trace circuit is interrupted.
   3. Controller shall have the capability of performing a self-diagnostic check on the system and advising maintenance personnel of the exact nature of any circuit problems.

C. Controller shall be fully compatible with heat trace and provided by same manufacturer as heat trace.
   1. Controller shall be powered from 480 VAC. A configurable dry contact shall be provided for heat trace fault.
   2. Controller shall have double pole solid-state switching, temperature control from -40 degrees F to 125 degrees F and a 30-amp rating from -40 degrees F to 125 degrees F ambient temperature.
      a. Controller shall be rated for the electrical and hazardous area classification of intended use.
   3. Power Supply: Controller power supply shall be 240 VAC with adjustable ground fault detection.
   4. Controller shall have battery backup system to retain programmed parameters in the event of a power failure.
   5. Enclosure: Unit shall be enclosed in minimum NEMA 4X stainless steel panels and in accordance with Section 16135.
   6. Network Capabilities: Controller shall have network capabilities enabling monitoring and programming from a central location.

2.03 CONNECTION KITS, END SEALS, SPLICE AND TEE KITS

A. Heat trace connection, end, splice, and tee kits shall be designed to meet or exceed the life of the heat trace and shall be given equal consideration and evaluation. Splicing and teeing shall only be used when it meets electrical classification of installation location.

B. Provide wiring, conduits, junction boxes, and any other electrical components as required.

2.04 ACCESSORIES

A. Electrical accessories shall be in accordance with Section 16050.

B. Power connection kits.

C. Termination kits.

D. Splice kits.

E. End seal kits.

F. Straps.

G. Thermostat.
   1. Manufacturer:
      a. Raychem Model AMC-1H.
      b. Chromalux B121.
      c. Or equal.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install heat tracing cable as indicated on the Drawings.

B. Wrap heat-tracing tape with aluminum tape prior to installing insulation.

C. Install pipe insulation as specified in Section 15082.

D. Install heat tape and controls in accordance with manufacturer’s published installation instructions.

3.02 FIELD QUALITY CONTROL

A. Manufacturer's Field Service.
   1. Inspect installed systems for proper installation.
   2. Instruct OWNER's personnel on operations and maintenance of the systems.

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. Section 01500 - Temporary Facilities and Controls.
   2. Section 15052 - Basic Piping Materials and Methods.

1.02 REFERENCES

A. Uniform Plumbing Code (UPC).

B. National Fuel Gas Code: ANSI Z 223.1 or NFPA 54.

C. American National Standards Institute/American Society of Mechanical Engineers (ANSI/ASME):
   1. B31.8 - Gas Transmission and Distribution Piping Systems.
   2. B31.1 - Power Piping.
   3. B31.3 - Process Piping.

D. Uniform Mechanical Code (UMC).

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 herein.
   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 Uniform Plumbing Code, and UL requirements.
   4. When testing with water, the specified test pressure is considered to be the pressure at the highest point of the piping section under test. Lower test pressure as necessary to prevent testing the lowest point above a safe test pressure.

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 in accordance with requirements of federal, state, county, and city regulations governing disposal of wastes in the location of the Project and disposal site.

1.04 SUBMITTALS

A. 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. 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 one percent plus or minus.
   4. Consider test complete when the mandrel can be pulled through the piping with reasonable effort by one 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. 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 ANSI/ASME B31.1, ANSI/ASME B31.3, ANSI/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 one-half 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. Provide temporary restraints when needed to prevent movement of piping. Pressure test piping with maximum leakage allowance after backfilling.
3. 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 four 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 Clay and Other Piping: 500 gallons per day per inch of 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. 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. 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 potable water while venting air.
   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.
   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 one 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

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SECTION 15958

MECHANICAL EQUIPMENT TESTING

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes: Testing of mechanical equipment and systems.

1.02 REFERENCES

A. American National Standards Institute (ANSI):
   1. ANSI S1.4 Specification for Sound Level Meters.

B. American National Standards Institute/Hydraulic Institute (ANSI/HI):
   1. ANSI/HI 1.1-1.5 Standard for Centrifugal Pumps for Nomenclature, Definitions, Application, and Operation.
   2. ANSI/HI 1.6 Standard for Centrifugal Pump Tests.
   3. ANSI/HI 3.1-3.5 Standard for Rotary Pumps for Nomenclature, Definitions, Application, and Operation.
   4. ANSI/HI 3.6 Standard for Rotary Pump Tests.
   5. ANSI/HI 4.1-4.6 Standard for Sealless Rotary Pumps for Nomenclature, Definitions, Application, Operation, and Test.
   6. ANSI/HI 5.1-5.6 Standard for Sealless Centrifugal Pumps for Nomenclature, Definitions, Application, Operation, and Test.
   7. ANSI/HI 7.1-7.5 Standard for Controlled Volume Pumps for Nomenclature, Definitions, Application, and Operation.
   8. ANSI/HI 8.1-8.5 Standard for Direct Acting for Steam Pumps for Nomenclature, Definitions, Application, and Operation.
   9. ANSI/HI 9.1-9.5 Standard for Pumps - General Guidelines for Types, Definitions, Application, and Sound Measurement.

1.03 SUBMITTALS

A. Schedule of factory tests and field tests as specified in Section 01756 and this Section.

B. Test instrumentation calibration data.

C. Start-up plan as specified in Section 01756.

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 the Specifications.
   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 individual equipment Sections of the Specifications.
   4. If testing is not specified in the equipment Section, provide Level 1 testing.
   5. Requirements of Section 01756 apply to Test Levels.

C. Witnessing: Source Quality Control Tests not witnessed unless specified otherwise in the equipment specification Section or Section 01756; Field Quality Control Tests shall be witnessed.

D. Instrumentation: Provide necessary test instrumentation which has been calibrated within one 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 01756 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 01756.
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 Hydraulic Institute Standards in addition to the requirements in this and other Sections.
2. Test Tolerances: In accordance with appropriate Hydraulic Institute Standards, except the following modified tolerances apply:
   a. From 0 to plus 5 percent of head at the rated design point flow.
   b. 0 to plus 5 percent of flow at the rated design point head.
   c. No negative tolerance for the efficiency at the rated design point.
   d. No positive tolerance for vibration limits. Vibration limits and test methods in Hydraulic Institute 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 spectra of acceleration versus frequency. Manufacturers: One of the following or equal:
   a. IRD, "Spike Energy" analysis.
   b. CSI, "Amplitude Demodulated Spectrum."
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 3200 lines, storage for up to ten 3200 line frequency spectra, RS232C data output port, circuitry for integration of acceleration data to velocity or double integration to displacement. Manufacturers: One of the following or equal:
   a. IRD, Fast Track.
   b. CSI, equivalent model.
2. Analyzer Settings:
   a. Units: English, inches/second, mils and g's.
   b. Fast Fourier Transform Lines: Most equipment 400 minimum; for motors, enough lines as required to distinguish motor current frequencies from rotational frequencies, use 3200 lines for motors with a nominal speed of 3600 rpm; 1600 lines minimum for High Frequency Enveloping; 800 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 g sensitivity, 10 g range, plus/minus 5 percent frequency response from 0.5 hertz to 850 hertz, magnetic mount. Manufacturers: One of the following or equal:
      1) Wilcoxon Research, Model 797L.
      2) PCB, Model 393C.

b. For High Speed Equipment: General purpose accelerometer, 100 millivolts per g sensitivity, 50 g range, plus/minus 3dB frequency response range from 2 hertz to 12,000 hertz when stud mounted, with magnetic mount holder. Manufacturers: One of the following or equal:
   1) Wilcoxon Research, Model 793.
   2) 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: Measure filtered vibration spectra for peak velocity and peak to peak displacement versus frequency in three perpendicular planes at each normally accessible bearing housing on the driven equipment, any gears and on the driver; one plane of measurement to be parallel to the axis of rotation of the component.
   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 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 for flow and head at two additional conditions; one at 25 percent below the rated flow and one 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: Measure filtered vibration spectra for peak velocity, peak to peak displacement versus frequency and measure vibration phase in three perpendicular planes at each normally accessible bearing housing on the driven equipment, any gears and on the driver; one 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.

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 and 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 three 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 one-half 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 four 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 specification) and record observations on noise levels.

3. Level 3 Vibration Test:
   a. Requirements: Same as Level 3 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 three 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 four 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 for one half 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 specification) 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 ANSI/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 individual 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. First critical speed of the constant, variable, and 2-speed driven equipment is to be at least 25 percent above the maximum operating speed or 25 percent below the minimum operating speed.

2. Second critical speed of any 2-speed or the variable speed equipment is to be at least 25 percent above or below the maximum operating speed or 25 percent below the minimum operating speed.

3.06 FIELD QUALITY CONTROL

A. Test equipment as specified for each type of test at the test levels specified in individual 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 is not to exhibit unfiltered readings in excess of following:

Operating Speed (revolutions per minute)	Centrifugal Blowers	Unfiltered (Overall) Peak-to-Peak Amplitude (mils)		
		Other Rotating Equipment	Non-Clog Mixed Flow Pumps	Clean Fluid Pumps
0 - 300	N/A	5.0	6.0	6.0
301 - 600	N/A	4.0	5.0	5.0
601 - 900	N/A	3.0	4.0	3.0
901 - 1,200	N/A	2.0	3.5	2.0
1,201 - 1,500	N/A	1.8	3.0	1.8
1,501 - 1,900	N/A	1.5	2.5	1.5
1,801 - 2,400	N/A	1.0	2.0	1.0
2,401 - 3,000	N/A	0.8	1.5	0.8
3,001 - 3,600	1.25	0.7	1.3	0.7
Above 3,600	1.0	0.6	1.2	0.6

Note: For all equipment, axial shaft displacements not to exceed 50 percent of the maximum radial shaft displacements relative to the casing.

C. Vibration Velocity Limits: Unless otherwise specified, equipment 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 or Mixed Flow Pumps	0.35	0.25
Clean Fluid Pumps	0.25	0.20
Motors and Steady Bearings	0.25	0.20

Item	Unfiltered Overall Limit (inches per second)	Any Filtered Peak Limit (inches per second)
Gear Reducers, Radial	Not to exceed AGMA 6000-A88 limits	
Other Reducers, Axial	0.10	0.10
Centrifugal 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 subrotational, 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 two times the rotor bar pass frequency.
   d. Phasing problems evidenced by one third 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 01756 and this Section.

B. General Check-out: 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 17950 and 16950.
   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 01756.

END OF SECTION

SECTION 16010

ELECTRICAL REQUIREMENTS

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes: Electrical distribution system and utilization equipment.

1.02 SYSTEM DESCRIPTION

A. Furnish and install a tested and working electrical system, as indicated on the Drawings and as specified. System includes all items not specifically mentioned in these Specifications or indicated on the Drawings or accepted Shop Drawings, but which are obviously necessary to make a complete working installation, and shall be deemed to be included herein.

B. Notify ENGINEER of discrepancies within the Contract Documents and discrepancies between the Contract Documents and actual field conditions.

C. The Specifications and Drawings indicate or specify minimum sizes of equipment, electric devices, and other components of electrical system, but the Specifications and Drawings do not indicate every offset and fitting, or every structural or mechanical difficulty that may be encountered during the execution of the Work.

D. Install equipment at locations indicated on the Drawings as closely as field conditions permit. Obtain accepted equipment submittal dimensions prior to installing pads, conduits, and cable trays.

E. Make minor variations to alignment of equipment and/or installation of raceway systems to avoid conflict with other portions of the Work.

F. Single Line Diagrams: Single line diagrams indicate circuit voltages for low voltage equipment as follows:
   1. 4xx is 480 volts, 3xx is 277 volts, 2xx is 240 volts, 1xx is 120 volts circuits.
   2. Single line diagrams also indicate wire and conduit sizes, circuit protection rating, and other pertinent data. Use single line diagrams to resolve conflicts.
   3. When not indicated on the Drawings, provide grounding in accordance with NEC Article 250 and as specified in Section 16062.

G. Electrical and Telephone Utility Services:
   1. Provide electrical work in accordance with requirements of the serving utility, Sierra Pacific Power Company, and local and state inspection authorities. Note that some service requirement details are indicated on the Drawings and are in conformance with the utility's requirements at the time of design.
   2. Telephone Utility Services: Provide telephone work in accordance with requirements of local and state inspection authorities.
   3. Coordinate and obtain inspections and final installation approval from serving utilities and other authorities having jurisdiction.

H. Temporary Power:
   1. Provide and maintain temporary power, lighting, and telephone systems as needed for construction as specified in Section 01500. Include weatherproof panel(s) for main breakers and electrical power distribution system.
   2. Install temporary wiring in accordance with NEC Article 305 with Type SO portable cable, watertight connections, and ground fault interrupting equipment. After construction is completed, remove temporary systems.

1.03 PERFORMANCE REQUIREMENTS

A. Operate electrical equipment successfully at full-rated load, without failure, at an ambient air temperature of 40 degrees Celsius, and rated for an altitude of 4,600 feet.

B. Coordination of Electrical Equipment Rating: Verify actual equipment, motor full-load, and locked-rotor current ratings. When providing equipment with different motor full-load and locked-rotor current ratings than indicated on the Drawings, coordinate branch circuit conductor sizes, motor overload protection, motor controllers, control power transformers, and branch circuit overcurrent protection required for equipment provided.

C. Branch Circuit Conductor Current Carrying Capacity: Minimum 125 percent of the full-load current rating of equipment.

D. Branch Circuit Conductor Size: Adequate to prevent voltage drop greater than 2 percent from branch circuit protection device to equipment with equipment running at full-load and rated voltage. Include conductor derating in accordance with ambient temperature and conduit fill requirements.

E. Motor Running Overload Protection Devices:
   1. Rated or selected to trip at no more than the following percent of motor nameplate full-load current rating:
      a. 125 percent for motors with marked service factor not less than 1.15.
      b. 125 percent for motors with marked temperature rise not over 40 degrees Celsius.
      c. 115 percent for all other motors.
   2. Size and provide upon verification of actual motor or nameplate data.
   3. Where power factor correction capacitors are provided on load side of motor running overload protection device, selection or setting shall be based on the improved power factor of motor circuit and not the full-load nameplate current of motors.

F. Overload Heaters Required for Motors with Temperature Rise of 50 Degrees Celsius: As selected from motor controller manufacturer's overload heater selection tables.

G. Motor Controller Size: Coordinated with horsepower size of motor.

H. Motor-branch-circuit Short Circuit and Ground Fault Protections Device: Capable of tripping open in 30 seconds or less on locked-rotor current of motor. This device shall also protect the motor-branch-circuit conductors and the motor control apparatus against overcurrent due to short-circuit or ground faults. Protect motor control circuits with device type specified or as indicated on the Drawings.

1.04 SUBMITTALS

A. Shop Drawings and Product Data:
   1. Include data on and details of control devices, fixtures, wire, cables, raceways, and other electrical equipment specified or indicated on the Drawings.
   2. Include harmonic study and other calculations and studies as specified.

B. Cutting and Patching Requests: Submit as specified in Section 01732.

C. Project Record Documents:
   1. Submit in accordance with Section 01770. Include drawings of wiring terminations at electrical equipment including, but not limited to:
      a. Terminal/junction boxes.
      b. Revised Shop Drawings reflecting modifications made during progress of the Work including testing, and revised Specifications and Drawings with conductors identified identically as on the Specifications and Drawings and accepted Shop Drawings. Updated Shop Drawings shall include all drafting work.

D. Acceptance Testing Information and Documents: Submit as specified in Section 16950.

1.05 QUALITY ASSURANCE

A. Regulatory Requirements: Perform electrical work, including connection to electrical equipment integral with mechanical equipment, in accordance with latest published requirements of the following codes and code/standard making organizations:
   1. American National Standards Institute (ANSI).
   2. American Society for Testing and Materials (ASTM).
   3. Institute of Electrical and Electronics Engineers (IEEE).
   4. Insulated Cable Engineers Association (ICEA).
   5. National Electrical Code (NEC).
   6. National Electrical Contractors Association (NECA).
   7. National Electrical Safety Code (NESC).
   8. National Electrical Manufacturers Association (NEMA).
   9. National Fire Protection Association (NFPA).
   10. State and local codes.
   11. Uniform Building Code (UBC).

B. When applicable, materials and equipment used in performance of electrical work shall be listed or labeled by Underwriter's Laboratories or other equivalent, recognized, and independent testing laboratory, for the class of service intended.

C. Manufacturer Qualifications:
   1. Low Voltage Equipment: Manufacturer of proposed product with components uniquely selected by engineering review.
      a. Proprietary bussing and enclosure designs listed by UL in manufacturer's own file for minimum 15 years with satisfactory performance record.
      b. Capable of providing warranty for assembly when built-up with components from various manufacturers.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Ship electrical panels, switchgear, switchboards, motor control centers, variable frequency drives, and other electrical distribution equipment in sealed dust and moisture-proof plastic sheet enclosures. Equipment containing dirt, dust, water, grease, rust, or damaged parts or components may be rejected.

B. Provide for delivery, unloading, transportation, and storage of equipment until installation. Protect electrical and instrumentation equipment and panels from physical and environmental damage. Store and maintain equipment in a weatherproof building until installed.

C. Store electrical equipment, including switchgear, motor control centers, variable frequency drives, instrumentation control panels, and other enclosures that house electronic equipment rated for a specified ambient or environmental temperature range, in air conditioned buildings to protect equipment from temperatures above 90 degrees Fahrenheit and heated buildings to protect equipment from temperatures below 40 degrees Fahrenheit. Assume liability for the storage facilities or equipment stored therein.

D. Maintain storage facilities in neat condition with utilities. Maintain stored equipment in same condition as when received.

E. Provide continuous access for inspection of stored equipment.

1.07 SEQUENCING AND SCHEDULING

A. Sequence and Schedule as specified in Sections 01352, 01140, and progress schedule submitted as specified in Section 01324A.

B. Coordinate work with ENGINEER to minimize downtime of existing operating equipment and electrical distribution system and to preclude unsafe operations. Notify OWNER 10 days prior to power interruptions. Coordinate downtime with OWNER. Before work is performed on low voltage or medium voltage circuits, or in manholes containing low voltage or medium voltage circuits, identify and de-energize the circuits.

1.08 DEMOLITION

A. Survey the existing electrical systems and equipment identified for removal with representatives from the other trades prior to performing any demolition work. Identify all conduit and equipment to be removed with tags or paint.

B. Where a piece of equipment is to be removed all associated ancillary components and associated wiring and conduit shall also be removed.

C. Building or structures scheduled for complete demolition shall be made safe from electrical shock hazard prior to demolition. Disconnect all electrical power, communications, alarm and signal system.

D. Equipment scheduled to be turned over to the OWNER shall be carefully disconnected, removed and delivered to the OWNER at the existing site. Provide labor, hoisting and transportation of the equipment. All other miscellaneous

electrical materials, devices, etc, associated with the equipment being turned over shall be demolished and removed from the site. The following equipment shall be turned over to the OWNER:

1. MCCs/VFDs.
2. Breakers.
3. Starters.
4. Disconnect switches.

E. Remove electrical work associated with equipment scheduled for demolition except those portions indicated to remain or be reused.

F. Remove unused exposed conduit back to point of concealment including abandoned conduit above accessible ceiling finishes. Remove unused wiring in concealed conduits back to source (or nearest point of usage).

G. Disconnect abandoned outlets and remove devices. Remove abandoned outlets if conduit servicing them is abandoned and removed. Provide blank covers for abandoned outlets which are not removed.

H. Disconnect and remove abandoned panelboards, disconnect switches, control stations, distribution equipment, etc.

I. Disconnect and remove abandoned luminaries. Remove brackets, stems, hangers and other accessories.

J. Repair adjacent construction and finishes damaged during demolition and extension work.

K. Where electrical systems pass through the demolition areas to serve other portions of the premises, they shall remain or be suitably relocated and the system restored to normal operation.

L. Coordinate outages in systems with the OWNER. Where duration of proposed outage cannot be allowed by the OWNER, provide temporary connections as required to maintain service.

M. Removal and relocation of existing conduit, wire and equipment have not been detailed on the Drawings. Survey the affected areas before submitting bid proposal.

N. Trace out existing wiring that is to be relocated, or removed and perform the relocation or removal work as required for a complete operating and safe system.

O. Continuous service is required on all circuits and outlets affected by these changes, except where the OWNER will permit an outage for a specific time. Obtain OWNER's consent before removing any circuit from continuous service.

P. Remove exposed conduits, wireways, outlet boxes, pull boxes and hangers made obsolete by the alterations, unless specifically designated to remain. Patch surfaces and provide blank covers for abandoned outlets, which are removed.

Q. All equipment, materials, controls, motor starters, branch and feeder breakers, panelboards, transformers, wiring, raceways, etc, furnished and installed to

temporarily keep circuits energized shall be removed when the permanent installation is fully operational.

1.09 DISPOSITION OF REMOVED MATERIALS AND EQUIPMENT

A. In general, it is intended that material and equipment indicated to be removed and disposed of by the CONTRACTOR shall, upon removal, become the CONTRACTOR's property and shall be disposed of off the site by the CONTRACTOR, unless otherwise directed by the OWNER. A receipt showing acceptable disposal of any legally regulated materials or equipment shall be given to the OWNER.

B. The electrical equipment as specified under Section 1.08D shall be removed and shall be moved by the CONTRACTOR to a location on the site for storage as directed by the OWNER:

PART 2 PRODUCTS

Not Used.

PART 3 EXECUTION

3.01 PREPARATION

A. Cutting, Patching and Repairing: Cut and patch the Work as specified in Section 01732. Where it becomes necessary to cut into existing work for the purpose of making electrical installations, use core drills for making circular holes. Other demolition methods for cutting or removing shall be reviewed by the ENGINEER prior to starting the work.

3.02 INSTALLATION

A. Corrosion Protection:
   1. Isolate dissimilar metals, except conduit and conduit fittings, that may come in contact, with neoprene washers, 9 mil polyethylene tape, or gaskets.
   2. Restore factory finishes which are damaged or rusted to their original new condition in accordance with manufacturer's instructions.

B. Install electrical work prior to placing floors and walls. Provide all sleeves and openings through floors and walls required for passage of all conduits and other raceways. Sleeves shall be rigidly supported and suitably packed or sealed to prevent ingress of wet concrete or water.

C. Provide all insets and hangers required to support raceways and other electrical equipment. If the inserts, hangers, sleeves, or openings, are improperly placed or installed, do all necessary work to rectify the errors.

3.03 CLEANING

A. Clean each piece of electrical equipment, both inside and outside, and retouch equipment to match existing paint.

3.04 PROTECTION

A. Protect products and provide heat to eliminate condensation until acceptance by OWNER.

END OF SECTION

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SECTION 16050

BASIC ELECTRICAL MATERIALS AND METHODS

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes: Basic electrical materials and methods.

1.02 REFERENCES

A. American Society for Testing Materials (ASTM):
   1. A 525 - Specification for General Requirements for Steel Sheet, Zinc-Coated (Galvanized), by Hot-Dip Process.

B. National Electrical Manufacturers' Association (NEMA).

1.03 SYSTEM DESCRIPTION

A. Design Requirements:
   1. Connections of electrical equipment to supports shall be designed to resist the operating forces plus seismic forces.
   2. Seismic design shall conform to the requirements of Section 01612. Calculations shall be by a registered civil or structural engineer in the state where the Project is located.

1.04 SUBMITTALS

A. Structural calculations for electrical equipment anchorage.

B. Shop drawings and product data.

1.05 WARRANTY

A. Submit manufacturer's standard warranty.

1.06 EXTRA MATERIALS

A. Furnish and install a minimum of 25 percent spare terminal blocks in each terminal/junction box.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Unless specified otherwise indicated on the Drawings, the fabricator of major electrical equipment, such as lighting and distribution panelboards, switchgear, variable frequency drives, and motor control centers, shall also be the manufacturer of the major devices herein.

2.02 MATERIALS

A. Materials, equipment, and parts comprising any unit or part thereof specified or indicated on the Drawings shall be new and unused, of current manufacture, and of highest grade consistent with the industrial industry standards. Damaged materials, equipment, and parts are not considered to be new and unused and will not be accepted.

2.03 EQUIPMENT

A. Support Channels: Steel, hot-dip galvanized with G90 coating in accordance with ASTM A 525, or stainless steel.
   1. Manufacturers: One of the following or equal:
      a. Unistrut.
      b. Superstrut.
      c. Globe Strut.

B. Support Channel Bolts, Nuts, and Washers: Stainless steel.

C. Non-fused Terminal Blocks: Sized as required for conductors.
   1. Manufacturers: One of the following or equal:
      a. Square D Company.
      b. Buchanan.

D. Fused Terminal Blocks: Circuit isolation, fused switch type, sized as required for conductors. Fuse size shall be based upon actual load and conductors to be protected.
   1. Manufacturers: One of the following or equal:
      a. Square D Company.
      b. Buchanan.

E. Control Relays:
   1. Industrial 600 volt, 10 ampere type with contact arrangement and operating coils of proper voltage as required by control circuit sequence; with minimum of 4 reversible-pole contacts; coils sealed by pressure molding.
   2. Non-industrial or plug-in type control relays shall be prohibited unless accepted in writing.
   3. Manufacturers: One of the following or equal:
      a. Square D Company.
      b. Cutler-Hammer.

F. Intrinsically Safe Relays:
   1. Factory Mutual approved to allow the use of every type of remote pilot device located in Class 1, Division 1 or 2, hazardous areas by providing a pilot circuit incapable of releasing sufficient electrical energy to ignite gases and vapors classified in Groups A, B, C, and D.
   2. Output relay with double pole, double throw contacts continuous rating of 10 amperes at 120 volts alternating current, capable of operating on the voltage indicated.
   3. Manufacturers: One of the following or equal:
      a. B/W - Controls Series 53.
      b. Cutler-Hammer - Powered Relay.

G. Reset Timers and Repeat Cycle Timers:
   1. Industrial type; 120 volts alternating current, 60 hertz operating power; 6 amperes minimum at 120 volts alternating current output unless otherwise indicated on the Drawings or specified.
   2. In enclosure as indicated on the Drawings or specified; plug-in or non-industrial timers shall be prohibited unless accepted in writing.
   3. Manufacturers: One of the following or equal:
      a. Eagle.
      b. Paragon.

H. Twenty-Four Hour Timers:
   1. Heavy-duty industrial, 120 volts, 60 hertz alternating current operating power, electronic type; 15 amperes at 120 volts alternating current output, single channel type; lithium battery-backed; single pole double throw.
   2. In NEMA 3 enclosure; plug-in or non-industrial timers shall be prohibited unless accepted in writing.
   3. Manufacturers: One of the following or equal:
      a. Paragon, EC Series
      b. Tork, equivalent model.

I. Timing Relays: Heavy-duty industrial, 600 volt, 10 amperes.
   1. Manufacturers: One of the following or equal:
      a. Square D Company.
      b. Cutler-Hammer.

J. Alarm Horns: Capable of producing an adjustable audible sound which shall be minimum 100 decibels at 10 feet from the horn, accepting up to 8 different plug-in tone modules, and having distinct tones so no 2 horns have the same tone; receiving 120 volt power from its respective control panel as specified or as indicated on the Drawings.
   1. Manufacturers: One of the following or equal:
      a. Edwards Signaling.
      b. Federal Signal.

K. Thermostats: Unless otherwise specified elsewhere in the Contract Documents, the thermostats shall be:
   1. Heavy-duty type with full load rating of 120 volts, 16 amps.
   2. Provided with a clear plastic splash-proof protective thermostat cover to inhibit corrosion and moisture damage.
   3. Manufacturers: One of the following or equal:
      a. Honeywell, T6051 Series.
      b. Rockwell, equivalent.

L. Warning Lights:
   1. Warning rotating lights, 40 watt, suitable for indoor and outdoor use, corrosive environment.
   2. Red color lens.
   3. Shall direct light in a 360-degree pattern.
   4. With all necessary accessories for wall mounting or as specified otherwise elsewhere in these Contract Documents.
   5. Voltage: 120.

6. Manufacturers: One of the following or equal:
   a. Federal Signal Model 121.
   b. Edwards Signaling equivalent.

M. Nameplates:
   1. Type: Black lamicoid with white letters.
   2. Fastener: Round head stainless steel screws.

N. Automatic Equipment and High Voltage Warning Signs:
   1. Type: Suitable for exterior use and meeting OSHA regulations.

O. Underground Hazard Tape: 6 inches wide.
   1. Manufacturers: One of the following or equal:
      a. Panduit.
      b. Brady.

PART 3 EXECUTION

3.01 GENERAL

A. Verify dimensions indicated on the Drawings. Actual locations, distances, and levels will be governed by actual field conditions. The CONTRACTOR shall also review information indicated on the Drawings for architectural, structural, yard, mechanical, and other specialties, and the accepted electrical and mechanical shop drawings, and shall adjust his work to conform to all conditions indicated thereon.

B. Coordinate for consistency lens colors of all pilot lights included in all equipment assemblies specified in Divisions 11 through 17 (subject to ENGINEER's acceptance).

3.02 EQUIPMENT INSTALLATION

A. Anchor electrical equipment to building floors, electrical equipment foundations, or other supports by bolts and anchor bolts and studs.

B. Do not anchor electrical equipment with concrete anchors or flush shells.

C. Anchor each piece of electrical equipment with minimum 1/2 inch diameter Type 316 stainless steel bolts, anchor bolts, or studs. Acceptable connectors shall be furnished in each corner of each section of electrical equipment, minimum.

D. Where plates are embedded in concrete supporting electrical equipment, fasten electrical equipment to the embedded plates with minimum 1/2-inch diameter welded studs. Where required, the number of studs connecting the embedded plates to floors shall be increased as required based upon the calculations of seismic forces in order to resist the forces from the electrical equipment supplied. The additional studs shall be deemed as part of these Contract Documents.

3.03 TORQUING

A. After installing and before energizing electrical equipment, torque each bolted bus and cable connection in accordance with manufacturer's recommendations with

calibrated torque wrenches. Include each bolt at each connection, both factory and field installed, for motor control centers, variable frequency drives, bus ducts, switchgear, switchboards, and other equipment installed.

3.04 CONDUCTOR FASTENERS

A. Use screw type conductor fasteners and other permanent, such as epoxy conductor adhesives, in junction or pull boxes, termination cabinets, panels, panelboards, switchboards, switchgear, motor control centers, variable frequency drives, or other enclosures containing electrical devices and/or conductors. Do not use glue-on type conductor fasteners.

3.05 SUPPORT CHANNELS

A. Install channels, as required for support of raceways, cable trays, device enclosures, and other electrical equipment.

B. Separate iron or steel supports from aluminum with 1/4-inch neoprene or other non-metallic gaskets.

C. Paint field cuts and scratches of galvanized steel channels with a cold galvanizing spray paint.

3.06 TERMINAL BLOCKS

A. Furnish and install terminal blocks in control panels, cabinets, terminal/junction boxes, variable frequency drives, motor control centers, switchgear and similar equipment and identify the terminal blocks by numbering and labeling in accordance with accepted shop drawings. The terminal blocks shall be circuit isolation fused-switch type where indicated on the Drawings and as required.

3.07 NAMEPLATES

A. Furnish and install nameplates where indicated on the Drawings or specified.

B. Each disconnect means for service, feeder, branch, or equipment conductors and push-button stations shall have nameplates indicating its purpose or identifying the load.

3.08 ADJUSTING

A. Adjust, set timers and contacts for proper equipment operation in accordance with Section 01756.

3.09 DEMONSTRATION

A. Demonstrate operation of equipment.

END OF SECTION

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SECTION 16062

GROUNDING

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes: Grounding electrode systems, consisting of concrete encased bare ground conductors and ground rods.

1.02 REFERENCES

A. National Electrical Code (NEC), Article 250 - Grounding.

PART 2 PRODUCTS

2.01 MATERIALS

A. Driven Ground Rods:
   1. Copper-covered steel.
   2. 3/4-inch diameter.
   3. 10 feet long, minimum.

B. Ground Conductor: Bare copper.

C. Precast Ground Wells: As specified in Section 02084, Utility Structures.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install concrete encased bare ground conductor in each duct bank. Run grounding electrode system conductors continuously in duct banks, through manholes, handholes, other raceway boxes, and cable tray exteriors. Connect conductors to structure ground ring or grounding system to provide a continuous grounding electrode system.

B. Bond electrical enclosures, including metallic raceways, panels, switchboards and other similar metallic panels, cases and devices associated with power, instrumentation, and control systems to the grounding electrode system.

C. Drive ground rods and install grounding conductors prior to construction of concrete slabs and duct banks.
   1. Extend grounding conductors through concrete to accessible points for grounding equipment and electrical enclosures.
   2. Install grounding system at each structure where switchgear, motor control centers, switchboards, panelboards, panels, or other electrical equipment are installed.

D. Provide either exothermic welded (underground connection) or mechanical connections (aboveground connection) for grounding cable to rods or cable.

E. When size is not indicated on the Drawings, size grounding conductors in accordance with NEC Table 250-66 and Table 250-122.

F. Install a green insulated equipment grounding conductor, or multi-conductor cable with integral green insulated grounding conductor, with each feeder and branch circuit from the power source grounding means to the load equipment or device.

G. Install ground bushings at both ends of rigid conduit runs. Do not use locknuts. Bond ground bushings to the grounding system.

H. When not indicated on the Drawings, install grounding electrode systems in compliance with NEC-250, Part C.

I. Furnish and install precast ground well boxes in accordance with Section 02084.

3.02 TELEPHONE PANEL GROUND

A. Install individual ground rod or ground system at telephone panels, and connect the metal chassis to the grounding electrode system, in accordance with telephone company requirements.

3.03 ANTENNA GROUND

A. Install individual ground rod or ground system for communication system antenna, and connect to grounding electrode system, in accordance with the radio manufacturer's requirements.

3.04 FIELD QUALITY CONTROL

A. Test ground resistance, as specified in Section 16950, of entire system and at each building/structure where electrical equipment is installed.

B. Invite ENGINEER to witness ground resistance testing.

C. Where maximum allowable ground resistance of 5 ohms is exceeded, install additional grounding mats or ground rods until ground resistance is equal to or below maximum allowable ground resistance.

END OF SECTION

SECTION 16075

ELECTRICAL IDENTIFICATION

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes: Identification of electrical conductors, raceways and equipment, and electrical equipment signs.

1.02 REFERENCES

A. National Electrical Code (NEC):
   1. Article 110–22 - Disconnecting Means.
   2. Article 210–4 - Multiwire Branch Circuits.
   3. Article 200 - Use and Identification of Grounded Conductors.
   4. Article 408 - Switchboards and Panelboards.
   5. Article 300 - Wiring Methods.

1.03 SUBMITTALS

A. Shop Drawings:
   1. Include tagging system, labels, markers, hazard tape, nameplates, and signs.

B. Product Data: Include tagging system, labels, markers, and hazard tape.

C. Project Record Documents:
   1. Document wire, cable, and conductor tags, and bundle tags installed in accordance with the Contract Documents.
   2. Document installed wire, cable, and conductor tags and bundle tags when not specifically indicated.
   3. Indicate on Record Drawings deviations from accepted shop drawing conductor identification.

1.04 QUALITY ASSURANCE

A. Pre-installation Conference:
   1. Conduct in accordance with Section 01312.
   2. Purpose: To clearly define requirements specified for circuit/cable/conductor identification, hold a meeting including representatives of CONTRACTOR, OWNER, and ENGINEER prior to significant cable or conductor purchase and installation/termination.

PART 2 PRODUCTS

2.01 LABELS

A. Manufacturers: One of the following or equal:
   1. Brady.

2. Seton.

B. Type: Sleeve type.

2.02 CONDUCTOR AND CABLE MARKERS

A. Manufacturers: One of the following or equal:
1. Brady.
2. Seton.

B. Type: Slip-on PVC sleeve or strap-on type.

C. Printed using Brady marker "XC PLUS," or equal.

D. Markers used in tunnels or other wet locations shall be on heat-shrinkable marking sleeves.

E. Use self-laminating vinyl on white background for markers within electrical equipment such as panels, termination cabinets, motor control centers.

2.03 RACEWAYS IDENTIFICATION (TAGS)

A. Conduit numbers shall be pressure stamped into a noncorrosive 2 inch long, 1/2-inch wide stainless steel tape, Dymo marking system or equal. A tag with number shall be fixed with No. 18 AWG or larger Type 316 stainless steel wire, to each conduit segment and at the end of each conduit and within 3 feet of each pull box, panelboard, and switchboard.

2.04 NAMEPLATES, LABELS AND SIGNS

A. Nameplates:
1. Type: Black lamicoid with white letters.
2. Fastener: Round head stainless steel screws.

B. Automatic Equipment and High Voltage Warning Signs:
1. Type: Suitable for exterior use and meeting OSHA regulations.

C. Underground Hazard Tape: 6-inches wide.
1. Manufacturers: One of the following or equal:
   a. Panduit.
   b. Thomas and Betts.

PART 3 EXECUTION

3.01 CIRCUIT IDENTIFICATION

A. Identify 3-phase system conductors and cables as Phases A, B, and C and identify 1-phase system conductors and cables at electrical equipment including, but not limited to, switchgear, switchboards, panelboards, motor control centers, and motors.
1. Match OWNER's existing electrical system identification scheme or meet requirements of the authority responsible for the project.

2. 3-phase 480 Volts AC System Conductors: Phase A, brown; Phase B, orange; Phase C, yellow.
3. Single-Phase Conductors for 120/240 VAC Circuits: Phase A, black; Phase B, red; Phase C, blue.
4. Neutral Conductor: White for 120 VAC and gray for 277 VAC.
5. Insulated Equipment Grounding Conductor: Green.
6. General Purpose AC Control Conductors: Purple.
7. General Purpose DC Control Conductors: Purple with white stripes.
8. Control and Instrumentation Field Wiring:
    a. 24 VDC From Power Supply (+) :Purple
    b. 24 VDC Discrete Input Signal :Orange
    c. 24 VDC Discrete Output Signal: Blue
    d. 24 VDC Zero Voltage (Common): Brown
    e. 120 VAC Discrete Signals: Red
    f. Instrumentation Signals: Black (Positive)
    g. (4-20 mA Twisted Shielded Pair): Clear or White (Negative)
    h. Data Highway Cable or Fiber: White Jacket
    i. HMI Network Cable or Fiber: Grey Jacket

B. Use color coding and phasing consistent throughout the site. Bus bars at panelboards and motor control centers to be connected Phase A-B-C, top to bottom, or left to right facing connecting lugs.

C. Conductors Number 2 American Wire Gauge (AWG) and smaller to be factory color coded with a separate color for each phase and neutral, which shall be used consistently throughout the system. Larger cables to be coded by the use of colored tape.

D. In addition to color coding, for all 1-phase and 3-phase systems, identify each cable (single or multi-conductor) and conductor at each end, in each manhole, pullbox, cable tray, or other component of the raceway system. This identification is applicable to all power, control, alarm, signal, and instrumentation cables, and conductors.

E. Identify each cable (single or multi-conductor) and groups or bundles of individual single conductors in each manhole, pullbox, cable tray or other component of the raceway system with circuit identification markers. Implement a "from-to" cable/conductor bundle tagging system as part of this identification effort.

F. Identify each individual conductor at each termination. This includes such locations as switchgear, switchboards, motor control centers, variable frequency drives, control panels, junction/terminal boxes, all field devices, and all other locations where conductors are terminated. Identify the termination of these conductors in accordance with the accepted shop drawings. Tag conductors with sleeve type labels.

G. Where more than 1 nominal voltage system exists, identify each ungrounded system conductor by phase and system. Permanently post means of identification at each branch-circuit panelboard, switchboard, switchgear, motor control center, or other type of power distribution equipment.

H. Include the following minimum information for wire and cable identification.
   1. Circuit number or load identification tag number.
   2. Origin (from source).
   3. Destination (to load).

3.02 NAMEPLATES

A. Furnish and install nameplates for all electrical equipment indicated on the Drawings or specified.

B. Each disconnect means for service, feeder, branch, or equipment conductors and pushbutton stations shall have nameplates indicating its purpose or identifying the load.

3.03 AUTOMATIC EQUIPMENT WARNING AND HIGH VOLTAGE SIGNS

A. Mount permanent warning signs at mechanical equipment which may be started automatically or from remote locations. Fasten warning signs with round head stainless steel screws or bolts, located and mounted in a manner acceptable to ENGINEER.

B. Mount permanent and conspicuous warning signs on (front and back) equipment, doorways to equipment rooms, pull boxes, manholes, where the voltage exceeds 600 volts.

C. Place a warning ribbon or other effective means suitable for conditions above ductbank underground installations.

D. Place warning signs on utilization equipment that has more than one source of power. Provide panel and circuit number of conductor tag of the power source disconnect.

E. Place warning signs on utilization equipment that has 120 VAC control voltage source used for interlocking. Provide panel, circuit number, and conductor tag of control voltage source disconnect.

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. Communication wire and cable.

1.02 REFERENCES

A. American Society for Testing and Materials (ASTM):
   1. B 3 - Standard Specification for Soft or Annealed Copper Wire.
   2. B 8 - Specification for Concentric-Lay–Stranded Copper Conductors, Hard, Medium-Hard, or Soft.

B. Insulated Cable Engineers Association (ICEA).

C. National Electrical Code (NEC):
   1. Article 250 - Grounding.
   2. Article 310 - Conductors for General Wiring.
   3. Article 760 - Fire Alarm Systems.

D. Underwriter's Laboratories Inc., (UL):
   1. UL 1277 Subject - Electrical Power and Control Tray Cables with Optional Optical-fiber Members.

1.03 SUBMITTALS

A. Shop Drawings: Show splice locations.

B. Product Data: Include wires, cables, pulling compounds, and splicing materials.

1.04 QUALITY ASSURANCE

A. Conform to ASTM and ICEA standards.

B. Furnish mechanical conductor connector and heat-shrink type insulation by same manufacturer.

PART 2 PRODUCTS

2.01 WIRE AND CABLE MATERIALS

A. Conductors: ASTM B 8, soft drawn copper, maximum 12 months old, minimum 97 percent conductivity. American Wire Gauge (AWG) sizes as indicated on the Drawings, Class B or C stranded.

B. Insulation Thickness: Minimum specified by NEC Article 310.

C. Conductor Sizes: As indicated on wiring schedules and Drawings.

2.02 600-VOLT CLASS CABLE

A. Power Wire and Cable:
   1. Manufacturers: One of the following or equal:
      a. Okonite Company.
      b. BICC Cable.
      c. Rockbestos Company.
      d. Southwire.

B. Control Wire and Cable:
   1. Manufacturers: One of the following or equal:
      a. Okonite Company.
      b. BICC Cable.
      c. Rockbestos Company.
      d. Southwire.

C. Insulation for Individual Wires or Multiple Conductor Cable for Power and Control Circuits:
   1. Type XHHW-2 insulation for use in dry and wet locations and underground ductbanks.

D. Jackets for Multiple Conductor Cable for Power and Control Circuits: Type CPE.

E. Tray Cable:
   1. Minimum size Number 1/0 AWG for single wires.
   2. Multi-conductor cable listed and identified on its surface as suitable for cable tray use, Type TC cable in accordance with NEC Article 392.
   3. Multi-Conductor Cables Requiring Connection to Neutral: Provided with integral white insulated conductor with ambient temperature adjustment in accordance with NEC Table 310-16.

F. Multi-Conductor Cable Insulated Grounding Conductors:
   1. Color: Integral green.
   2. Sizes: In accordance with NEC 250-122.

G. Solid-conductor wire, Number 12 AWG and smaller, may be used only for lighting and receptacle circuits.

2.03 INSTRUMENTATION CLASS CABLE

A. Single Pair or Triad Applications:
   1. Manufacturers: One of the following or equal:
      a. The Okonite Company, Okoseal-N Type P-OS.
      b. Equivalent manufactured by Cooper Industries, Belden Wire and Cable Division.

B. Multiple Pair or Triad Applications:
   1. Manufacturers: One of the following or equal:
      a. The Okonite Company, Okoseal-N Type SP-OS.
      b. Equivalent manufactured by Cooper Industries, Belden Wire and Cable Division.

C. Approved for cable tray installation in accordance with the National Electrical Code.

D. Number of Individually Shielded, Twisted Pairs and Triads: As indicated on the Drawings or as necessary for the application.

E. Voltage Rating: 600 volts.

F. Cable Type: TC.

G. Temperature Rating: 90 degrees Celsius dry location, 75 degrees Celsius wet location.

H. Conductors: Bare, soft annealed copper in accordance with ASTM B 3, Class B, 7-strand concentric in accordance with ASTM B 8.

I. Conductor Insulation: Flame-retardant polyvinyl chloride, 15 mils nominal thickness, with nylon jacket 4 mils nominal thickness, 90 degrees Celsius temperature rating in accordance with Underwriter's Laboratory Subject 1277.

J. Color Code: Provide conductor color code as specified in Section 16075.

K. Single Pair or Triad Shielding:
   1. Group Shielding: Minimum 1.35 mil double-faced aluminum/synthetic polymer-backed tape overlapped to provide 100 percent coverage.
   2. Drain Wire: 7-strand tinned copper drain wire, 2 sizes smaller than conductor.

L. Multiple Pair or Triad Shielding:
   1. Group Shield: 1.35-mil aluminum-polyester tape overlapped to provide 100 percent coverage and a 7-strand tinned copper drain wire, 2 sizes smaller than conductor. Completely isolate group shields from each other.
   2. Cable Shield: 2.35 mils double-faced aluminum and synthetic polymer backed tape overlapped to provide 100 percent coverage and a 7-strand tinned copper drain wire, same size as conductors.

M. Jacket: Black, flame-retardant in accordance with Underwriter's Laboratory Subject 1277, 90 degrees Celsius temperature rating, rip cord laid longitudinally under jacket to facilitate removal.

N. Conductor Size: Number 16 AWG minimum unless otherwise indicated on the Drawings.

O. Numerically identify one conductor within each pair and triad.

2.04 COMMUNICATION CABLE

A. Manufacturers: One of the following or equal:
   1. Cooper Industries, Belden Wire and Cable Division.
   2. American Telephone and Telegraph.

B. Number of Twisted Pairs: As indicated on the Drawings.

C. Voltage Rating: 300 volts.

D. Insulation: Thermoplastic, color-coded in accordance with telephone industry standards.

E. Jacket: High molecular weight polyethylene, surface printed with year of manufacture and cable description at maximum 24 inch intervals.

F. 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.

G. Inner Jacket: High molecular weight polyethylene, able to provide strength and surge barrier.

H. Conductors: ASTM B3, solid, soft, bare copper.

I. Conductor Size: Minimum Number 22 AWG , unless otherwise indicated on the Drawings.

J. Fabrication:
   1. Twist insulated conductors into pairs with varying lengths of lay.
   2. Apply non-hygroscopic core tape over cable core as a dielectric and heat barrier.

2.05 RELATED MATERIALS

A. Splicing Material:
   1. In conformance with ANSI C119.1, IEEE 383, and ICEA 5-19-81.
   2. Manufacturers: One of the following or equal:
      a. Elastimold.
      b. Thomas-Betts.
      c. Raychem, FCSM Series.

B. Wire Nuts:
   1. Rated 600 volt with live-spring feature for tight fitting connections.
   2. Manufacturers: One of the following or equal:
      a. 3M.
      b. Thomas and Betts.

C. Junction Boxes and Terminal Cabinets: As specified in Section 16134.

D. Pulling Compound: As recommended by conductor manufacturer.

2.06 WIRE AND CABLE FABRICATION

A. Permanently mark American Wire Gauge (AWG) size, grade of insulation, voltage, and manufacturer's name on outer covering at maximum 24-inch intervals.

B. Identify and mark conductors in accordance with NEC Article 310.

C. Color code wire and cable as specified in Section 16075.
   1. Integrally color insulation for Number 2 AWG and smaller.
   2. Wrap colored tape around cable larger than Number 2 AWG.

D. Fabricate cable ends with provisions for field testing.

2.07 SOURCE QUALITY CONTROL

A. Test full lengths in accordance with ASTM and ICEA Standards.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install continuous circuit conductors from source to load without splices or terminations in intermediate manholes or pull boxes, except for Number 10 AWG and smaller conductors for lighting and receptacles.

B. Splices:
   1. Where splices are necessary because of extremely long wire or cable lengths that exceed standard manufactured lengths, install and label junction boxes for power conductors or termination cabinets for control and instrument conductors.
   2. Power and control conductors routed in common raceways may be spliced in common junction boxes.
   3. Install NEMA 4X junction and terminal boxes in wet and outdoor locations. Clearly label junction and terminal boxes containing splices with the word "SPLICE."
   4. Leave sufficient slack at junction boxes and termination boxes to make proper splices and connections. Do not pull splices into conduits.

C. Properly coat wires and cables with pulling compound before pulling into conduits and prevent mechanical damage to conductors during installation.

3.02 600-VOLT CLASS CABLE

A. Size power conductors in accordance with National Electrical Code when sizes are not indicated on the Drawings.

B. Install minimum Number 12 AWG wiring for power circuits unless otherwise specified or indicated on the Drawings, and minimum Number 14 AWG for control wiring unless otherwise specified.

C. Install minimum 14 AWG for internal panel control wiring with type MTW or SIS insulation.

D. Do not exceed cable manufacturer's pulling tension and side-wall pressures.

E. Terminations and Splices (600 Volt or Less):
   1. Terminations: Terminate control and instrument conductors in terminal boxes in accordance with Section 16134.
   2. Splicing: Join conductors mechanically with splice connectors and install heat-shrink type insulation. Splice conductors in accordance with manufacturer's instructions. Make waterproof heat shrink type splices in wet and below grade locations.
   3. Splice or weld grounding conductors of different sizes.
   4. Conductor Number 10 AWG and smaller for lighting and receptacle circuits may be spliced in junction boxes with wire nuts.

F. All conductors of size No. 10 AWG and smaller for installation in cable trays and continuing without splices via other conduits; they shall be of the multi-conductor type with overall jacket.

3.03 INSTRUMENTATION CLASS CABLE

A. Install instrumentation class cables in separate raceway systems.
   1. Install instrument cable in metallic conduit within non-dedicated manholes or pull boxes.
   2. Install cable without splices between instruments or between field devices and instrument enclosures or panels.

B. Do not make intermediate terminations, except in designated terminal boxes indicated on the Drawings.

C. Ground cable shields at only one location, typically at panels, not at field instruments.

3.04 COMMUNICATION CABLE

A. Install communication cables in dedicated raceways, including through ductbanks, manholes, and pull boxes.

3.05 SIGNAL CABLE AND CONDUIT INSTALLATION

A. Separate and isolate electrical signal cables from sources of electrical noise and power cables by minimum 12 inches.

3.06 FIELD QUALITY CONTROL

A. Testing: As specified in Section 16950.

B. Grounding: As specified in Section 16062.

3.07 WIRING ALLOWANCES

A. CONTRACTOR shall include allowance of necessary conductors and termination to provide any and all motorized equipment, electrical outlets, fixtures, communication outlets, instruments, and devices within 10 linear feet of location shown on the Drawings.

B. CONTRACTOR shall include allowance of necessary conductors and related materials to provide any and all pull boxes, manholes and ductbanks within 20 linear feet of location shown on the Drawings.

C. Prior installation of any raceway or related items identified in paragraphs A and B above, the Owner shall have the right to make changes related to preferred location, at no additional cost.

D. CONTRACTOR shall include allowance to provide necessary conductors for all equipment specified, identified in wiring/raceway schedules, equipment schedules, panelboards schedules, electrical single line diagrams, block diagrams, process and instrumentation diagrams (P&IDs), fixture schedules, and devices. Said necessary conductors may-not be shown on the plan drawings, but they shall be sized by CONTRACTOR in accordance with requirements of the National Electrical Code, and included in this allowance if the conductors are necessary for the complete operation of the included device or equipment.

END OF SECTION

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SECTION 16125

FIBER OPTIC CABLE AND APPURTENANCES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes requirements for:
   1. Fiber optic cable:
      a. Fiber splices and terminations.
      b. Related accessories.

B. The Contract Documents are a single integrated document, and as such all Divisions and Sections apply. It is the responsibility of the CONTRACTOR and its subcontractors to review all sections to ensure a complete and coordinated project.

C. Furnish a complete fiber optic network as indicated on the Drawings, shown on the cable or system block diagrams.

1.02 REFERENCES

A. Refer to 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.”

F. U.S. Department of Agriculture, Rural Electrification Agency REA-PE-90, "Totally Filled Fiber Optic Cable.”

1.03 DEFINITIONS

A. Refer to Sections 16050 and 17050.

1.04 SUBMITTALS

A. Furnish submittals in accordance with Sections 01330 and 16050.

B. Product Data:
1. Complete manufacturer’s brochures that identify materials and options. Mark-up to clearly show options and components to be provided, and cross out any options or components that are not provided.
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 01340.

F. Test Reports:
   1. Submit the results of all tests specified 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.

1.05 QUALITY ASSURANCE

A. Refer to 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.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Refer to 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.

1.07 PROJECT OR SITE CONDITIONS

A. Refer to Section 16050.

1.08 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.

1.09 SCHEDULING

A. Refer to Section 16050.

1.10 WARRANTY

A. Refer to Section 16050.

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 MANUFACTURED UNITS

A. General fiber cable requirements:
   1. Suitable for the installed environment.
   2. Color-coded fibers according to EIA/TIA-598, "Color Coding of Fiber Optic Cables."
   3. Color-coded buffer tubes according to EIA/TIA-598, "Color Coding of Fiber Optic Cables."

4. Furnish buffer tube of a single layer nylon construction of 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) 2670 N (600 lbf) for armored cables, 1334 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/centimeters applied uniformly over the length of the cable.
    c. Armored fiber optic cables: compressive load withstand of 440 N/centimeters 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. Outside Plant Cable:
   1. General:
      a. Application: Outside of structures.
   2. Cable Construction:
      a. Cable Type: Outdoor only:
         1) Completely preventing the entrance of water.
      b. Fiber Count: 12 pair.
      c. Fiber Type: Multimode.
      d. Buffer Tube: Loose Tube.
      e. Armoring: None.
      f. Strength Member: Central nonmetallic strength member with a coefficient of thermal expansion similar to the fibers.
      g. Design and Test Criteria: ICEA S-87-640.
   3. Where required, fill each buffer tube with a non-hygroscopic, non-nutritive to fungus, electrically non-conductive, homogenous gel, that is free from dirt and foreign matter:
      a. The gel to be readily removable with conventional non-toxic solvents.
   4. Armored cables constructed with an inner sheath of low or medium density polyethylene:
      a. Minimum inner sheath jacket thickness of 0.5 millimeters.
      b. Armor constructed of a corrugated stainless steel tape, plastic-coated on both sides for corrosion resistance, and applied with an overlapping seam with the corrugations in register.
      c. Recoat all armor splices with plastic to further enhance the armor's corrosion resistance.
      d. Outer jacket:
         1) Apply over the corrugated steel tape armor.
         2) Low or medium density polyethylene with a minimum nominal jacket thickness of 1.25 millimeters.
         3) Provide the polyethylene containing carbon black to provide ultraviolet light protection and that does not promote the growth of fungus.
   5. Loose-tube cables shall exhibit no flow (drip or leak) at 80 degrees Celsius:
      a. Weight of any compound that drips from the sample: Less than 0.05 grams (0.002 ounce).
      b. Test a representative sample of cable in accordance with FOTP-81, "Compound Flow (Drip) Test for Filled Fiber Optic Cable:"
         1) Prepare the test sample in accordance with method A.
   6. Manufacturers: One of the following or equal:
      a. ADC/KRONE loose tube outside plant cable.
      b. Berk-Tek.
      c. Corning Cable Systems.
      d. Pirelli.

C. Indoor Cable:
   1. General:
      a. Application: The interior of structures where exposure to moisture can be minimized.
   2. Cable Construction:
      a. General:
         1) Cable Type: Indoor - Flame Retardant, Low Smoke, Zero Halogen.
         2) Fiber Count: 12 pair.

3) Fiber Type: Multimode.
4) Buffer Tube: Loose Tube.
5) Armoring: None.
6) Strength Member: Central nonmetallic strength member with a coefficient of thermal expansion similar to the fibers.
7) Approvals and Listings: NEC.
8) Design and Test Criteria: S-83-596.

b. Testing:
1) All fibers in the cable: proof test of 100 kpsi.
2) Each optical fiber: Bellcore GR-409 strip force testing.
3) 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 areas (excluding plenums) without being enclosed in conduit.
4) Flame retardant riser rated conforming to UL 1666.
5) Printed with all necessary UL marks and manufacturer identification.
6) With sequential printing of footage in 2-foot increments.
7) With a ripcord incorporated under the cable jacket.

D. 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: 12 pair.
3) Fiber Type: Multimode.
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) Corning Cable Systems Freedm® One (OFNR Tight-Buffered).
   3) KRONE LSZH, Indoor/Outdoor (OFNR) distribution cables.

E. 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 +/- 0.7µm.
d.	Cladding Non-circularity:	< .7 percent.
e.	Numerical Aperture:	14 +/-0.015.
f.	Maximum Attenuation:	.4 dB/km @ 1310 nm. .3 dB/km @ 1550 nm.
g.	Gigabit Ethernet Distance:	5000 m @ 1310 nm.
h.	Coating Diameter:	245 +/- 5 µm.
i.	Cabled Cutoff Wavelength:	< 1260.
j.	Mode-Field Diameter:	9.2 +/- 0.4 µm @ 1310 nm 10.4 +/- 0.5 µm @ 1550 nm.
k.	Zero Dispersion Wavelength:	1313 nm.
l.	Dispersion Slope:	.086 ps/(nm^2*km).

4. Manufacturers: One of the following or equal:
   a. ADC/KRONE Group.
   b. Berk-Tek.
   c. Corning Cable Systems.

F. Multimode 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. Multimode fiber characteristics:

a.	Fiber Type:	Multimode.
b.	Core Diameter:	62.5 +/-2.5 µm.
c.	Clad Diameter:	125 +/-2.0 µm.
d.	Core-to-Cladding Offset:	3.0 µm.
e.	Cladding Non-Circularity:	< 1 percent.
f.	Numerical Aperture:	0.275 +/-0.015.
g.	Maximum Attenuation:	3.5 dB/km @ 850 nm. 1 dB/km @ 1300 nm.
h.	Minimum Bandwidth:	200 MHz*Km @ 850 nm. 500 MHz*Km @ 1300 nm.
i.	Coating Diameter:	245 +/- 5 µm.
j.	Cabled Cutoff Wavelength:	N/A.
k.	Mode-Field Diameter	N/A.
l.	Zero Dispersion Wavelength:	N/A.

2.03 ACCESSORIES

A. Patch Cords:
   1. General:
      a. Connector types to match supplied equipment and the patch panel terminations.
      b. Provide 2 spare patch cords (or 1 duplex patch cord) of each type used at each PLC or network cabinet.
      c. Factory assembled and optically tested.
   2. Manufacturers: One of the following or equal: KRONE, Corning Cable Systems.
      a. Multimode:
         1) 62.5 SC/SC duplex patch cords.
         2) 62.5 SC/ST duplex patch cords.
         3) 62.5 ST/ST duplex patch cords.
      b. Single Mode:
         1) Single Mode SC/SC duplex patch cords.
         2) Single Mode SC/ST duplex patch cords.
         3) Single Mode ST/ST duplex patch cords.

B. Fiber Connectors:
   1. Provide heat-cured epoxy and polish kit type fiber optic cable connectors:
      a. Including, but not limited to, all necessary items to perform the connections and polishing:
         1) Connectors.
         2) Hardware.
         3) Tools.
         4) Epoxy.
         5) Oven.
   2. Provide type SC terminations with composite hardware, oven-cured epoxy, and composite or ceramic ferrules:
      a. Crimp on or UV-curable connectors are not acceptable.
   3. Provide connectors rated for maximum insertion loss of 0.2 decibels (MM).
   4. Manufacturers: One of the following or equal: KRONE, Corning Cable Systems:
      a. Multimode: epoxy/polish MM connectors.
      b. Single Mode: epoxy/polish SM connectors.

2.04 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 2700 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 conduit spans:
   1. Run the test 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. Refer to Section 16050.

B. Install all fiber optic system components in accordance with the recommendations of the manufacturer.

C. Install fiber optic cable in continuous lengths without intermediate splices, except where approved by the ENGINEER.

D. 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.
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.

E. After the cables are installed and spliced:
   1. Rack.
   2. Seal spare conduits.
   3. Leave a minimum of 20 feet of fiber optic cable at each end of splice.

4. Racking requirements:
    a. Loosely secured in racked position with Ty-Raps or equal.
    b. Attach imprinted plastic coated cloth identification/warning tags to the cables in at least 2 locations in each handhole. As Manufactured by Brady or Thomas & Betts.
    c. Protect all coiled cable to prevent damage to the cable and fibers.
    d. Secure cables to brackets and racking hardware that extend from the sidewalls of the handhole.
    e. After all cables at each handhole are securely racked, seal unused conduits and void areas around conduit containing cables using Semco or equal material.

F. Armored fiber optic cables containing metallic members shall be grounded per the requirements of Article 770 of the National Electrical Code.

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, rearranagable, 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.

H. Terminations:
1. Terminate outdoor cables using a breakout kit that seals the cable and provides physical protection for the fiber strands.

2. Terminate indoor 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 according with Section 16075 requirements for the labeling of cables.

3.04 FIELD QUALITY CONTROL

A. Refer to 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 1310 and 1550 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.

3.05 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.

3.06 PROTECTION

A. Refer to Section 16050.

B. Protect the fiber system from physical damage and the encroachment of dust, before, during and after installation.

END OF SECTION

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SECTION 16133

CONDUITS

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Galvanized rigid steel conduit.
   2. Liquid-tight flexible conduit.
   3. Polyvinyl chloride-coated rigid steel conduit.
   4. Rigid nonmetallic polyvinyl chloride conduit.
   5. Explosion-proof flexible conduit.

1.02 REFERENCES

A. American National Standards Institute (ANSI):
   1. C80.1 - Rigid Steel Conduit, Zinc Coated.

B. Electrical Manufacturers Association (NEMA):
   1. RN-1 - Polyvinyl Chloride (PVC) Externally Coated Galvanized Rigid Steel Conduit and Intermediate Metal Conduit.

C. National Electrical Code (NEC):
   1. Table 300-5 - Minimum Cover Requirements (0 to 600 volts, Nominal).
   2. Article 500 - Hazardous (Classified) Locations.

D. Underwriters Laboratories, Inc (UL):
   1. UL 6 - Rigid Metal Conduit.

1.03 SUBMITTALS

A. Product data.

PART 2 PRODUCTS

2.01 CONDUIT

A. Galvanized Rigid Steel Conduit:
   1. Domestic raw steel, made smooth, clean, and free of burrs and rough spots to enhance wire pulling; interior and exterior surfaces coated with solid, unbroken layer of zinc; threads hot dip galvanized after cutting; entire surface finish coated with secondary bichromate treatment applied over galvanizing able to extend surface protection and prevent oxidation; threads protected by color coded end caps to provide quick trade size identification.
   2. Manufacturers: One of the following or equal:
      a. LTV Steel Tubular Products Company, Galvite.
      b. Triangle PWC, Inc.
      c. Allied Tube and Conduit Corporation.

B. Liquid-tight Flexible Conduit:
   1. Grounding type, weatherproof, watertight, maximum 60-inch lengths.
   2. Manufacturers: One of the following or equal:
      a. American Brass Company.
      b. General Electric.
      c. Ocal, Inc.
   3. Explosion proof flexible conduit: Manufacturer:
      a. O-Z/Gedney
      b. Or approved equal.

C. Polyvinyl Chloride-coated Rigid Steel Conduit:
   1. Galvanized rigid steel conduit with coating conforming to ANSI C80.1 and UL 6; bendable without damage to coatings.
   2. Manufacturers: One of the following or equal:
      a. Perma Kote by Robroy Industries.
      b. Ocal, Inc.

D. Rigid Nonmetallic Polyvinyl Chloride Conduit:
   1. High density, Schedule 40, 90 degrees Celsius, heavy-duty polyvinyl chloride, made from virgin polyvinyl chloride compound; maximum 6 grams per 100 grams smoke emission.
   2. Manufacturers: One of the following or equal:
      a. Carlon.
      b. Triangle Conduit and Cable.

2.02 RELATED MATERIALS

A. Couplings, Connectors, and Fittings:
   1. Threaded.
   2. Manufactured with same materials and process as corresponding conduit.

B. Condulet Fittings:
   1. With wedge nut covers, weathertight when located outdoors or in wet or corrosive locations indicated on the Drawings, matching type for corresponding conduit systems.
   2. Manufacturers: One of the following or equal:
      a. Crouse-Hinds.
      b. Appleton.

C. Galvanized Rigid Steel Conduit Expansion Fittings for Exposed Locations:
   1. Manufacturers: One of the following or equal:
      a. OZ/Gedney, Type AX with jumper.
      b. Appleton, Type XJ with Jumper.

D. Galvanized Rigid Steel Conduit Expansion Fittings at Structural Expansion Joints:
   1. Manufacturers: One of the following or equal:
      a. Spring City, Type D.
      b. Crouse-Hinds, Type D.

E. Conduit Seals:
   1. Manufacturers: One of the following or equal:
      a. Appleton.
      b. Crouse-Hinds.

F. Polyvinyl Chloride-coated Rigid Steel Conduit Couplings: One provided loose with each length of conduit.

G. Fasteners for Polyvinyl Chloride-Coated Rigid Steel Conduit: Polyvinyl chloride-coated steel fasteners with Type 316 stainless steel bolts, nuts, and hardware.

H. Fasteners for Galvanized Rigid Steel Conduit: Galvanized steel fasteners with Type 316 stainless steel bolts, nuts, and hardware.

I. Conduit Mounting Strut:
   1. Type 316 stainless steel for mounting of polyvinyl chloride-coated rigid steel conduit.
   2. Hot-dip galvanized for other conduit types.

J. Conduit Thruwall Seals:
   1. Hot-dip galvanize.
   2. Polyvinyl chloride oversize sleeve.
   3. Manufacturers: One of the following or equal:
      a. O-Z/Gedney, Type "WSK."

2.03 POLYVINYL CHLORIDE-COATED RIGID STEEL CONDUIT FABRICATION

A. Coat rigid steel conduit, conduit fittings, and hangers with polyvinyl chloride.

B. Conduit:
   1. Ensure that surfaces, including galvanizing, remain intact and undisturbed on both inside and outside of conduit throughout preparation and application processing.
   2. Bond polyvinyl chloride coating to outer surfaces of conduit except threads.
   3. Provide bond between polyvinyl chloride coating and conduit surface that is greater than tensile strength of plastic.
   4. Provide minimum 40-mil thick coating on conduit.
   5. Coat interior of conduit and condulet fittings with nominal 2-mil thick corrosion-resistant urethane finish.
   6. Coat threads with clear urethane finish.

C. Couplings:
   1. Bond polyvinyl chloride coating to outer surfaces of couplings.
   2. Extend polyvinyl chloride sleeve equal to outside diameter of uncoated conduit beyond both ends of coupling approximately 1 pipe diameter or 1-1/2 inches, whichever is smaller.
   3. Provide minimum 40-mil thick coatings on couplings and sleeves.
   4. Bond polyvinyl chloride coating to outer surface of conduit bodies and fittings.
   5. Extend polyvinyl chloride sleeves from hubs.
   6. Provide same coating thickness on conduit bodies, fittings, and sleeve walls as on couplings in length and thickness.
   7. Coat covers on conduit bodies on both sides so covers are completely interchangeable.
   8. Coat interior of conduit couplings, sleeves, and conduit bodies with corrosion-resistant urethane finish.

D. Ensure that inside of conduit bodies remain undisturbed during processing and retain manufacturer's finish.

E. Polyvinyl Chloride Coated, Mounting Hardware, and Associated Fittings:
   1. All mounting hardware and associated fittings shall be polyvinyl chloride coated in accordance with the intent of reference NEMA RN-1.
   2. The polyvinyl chloride exterior coating shall have a normal thickness of 40 mils (.040 inch) except where part configuration or application otherwise dictate.
   3. All fasteners for polyvinyl chloride coated fittings and mounting hardware shall be of the Type 316 stainless steel.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install conduit runs in accordance with schematic representation as indicated on the Drawings and as specified. Modify conduit runs to suit field conditions, as accepted by the ENGINEER.

B. Install conduit runs for lighting and receptacle circuits, whether or not indicated on the Drawings, for circuit numbers indicated on the Drawings.

C. Install straight and true conduit runs with uniform and symmetrical elbows, offsets, and bends. Make changes in direction with long radius bends or with condulet fittings.

D. Install conduit runs so that runs do not interfere with proper and safe operation of equipment and not block or interfere with ingress or egress, including equipment removal hatches.

E. Expose conduit runs in buildings and structures, unless otherwise indicated on the Drawings.

F. Securely fasten exposed conduits with clamps or straps. Run exposed conduit on walls and ceilings only, parallel to planes of walls or ceilings. Do not run conduit diagonally. Securely fasten exposed polyvinyl chloride-coated rigid steel conduits with Type 316 stainless steel clamps or straps.

G. Use flexible conduit for short lengths required to facilitate connections between rigid conduit and motors, vibrating equipment, or control equipment.

H. Support conduit runs on water-bearing walls 1 inch away from wall on an accepted channel. Use hot-dip galvanized steel or stainless steel channels, consistent with type of conduit being installed. Do not run conduit in water-bearing walls unless otherwise indicated on the Drawings.

I. Encase underground conduit runs, including conduit runs below slabs-on-grade, in a concrete envelope as specified in Section 03300 and indicated on the Drawings.

J. Install underground installations of direct buried cable, conduit, or other raceways to meet minimum cover requirements of NEC Table 300-5. Exceed minimum NEC requirements where indicated on the Drawings or specified.

K. Thoroughly ream conduit after threads have been cut to remove burrs. Seal joints with accepted conductive sealant compound and make watertight. Set up joints tight. Use bushings or conduit fittings at conduit terminations.

L. Install runs between pull boxes or junction boxes with total bends equaling not more than 360 degrees. Install NEC required pull boxes at locations acceptable to the ENGINEER. Plug conduits brought into pull boxes, manholes, handholes, and other openings until used to prevent entrance of moisture. Cap spare conduits and provide plastic pulling tape below threaded cap. Provide bonding bushing and bond wire.

M. Provide appropriate hangers, supports, fasteners, and seismic restraints to suit applications.

N. After complete installation of 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. Remove and replace conduits through which mandrel will not pass.

O. Clean and ensure that new and existing conduit runs are not crushed or creased. Verify internal dimensions of existing conduit prior to installation of conductors. Verify that no foreign objects or obstructions are present in conduit prior to installing conductors.

P. Install conduit system to provide firm mechanical assemblies with electrical conductivity throughout.

Q. Install expansion fittings across expansion joints and at other locations where necessary to compensate for thermal or mechanical expansion and contraction as indicated on the Drawings.

R. Install conduits complete between outlets, boxes, and circuit source before conductors are installed.

S. Install minimum 2-inch ductbank raceways, unless otherwise indicated on the Drawings.

T. Make ductbank raceway to external conduit size transitions at pullboxes and manholes.

U. 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 pullboxes.

V. Install conduit thruwall seals where indicated on the Drawings.

3.02 POLYVINYL CHLORIDE-COATED RIGID STEEL

A. Attach cover to conduit body with Type 316 stainless steel screws.

B. Where patching is required, apply 40-mil thick polyvinyl chloride coating in accordance with manufacturer's instructions.

3.03 RIGID NONMETALLIC POLYVINYL CHLORIDE

A. Reinforce encasement as indicated on the Drawings. Install conduit supports at 30-inch intervals.

3.04 CONDUIT SEALS

A. Install conduit entering or leaving NEC Article 500 hazardous areas with conduit seals.

B. Install conduit entering or leaving chlorination facilities, or areas of buildings in which chlorine storage or distribution equipment is located with conduit seals.

C. Install conduit seals in other hazardous locations as required by NEC.

D. Provide drains on conduit seals in locations where water accumulation is likely to enter a device or enclosure.

3.05 SCHEDULES

A. Conduit Sizes: In accordance with NEC, unless otherwise indicated on the Drawings or specified as follows:
   1. Concealed conduit in partitions or accessible ceilings: Minimum 3/4 inch.
   2. Exposed Conduit: Minimum 3/4 inch.
   3. Rigid Steel Encased In Concrete: Minimum 1 inch.
   4. Rigid Non-metallic Polyvinyl Chloride Encased In Concrete: Minimum 2 inches.
   5. Direct Buried Conduit Size: Minimum 2 inches.

B. Conduit Uses and Applications:
   1. Rigid Steel Conduit: Exposed Conduit Runs in dry and non-corrosive locations.
   2. Polyvinyl Chloride-Coated Rigid Steel Conduit:
      a. Entering or exiting concrete including minimum 12 inches above and below grade or finished floor.
      b. In corrosive NEMA 4X designated areas, NEMA 6 designated areas, and NEMA 7 designated areas.
      c. In exposed outdoor locations.
   3. Liquid Tight Flexible Conduit: Exposed connection as specified herein, and final motor and instrument connection in non-hazardous areas.
   4. Flexible Metal Conduit: Not used.
   5. Electrical Metallic Tubing: Not used.
   6. Rigid Nonmetallic Polyvinyl Chloride Conduit: Runs concealed or concrete encased in walls, floors, and underground duct banks.
   7. Explosion Proof Flexible Conduit: Final connection of equipment in hazardous areas or wherever Flexible Conduit is required in Class I, Div. I area.

3.06 RACEWAYS ALLOWANCES

A. CONTRACTOR shall include allowance of necessary raceways and supports to provide any and all motorized equipment, electrical outlets, fixtures, communication outlets, instruments, and devices within 10 linear feet of location shown on the Drawings.

B. CONTRACTOR shall include allowance of necessary raceways, trench, excavation, backfill, and related materials to provide any and all pull boxes, manholes, and ductbanks within 30 linear feet of location shown on the Drawings.

C. Prior to installation of any raceway or related items identified in paragraphs A and B above, the Owner shall have the right to make changes related to preferred location, at no additional cost.

D. CONTRACTOR shall include allowance to provide necessary raceways for all equipment specified, identified in wiring schedules, equipment schedules, panel boards schedules, electrical single line diagrams, block diagrams, process and instrumentation diagrams (P&IDs), fixtures schedules, and devices. Said necessary conduits may not be shown on the plan drawings, but they shall be sized by CONTRACTOR in accordance with requirements specified and the National Electrical Code, and include in this allowance, the raceways necessary for the installation of the conductors and for the complete operation of the included device or equipment.

3.07 RACEWAYS IDENTIFICATION

A. Each new conduit, new wireway, and new boxes shall be identified by a specific number. The numbering system shall be in accordance with identification named on the Drawings or the process equipment identification. Products for identification of raceways are specified in Section 16075.

END OF SECTION

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SECTION 16134

BOXES

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Outlet boxes, device boxes, metallic pull boxes, junction boxes, termination boxes.
   2. Concrete pull boxes.
   3. Fasteners used with wiring devices.
   4. All boxes shall be UL labeled.

1.02 REFERENCES

A. American National Standards Institute/National Electrical Manufacturers Association (ANSI/NEMA):
   1. OS1 - Sheet-Steel Outlet Boxes, Device Boxes, Covers, and Box Supports.
   2. OS2 - Nonmetallic Outlet Boxes, Device Boxes, Covers, and Box Supports.

B. National Electrical Code (NEC):
   1. Article 314 - Outlet, Device, Pull and Junction Boxes, Conduit Bodies and Fittings.

C. National Electrical Manufacturers Association (NEMA):
   1. NEMA FB1 - Fittings, Cast Metal Boxes, and Conduit Bodies for Conduit and Cable Assemblies.
   2. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum).

1.03 SUBMITTALS

A. Product Data.

B. Shop Drawings: Include identification and sizes of pull boxes for ENGINEER's acceptance prior to fabrication and installation.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Device Boxes, Metallic Pull Boxes and Junction Boxes: One of the following or equal:
   1. Crouse-Hinds.
   2. Appleton.
   3. O-Z/Gedney

B. Floor Outlet Boxes with 1 Inch Conduit Knockouts: One of the following or equal:
   1. Steel City, 640 Series.

2. Hubbell.

C. Concrete Pull Boxes with Covers: One of the following or equal:
1. Quickset.
2. Utility Vault Company.

2.02 DEVICE BOXES AND JUNCTION BOXES

A. Materials: Heavy-duty rigid steel or rigid copper free aluminum, compatible with the location and conduit system being used, unless otherwise specified or indicated on the Drawings.

B. For Indoor or Non-corrosive Areas: Provide cast FD type device boxes with epoxy finish, and compatible with the location and conduit system being used.

C. For Outdoor Locations, Corrosive Areas, or Wet Process Locations: Provide cast FD type boxes with PVC coating for outdoor locations, corrosive areas and wet process locations and compatible with the location and conduit system being used.

D. Coverplates:
1. Indoor: Provide lighting switch and receptacle boxes of Type 316 stainless steel cover plates with cover gaskets, except where otherwise specified or indicated on the Drawings. Provide other boxes with Type 316 stainless steel cover screws and with cover gaskets.
2. Outdoor and Corrosion Resistant: Provide lighting switch and receptacle boxes, weatherproof with yellow fiberglass lift cover plates with cover gaskets.

2.03 FLOOR OUTLET BOXES

A. Suitable for receptacles, communications and data outlets as specified and indicated on the Drawings, complete with gaskets and cover plates.

B. Dual-gang, heavy-duty cast iron, suitable for wiring devices to be installed to make a complete and operable system and installation.

2.04 CONCRETE PULL BOXES

A. Precast concrete pull boxes in locations indicated on the Drawings and as required by NEC.

B. Designed for heavy traffic conditions, with pull box and cover designed for heavy traffic bridge loading.

C. Minimum 4 feet by 4 feet by depth as necessary for ductbank depth, required with 3/4-inch diameter pulling irons located at each end. Constructed of reinforced Class A concrete.

D. Identification: Furnish covers with "Electrical" engraved on top side.

2.05 METALLIC PULL BOXES

A. Boxes for applications in dry and non-corrosive locations:

1. Fabricated from 11 gauge (minimum) steel or aluminum, completely weatherproof with gasketed removable covers; compatible with type of conduit systems being used; manufactured, furnished, and installed complete with grounding lug.

B. Boxes for applications in wet areas, outdoor locations and NEMA 4X designated areas: Fabricated from 11 gauge, 316 stainless steel, with gasketed covers and labeled NEMA 4X.

C. Boxes in Locations Subject to Flooding, Temporary Submersion, or for Applications in NEMA 6 Designated Areas: Boxes shall be fabricated of cast aluminum, with gasketed cover, stainless steel cover screws, ground flange and listed NEMA 6.

2.06 FASTENERS

A. Electroplated or stainless steel in boxes with wiring devices.

B. Screws, Nuts, Bolts, and Other Threaded Fasteners: Stainless Steel.

PART 3 EXECUTION

3.01 INSTALLATION

A. General: Comply with the National Electrical Code.

B. Terminal blocks installed in junction/terminal boxes as specified in Section 16050.

C. Install concrete pull boxes on 12 inches of compacted clean aggregate base course as specified in Section 02722, and in such a manner that the cover of the pull box will be flush with finish grade.

D. Provide weatherproof conduit hubs for all conduit connections to metallic pull boxes.

E. Phosphatize and prime with rust-resistant paint metallic pull box surfaces. Finish shall be 2 coats of ANSI 61 gray enamel paint.

F. Size pull boxes to meet National Electrical Code requirements and to provide sufficient room for the future conduits and cables indicated on the Drawings.

G. Furnish and install pull boxes as indicated on the Drawings and as specified. Install additional pull boxes as required to meet cable manufacturer's pulling tension requirements.

H. Install pull boxes such that access to them is not restricted by obstructions such as pipes, valves, ladders.

I. Secure metallic pull box covers with Type 316 stainless steel screws or bolts with coated threads.

J. Provide adequate supporting pillar(s) for boxes to be located above ground or above decks, where there is no structural wall or surface for box mounting.

3.02 ADJUSTMENT

A. Adjust equipment as specified in Section 01756.

END OF SECTION

SECTION 16140

WIRING DEVICES

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes: Wiring devices including the following:
   1. Snap switches and toggle switches.
   2. Fluorescent dimmer switches.
   3. Plugs and receptacles.
   4. Control and push-button stations.
   5. Pilot devices.

1.02 SUBMITTALS

A. Product Data.

1.03 QUALITY ASSURANCE

A. Provide industrial grade products for wiring devices. Commercial grade products are not acceptable, unless otherwise specified or indicated on the Drawings.

B. Coordinate lighting fixture ballasts with dimming switches.

1.04 WARRANTY

A. Submit manufacturer's standard warranty.

PART 2 PRODUCTS

2.01 SNAP OR TOGGLE SWITCHES

A. Manufacturers: One of the following or equal:
   1. Hubbell.
   2. General Electric.
   3. Leviton.
   4. Cooper.

B. Number of Poles: As indicated on the Drawings.

C. Rating: 20 amperes, 125 volt.

D. Special Switches and Covers: As specified or indicated on the Drawings.

2.02 120 VOLT RECEPTACLES

A. Manufacturers: One of the following or equal:
   1. Hubbell.

2. General Electric.
3. Leviton.
4. Cooper.

B. Duplex Receptacles: 2-pole, 3-wire, grounded, 125 volts, industrial, rated at 20 amperes.
1. Special Receptacles and Covers: As specified in Section 16134 or as indicated on the Drawings.

C. Ground Fault Interrupter Receptacles (GFI): Rated at 20 amperes at 125 volts alternating current.

2.03 240 VOLT RECEPTACLES

A. Manufacturers: One of the following or equal:
1. Hubbell.
2. General Electric.
3. Leviton.
4. Cooper.

B. Types: Single and 3-phase; suitable for equipment served.

C. Rating: 20 amperes at 250 volts alternating current, unless otherwise indicated on the Drawings**.**

2.04 480 VOLT PLUGS AND RECEPTACLES

A. Manufacturers: One of the following or equal:
1. Meltric Decontactor.

B. Types: Heavy duty, 3-phase, weather resistant, grounding type, 4-wire, 4-pole device, suitable for equipment served.

C. Rating: 30 amperes at 480 volts alternating current, unless otherwise indicated on the Drawings or specified.

2.05 UNINTERRUPTIBLE POWER SYSTEM RECEPTACLES

A. Manufacturers: One of the following or equal:
1. Hubbell.
2. Square D Company.
3. Leviton.
4. Bryant.
5. Cooper.

B. Type: Surge suppression/isolated ground, orange, minimum 20A rated at 125 volts alternating current, with gasketed cover plate.

2.06 LOCAL PUSH-BUTTON MOTOR CONTROL STATIONS

A. Manufacturers: One of the following or equal:
1. Furnas Electric Company.
2. Square D Company.

3. Allen Bradley.
4. Siemens.
5. Cutler Hammer.
6. General Electric.

B. Types: Heavy duty, oiltight/watertight.

C. Components: Selector Switches, LED pilot light, and push buttons.

D. Enclosures: As follows, unless otherwise indicated on the Drawings or specified:
1. For Nonhazardous Indoor Locations: NEMA 12.
2. For Hazardous Indoor Locations: NEMA 7.
3. For Outdoor Locations: NEMA 4X.
4. For Hazardous Outdoor Locations: NEMA 4 and NEMA 7.

E. Field Located Maintained Push Buttons: Red mushroom head, push-to-stop, pull-to-reset, with maintained contacts.

2.07 PILOT DEVICES

A. Manufacturers: One of the following or equal:
1. Furnas Electric Company.
2. Square D Company.
3. Allen Bradley.
4. Siemens.
5. Cutler Hammer.
6. General Electric.

B. Type: Heavy duty, suitable for mounting in control stations, on switchgear, switchboards, variable frequency drives, motor control centers, control panels, and other electrical equipment.

C. Components: Oiltight/watertight push buttons, selector switches, LED pilot light, and incidental items.

D. Casting: Durable 1 piece with chrome plated octagonal mounting nuts.

E. Push Buttons: Heavy-duty plastic.

F. Pilot Light Lenses: Shatter resistant plastic, push-to-test.

2.08 CORD CONNECTOR GRIPS

A. Non-hazardous Areas:
1. Manufacturers: One of the following or equal:
a. Killark, Series Z.
2. Aluminum cord connector.
3. Stainless steel mesh grip.

B. Hazardous Areas:
1. Manufacturers: One of the following or equal:
a. Killark, Series ZE.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install wiring devices in accordance with manufacturer's instructions.

B. Mount wiring devices as indicated on the Drawings**.**

3.02 LOCAL PUSH-BUTTON MOTOR CONTROL STATION INSTALLATION

A. Install Start-Lockout-Stop push-button control stations adjacent to every motor unless otherwise indicated on the Drawings.

3.03 ADJUSTMENT

A. Adjust wiring devices as specified in Section 01756.

3.04 PROTECTION

A. Protect products until acceptance by OWNER.

END OF SECTION

SECTION 16144

DISCONNECT SWITCHES

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes: Fusible and nonfusible disconnect switches.

1.02 SUBMITTALS

A. Product Data: Include manufacturer's specifications and description.
   1. Include outline drawings with dimensions, and equipment ratings for voltage, capacity, horsepower, and short circuit.

B. Shop Drawings.

C. Manufacturer's Installation Instructions: Indicate application conditions and limitations of use stipulated by Product testing agency specified under Regulatory Requirements. Include instructions for storage, handling, protection, examination, preparation, installation, and starting of Product.

1.03 WARRANTY

A. Submit manufacturer's standard warranty.

1.04 MAINTENANCE

A. Spare Parts: Furnish 1 set of spare fuses for each fused disconnect switch.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Disconnect Switches: One of the following or equal:
   1. Square D Company.
   2. Cutler-Hammer.

2.02 DISCONNECT SWITCHES

A. Type:
   1. Heavy-duty safety switches with a quick-make, quick-break operating mechanism, full cover interlock and indicator handle.
   2. Where required, furnish with fuses where indicated on the Drawings.

B. Unless otherwise specified herein or indicated on the Drawings, disconnect switches shall be in NEMA 12 enclosures for indoor installations and in NEMA 4X enclosures for outdoor installations.
   1. Disconnect switch enclosures shall be compatible with type of conduit system being used.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install devices in accordance with manufacturer's instructions and accepted shop drawings.

B. Provide adequate supporting pillar(s) for disconnect switches to be located above ground or above decks, where there is no structural wall or surface for box mounting.

END OF SECTION

SECTION 16222

MOTORS

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes: Single-phase motors, direct current motors, and 3-phase motors up to and including 200 horsepower.

1.02 REFERENCES

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

B. Institute of Electrical and Electronic Engineers (IEEE).

C. National Electrical Manufacturers' Association (NEMA):
   1. MG-1 - Motors and Generators.

1.03 DEFINITIONS

A. Solid-State Motor Controller: Includes variable frequency drives and solid-state reduced voltage starters.

B. Nominal Efficiency: The average full load efficiency value of a large population of the manufacturer's motors of the same design.

C. Minimum Efficiency: The minimum full load efficiency value of any individual motor associated with the nominal motor efficiency.

1.04 SUBMITTALS

A. Product Data:
   1. Descriptive bulletins.
   2. Outline drawings with dimensions.
   3. Cut-away and exploded view drawings.
   4. Parts list with material designations.
   5. Nameplate data.
   6. Motor weight, frame size, and conduit box location.
   7. Description of insulation system.

B. Design and Performance Data:
   1. Bearing design and bearing life calculations.
   2. Performance Data Required by Schedule A, Nameplate Data, and Following Information:
      a. Service factor.
      b. Efficiency at 1/2 and 3/4 load.
      c. Power factor at 1/2 and 3/4 load.

d. When required for power factor improvement, capacitor size in KVAR with calculation data for motors sized 50 horsepower and above.

3. Special features including condensation heaters and winding temperature detectors.
4. Performance data for motors with synchronous speed of 900 revolutions per minute and below.
5. Factory test reports with test reference standard identified.

1.05 QUALITY ASSURANCE

A. 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. Is suitable for operation with the proposed variable speed drive unit.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Motors: One of the following or equal:
1. Toshiba.
2. General Electric.
3. Reliance.
4. Baldor.

2.02 ELECTRICAL MOTORS

A. General:
1. Manufactured with cast iron frames in accordance with NEMA MG 1, and in accordance with specified requirements.
2. Alternating Current Motors: Squirrel cage induction type suitable for 60-hertz power.
3. Where not otherwise specified or indicated on the Drawings:
   a. Motors 1 Horsepower and Larger: 3-phase, 460 volt.
   b. Motors less than 1 Horsepower: Single phase, 120 volt.
4. 2-speed Motors: Dual winding design.
5. Temperature Rating and Altitude Requirements: Where not otherwise specified or indicated on the Drawings, provide motors that are rated suitable for continuous operation in 40 degree Celsius ambient temperature at project site altitude.
   a. Temperature Rise under Full Load: Not to exceed that for Class B insulation (80 degrees Celsius).
6. Motor Data: Specific motor data including horsepower, speed, and enclosure type are indicated on the Drawings and specified under equipment for which motor is required.
7. Torque and Power of Motors:
   a. Provide motors that develop sufficient torque for required service throughout acceleration range at voltage 10 percent less than motor nameplate rating.
   b. Provide motors that develop sufficient torque when started using reduced voltage starters.

8. Motor Leads and Insulating Material: Insulated leads with non-wicking, non-hydroscopic material. Class F insulation.
9. Grounding Lugs: Provide inside conduit boxes for motor frame grounding.
10. Hardware: Type 316 stainless steel.

B. Provide motors that are special premium efficiency type, except motors that are to be used on hoisting equipment, heat pumps, unit heaters, sump pumps, and lubricating oil transfer pumps.
   1. Provide premium efficiency type motors having nominal full load efficiencies and power factors as specified in Schedule A appended to this Section.
   2. Actual full load efficiency of individual motors within the nominal efficiency band shall not be less than the minimum efficiency value specified in Schedule A.

C. Condensation Heaters:
   1. Use: Required in motors in outdoor applications.
   2. Type: Cartridge or flexible wrap-around type installed within motor enclosure adjacent to core iron.
   3. Rating, Phase and Wattage: Rated for 120 volt, single phase with wattage as required.
   4. Bring power leads for heaters into conduit box.

D. Winding Temperature Detectors:
   1. When specified for individual equipment and on alternating current motors connected to a solid-state motor controller, provide factory installed winding temperature detector with leads terminating in conduit box.
   2. Provide detectors that protect motor against damage from overheating caused by single phasing, overload, high ambient temperature, abnormal voltage, locked rotor, frequent starts, or ventilation failure.
      a. For Motors Less than 200 Horsepower: Provide detector that has normally closed contacts.
      b. For Motors 200 Horsepower and Larger: Provide with resistance temperature detectors, 2 per each phase.
   3. Auxiliary Relays and Controls: Provide relays and controls and mount them in controller enclosure which is suitable for the environment.

E. Internal Cooling Motors: Design motors having speeds of 900 revolutions per minute and less, and motors that are connected to solid-state motor controllers with special attention to internal cooling.

2.03 SINGLE PHASE MOTORS

A. Capacitor start type rated for operation at 115 volts, 60 hertz, unless otherwise specified or indicated on the Drawings.

B. Totally enclosed, fan cooled motors manufactured in accordance with NEMA MG 1-10.35.

C. Ball Bearings: Sealed.

D. 1/2 Horsepower or Less Fan Motors:
   1. Split-phase or shaded pole type when standard for the equipment.

2. Open type when suitably protected from moisture, dripping water, and lint accumulation.

E. 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.

2.04 DIRECT CURRENT MOTORS

A. Designed to operate from 180 volts direct current.

B. Sealed ball bearings having ABMA B-10 life of 60,000 hours or more.

C. Insulation System: NEMA 1-1.65, Class F, resistant to attack by moisture, acids, alkalies, and mechanical or thermal shock.

D. Totally enclosed fan cooled enclosures.

2.05 3-PHASE MOTORS

A. Suitable for 460 volt 3-phase power unless otherwise specified or indicated on the Drawings.

B. NEMA Design B except where driven load characteristics require other than normal starting torque.
   1. Starting kilovolt ampere per horsepower (locked rotor) are not to exceed values specified in NEMA MG-1-10.37.

C. Motor Bearings: Antifriction, regreasable, and filled initially with grease suitable for ambient temperatures to 40 degrees Celsius.
   1. Suitable for intended application and have ABMA B-10 rating life of 60,000 hours or more.
   2. Fit bearings with easily accessible grease supply, flush, drain, and relief fittings using extension tubes where necessary.
   3. Provide two pole motors with sleeve type bearings.

D. Insulation Systems:
   1. Comply with NEMA 1-1.65.
   2. Class F system with Class B temperature rise.
   3. Resistant to attack by moisture, acids, alkalies, and mechanical or thermal shock.

E. Conduit Boxes: Cast iron or stamped steel, split from top to bottom and capable of being rotated to 4 positions.
   1. Provide gaskets between following:
      a. Frames and conduit boxes.
      b. Conduit boxes and box covers.

F. Motor Enclosures: Provide one of the following types:
   1. Open Drip Proof: Stamped steel conduit boxes; 1.15 service factor at 40 degrees Celsius.

2. Totally Enclosed Fan Cooled: Cast iron conduit box; 1.15 service factor at 40 degrees Celsius ambient; 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; upgraded insulation by minimum of 3 dips and bakes and sealer coat of epoxy or silicone.
3. Explosion-proof: 1.15 service factor at 40 degrees Celsius; tapped drain holes with corrosion resistant plugs for frames 286T and smaller and automatic breather and drain devices for frames 324T and larger; UL label for Class I, Division 1, Group D hazardous area.
4. Severe Duty: Corrosion resistant type conforming to motors designated by manufacturer as "Chemical Duty," "Mill and Chemical," "Custom Severe Duty," or similar applicable manufacturer's quality designation with 1.15 service factor at 40 degrees Celsius; 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; epoxy finish; and upgraded insulation using encapsulated or dip and bake windings.
5. Submersible: Watertight casing with insulated windings which are moisture resistant.
   a. Pump Motors Specified to be Submersible: Provide motors having cooling characteristics suitable for continuous operation in totally, partially, or nonsubmerged condition without overheating or other damage.
   b. Electrical Cables: Provide cables of adequate length to allow unit to be wired without splices.

2.06 MOTOR SIZES

A. Motor sizes specified in the Specifications and indicated on the Drawings are minimum sizes.

B. Provide motors, electrical circuits, and equipment of ample horsepower capacity to operate equipment without exceeding rated nameplate horsepower, full-load current at rated nameplate voltage, or overheating at maximum load capacity.

2.07 SOURCE QUALITY CONTROL

A. Factory Testing of 3-Phase Motors:
   1. When specified in individual equipment specifications, factory test motors. Include testing of:
      a. No load current.
      b. Locked rotor current.
      c. Winding resistance.
      d. High potential.
   2. Perform in accordance with applicable NEMA Standards.
   3. Furnish copies of test reports.

B. Efficiency Testing: Factory test in accordance with IEEE 112, using method A or B of Section 5, as appropriate for motor rating.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install motors in accordance with manufacturer's instructions.

3.02 SCHEDULES

A. Schedule A: Full load motor efficiency and power factor rating requirements for premium efficiency, 460 volt, 3-phase horizontal motors.

SCHEDULE A

FULL LOAD MOTOR EFFICIENCY AND POWER FACTOR RATING REQUIREMENTS FOR PREMIUM EFFICIENCY, 460 VOLT, 3 PHASE HORIZONTAL AND VERTICAL MOTORS

		Protected (Open Drip Proof)[1]			Totally Enclosed Fan Cooled[1]		
Nominal Horsepower (Horsepower)	Syn. (revolutions per minute)	Minimum Efficiency (Percent)	Nominal Efficiency (Percent)	Power Factor (Percent)	Minimum Efficiency (Percent)	Nominal Efficiency (Percent)	Power Factor (Percent)
1	1,800	81.5	84.0	70.9	81.5	84.0	77.7
	1,200	78.5	81.5	57.0	78.5	81.5	57.0
1-1/2	3,600	81.5	84.0	86.0	81.5	84.0	86.0
	1,800	81.5	84.0	73.0	81.5	84.0	77.4
	1,200	81.5	84.0	67.8	84.0	86.5	67.8
2	3,600	81.5	84.0	87.7	84.0	86.5	87.7
	1,800	81.5	84.0	76.7	81.5	84.0	78.8
	1,200	84.0	86.5	68.1	85.5	87.5	68.1
3	3,600	80.0	82.5	90.4	84.0	86.5	82.8
	1,800	86.5	88.5	78.9	86.5	88.5	79.2
	1,200	87.5	89.5	71.0	87.5	89.5	71.0
5	3,600	86.5	81.5	84.5	86.5	88.5	87.0
	1,800	87.5	88.5	80.4	86.5	88.5	81.0
	1,200	88.5	89.5	73.0	87.5	89.5	74.4
	900	87.5	87.5	70.0	87.5	89.5	70.5

SCHEDULE A

FULL LOAD MOTOR EFFICIENCY AND POWER FACTOR RATING REQUIREMENTS FOR PREMIUM EFFICIENCY, 460 VOLT, 3 PHASE HORIZONTAL AND VERTICAL MOTORS

		Protected (Open Drip Proof)[1]			Totally Enclosed Fan Cooled[1]		
Nominal Horsepower (Horsepower)	Syn. (revolutions per minute)	Minimum Efficiency (Percent)	Nominal Efficiency (Percent)	Power Factor (Percent)	Minimum Efficiency (Percent)	Nominal Efficiency (Percent)	Power Factor (Percent)
7-1/2	3,600	86.5	88.5	86.7	87.5	89.5	86.3
	1,800	87.5	89.5	83.3	88.5	90.2	84.4
	1,200	88.5	90.2	78.2	88.5	90.2	78.3
	900	87.5	89.5	72.0	87.5	89.5	72.0
10	3,600	88.5	90.2	85.5	89.5	91.0	87.5
	1,800	88.5	90.2	82.8	88.5	90.2	86.0
	1,200	89.5	91.0	80.5	89.5	91.0	81.0
	900	89.5	91.0	75.8	88.5	90.2	76.0
15	3,600	88.5	90.2	86.7	89.5	91.0	87.4
	1,800	90.2	91.7	81.9	91.0	92.4	82.7
	1,200	89.5	91.0	81.7	90.2	91.7	78.9
	900	89.5	91.0	76.8	88.5	90.2	77.0
20	3,600	90.2	91.7	87.1	90.2	91.7	88.7
	1,800	91.0	92.4	83.1	91.0	92.4	84.2
	1,200	90.2	91.7	83.7	90.2	91.7	79.0
	900	90.2	91.7	77.2	89.5	91.0	77.2
25	3,600	90.2	91.7	88.1	91.0	92.4	85.5
	1,800	91.7	93.0	82.7	92.4	93.6	84.3
	1,200	91.0	92.4	79.2	91.0	92.4	83.5
	900	90.2	91.7	76.3	90.2	91.7	76.4

SCHEDULE A

FULL LOAD MOTOR EFFICIENCY AND POWER FACTOR RATING REQUIREMENTS FOR PREMIUM EFFICIENCY, 460 VOLT, 3 PHASE HORIZONTAL AND VERTICAL MOTORS

		Protected (Open Drip Proof)[1]			Totally Enclosed Fan Cooled[1]		
Nominal Horsepower (Horsepower)	Syn. (revolutions per minute)	Minimum Efficiency (Percent)	Nominal Efficiency (Percent)	Power Factor (Percent)	Minimum Efficiency (Percent)	Nominal Efficiency (Percent)	Power Factor (Percent)
30	3,600	91.7	93.0	88.3	91.0	92.4	73.9
	1,800	91.7	93.0	83.3	92.4	93.6	83.1
	1,200	91.7	93.0	82.1	91.7	93.0	83.5
	900	91.7	93.0	76.0	91.0	92.4	76.5
40	3,600	92.4	93.6	89.2	92.4	93.6	87.5
	1,800	93.0	94.1	80.8	93.0	94.1	82.3
	1,200	92.4	93.6	82.2	92.4	93.6	80.5
	900	91.7	93.0	75.0	91.7	93.0	75.5
50	3,600	91.7	93.0	86.3	91.7	93.0	87.7
	1,800	93.0	94.1	83.3	93.0	94.1	84.2
	1,200	92.4	93.6	83.0	92.4	93.6	80.6
	900	92.4	93.6	79.2	91.7	93.0	79.5
60	3,600	92.4	93.6	88.8	92.4	93.6	88.9
	1,800	94.1	95.0	84.5	94.1	95.0	84.2
	1,200	93.6	94.5	84.4	93.0	94.1	85.4
	900	92.4	93.6	78.8	91.7	93.0	79.3
75	3,600	93.6	94.5	87.5	93.6	94.5	89.7
	1,800	94.1	95.0	85.0	94.1	95.0	85.5
	1,200	94.1	95.0	85.0	94.1	95.0	85.0
	900	93.6	94.5	84.5	93.0	94.1	78.6

SCHEDULE A

FULL LOAD MOTOR EFFICIENCY AND POWER FACTOR RATING REQUIREMENTS FOR PREMIUM EFFICIENCY, 460 VOLT, 3 PHASE HORIZONTAL AND VERTICAL MOTORS

		Protected (Open Drip Proof)(1)			Totally Enclosed Fan Cooled(1)		
Nominal Horsepower (Horsepower)	Syn. (revolutions per minute)	Minimum Efficiency (Percent)	Nominal Efficiency (Percent)	Power Factor (Percent)	Minimum Efficiency (Percent)	Nominal Efficiency (Percent)	Power Factor (Percent)
100	1,800	94.5	95.4	85.0	94.5	95.4	85.0
	1,200	94.1	95.0	85.0	94.1	95.0	81.3
	900	93.6	94.5	80.2	93.0	94.1	77.8
125	1,800	94.5	95.4	86.9	94.5	95.4	88.5
	1,200	94.1	95.0	81.5	94.1	95.0	85.8
	900	94.1	95.0	--	93.6	94.5	80.4
150	1,800	95.0	95.8	86.4	95.0	95.8	86.3
	1,200	94.5	95.4	77.6	94.5	95.4	83.9
	900	94.1	95.0	--	93.6	94.5	79.7
200	1,800	95.0	95.8	84.6	95.0	95.8	87.5
	1,200	94.5	95.4	78.5	94.5	95.4	87.3
	900	94.5	95.4	--	94.1	95.0	80.0

NOTES:

(1) Motor data for continuous duty, NEMA Design B, 1.15 service factor, 40 degrees Celsius ambient, Class F insulation, 3 phase, 460 volt, at listed speed rating.
(2) Correct to 95 percent power factor and submit capacitor size in KVAR as specified in Article titled "Submittals."
(3) Totally enclosed fan cooled efficiencies apply to both horizontal and vertical motors.

END OF SECTION

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SECTION 16268A

UNINTERRUPTIBLE POWER SUPPLIES UNDER 3 KILOVOLT-AMPERES

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes: Under 3 kilovolt-amperes, single-phase, uninterruptible power supplies.

1.02 SUBMITTALS

A. Shop Drawings and Product Data:
1. Uninterruptible power system and block diagrams.
2. Schematic and Control diagrams.
3. Output wiring diagrams.
4. UPS sizing and load calculations.
5. Data on footprint and noise specifications.
6. Equipment outline and equipment weight.
7. Front elevation.
8. System connection diagrams.
9. System instructional manuals that describe installation, operation, and servicing procedures, including troubleshooting.
10. Internal wiring diagrams.
11. List of recommended spare parts.

1.03 ENVIRONMENTAL REQUIREMENTS

A. Uninterruptible power supplies shall be operated in the following environment:
1. Full Load Ambient Temperature: 0 to 40 degrees Celsius.
2. Non-operating Ambient Temperature: Minus 10 to 70 degrees Celsius.
3. Relative Humidity: 0-95 percent, non-condensing.
4. Operating Altitude: Up to 4,600 feet.
5. Acoustical Noise: 75 decibels at 5 feet after installation.

1.04 WARRANTIES

A. Warrant to correct uninterruptible power supply defects for 2 years, including costs of parts, labor, and travel.

B. Warrant batteries for a minimum of 5 years.

PART 2 PRODUCTS

2.01 UNINTERRUPTIBLE POWER SUPPLIES

A. Manufacturers: One of the following or equal:
1. Deltec.
2. Emerson.

3. Square D.
4. Liebert.
5. Exide.

B. Electrical Characteristics:
1. Input: 120 volts alternating current within 10 percent; 60 hertz within 5 percent; single phase.
2. Output: 120 volts alternating current within 0.5 percent; single phase; 60 hertz within 0.1 percent; with 5 percent voltage adjustment; power factor 1.0 to 0.7 lagging; overload 125 percent for 10 minutes.

C. Completely Integrated; Capable of:
1. Providing regulated and transient-free alternating current power from the unregulated alternating current power line under normal conditions and from the storage battery under abnormal conditions, including complete power line failure.
2. Automatically bypassing the uninterruptible power supply and connecting loads directly to the alternating current line power supply in order to maintain power output in the event of uninterruptible power supply failure and capability of manually bypassing the uninterruptible power supply and connecting loads directly to the line power supply during uninterruptible power supply maintenance.
3. True “on-line,” power-conditioning, pulse-width modulated or ferroresonant type.

D. Features: Include the following for each uninterruptible power supply:
1. Rack-mount hardware.
2. Solid state inverter.
3. Indicating light for normal power.
4. Output frequency meter.
5. Alternating current output volt meter.
6. Test switch, capable of simulating power failure.
7. Solid state battery charger.
8. Make-before-break manual bypass switch.
9. Alternating current output ammeter.
10. Time delay timer, adjustable, capable of providing transfer back to UPS power in 1 to 5 minutes.
11. Input circuit breaker.
12. Output circuit breaker.
13. Dual charge rate battery charger and indicating pilot light.
14. Automatic transfer to battery system when input voltage source drops below 85 percent of normal.
15. Battery monitor capable of monitoring battery failure, charge abnormalities, and emergency inverter operation.
16. Input Protection for Each Uninterruptible Power Supply:
    a. Molded cast circuit breaker; 20 amperes, 10,000 amperes interrupting capability, minimum.

2.02 BATTERIES

A. Manufacturers: One of the following or equal:
   1. McGraw Edison Company.
   2. Nife.

B. Batteries:
   1. Nickel-cadmium, UL listed, non-gassing.
   2. Maintenance-free.
   3. Capable of providing power for 15 minutes under full rated load.

2.03 SOURCE QUALITY CONTROL

A. Inspect, functionally test, and endurance load test the uninterruptible power supply. For endurance test, subject uninterruptible power supply equipment to at least 2 times the rated duration specified for the battery system at full load at an ambient temperature equal to or greater than the maximum ambient temperature specified herein.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install products in accordance with manufacturer's instructions.

END OF SECTION

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SECTION 16305

ELECTRICAL SYSTEMS STUDIES

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Requirements for Short Circuit Fault Analysis Study and Protective Devices Coordination Study:
      a. The protective device coordination study includes protective device settings for all functions indicated on the Drawings. Including, but not limited to:
         1) Current.
         2) Voltage.
         3) Frequency.
         4) Negative sequence.
         5) Machine protection functions.
   2. Requirements for Arc-Flash Hazard Study.

1.02 REFERENCES

A. American National Standards Institute/Institute of Electrical and Electronics Engineers (ANSI/ IEEE):
   1. ANSI/IEEE Std - 141 - IEEE Recommended Practice for Electric Power Distribution for Industrial Plants (Red Book).
   2. ANSI/IEEE Std. 242 - IEEE Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems (Buff Book).
   3. ANSI/IEEE Std. 399 - IEEE Recommended Practice for Industrial and Commercial Power Systems Analysis (Brown Book).
   4. ANSI/IEEE 1015 - IEEE Recommended Practice For Applying Low Voltage Circuit Breakers Used in Industrial and Commercial Power Systems (Blue Book).
   5. IEEE Graphic and Letter Symbols and Reference Designations.
   6. IEEE Yellow Book - Guide for Maintenance, Operation and Safety on Industrial and Commercial Power Systems.
   7. IEEE Standard 1584 - IEEE Guide for Performing Arc-Flash Hazard Calculations.
   8. IEEE Std. C37.2 - IEEE Standard Electrical Power System Device Function Numbers and Contact Designations.
   9. IEEE Std. C37.91 - IEEE Guide for Protective Relay Applications to Power Transformers.
   10. IEEE Std. C37.102 - IEEE Guide for AC Generator Protection.
   11. IEEE Std. C37.96 - IEEE Guide for AC Motor Protection.
   12. IEEE Std. C37.95 - IEEE Guide for Protective Relaying of Utility-Consumer Interconnections.
   13. IEEE Std. 1574 - IEEE Standard for Interconnecting Distributed Resources with Electric Power Systems.

B. National Fire Protection Agency:
   1. NFPA 70 - National Electrical Code (NEC).
   2. NFPA 70E - Standard for Electrical Safety in the Workplace.

1.03 SYSTEM DESCRIPTION

A. General Study Requirements:
   1. Obtain complete and accurate single line diagrams of the facility, including existing single line diagrams shown on Drawings.
   2. Obtain, for all existing and new equipment, the required field data for preparation of the study. This shall include, but not limited to:
      a. Transformer kVA and impedances.
      b. Generator impedances.
      c. Bus withstand ratings.
      d. Cable and bus data.
      e. Protective device taps, time dials, instantaneous pickups, and time delay settings.
   3. Obtain the Electric Utility information on the available single-phase and three-phase fault current with respective X/R ratios, utility protective device settings including manufacturer and model number. The study shall model information one level above the point of connection:
      a. Utility tolerances and voltage variations.
   4. Obtain equipment ratings and configurations from the manufacturer's final submittal requirements and project drawings as required.
   5. For the Short Circuit Fault Analysis and Protective Device Study all equipment shall be modeled down to, but not limited to, the smallest adjustable or fixed 100-amp trip circuit breaker in the 480-volt distribution system.
   6. The short-circuit fault and coordination study shall include new and modified equipment in the power distribution system. Study scenarios shall include, but not be limited to, normal source (Utility), standby generators, motor contribution, and other separately derived sources down to, but not limited to the smallest adjustable trip circuit breaker or fixed 100-amp trip circuit breaker in the 480-volt distribution system. Normal system connections and those that result in maximum fault conditions shall be covered in the study.
   7. The individual performing the arc-flash hazard study shall visit the site and collect all necessary field data in order to perform and complete a comprehensive arc-flash hazard study.
   8. The scope of the Arc-Flash Hazard Study shall be as defined for the short-circuit fault and coordination study. In addition, the Arc-Flash Hazard Study shall include all 240 volt and 208-volt systems fed from transformers larger than or equal to 125 kVA.
   9. Equipment and Conductor data:
      a. Use impedances based on actual installed or specified conductors, unless otherwise indicated.
      b. Use cable and bus resistances 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.

f. Use conductor length based on installation.
g. Use transformer rating and impedance based on the nameplate data.
h. Use motor/generator parameters based on actual installed/nameplate or specified on Drawings/Specification, unless otherwise indicated.

B. Short-Circuit Fault Analysis Study Requirements:
1. The short-circuit fault analysis shall be performed and submitted in two 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 short-circuit momentary symmetrical value at each switchgear lineup, switchboard, motor control center, distribution panelboard, branch circuit panelboard, and other significant overcurrent protective devices located throughout the distribution system.
3. Calculate line to ground momentary short circuit at all buses.
4. Evaluate bus bracing, fuse interrupting capacity and circuit breaker adjusted interrupting capacities against the fault currents, and calculate X/R values. Flag inadequate devices and document all acceptable devices and equipment.
5. Provide calculation methods, assumptions, one-line diagrams, source impedance data including Utility X/R ratios, typical values, recommendations, and areas of concern.
6. Calculate 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 at each switchgear lineup, unit substation primary and secondary terminals, switchboard, motor control center, distribution panelboard, branch circuit panelboard, and other significant overcurrent protective devices located throughout the distribution system.
7. Provide calculation methods, assumptions, one-line diagrams, and source impedance data, including Utility X/R ratios, typical values, recommendations, and areas of concern. One-line diagrams shall include node numbering as used in the short circuit study.

C. Protective Device Coordination Study Requirements:
1. Provide log-log form time-current curves (TCC's) 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.
   b. Include a detailed description of each protective device identifying its type, function, manufacturer, and time-current characteristics. 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. These details can be included in the TCC.

2. TCC's shall include new, modified and existing equipment in the power distribution system where required to demonstrate coordination. This shall 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. In addition, include all devices down to the largest branch circuit and largest feeder circuit breaker in each motor control center, and main breaker in branch panelboards.
   b. Provide separate ground fault TCC's 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 TCC's show transformer full load currents, transformer magnetizing inrush, and ANSI transformer withstand parameters.
   e. 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.
   f. Coordinate time interval medium-voltage relay characteristic with upstream and downstream device to avoid nuisance tripping.
   g. Include utility protective device characteristic.
3. Site Generation: When site generation (including cogeneration, standby, and emergency generators) is provided, include phase and ground coordination of the generator protective devices. Show the generator decrement curve and damage curve along with the operating characteristic of the protective devices.
4. Suggest modifications or additions to equipment rating or settings in a tabulated form.
5. Cable damage curves.
6. Transformer damage curves.
7. Voltage and Frequency relays:
   a. Provide settings for all voltage and frequency relays based upon actual Utility and generator tolerances and specifications.
8. Motor and Generator protective relays:
   a. Provide settings for all motor and generator protective relays based on the manufacturer's recommended protection requirements and IEEE standards.

D. Arc-Flash Hazard Study Requirements:
1. Include the calculated arc-flash boundary and incident energy (calories/square centimeter) at key points: switchgear, switchboards, motor control centers, panelboards, transfer switches etc, throughout the scope of the system as defined in this specification.
   a. Perform Arc-flash calculations for both the line side and load side of switchgear, switchboard, and motor control center main breakers.
   b. Perform arc-flash calculations for all short-circuit scenarios with all motors on for 3 to 5 cycles and with all motors off.
   c. Protective device clearing time shall be limited to 2 seconds, maximum.
2. Provide a detailed verbal discussion and explanation of the tabulated outputs.
3. Provide executive summary of the study results.

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 directing the short circuit and protective device coordination and the arc-flash hazard study shall meet with the OWNER and ENGINEER up to and including three times.
2. The purpose of the three 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:
      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 three weeks notice to the OWNER and ENGINEER in advance of the projected meeting date.
4. By virtue of the fact that this is a professional study and that the OWNER has 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.

1.04 SUBMITTALS

A. Furnish submittals in accordance with Sections 01330 - Submittal Procedures and 16050 - General Requirements For Electrical Work.

B. Studies and Reports:
1. Provide six bound copies of all final reports. Electronic copy on a compact disk (CD) of the report shall also be submitted.

2. The final report shall include the sections listed below:
   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 with all essential short-circuit device information.
   d. Short-circuit fault analysis study shall include:
      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's 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) Time-current curves (TCC's) graphically indicating the coordination proposed for the system on log-log graphs. At least three 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. Arc-Flash:
      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.

C. Submit the credentials of the individual(s) performing the study and the individual in responsible charge of the study.

D. 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, coordination and or arc-flash studies. These changes shall be provided as part of the scope of work.

E. Submit course outline for OWNER'S training.

1.05 QUALITY ASSURANCE

A. 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 five years experience in power system analysis is required for the individual in responsible charge of the studies.
   3. The short-circuit study, protective device coordination study and arc-flash hazard study shall be performed with the aid of a digital computer program. Point to point calculations are not acceptable.

B. The study methods and results shall be in accordance with the latest ANSI/IEEE and NFPA Standards.

C. The study shall be performed by an independent firm.

1.06 SEQUENCING

A. Submit the initial short-circuit study prior to submittal of any electrical equipment shop drawings.

B. Submit the final short-circuit study and protective device coordination study.

C. Site visit to gather data on the existing system for the arc-flash study.

D. First arc-flash meeting.

E. Submit the arc-flash hazard study.

F. Second arc-flash meeting.

G. Third arc-flash meeting and final reports.

H. OWNER'S training.

PART 2 PRODUCTS

2.01 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.
    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.

PART 3 EXECUTION

3.01 INSTALLATION

A. After review and acceptance of the arc-flash hazard 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.

3.02 FIELD QUALITY CONTROL

A. Test protective devices as specified in section 16950.

B. Submit with any related field changes with final copies of studies and documentation.

C. 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.

3.03 ADJUSTING

A. After review and acceptance of the recommend settings, the supplier’s field service technician shall set all recommended settings.

B. Install arc-flash hazard labels on all equipment covered by the study.

3.04 TRAINING

A. Provide a minimum of 1 training sessions for the OWNER’S electrical maintenance personnel.
    1. Each session shall be a minimum of 4 hours.

B. The training shall cover at a minimum:
   1. Hazards associate with arc-flash.
   2. Causes of arc-flash.
   3. Explanation of the arc-flash labels installed on the OWNER'S electrical equipment.
   4. Proper use of Personal Protective Equipment.
   5. PPE requirements for maintenance work.

C. The individual in charge of the arc-flash study or qualified representative shall conduct the training sessions.

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SECTION 16342

600 VOLT MOTOR CONTROL CENTERS

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes:
   1. 600 volts-alternating current motor control centers, ready to use, completely engineered and assembled.
   2. Motor control center additions or modifications.

1.02 REFERENCES

A. National Electrical Manufacturer's Association (NEMA):
   1. ICS-2 - Industrial Control Devices, Controllers, and Assemblies.

B. Underwriters Laboratories (UL):
   1. UL 845 - Motor Control Centers.

C. National Electrical Code (NEC):
   1. Article 430 - Motors, Motor Circuits, and Controllers.

1.03 DESIGN REQUIREMENTS

A. Unit Responsibility:
   1. Motor control center fabricator shall be the manufacturer of the major components therein; engineered motor control centers shall be by the component and housing manufacturer.
   2. The manufacturer shall comply with other Sections of the Specifications describing components such as dry-type transformers, panelboards, relays, circuit breakers, motor circuit protectors, magnetic starters, pilot devices, and other such equipment which will be components within the motor control center.

B. Provide UL label, where applicable, on each vertical section and individual unit as an evidence of compliance with UL 845.

C. The motor circuits as indicated on the Drawings may need to be modified to comply with the motor power factor correction requirements set forth in other Sections of the Specifications.

D. Provide lifting eyes on each section to facilitate handling.

1.04 SUBMITTALS

A. Shop Drawings:
   1. Plan, front and side view drawings, including overall dimensions of each motor control center. Identify shipping slips and show conduit stub-up area locations indicated on the Drawings.

2. Internal schematic and point-to-point wiring diagrams of each plug-in unit, including circuits of the variable frequency drives and solid-state reduced-voltage controllers that are part of the motor control center. Wiring diagrams shall include wire identification and terminal numbers. Indicate devices regardless of their physical location on the diagrams. Indicate on diagrams the specific device location symbols and their respective legend as indicated on the Drawings. Match identification numbers of motor starter, relay, timer coil, and respective contacts with those indicated on the Drawings. Identify on each respective wiring diagram specific equipment names consistent with those indicated on the Drawings.
3. External connection diagram showing the wiring to the external controls and devices associated with the motor control center.
4. Single-line diagrams for each motor control center showing circuit breakers, motor circuit protectors, motor starters, variable frequency drives, instrument transformers, meters, relays, timers, control devices, lighting and distribution transformers, panelboards, and other equipment comprising the complete assembly. Indicate electrical ratings of equipment and devices on these single-line diagrams.
5. Bill of material list for each motor control center and each motor control unit.
6. Nameplate schedule for each motor control center.

B. Project Record Documents:
1. Submit in accordance with Section 01770.
2. Submit an additional set of Drawings showing motor control center system. Reference the Contract Drawings by circuit numbers, equipment designations, and locations.

C. Manufacturer's installation instructions.

1.05 QUALITY ASSURANCE

A. Each component, as well as the complete assembly, shall be constructed and tested in accordance with latest NEMA Standards for Industrial Control, publication ICS-2.

1.06 WARRANTY

A. Submit manufacturer's standard warranty.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. The following, no equal:
1. Allen-Bradley Company.
2. Match existing motor control center for MCC additions or modifications.

2.02 ENCLOSURES

A. In accordance with NEMA Standard, as indicated on the Drawings and as specified.

B. NEMA Type 1 with closed cell neoprene gasket industrial use enclosure, unless otherwise indicated on the Drawings.

C. Rigidly form each vertical section that holds the units of minimum 12 gauge, cold-rolled steel.

D. Provide the vertical front-of-board-construction with a 21 inch depth.

E. Wiring: NEMA Class II, Type B.

2.03 UNIT DOORS

A. Mount on the stationary structure and hinge on side away from vertical wireway, with slotted thumb screws to hold in closed position.

B. Provide positive action linkage with disconnect operating mechanism. Design mechanism so that it can be locked in the OFF position with 1 to 3 padlocks. When handle is not padlocked, door to open by release of door interlock with small tool.

C. When door is closed, operating mechanism shall indicate ON or OFF position, and door interlock shall automatically become effective. Design disconnect operating mechanism against inadvertent operation when door is open.

D. Provide each plug-in unit door with nameplate, specified elsewhere, that indicates circuit number, load name and tag number, where applicable. Attach nameplate to door with stainless steel screws.

2.04 MOTOR CONTROLLER UNITS

A. Plug-in type, sized to accommodate up to six NEMA Size 1 units in 1 vertical section.

B. Completely enclose with sheet steel.

C. Provide a wireway inside unit to accommodate wiring without removing barriers or plates.

D. Control Wiring Within Each Unit and Interconnection Wiring Between Units: Copper, MTW, 90 degrees Celsius, 600 volt, Number 14 AWG minimum.

E. Size power wiring to suit maximum horsepower rating of unit, Number 12 AWG minimum.

F. Identify power and control wiring at each termination point (both ends) in accordance with accepted shop drawings, using appropriate labels specified in Section 16075.

2.05 WIRING TROUGHS

A. Provide continuous horizontal wiring troughs at both top and bottom of each section. The troughs shall line up to form a continuous wireway for full length of center.

B. Provide a large continuous, full height vertical wiring trough in the right side of each section.

2.06 TERMINAL STRIPS

A. Starters of Size 2 and Smaller: Terminate starter wiring (power and control wiring), and external field wiring on terminal strips provided in each unit.

B. Starters of Size 3 and Larger: Terminate control leads on the terminal strips.

C. Characteristics: As specified in Section 16050.
   1. Split-type to facilitate wiring connections for disconnecting factory or field conductors.
   2. Rated to accept conductor sizes as specified and as indicated on the Drawings.
   3. Provide with a minimum of 25 percent spare terminals.
   4. Rate terminal strips as disconnecting means for foreign interlock voltages.

2.07 BUS

A. Horizontal Bus Bars: Tin-plated insulated copper of the ampacity indicated on the Drawings. Unit bus bar stabs shall ensure high contact pressure.

B. Vertical Bus Bars: Tin-plated copper effectively isolated from accidental contact by plastic insulating medium in units, including spaces.

C. Bus Bar Supports: High impact strength, noncarbonizing insulating material mounted on padded steel brackets to provide adequate dielectric strength and creepage distance.

D. Bus Structure: Capable of withstanding not less than 65,000 rms ampere short circuit current in accordance with NEMA standards. In the event the results of the CONTRACTOR's short circuit fault analysis, as accepted by the ENGINEER, indicate that a higher short circuit duty rating of the motor control center is required, furnish the MCC with that higher rating.

E. Horizontal bus other than 600 amperes, and vertical bus other than 300 amperes shall be as specified or indicated on the Drawings.

F. Provide tin-plated copper horizontal ground bus continuous across full length of MCC. Provide copper vertical ground bus, which is solidly connected to the horizontal ground bus, in each vertical section containing starter or feeder units. Provide vertical ground bus with provisions for connecting the equipment grounding conductor at the associated unit location.

2.08 PAINTING

A. Finish metal surfaces and structural parts with a phosphatizing, or equal, treatment prior to painting. Paint control centers with gray undercoat equal to zinc chromate.

B. Finish interior surfaces including bus support angles, control unit back plates, and top and bottom unit barrier plates with baked white enamel.

C. Finish exterior of enclosure with ANSI 61 Gray, or in a color selected by ENGINEER.

2.09 FUTURE SPACES AND SPARES REQUIREMENTS

A. Provide spaces and spares for future combination starter and other units in the motor control centers. Furnish spaces with hardware to accommodate future plug-in control unit without modification of vertical sections. Provide number of spaces and spares required for future control units as indicated on the Drawings.

B. Provide additional vertical sections to ensure total number of spaces as indicated on the Drawings. Number of vertical sections are contingent upon specific manufacturer's final proposed and ENGINEER-accepted configuration of MCC units.

C. Unless indicated or specified otherwise, each spare motor starter shall include, as a minimum, a running time meter and a "run" pilot light.

2.10 DEVICES

A. Devices such as magnetic starters, circuit breakers, relays, timers, push buttons and other pilot devices, nameplates, conductors, circuit identification, shall conform to other Sections of the Specifications.

2.11 MOTOR CONTROL CENTER ADDITIONS

A. Provide complete motor control center sections or individual MCC units to be added to existing motor control centers in accordance with this Section and as indicated on the Drawings.

B. Provide additions that are of the same manufacturer, type, rating and color as the existing motor control centers. Provide hardware necessary to connect the buses of the new and existing MCCs, including ground buses.

C. Provide enclosures that match existing.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install motor control centers to allow complete unit door swing required for unit removal. This is specifically required where a vertical section of MCC is set next to a wall to the left of the MCC station.

B. Install motor control centers on 1.5 inch housekeeping pads where indicated on Drawings.

3.02 FIELD QUALITY CONTROL

A. Testing: Test as specified in Section 16950.

3.03 DEMONSTRATION

A. Demonstrate operation of equipment.

3.04 PROTECTION

A. Protect products until acceptance by OWNER.

END OF SECTION

SECTION 16412

LOW VOLTAGE CIRCUIT BREAKERS

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes: Low voltage circuit breakers as indicated on the Drawings and as specified.

1.02 REFERENCES

A. National Electrical Manufacturers Association (NEMA): Standards Publication No. AB1.

B. National Electrical Code (NEC): Article 430-52.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Circuit Breakers: Manufacturers: One of the following, no equal:
   1. Allen-Bradley Company.

B. Motor Circuit Protectors: One of the following manufacturers, no equal:
   1. Allen-Bradley Company.

2.02 CIRCUIT BREAKERS - LOW VOLTAGE

A. Circuit Breaker Frame and Trip Ratings: As indicated on the Drawings and coordinated with the ratings of the equipment actually furnished. Modify ratings where necessary to suit this equipment and in accordance with the short circuit fault analysis and protective device coordination study.

B. Circuit Breakers for Motor Control Centers: As specified and indicated on the Drawings. Where no indication of type is given on the Drawings, the following governs:
   1. When an integral part of a UL-listed combination controller: Motor circuit protectors.
   2. All other circuit breakers: Molded case circuit breakers.

C. Provide motor circuit protectors and circuit breakers with non-aluminum line and load terminals suitable for the required conductor type, size, and number of conductors.

D. Panelboard Circuit Breakers: Bolt-in type. Snap-in circuit breakers are not acceptable.

2.03 MOLDED-CASE CIRCUIT BREAKERS

A. Molded-case Circuit Breakers: Ambient compensating which provides inverse time delay overload and instantaneous short circuit protection by means of a thermal magnetic element. Accomplish compensation by a secondary bimetal that will allow the breaker to carry rated current between 25 degrees Centigrade and 50 degrees Centigrade with tripping characteristics which are approximately the same throughout this temperature range.

B. Circuit Breaker Ratings and Modifications: As indicated on the Drawings.

C. On Breakers with Interchangeable, Thermal, Adjustable Magnetic Trip: The accessibility and position of the adjustment knob shall not be changed from those on the standard breaker.

D. Circuit Breakers for Mounting in Motor Control Centers or for Separate Mounting: Air-break type, quick-make and quick-break, 600 volt, with number of poles as indicated on the Drawings. Minimum Frame Size: 100 amperes.
   1. Provide each breaker pole with inverse time delay and instantaneous circuit protection.

E. Breakers: Operated by a handle and provided with a quick-make, quick-break switching mechanism that is mechanically trip free from the handle so that the contacts cannot be held closed against short circuits and abnormal currents.
   1. Tripping Due to Overload, Short Circuit, or Ground Fault: Clearly indicate tripping by the handle automatically assuming a position between the manual ON and OFF positions.
   2. Latch Surfaces: Ground and polished.
   3. Poles: Constructed so they all open, close and trip simultaneously.
   4. Conform to the applicable requirements of NEMA Standard No. AB1.

F. Breakers: Completely enclosed in a molded case.
   1. Non-interchangeable Trip Breakers: Sealed covers.
   2. Interchangeable Trip Breakers: Sealed trip unit to prevent tampering.
   3. Ampere Ratings: Clearly visible.
   4. Contacts: Non-welding silver alloy.
   5. Arc Extinction: Accomplished by means of arc chutes.

G. Minimum Interrupting Ratings: At least equal to the available short circuit at the line terminals as determined by the CONTRACTOR's short circuit fault analysis and as accepted by the ENGINEER, but not less than 65,000 RMS amperes.

2.04 MOTOR CIRCUIT PROTECTORS

A. Motor Circuits: Protected by motor circuit protectors, as permitted by Item I below.

B. Motor Circuit Protectors: Operated by a handle and provided with a quick-make, quick-break switching mechanism that is mechanically trip free from the handle so that the contacts cannot be held closed against short circuits and abnormal currents.
   1. Tripping: Clearly indicated by the handle automatically assuming a position between the manual ON and OFF positions.
   2. Latch Surfaces: Ground and polished.

3. Poles: Constructed so they all open, close, and trip simultaneously.

C. Motor Circuit Protectors: Completely enclosed in a molded case.
1. Trip Unit: Sealed to prevent tampering.
2. Ampere Ratings: Clearly visible.
3. Contacts: Non-welding silver alloy.
4. Arc Extinction: Accomplished by means of arc chutes.

D. Provide each pole of motor circuit protectors with instantaneous short circuit protection by means of a single adjustable magnetic only element. The single adjustment screw is to adjust all poles simultaneously.

E. Furnish motor circuit protectors with provision for locking the maximum achievable trip setting to values less than maximum obtainable trip setting. Each adjustment typically to have 8 main setting points and mid-setting points following a linear scale so that each point has a significant value within calibration tolerances.

F. Motor Circuit Protectors: Suitable for use with current limiters, having 100,000 ampere interrupting capacity and a built-in trip indicator, that are fully coordinated with the motor circuit protectors so that the motor circuit protectors will open all 3 phases if the limiter operates.
1. Current limiters shall be so constructed that they can only be replaced by an identical or similar limiter having the same interrupting capacity.

G. Minimum Interrupting Rating: At least equal to the available short circuit current at the line terminals as determined by the CONTRACTOR's short circuit fault analysis as accepted by the ENGINEER, but not less than 65,000 RMS amperes.

H. Motor Circuit Protectors Continuous Current Rating: As specified herein or as indicated on the Drawings.
1. Setting: The motor circuit protectors setting shall be in accordance with the CONTRACTOR's protective device coordination study as accepted by the ENGINEER and in accordance with the motor circuit protectors manufacturer's recommendation based on motor nameplate current or actual motor current, whichever is larger.

I. Utilize an instantaneous trip circuit breaker or motor circuit protector only as part of a listed combination motor controller which provides coordinated motor branch-circuit overload, and short-circuit and ground-fault protection in accordance with NEC Article 430-52.

PART 3 EXECUTION

Not Used.

END OF SECTION

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SECTION 16414

600 VOLT FUSES

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes: 600-volt class fuses.

1.02 REFERENCES

A. Underwriters Laboratories (UL):
   1. I-508 Industrial Control Equipment.

B. International Electrotechnical Commission (IEC).

1.03 SUBMITTALS

A. Shop Drawings: Include drawings of spare fuse cabinet(s) and complete list of fuses indicating manufacturer, UL Class, and ampere rating for each location where fuses are to be installed.

B. Product Data: Include time-current and peak let-through curves for each class of fuse.

1.04 WARRANTY

A. Submit manufacturer's standard warranty.

1.05 MAINTENANCE

A. Spare Fuses:
   1. 0-2000 Amperes: 10 percent minimum, but not less than 3 of each size and type installed under any Division of these Specifications.
   2. Over 2000 Amperes: Minimum 3 of each type and size.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Fuses - 600 V and Accessories:
   1. UL Class L Fuses: Manufacturers: One of the following or equal:
      a. KLPC by Littelfuse.
      b. KRP-C by Bussmann.
   2. UL Class L 600 V ac/dc Fuses: Manufacturers: One of the following or equal:
      a. LDC by Littelfuse.
   3. UL Class RK1 Fuses: Manufacturers: One of the following or equal:
      a. LLN-RK/LLS-R by Littelfuse.
      b. LPN-RK/LPS-RK by Bussmann.

4. UL Class RK5 Fuses: Manufacturers: One of the following or equal:
   a. FLNR/FLSR by Littelfuse.
   b. FRN-R/FRS-R by Bussmann.
5. UL Class J Fuses: Manufacturers: One of the following or equal:
   a. JTD by Littelfuse.
   b. LPJ by Bussmann.
6. UL Class T Fuses: Manufacturers: One of the following or equal:
   a. JLLN/JLLS by Littelfuse.
   b. JJN/JJS by Bussmann.
7. UL Class CC Fuses: Manufacturers: One of the following or equal:
   a. CCMR/KLDR by Littelfuse.
   b. FNQ-R by Bussmann.
8. Fuses for Fluorescent Ballasts: Manufacturers: One of the following or equal:
   a. LGR by Littelfuse.
   b. GLR by Bussmann.
9. Fuse-Holders for Fluorescent Ballasts: Manufacturers: One of the following or equal:
   a. LHR by Littelfuse.
   b. HLR by Bussmann.
10. Fuse-Holders for HID Fixtures: Manufacturers: One of the following or equal:
    a. 5710CC/5710CCP by Littelfuse.
    b. HPF-RR by Bussmann.

2.02 GENERAL

A. Provide fuses 600 volt and below as indicated on the Drawings and as specified.

B. Fuses shall have a minimum interrupting rating of 200,000 amperes.

C. Completely install, connect, and test for insulation integrity distribution, conversion, or utilization equipment requiring fuses, prior to installation of fuses.

D. Provide fuses bolted in place with "Belleville" washers between each bolt head or nut, or fuse blade.

E. Affix a label indicating recommended torque for fuse mounting bolts or studs to the inside of fuse access doors.

F. Provide durable, readily visible label inside each fuse enclosure, clearly indicating the correct type and size of replacement fuse. Label shall not cover or interfere with equipment manufacturer's instructions.

G. Provide UL Class and type fuses as indicated on the Drawings and as specified. The specifications are non-proprietary, but not generic. Fuse classes shall conform to the detailed requirements of these Specifications.

H. To Assure Selective Coordination of Protective Devices:
   1. Provide fuses for new facilities by the same manufacturer.
   2. Provide fuses for renovations of the same manufacturer as existing fuses. When modifying or expanding existing facilities, remove existing one-time and renewable cartridge fuses with 10,000-ampere interrupting ratings and replace with dual-element RK5 fuses as specified.

2.03 FUSES FOR SERVICES, SWITCHBOARD MAINS, FEEDERS, AND BRANCH CIRCUITS

A. Fuses 0 to 600 Amperes: Except as specified in Paragraph C below, provide UL listed RK1 dual-element, time-delay fuses with ampere ratings as indicated on the Drawings except as may be modified by these Specifications.

B. RK1 fuses shall consist of a separate thermal overload element and one or more short-circuit element. Overload Element: Spring-loaded, time-delay to open at 400 degrees Fahrenheit or less when subjected to a no-load oven test. Melting and total-clearing I^2t values shall enable fuses to selectively coordinate at a 2:1 ratio with fuses of the same make and class.

C. Fuses 601 to 6000 Amperes: Provide UL listed Class L fuses. Seal the juncture of fuse body and terminal with an "O" ring. Fuses shall have 10 seconds minimum time-delay at 500 percent rating.

D. Class L fuses shall selectively coordinate at a 2:1 ratio with Class L fuses of the same make, at a 4:1 ratio with manufacturer's Class RK5 fuses, and 2:1 ratio with manufacturer's Class RK1 fuses.

E. 200 to 600 ampere fuses indicated as Class "L" shall be UL recognized and have dimensions identical to 601 to 800-ampere Class L fuses.

2.04 FUSES FOR MOTOR BRANCH CIRCUITS

A. Motor controllers shall have IEC (International Electrotechnical Commission) Type 2 protection or better. If fuses as specified do not meet control manufacturer's recommendations for Type 2 protection, provide fuse Classes as recommended by control manufacturer.

B. Fuse ampere ratings shall not exceed manufacturer's recommended values. If manufacturer does not have such standards, provide fuses as specified in Paragraphs C through G below.

C. Provide Class RK1 fuses as indicated on the Drawings and as specified, rated in accordance with the fuse manufacturer's recommendations for backup running protection of motor circuits containing overload relays.

D. Determine fuse ratings for motor branch circuits by actual full-load currents of motors provided, not by NEC Table of Standard Motor Full Load Amperes.

E. (EXCEPTION) Fuses in motor control centers may be time-delay Class J or Class CC fuses, if MCC manufacturer's standard designs are these fuses.

F. Time-delay Class J fuse ratings shall not exceed 150 percent of motor full load current except as permitted in Paragraph H below. Follow fuse manufacturer's recommendations for Class CC fuses.

G. Provide Class L fuses for motor branch circuits requiring fuses over 601 amperes, whether individual or grouped (MCC), sized at 150 percent of motor full load current except as permitted in Paragraph H, below.

H. 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. Increased requirements for an individual motor shall not be cause for increasing size of all fuses.

2.05 FUSING OF CONTROL CIRCUITS

A. Utilize UL listed branch-circuit fuses for required control circuit protection. Provide RK1 fuses as specified, or time-delay Class CC fuses installed in UL listed Class CC fuse blocks.

B. Provide minimum protection for control circuits in accordance with the latest revision of UL Standard 508 for Industrial Control.

C. Control Power Transformers: Fuse primary circuit of control power transformers. Provide fuse ratings in accordance with NEC requirements. Provide RK1 fuses or time-delay UL listed Class CC fuses installed in UL listed Class CC fuse blocks.

2.06 FUSING FOR FLUORESCENT AND H.I.D. LIGHTING FIXTURE BALLASTS

A. Individually fuse 300 volts and below fluorescent fixture ballasts. Electronic ballasts containing both internal fusing and Class P thermal protection are not required to have external fusing.

B. Fuse other ballasts in accordance with fixture or ballast manufacturer's recommendations. Mount fuse-holders in ballast wiring channel. Fuse-holders and fuses may be Littelfuse LHR with LGR fuses or Bussmann HLR with GLR fuses.

C. Individually fuse HID lighting fixture ballasts and discharge lighting fixtures over 300 volts with fuses rated in accordance with fixture manufacturer's recommendations.

D. Locate fuse-holders on ballast or fixture housing, accessible from outside of fixture. Provide UL Class CC fuses.

2.07 FUSES FOR METERING CENTERS, LOAD CENTERS, AND FOR BACKUP PROTECTION OF CIRCUIT BREAKERS

A. Provide RK1, Class J or Class L fuses as specified, or UL listed Class T fuses.

B. Littelfuse JLLN and JLLS Series, or Bussmann JJN and JJS Series. Fuse ampere ratings shall not exceed maximum recommended by equipment manufacturer.

2.08 SPARE FUSE CABINET(S)

A. Type:
   1. Seam-welded minimum 16 gage steel.
   2. Approximately 30 inches by 24 inches by 12 inches.
   3. Full width steel shelf.
   4. Key-locked, hinged door fitted with dust resisting gasket.
   5. Wall mounted.
   6. Grey enamel finish.

7. SPARE FUSE CABINET permanently marked on outside of door.
8. Suitable frame or pocket inside door of each cabinet with typewritten spare fuse inventory in clear plastic protective insert.

B. Provide as many cabinets as required to hold entire spare fuse inventory.

PART 3 EXECUTION

3.01 INSTALLATION

A. Evenly torque mounting bolts and nuts to ASTM recommendations for type and diameter of mounting bolts or studs provided. Affix a label to the inside of fuse access doors indicating recommended torque for fuse mounting bolts or studs.

B. Install spare fuse cabinets where instructed by the OWNER.

3.02 INITIAL START-UP AND SPARE FUSES

A. Replace fuses opened during start-up and testing. At Contract completion, each fuse-holder shall contain serviceable fuses as specified.

B. After completion of testing, deliver spare fuses in quantities specified. Fuses shall be new, in manufacturer's original packaging, and stored in a clean, dry location.

3.03 DEMONSTRATION

A. Demonstrate equipment in accordance with Articles 2.02, 2.08, 3.01, and 3.02.

3.04 PROTECTION

A. Protect products until acceptance by OWNER.

END OF SECTION

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SECTION 16422

MOTOR CONTROL

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes: Manual starters, magnetic contactors, overload relays, combination starters, and related motor controllers.

1.02 REFERENCES

A. National Electrical Code (NEC):
   1. Article 430 - Motors, Motor Circuits, and Controllers.

B. National Electrical Manufacturers Association (NEMA).

1.03 SUBMITTALS

A. Shop Drawings: Submit in accordance with Section 01330.

B. Manufacturer's installation instructions.

1.04 WARRANTY

A. Submit manufacturer's standard warranty.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Manual Motor Starters: One of the following, no equal:
   1. Allen-Bradley Company.

B. Full Voltage Magnetic Starters: One of the following, no equal:
   1. Allen-Bradley Company.

C. Reduced Voltage Solid-State Motor Starters: One of the following, no equal:
   1. Allen-Bradley Company.

2.02 STARTERS

A. Suitable for the horsepower ratings specified, and in accordance with NEC Article 430.

B. Verify motor ratings and coordinate starter and overload trip ratings with actual horsepower and nameplate current ratings of motors installed.

C. Magnetic Contactors: Factory adjusted and chatter free.

D. Overload Relays: Install bimetallic type overload relays in each line conductor as indicated on the Drawings. Provide contacts for remote monitoring of overload status as indicated on the Drawings.

E. Mount extended overload reset buttons to be accessible for operation without opening door of enclosure. Plastic overload relay reset buttons with plastic operator shafts are unacceptable.

F. Provide starters Size 2 and larger with arc quenchers on load breaking contacts.

G. Minimum Size Starter: NEMA Size 1, and not smaller than size indicated on the Drawings.

H. Provide starters of sufficient size to accommodate motors furnished, including larger starters required for larger motors supplied by CONTRACTOR.

I. Combination Starters: Furnish complete with a 120-volt control transformer unless otherwise noted.

J. Control Fuses: Size and furnish as required and where indicated in the schematics.

2.03 MANUAL MOTOR STARTERS

A. Across-the-line manual motor starters for motors up to 1 horsepower, 600 volts shall have the electrical characteristics indicated on the Drawings.

B. Provide single-pole or 3 pole as indicated on the Drawings with overload devices.

C. Provide handles that clearly indicate the ON, OFF with lockout, and TRIPPED positions, pilot light, and positive, quick-make, quick-break mechanisms.

D. Provide enclosures as indicated on the Drawings. Where not indicated, provide NEMA 12 enclosures for indoor location and NEMA 4X enclosures for outdoor locations. Provide enclosures compatible with type of conduit system being used for each specific application.

2.04 FULL VOLTAGE MAGNETIC STARTERS

A. Across-the-line full voltage magnetic starters for up to 600 volts shall have electrical characteristics indicated on the Drawings.

B. Provide positive, quick-make, quick-break mechanisms; padlockable enclosure doors; 3 overload relays with plus or minus 15 percent adjustment from nominal heater rating on the overload relay; cover mounted reset button, and at least 3 reversible contacts in addition to hold-in contact.

C. Provide magnetic starter enclosures as indicated on the Drawings. Where not indicated, provide NEMA 12 enclosures for indoor locations and NEMA 4X enclosures for outdoor locations. Provide enclosures compatible with type of conduit being used for each specific application.

D. Provide magnetic starters in accordance with latest NEMA Standards.

2.05 SOLID-STATE REDUCED-VOLTAGE MOTOR STARTERS

A. To be furnished and connected as specified and indicated on the Drawings.
   1. The starters, designated reduced voltage solid state starter (RVSS), shall consist of a power section, a one-piece or two-piece printed circuit logic board and a field wiring interface terminal board.
   2. Each starter shall be provided with a main incoming protective device and current-limiting fuses. The protective device shall be padlockable in OFF position.
   3. The starter units shall be complete with a logic card which shall permit adjustable acceleration and deceleration ramping, from 4 to 30 seconds time duration.
   4. All RVSS starters supplied on this project shall be the product of a single manufacturer.
   5. Enclosure: NEMA 1 gasketed, floor-standing.

B. Construction - Internal:
   1. Rated and constructed to match the ratings as shown on Drawings.
   2. It shall consist of three sets of back-to-back phase controlled power semiconductors.
   3. The power section shall have metal oxide varistor (MOV) type surge suppressors across the SCRs rated 10 percent above the SCR rated voltage. The power semiconductors shall be rated with peak inverse voltage at least 2 times SCR rated line-to-line voltage. Suitably rated snubbers for voltage suppression shall be included.
   4. The power section shall include a magnetic input contactor. Current limiting fuses shall be provided for protection of the SCR stacks against short circuit conditions.
   5. Resistor/capacitor snubber networks shall be used to prevent false firing of SCRs due to dv/dt characteristics of the electrical system.
   6. The one-piece or two-piece logic board shall be mounted for easy testing, service, and replacement. 3-phase current sensing shall be required.
   7. The logic board shall use quick disconnect plug-in connectors for current transformer inputs, line and load voltage inputs, and SCR gate firing output circuits.
   8. The logic circuitry shall include, as a minimum:
      a. Single phase protection.
      b. Undervoltage protection.
      c. Short circuit electronic trip overcurrent protection. Time shall not exceed 3 cycles.
      d. Inverse time running overcurrent protection.
      e. Auxiliary trip circuitry.
      f. Gate firing circuit lockout protection on trip.
      g. Fault relay lockout protection.
      h. 100 percent to 130 percent full load running current trip adjustment.
      i. 200 percent to 300 percent starting current limit adjustment.
      j. Dwell time at current limit with ramp continuation after acceleration.
      k. Individual light emitting diodes (LED) for trip and phase loss.
      l. Minimum and maximum voltage adjustments.
      m. Current stability adjustment.
      n. Initial torque adjustment.

9. RVSS vertical section control circuits shall accommodate/include the following:
   a. Motor winding over temperature shutdown as specified elsewhere and indicated on the Drawings.
   b. Other features to meet requirements as specified for the solid-state starters in respective motor control center or variable frequency drives Sections of these Specifications and specified in the control descriptions.
10. The logic board shall include, as standard, current and motor slip sensing circuitry that continually monitor motor load and regulate motor voltage to minimize motor kilowatt-hour energy consumption.
11. In addition, an auxiliary multi-function logic board shall be included to provide the following:
   a. Voltage Ramp Up: Adjustments for initial torque (0 to 50 percent) and ramp time (4 to 30 seconds).
   b. Voltage Ramp Down: Reverse voltage ramp (line volts to zero) adjustable (4 to 30 seconds) to provide for smooth stop. Automatic shutdown at end of voltage ramp.
   c. Output Contacts: Unit shall have a relay output contact to provide the indications for up-to-speed and zero speed.
12. The solid state logic shall be phase insensitive or with phase rotation protection. Logic board shall be coated with corrosion resistant coating.
13. 2 ground lugs shall be furnished, one for incoming and one for outgoing ground connections.
14. Power terminations shall consist of pressure type terminals for top or bottom entrance.
15. Position of operating handle shall indicate ON or OFF condition of incoming disconnect and shall included provision for padlocking in the OFF position.
16. Where shown on Drawings, each starter shall be equipped with a motor management and protection relay, Multilin Model SR369, or equal together with the associated current and potential transformers. The relay protective and monitoring functions shall be completely integrated into the RVSS system and connected to the motor winding temperature sensors (platinum, 100 ohms, 3-wire RTDs) and the motor bearing temperature sensors (platinum, 100 ohms, 3-wire RTDs).

C. Operation Requirements:
   1. Coordinate the equipment rating and operational and electrical characteristics to ensure that the RVSSs will operate satisfactorily and without interference when all equipment may be connected to a common source MCC bus as indicated on the single line diagram.
   2. It is the responsibility of the RVSS supplier to confirm starting torque requirements of each motor/pump load combination using manufacturer's performance curves and data and then ensure that each starter furnished will provide these requirements.

D. Source Quality Control:
   1. The manufacturer of the respective MCC assembly shall supply certified test results to confirm that the controller has been tested to substantiate designs according to applicable ANSI and NEMA Standards. 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.

2. 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 ICA 2-230.40.

PART 3 EXECUTION

3.01 INSTALLATION

A. Motor controllers shall be installed per manufacturer’s instructions.

3.02 APPLICATION

A. Supply circuit breaker trip elements and starter overload trip elements to meet above normal ambient temperatures where such conditions are anticipated (subject to ENGINEER's acceptance).

3.03 DEMONSTRATION

A. Demonstrate operation of equipment.

3.04 PROTECTION

A. Protect products until acceptance by OWNER.

END OF SECTION

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SECTION 16448

PANELBOARDS

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes: Dead-front panelboards, including lighting distribution and control panelboards.

1.02 REFERENCES

A. National Electrical Manufacturers Association (NEMA):
   1. NEMA 250 - Enclosures for Electrical Equipment (1,000 Volts Maximum).

B. Underwriter's Laboratories, Inc. (UL):
   1. UL 67 - Panelboards.

1.03 PERFORMANCE REQUIREMENTS

A. Minimum Interrupting Capacity of Device: Equal to available short circuit current at line terminals as determined by CONTRACTOR's short circuit fault analysis as accepted by ENGINEER, but not less than 22,000 amperes.

B. Provide main bus rating of panelboards, number of poles, and provisions for number of circuits as indicated on the Drawings.

1.04 SUBMITTALS

A. Product Data: Include manufacturer's specifications and description.

B. Shop Drawings: Submit in accordance with Section 01330. Include panelboard layout.

1.05 WARRANTY

A. Provide manufacturer's standard warranty.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Panelboards: One of the following, no equal:
   1. Allen-Bradley Company.

2.02 INTERIOR

A. Bus: Size main bus bars in accordance with UL standards to limit temperature rise on any current carrying part to a maximum of 50 degrees Centigrade above specified ambient maximum.
   1. Tin-plated copper bussing.

B. Install protective devices such that they can be replaced without disturbing adjacent units. Wire connectors shall be suitable for wire sizes indicated on the Drawings.

C. Number branch circuits and spares as indicated on the Drawings and furnish complete typed circuit schedule in directory cardholder affixed to panel under a transparent cover.

D. Phase busing shall be full size and height without reduction. Include full size neutral bars with suitable lugs for the maximum number of circuits which can be connected to the panel.

E. Spares and spaces for future protective devices in panels indicated on the Drawings shall be bussed for panel rating or the main circuit breaker rating.

F. Provide panels with tin-plated copper ground bus separate from neutral bars. Ground bus to have suitable lug for each circuit breaker installed including future circuits.

2.03 ENCLOSURES

A. Size panelboards sufficiently to provide minimum 4 inches of gutter space on all sides. Doors shall be such that:
   1. Live parts shall not be exposed when circuit breakers or switches are put in service.
   2. Hinges and latches shall not require tools to operate.

B. Furnish lock and minimum 2 keys each panelboard. Key all panelboard locks alike.

C. Enclosure type as indicated on the Drawings. Where not indicated on the Drawings:
   1. Indoor Enclosures: NEMA 12.
   2. Outdoor Enclosures: NEMA 4X.

D. Mounting shall be as indicated on the Drawings.

E. Finish stand alone panelboards with a primer, rust-resistant phosphate undercoat and 2 coats of oven-baked enamel with finish color ANSI 61 gray or a color to be selected by the ENGINEER.

F. Finish motor control center mounted panelboards to match the MCC finish and color, unless directed otherwise.

2.04 CIRCUIT BREAKERS

A. Circuit Breakers: As specified in Section 16412.

2.05 IDENTIFICATION

A. Label panelboards to indicate use as service entrance equipment where indicated on the Drawings or specified.

B. Label panelboards with UL short circuit current rating.

C. Provide each panelboard which is not an integral part of a motor control center with a lamicoid nameplate on outside of door, as specified in Section 16075, Electrical Identification.

PART 3 EXECUTION

3.01 INSTALLATION

A. As indicated on the Drawings, or as required, in a workmanlike manner.

3.02 FIELD QUALITY CONTROL

A. Test main circuit breaker(s) as specified in Section 16950.

END OF SECTION

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SECTION 16500

LIGHTING

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes: Lighting fixtures, lamps, ballasts, poles, and accessories.

1.02 REFERENCES

A. Underwriter's Laboratories (UL):
   1. UL 1029 - High-Intensity Discharge Lamp Ballasts.

1.03 SUBMITTALS

A. Product Data:
   1. Applicable coefficients of utilization tables, isolux chart of illumination on a horizontal plane, beam efficiency, horizontal and vertical beam spread, beam lumens.
   2. Submit pole seismic and wind-load design calculations before fixtures and poles are manufactured.

B. Samples: Include finish Sample for lighting fixtures and poles.

C. Manufacturer's installation instructions.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Lighting Fixtures: As noted on Lighting Fixture Schedule.

B. Lamps: One of the following or equal:
   1. General Electric Company.
   2. GTE Sylvania Lighting.
   3. Philips Lighting Company.

C. Ballasts for Fluorescent Lamps: One of the following or equal:
   1. Advance.
   2. Universal.
   3. GTE Sylvania Lighting.

D. Ballasts, HID Lamps: One of the following or equal:
   1. Advance.
   2. Holophane.
   3. GTE's Sylvania Lighting.

E. Plugs and Receptacles: As specified in Section 16140.

2.02 FIXTURES

A. Lighting Fixtures: As described in Lighting Fixture Schedule, as specified, and as indicated on the Drawings.
   1. Fixtures shall include lamps, ballasts, poles, mounting hardware, and appurtenances to provide complete operating units.

B. Fluorescent Lamps:
   1. Rapid start type.
   2. T8 type, 32W; 2900 lumens.

2.03 BALLASTS

A. General:
   1. Energy saving type suitable for use with energy saving lamps.
   2. High power factor type, with power factor not less than 90 percent.
   3. Cold weather (low temperature) rated for outdoor use.
   4. Internally fused ballast.

B. Ballasts for Fluorescent Lamps:
   1. Bear CBM and ETL labels certifying that ballasts meet pertinent requirements.
      a. Electronic ballasts for T8 32W.
      b. Energy saving ballasts for T12 40W lamps.
   2. Contain a built-in thermal protector to disconnect ballast permanently prior to failure, or be fused.
   3. High efficiency and constant wattage type.
   4. Of 2 windings where required by applicable codes.
   5. Use dimming ballasts with dimmer controlled fluorescent fixtures where indicated on the Drawings.
   6. Rated for location of installation.

C. Ballasts for High Intensity Discharge Lamps:
   1. Meet requirements of UL 1029.
   2. UL listed, UL labeled, or UL recognized.
   3. Copper windings.
   4. Be internally fused.

2.04 POLES

A. Design for wind design criteria as specified in Section 01614.

B. Design for seismic design criteria as specified in Section 01612 for the project site without structural damage.

C. Anchor Bolts, Washers, and Nuts: Stainless steel.

2.05 LIGHTING CONTACTORS

A. Silver-cadmium-oxide, double-break contacts.

B. 20 ampere rating for lighting circuits.

C. Mechanically held.

D. Number of poles as indicated on the Drawings with a minimum of 2 poles and a maximum of 12 poles for each contactor provided.

E. Provide timer-controlled with Hand/Off/Auto selector switch for outdoor lightings.

F. Manufacturers: One of the following or equal:
   1. Square D Company, Type LX.
   2. ASCO, Model 917.

PART 3 EXECUTION

3.01 INSTALLATION

A. Surface and Flush Mounted Fixtures: Solidly connected to a junction box.

B. Suspended Fixtures: Hung utilizing pendant mounting or stainless steel chains and hooks. Electrically connect each fixture, or row of fixtures, by conduit as specified elsewhere herein.

C. Pole Mounted Fixtures: Mount on steel, aluminum, or fiberglass poles as described in Lighting Fixture Schedule and as indicated on the Drawings.
   1. Ground or bond metal poles to the plant grounding system.
   2. Poles shall have adequate handholes in accordance with NEC requirements.
   3. Poles shall have weatherproof switches, receptacles, where indicated on the Drawings.

3.02 SPARES

A. Fixtures and Mounting Accessories: 1 spare for each type.

3.03 LIGHTING FIXTURE SCHEDULE

A. As indicated on the Drawings.

3.04 PROTECTION

A. Protect products until accepted by OWNER.

END OF SECTION

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SECTION 16950

ELECTRICAL TESTING

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes: Acceptance testing of electrical system, wiring, equipment, and grounding.

1.02 REFERENCES

A. National Electrical Testing Association (NETA):
   1. ATS-1999 - Acceptance Testing Specifications for Electric Power Distribution Equipment and Systems.

1.03 SUBMITTALS

A. Pre-test Submittals:
   1. Testing service qualifications.
   2. Testing personnel qualifications (resumes).
   3. Equipment testing schedule.
   4. Test data forms.

B. Submit Equipment Testing Schedule no later than 7 days prior to scheduled date of testing.

C. Post-test Submittals: Summary Test Report consists of the following:
   1. Summary of testing for the project.
   2. Description of the equipment tested.
   3. Description of the test and test procedures.
   4. Test results.
   5. Conclusions and recommendations.
   6. Completed test forms, including witness's signatures.
   7. List of test equipment and calibration documents.
   8. Date and time.
   9. Include the Following Data Tabulated for Each Piece of Equipment:
      a. Circuit number.
      b. Equipment or motor name and tag number (where applicable).
      c. Nameplate full-load-ampere rating.
      d. Motor service factor.
      e. Motor ambient temperature rating.
      f. Overload relay rating.
      g. Measured full load current.
      h. Measured discharge pressure (where applicable).
      i. Measured flow rate (where applicable).

D. Project Record Documents: Submit as specified in Section 01770. Note or indicate wiring deviations from Contract Documents on Project Record Documents.

1.04 QUALITY ASSURANCE

A. Testing Firm Qualifications:
   1. Obtain the services of an independent testing service firm not affiliated with any equipment manufacturer that is a Certified Full Member of NETA, and has a work history and qualifications acceptable to ENGINEER.
   2. Prequalified Testing Services and Manufacturing Firms:
      a. Electrical Reliability Services.
      b. Hampton Tedder.
   3. Qualifications of other testing service firms may be submitted.
   4. Testing service or testing personnel may be accepted or rejected based upon, but not limited to, the testing equipment intended to be used, the qualifications of the firm, and personnel.

B. Test Equipment Traceability:
   1. Testing firm shall have a calibration program which maintains applicable test instrumentation and equipment within rated accuracy.
   2. Equipment and instruments used to evaluate electrical performance shall be calibrated to a secondary standard traceable to the National Institute of Standards and Technology.
   3. Test equipment operating instructions and procedures shall be with the test equipment.

PART 2 PRODUCTS

Not Used.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify that electrical work is free from improper grounds, short circuits, and overloads.

B. Verify correctness of wiring first by visual comparison of the conductor connections with connection diagrams.

C. Make individual circuit continuity checks by using electrical circuit testers.

D. Verify correctness of wiring by actual electrical operation of electrical and mechanical devices in both manual and automatic modes of operation.

3.02 ACCEPTANCE TESTING

A. Perform testing and allow OWNER and ENGINEER to witness testing.

B. Perform electrical acceptance testing in accordance with NETA Standards.

C. Perform tests to assure that electrical equipment specified to be tested will operate within industry and manufacturer's published tolerances, and will perform safely. Record test result data, to be used as a baseline for future tests.

D. Test motorized equipment to verify conformance with the Contract Documents and for acceptance.

E. Install equipment with acceptable data. Equipment for which acceptable test data has not been submitted, or has been submitted but rejected, shall be deemed as not meeting Contract requirements.

F. Conduct 3 point fall of potential ground test by using equipment. Manufacturers: One of the following or equal:
   1. Biddle Company.
   2. Associated Research.

G. Test Project electrical equipment, including 600-volt electrical distribution equipment and grounding. Complete test reports for each individual piece of equipment.

H. Test Project electrical equipment included on, but not limited to, the following list:
   1. Motor Control Centers.
   2. Motors
   3. Molded Case Circuit Breaker (100 Amp and larger).
   4. Motor Circuit Protector (100 Amp and larger).
   5. Two-Winding Transformer.
   6. Transformer Turns Ratio.
   7. Ground Fault System.
   8. Insulation Resistance.
   9. Grounding Electrode Systems.

3.03 SUMMARY TEST REPORT

A. Upon completion of testing in every area, submit summary test report.

END OF SECTION

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SECTION 17050

PROCESS CONTROL AND INSTRUMENTATION SYSTEMS GENERAL

PART 1 GENERAL

1.01 SUMMARY

A. General requirements that apply to all process control and instrumentation systems for the entire project.

B. Related Sections:
   1. In addition to the responsibilities listed below, the SYSTEM SUPPLIER shall be responsible for all requirements of Division 16 and Division 17.
   2. The Contract Documents are a single integrated document, and as such all Divisions and Sections apply. It is the responsibility of the SYSTEM SUPPLIER to review all sections to insure a complete and coordinated project.
   3. Items involving electrical, control, and instrumentation construction may be shown on drawings or referred to in specifications that do not apply specifically to electrical, control and instrumentation systems. Since the Contract Documents are a single integrated document, it is the responsibility of the SYSTEM SUPPLIER to review all sections to ensure a complete and coordinated project.
   4. Items not involving electrical, control, and instrumentation construction may be shown on drawings or referred to in specifications that do apply specifically to electrical, control and instrumentation systems. Since the Contract Documents are a single integrated document, it is the responsibility of the SYSTEM SUPPLIER to review all sections to insure a complete and coordinated project.

C. The Contract Drawings, Documents, and overall design has been based on non-certified information furnished by various equipment manufacturers. It is incumbent on the part of the SYSTEM SUPPLIER to include in the bid all material and labor needed to install the actual equipment furnished.
   1. The SYSTEM SUPPLIER shall note that the instrument equipment specifications, ladder logic diagrams, and installation details are based on non-certified vendor information and indicate minimum scope of supply from the equipment manufacturer. The SYSTEM SUPPLIER shall include all costs in its bid to add additional instruments, wiring, computer inputs/outputs, controls, conduit, interlocks, electrical hardware, etc., into the design based on the equipment manufacturer's final certified vendor drawings. The SYSTEM SUPPLIER shall revise or produce new loop diagrams to meet the equipment manufacturer's wiring requirements. Such changes to instrumentation and electrical work shall be incorporated into the Scope of Work at no additional cost to the OWNER in light of the CONTRACTOR's knowledge that non-certified vendor information has been used in the design.

1.02 REFERENCES

A. Codes and Regulatory Compliance.
   1. The equipment, materials, installation, and other work shall conform to all applicable regulations, standards, specifications, and codes which are current as of the date of the final inspection for this contract.
   2. Without limiting the generality of other requirements of these specifications, all work specified herein shall conform to or exceed the applicable requirements of the referenced documents to the extent that the requirements therein are not in conflict with the provisions of this section; provided, that where such documents have been adopted as a code or ordinance by the public agency having jurisdiction, such code or ordinance shall take precedence.
   3. The equipment, materials, installation, and other work shall conform to all applicable regulations, standards, specifications, and codes which are current as of the date of bidding for this contract, including, but not limited to, those which are established by the following sources:
      a. Instrumentation, Systems, and Automation Society (ISA).
      b. National Electrical Manufacturers Association (NEMA).
      c. Occupational Safety and Health Administration (OSHA).
      d. American National Standards Institute (ANSI).
      e. National Fire Protection Association (NFPA).
      f. Institute of Electrical and Electronic Engineers (IEEE).
      g. National Electrical Code (NEC).
      h. Insulated Cable Engineers Association (ICEA).
      i. Federal Communications Commission (FCC).
      j. Underwriters Laboratory (UL).
      k. Local Power and Telephone Companies.
      l. Local Authorities having jurisdiction over the work.

B. Where the requirements set forth in these Specifications or on the Drawings are greater or more rigid than the mandatory requirements referenced above, the applicable Specifications or Drawings shall govern.

C. In the case of conflict between any mandatory requirements and Specifications or Drawings, the mandatory requirement shall be followed in each case, but only after submitting such proposed changes to the ENGINEER for approval.

D. Nothing contained in these Specifications or shown on the Drawings will be so construed as to conflict with any national, state, municipal, or local laws or regulations governing the installation of work specified herein, and all such acts, ordinances, and regulations, including the National Electrical Code, are hereby incorporated and made a part of these Specifications. All such requirements will be satisfied by the CONTRACTOR at no additional expense to the OWNER.

E. The Drawings and Specifications are complementary to each other; what is called for by one shall be as binding as if called for by both. If a conflict between Drawings and Specifications is discovered, this shall be referred to the ENGINEER as soon as possible for resolution. Should a conflict exist between the Drawings, Specifications, and/or mandatory requirements (i.e., codes, ordinances, etc.), it will be assumed that the more expensive method has been estimated, unless such alternate has been agreed to prior to submission of bids.

F. Safety:
   1. The ENGINEER's site responsibilities are limited solely to the activities of the ENGINEER and ENGINEER's employees on site. These responsibilities shall not be inferred by any party to mean that ENGINEER has responsibility for site safety. Safety in, on, or about the site is the sole and exclusive responsibility of the CONTRACTOR alone. The CONTRACTOR's methods of work performance, superintendence of the CONTRACTOR's employees, and sequencing of construction are also the sole and exclusive responsibilities of the CONTRACTOR alone. The OWNER warrants that: 1) The CONTRACTOR's responsibilities will be made clear in the OWNER's agreement with the CONTRACTOR; 2) The OWNER's agreement with the CONTRACTOR shall require the CONTRACTOR to indemnify, defend, and hold OWNER and ENGINEER harmless from any claim or liability for injury or loss arising from OWNER's or ENGINEER's alleged failure to exercise site safety responsibility; 3) OWNER's agreement with the CONTRACTOR shall require the CONTRACTOR to make OWNER and ENGINEER additional insured under the CONTRACTORS's general liability insurance policy, which insurance protection shall be primary protection for OWNER and ENGINEER. Given the foregoing, OWNER also shall, to the fullest extent permitted by law, waive any claim against ENGINEER, and indemnify, defend, and hold ENGINEER harmless from any claim or liability for injury or loss arising from ENGINEER's alleged failure to exercise site safety responsibility. OWNER shall also compensate ENGINEER for any time spent or expenses incurred by ENGINEER in defense of any such claim. Such compensation shall be based ENGINEER's prevailing fee schedule and expense reimbursement policy.
      a. The term "any claim" used in this provision means "any claim in contract, tort, or statute alleging negligence, errors, omissions, strict liability, statutory liability, breach of contract, breach or warranty, negligent misrepresentation, or other acts giving rise to liability."
      b. The term ENGINEER used in this provision means the prime engineer and all sub-engineers, sub-consultants, Electrical Engineer, and the Instrumentation Engineer.

1.03 DEFINITIONS

A. Definitions: Definitions of terms and other electrical considerations as set forth in the:
   1. National Electrical Code.
   2. Institute of Electrical and Electronic Engineers.
   3. Instrument Society of America.
   4. National Fire Protection Association.
   5. National Electrical Testing Association.

B. Specific Definitions:
   1. CCS: Central Computer System shall operate the SCADA system for operator interface, data storage and retrieval, archiving, alarming, and reporting.
   2. EC: Engineers console.
   3. FAT: Factory acceptance test.
   4. HMI: Human Machine Interface.
   5. ICSC: Instrumentation and Control System Contractor or System Integrator.

6. LCP: Local Control Panel containing operator interface devices, operators, etc. without a PLC.
7. LAN: Local Area Network.
8. MTU: Master Telemetry Unit used for communications and polling of the RTUs, and as an interface to the CCS and PLC.
9. OC: Operators console.
10. PC: Personal Computer.
11. PCIS: Process Control and Instrumentation System.
12. PCM: Process Control Module or PCS, containing any of the following devices: PLC, RIO, HMI.
13. PLC: Programmable Logic Controller.
14. PR: Printer.
15. RIO: Remote I/O device for the PLC which may be a remote I/O rack, or remote block I/O.
16. RTU: Remote Telemetry Unit that will include, a PLC, and either a telephone modem or radio modem for communications back to the MTU.
17. SC: Server computer.
18. SCADA: Supervisory Control and Data Acquisition system incorporating and including all parts of the PLCs, PCs, PCMs, RIOs, MTUs, CCS, etc.
19. VCP: Vendor Control Panel furnished by or with particular equipment.
20. RR: Remote rack contain PLC I/O cards, etc. driven by a PLC CPU not located in the I/O rack.

1.04 SYSTEM DESCRIPTION

A. Furnish, install, and place into service an operating instrumentation and control system (PCIS) to perform the specified monitoring, communications, alarm, control and display functions for the OWNER's facilities all in accordance with the requirements of the Contract Documents. Provide all Process Control and Instrumentation Systems complete and operable, in accordance with the Contract Documents.

B. Due to the critical importance of the plant operation and the installation of the new equipment, there are two pre-qualified system integrators:
   1. Sierra Controls, Carson City, NV.
   2. George T. Hall, Reno, NV.

C. All instrumentation and control systems for the entire project shall comply with the requirements of Division 17, whether referenced in the individual equipment specifications or not.
   1. It is the SYSTEM SUPPLIER's responsibility to inform all vendors of control systems, panels, and equipment of the requirements of Division 17.
   2. The requirements of Division 17 apply to all systems including field equipment, panels, hardware and software, etc.
   3. The OWNER will not be responsible for any additional costs due to the failure of the SYSTEM SUPPLIER to notify all parties of the Division 17 requirements.

D. System Overview: Provide all hardware and software needed for a complete, integrated plant control system, consisting of but not limited to:
   1. One new SCADAPack PLC as specified in Section 17720, in the Maintenance Shop as shown on Drawings.
   2. One new Modicon Modbus Plus Bridge as specified in Section 17720, in the Primary Sludge Pump Station, if necessary.
   3. Instrumentation and Controls as shown on the P&IDs and described in the Control Strategies and the rest of Division 17.
   4. The OWNER shall provide all the PLC and SCADA programming services.

1.05 SUBMITTALS

A. General:
   1. Submit copies of shop drawings, product data, operating manuals, and all other required submittals in accordance with the requirements of Division 1. Submittals shall show dimensions, construction details, wiring diagrams, controls, manufacturers, catalog numbers, and all other pertinent details.
      a. Submittals shall be organized and delivered for review by specification section.
         1) There may be more than one submittal for an individual specification section.
         2) Single submittals covering multiple specification sections will be returned without review. The ENGINEER will be reimbursed by the OWNER for all subsequent reviews and the OWNER will deduct the amount of the reimbursement from the CONTRACTOR’s contract. The ENGINEER's reimbursement will be on a time and expense basis and at the current billing rate of the ENGINEER. The ENGINEER will be the sole source for determining the suitability of any submittal.
   2. Submittals shall be fully indexed with a tabbed divider for each and every component. Pages within the tabbed sections shall be sequentially numbered. Submittals that are not fully indexed and tabbed with sequentially numbered pages, or are otherwise unacceptable, will be returned without review. The ENGINEER will be reimbursed by the OWNER for all subsequent reviews and the OWNER will deduct the amount of the reimbursement from the CONTRACTOR’s contract. The ENGINEER's reimbursement will be on a time and expense basis and at the current billing rate of the ENGINEER. The ENGINEER will be the sole source for determining the suitability of any submittal.
   3. Submittal Organization.
      a. First Page:
         1) Specification Section Reference.
         2) Name and telephone number of individual who reviewed submittal prior to delivery to ENGINEER.
         3) Name and telephone number of individual who is primarily responsible for the development of the submittal.
         4) CONTRACTOR’s review stamp and comments.
      b. Second Page:
         1) If a re-submittal, this page shall contain a response to each of the ENGINEER’s comments, and/or questions.
         2) In the order that the comments and/or questions were presented throughout the submittal.

3) Referenced by index section and page number on which the comment appeared.
4) Shall list any and all exceptions to the specifications, any items not excepted will be expected to be furnished as per the plans and specifications.

c. Remaining pages:
1) Actual submittal data.
2) Indexed.
3) Pages sequentially numbered.

d. Submittal organization shall be in the exact same order as the items are referenced, listed, and/or organized in the specification section.

e. 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.

4. Exceptions to Specifications:

a. The CONTRACTOR shall include a list of proposed exceptions to the specifications and drawings along with a brief explanation of each. Acceptance of the exceptions is at the sole discretion of the ENGINEER. All items not listed as exceptions shall be furnished in accordance with the specifications and drawings. All items that do not meet the requirements of the specifications, and were not previously accepted as exceptions, shall be replaced by the CONTRACTOR at no additional cost to the OWNER, even if the submittals contained information indicating the failure to meet the requirements.

b. Any exceptions to the specifications must be noted, and the reason for the exception delineated. If there is no back up for the deviation the submittal will be returned requiring revision and re-submit.

B. Shop Drawings: It is incumbent upon the CONTRACTOR to coordinate the work specified in these Sections so that a complete PCIS, electrical power, instrumentation, computer and control system for the facility will be provided and will be supported by accurate shop and record drawings.

1. As a part of its responsibility the SYSTEM SUPPLIER shall prepare and submit complete and organized shop drawings, as specified herein.

a. Interface between instruments, vendor control panels, motor control centers, motor starters, variable speed drives, control valves, flow meters, chemical feeders and other equipment related to the instrumentation, control, and SCADA system shall be included in the shop drawing submittal.

2. All drawings developed for the PCIS system shall be generated utilizing AutoCad by Auto Desk Version 14 or later, shall be delivered on CD(s), as well as hard copies on 11-inch by 17-inch plain bond paper.

3. Manuals written specifically for this project shall be generated utilizing Microsoft Word 2000 or later and shall be delivered on CD(s), as well as hard copies on 8.5-inch by 11-inch plain bond paper.

4. The organization of the initial shop drawing submittal required above shall be compatible to eventual inclusion with the Technical Manuals submittal and shall include final alterations reflecting record conditions.

a. Accordingly, the initial multiple-copy shop drawing submittal shall be separately bound in a standard size, 3-ring, loose leaf, vinyl plastic, hard cover, binder suitable for bookshelf storage.

b. Binder ring size shall not exceed 2 inches.

5. Interfaces between instruments, motor starters, control valves, variable speed drives, flow meters, chemical feeders, and other equipment related to the PCIS shall be included in the shop drawing submittal.

C. In these Contract Documents all systems, meters, instruments, and other elements are represented schematically, and are designated for the most part by numbers, as derived from criteria in Instrument Society of America Standard ANSI/ISA S5.1.
   1. The nomenclature and numbers designated herein and on the Drawings shall be employed exclusively throughout shop drawings, data sheets, and similar materials. Any other symbols, designations, and nomenclature unique to the manufacturer's standard methods shall not replace those used herein and on the Drawings.

D. During the period of preparation of this submittal, the CONTRACTOR shall authorize direct, informal liaison between the SYSTEM SUPPLIER and the ENGINEER for exchange of technical information. As a result of this liaison, certain minor refinements and revisions in the systems as specified may be authorized informally by the ENGINEER, but these shall not alter the Scope of Work or cause increase or decrease in the contract price. 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 formal exception to, or variation from these Contract Documents.

E. Should an error be found in a shop drawing during installation or startup of equipment, the correction, including any field changes found necessary, shall be noted on the drawing and submitted as final "RECORD DRAWINGS" prior to acceptance of the project.

F. The CONTRACTOR shall submit detailed shop drawings and data prepared and organized by the SYSTEM SUPPLIER.
   1. All shop drawings shall include the letterhead and/or title block of the approved SYSTEM SUPPLIER responsible for this project.
   2. The title block shall include, as a minimum:
      a. The SYSTEM SUPPLIER’s registered business name.
      b. Address.
      c. Project name.
      d. Drawing name.
      e. Revision level.
      f. Personnel responsible for the content of the drawing.
      g. Date.

G. The SYSTEM SUPPLIER shall respond to all comments on shop drawing re-submittals made by the ENGINEER either by making the noted correction or stating why it was not revised.
   1. Any re-submittal received by the ENGINEER, which does not contain responses to the ENGINEER's previous comments, shall be returned to the CONTRACTOR marked "REJECTED."
   2. No further review by the ENGINEER shall be performed until a response for these comments has been received.

H. The ENGINEER has allowed for up to and including two reviews of each submittal. The ENGINEER shall be reimbursed for all reviews after the first two reviews by the

OWNER, and the OWNER will deduct the amount of the reimbursement from the CONTRACTOR's contract. The ENGINEER's reimbursement shall be on a time and expense basis and at the current billing rate of the ENGINEER. The ENGINEER shall be the sole source for determining the suitability of any submittal.

I. The submittal shall be presented in nine distinct and complete parts in the following order, each in a separate bound set. Any incomplete submittal will be rejected and returned without comments.
   1. Cost Loading and Cash Flow.
   2. The complete system hardware items shall be submitted for review.
   3. After successful review of the hardware items, the Project Wide Loop Drawing submittal showing: control, interconnection, and loop drawings shall, be submitted for review.
   4. Testing and Start-up procedures.
   5. Technical Manuals.
   6. Training Submittals.
   7. Record Drawings.

J. Cost Loading and Cash Flow:
   1. The CONTRACTOR and the SYSTEM SUPPLIER shall develop a schedule, schedule of values, and cash flow summary for inclusion in the submittals.
   2. Failure to submit the schedule, schedule of values, or cash flow summary shall be cause for withholding any progress payment due for process control and instrumentation system work under sections in this Division.
   3. Cash Flow Summary:
      a. The cash flow summary shall be based on the submitted Schedule and equal in total to the CONTRACTOR's process control and instrumentation system bid price plus approved contract modifications.
      b. Expected payment requests for each month shall be included, as well as the cumulative payment requests to date for each month of the project.
      c. The net payment requests for each month after deducting retainage and the cumulative payment requests to date shall also be shown.

K. System Hardware Submittal: This submittal shall be included in a singular, all-inclusive submittal which shall include but not be limited to:
   1. A complete index appearing in the front of each bound submittal volume which lists each device by Tag and Loop number, type, and manufacturer. System groups shall be separated by labeled tags.
   2. Complete and detailed bills of materials:
      a. A bill of material list, including quantity, description, manufacturer, and part number, shall be submitted for each field mounted device or assembly, PCM, LCP, RTU, cabinet assemblies and sub-assemblies.
      b. Bills of material shall include all items within an enclosure.
   3. Fully executed data sheets according to ISA-S20 - Specification Forms for Process Measurement and Control Instruments, Primary Elements and Control Valves, for each component, together with a technical product brochure or bulletin. The technical product brochures shall be complete enough to verify conformance to all Contract Document requirements, and shall be edited to reflect only those features supplied with the device. The data sheets shall show:
      a. Component functional description used herein and on the Drawings.
      b. Manufacturers model number or other product designation.

c. Project tag number used herein and on the Drawings.
d. Project system or loop of which the component is a part.
e. Project location or assembly at which the component is to be installed.
f. Input and output characteristics.
g. Scale range and units and multiplier.
h. Requirements for electric supply.
i. Requirements for air supply.
j. Materials of construction and of component parts to be in contact with, or otherwise exposed to, process media, and or corrosive ambient air.
k. Special requirements or features, such as specifications for ambient operating conditions.
l. Features and options which are furnished.

4. A separate technical brochure or bulletin shall be included with each instrument data sheet.
   a. The data sheets shall be indexed in the submittal by systems or loops, as a separate group for each system or loop.
   b. If, within a single system or loop, a single instrument is employed more than once, multiple data sheets, one per instrument, with one brochure or bulletin may cover all identical uses of that instrument in that system.
   c. Each brochure or bulletin shall include a list of tag numbers for which it applies.
   d. Special options and features which are furnished shall be identified.
   e. System groups shall be separated by labeled tags.
5. Control Panel Hardware Engineering submittal Refer to Section 17710.
6. A priced list of recommended spare parts covering items which are furnished under this Contract with the name, address, and phone number of manufacturer and manufacturer's local service representative of these parts.

L. Hardware Submittals Minimum Requirements in addition to those specified in Section 17050:
   1. The control system hardware submittal shall include hardware specified under this Section and shall be a singular all-inclusive submittal.
   2. Complete grounding requirements for each system component including any requirements for PLCs, process LANs, and control room equipment.
   3. Requirements for physical separation between control system components and 120 VAC, 480 VAC, and medium voltage power cables.
   4. Data sheets shall be included for each control system component together with a technical product brochure or bulletin. These data sheets shall show:
      a. The component name as used within the Contract Documents.
      b. The manufacturer's model number or other identifying product designation.
      c. The project tag number.
      d. The project system of which it is a part.
      e. The project site to which it applies.
      f. The input and output characteristics.
      g. The requirements for electric power.
      h. The specifications for ambient operating conditions
      i. Details on materials of construction.
   5. Complete and detailed bills of materials: A bill of material list identifying all items within an enclosure, including:
      a. Quantity.
      b. Description.

c. Manufacturer.
d. Part number.

6. Calibration, adjustment, and test details for all control system components.

M. Shop Drawing Minimum Requirements in addition to those specified in Section 17050:
1. Site-specific arrangement and construction drawings for all equipment cabinets, including dimensions, identification of all components, preparation and finish data, nameplates, and the like.
   a. All drawings shall be scaled, as noted above, and shall show the position of the equipment at its intended installation location.
   b. All drawings must show a scaled representation of 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.
   c. All acquired access and clearances associated with the equipment must be shown with a statement of compliance to manufacturer's recommendations, NEC, and other applicable codes.
2. Detailed schematic drawings for all control systems as required in Section 17050.
3. Detailed loop drawings as required in Section 17050.

N. OWNER's Manuals additional minimum requirements:
1. General requirements for OWNER's manuals are as described in Section 17050.
2. Technical manuals for the PLCs, and all other SCADA system hardware.

O. System Test Procedures: additional minimum requirements:
1. General requirements for testing, calibration, precommissioning and start-up are as described in Section 17950.

P. Factory Test Procedure additional minimal requirements:
1. General requirements for testing, calibration, precommissioning and start-up are as described in Section 17950.

Q. Training.
1. Operator and Maintenance Training.
   a. Proposed training material, including a resume for the proposed instructors, indicating previous instructional experience, and a detailed outline of each lesson shall be submitted to the ENGINEER in accordance with paragraph 1.09 of this Section.
   b. The ENGINEER shall review the submitted data for suitability and provide comments that shall be incorporated into the course.

R. System Drawing Submittal:
1. Project-Wide Loop Drawing Submittal:
   a. The SYSTEM SUPPLIER shall furnish a Project-Wide Loop Drawing Submittal which completely defines and documents the contents of each monitoring, alarming, interlock, and control loop associated with equipment provided under Division 17, Division 16, as well as equipment provided under sections in other Divisions, existing, and OWNER furnished equipment which is to be incorporated into the PCIS.
   b. The submittal shall be a singular complete bound package.

c. A complete index in the front of each bound volume.
d. The loop drawings shall be indexed by systems or process areas.
e. All loops shall be tagged in a manner consistent with the Contract Documents.
f. Loop drawings shall be submitted for every analog and discrete monitoring and control loop.
g. Drawings showing definitive diagrams for every instrumentation loop system.
    1) These diagrams shall show and identify each component of each loop or system using legend and symbols from ANSI/ISA S5.4 - Instrument Loop Drawings, as defined by the most recent revision in ISA.
    2) Each system or loop diagram shall be drawn on a separate drawing sheet.
    3) Loop drawings shall be developed for all equipment associated with this project including vendor supplied packages, equipment provided under Divisions 16 and 17, and OWNER furnished equipment.
    4) The loop drawings shall also show all software modules and linkages.
h. In addition to the expanded ISA S5.4 requirements the loop diagrams shall also 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) MCC panel, circuit, and breaker numbers for all power feeds to the loops and instrumentation.
    4) Designation, and if appropriate, terminal assignments associated with, every manhole, pullbox, junction box, conduit, and panel through which the loop circuits pass.
        a) Use conduit numbers as found in Division 16 for identification of conduits.
    5) Vendor panel, instrument panel, conduit, junction boxes, equipment and SCADA System terminations, termination identification wire numbers and colors, power circuits, and ground identifications.

2. Panel and cabinet layout drawings shall be prepared and they shall include the following information:
    a. Front, side, and plan views to scale.
    b. Dimensions.
    c. Arrangement (interior and exterior).
    d. Mounting information, including conduit entrance location.
    e. Finish data.
    f. Tag number and functional name of items mounted in and on panel, console and cabinet.
    g. Nameplate legend which includes text, letter size, and colors to be used.
3. Instrument installation, mounting, and anchoring details for all components and assemblies, including access requirements and conduit connection or entry details shall be submitted in a hard copy format. Each instrument shall have a dedicated 8-1/2 inch by 11-inch detail which only pertains to the specific instrument by tag number. Each detail shall be certified by the instrument manufacturer that the proposed installation is in accordance with the instrument manufacturer's recommendations and is fully warrantable. These

certifications shall appear as a stamp on the hard copies. As a minimum, each detail shall have the following contents;

a. Show all 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.
b. Ambient temperature and humidity of the environment where the instrument is to be installed.
c. Corrosive qualities of the environment where the instrument is to be installed.
d. Hazardous rating of the environment where the instrument is to be installed.
e. Process line pipe or tank size, service, and material.
f. Process tap elevation and location.
g. Upstream and downstream straight pipe lengths between instrument installation and pipe fittings and valves.
h. Routing of tubing and identification of supports.
i. Mounting brackets, stands, and anchoring devices.
j. Conduit entry size, number, location, and delineation between power and signal.
k. NEMA ratings of enclosures and all components.
l. Clearances required for instrument servicing.
m. List itemizing all manufacturer makes, model numbers, quantities, lengths required, and materials of each item required to support the implementation of the detail.

4. Panel wiring and/or piping diagrams shall be prepared and integrated into the field wiring. They shall include the following information:
   a. Name of panel.
   b. Wiring and piping sizes and types.
   c. Terminal strip numbers.
   d. Functional name and manufacturer's designation for items to which wiring and piping are connected.
   e. Electrical control schematics in accordance with ANSI standards.
5. Field wiring and piping diagrams shall be prepared and be integrated with the panel wiring diagram. They shall include the following information:
   a. Wire and piping sizes and types.
   b. Conduits in which wiring is to be located.
   c. Panel (e.g., PCM, VCP, LCP, PLC, RTU's, etc.) termination strip numbers.
   d. Location, functional name, and manufacturers designation of items to which wiring and piping are connected.
6. Drawings showing schematic diagrams for control circuits.
   a. Complete details on the circuit interrelationship of all devices within and outside each control panel shall be submitted using schematic control diagrams.
   b. The diagrams shall show numbered terminals on components together with the unique number of the wire to be connected to each terminal, refer to Section 16120 for wiring numbering scheme.
   c. The diagrams shall also show terminal assignments from all primary measurement devices, such as flow meters, and to all final control devices, such as samplers, pumps, valves, and chemical feeders.

d. The CONTRACTOR shall furnish all necessary equipment identified in the supplier's shop drawings to facilitate inclusion of this information by the SYSTEM SUPPLIER.

7. Interface with existing control and monitoring system.
   a. This shall include any and all modifications made to existing measurement and control circuits, equipment and wiring.
   b. It is the responsibility of the SYSTEM SUPPLIER to ascertain actual field conditions of the existing circuits, equipment, and wiring.
   c. The OWNER will provide to the CONTRACTOR copies of all drawings and data that the OWNER can find that show such existing conditions.
      1) The OWNER makes no representation as to the completeness nor correctness of any such drawings and data and cannot guarantee that complete or partial data exists for any of the facilities included in this contract.
      2) Lack of such drawings shall not alleviate the contractual responsibility to ascertain and implement interfaces and modifications to existing measurement and control circuits, equipment and wiring.
8. Control Panel Wiring Diagram Submittal: refer to Section 17710.

S. Testing, Calibration, and Start-up Submittal.
   1. General requirements for testing, calibration, precommissioning and start-up are as described in Section 17950.

T. Technical Manuals: Seven final sets of technical manuals shall be supplied for the OWNER in accordance with section entitled "Contractor Submittals" as a condition of acceptance of the project.
   1. Information in the Technical Manuals shall be based upon the approved shop drawing submittals as modified for conditions encountered in the field during the work.
   2. Each set shall consist of 1 or more volumes, each of which shall be bound in a standard size, 3-ring, looseleaf, vinyl plastic hard cover binder suitable for bookshelf storage.
   3. Binder ring size shall not exceed 2 inches.
   4. Initially, 2 sets of these manuals shall be submitted to the ENGINEER for review after return of favorably reviewed shop drawings and data required herein.
      a. Following the ENGINEER's review, one set will be returned to the CONTRACTOR with comments.
      b. The sets shall be revised and/or amended as required and the requisite final sets shall be submitted to the ENGINEER 15 days prior to startup of systems.
      c. The ENGINEER will distribute the copies.
   5. The Technical Manuals shall have the following organization for each process:
      a. Section A - Process and Instrumentation Diagrams.
      b. Section B - Loop Drawings.
      c. Section C - Instrument Data Sheets.
      d. Section D - Sizing Calculations.
      e. Section E - Instrument Installation Details.
      f. Section F - Test Results.
      g. Section G - Operational Manual.
      h. Section H - Spare Parts List.

6. Signed results from Loop Testing, Pre-commissioning, and Performance Testing shall be included in Section H - Test Results.
7. In addition to updated shop drawing information reflecting actual installed conditions, each set of technical manuals shall include:
   a. Installation, connection, operating, calibration, setpoints (e.g., pressure, pump control, time delays, etc.), adjustment, test, troubleshooting, maintenance and overhaul instructions in complete detail.
   b. This shall provide the OWNER with comprehensive information on all systems and components to enable operation, service, maintenance and repair.
   c. Exploded or other detailed views of all instruments, assemblies, and accessory components shall be included together with complete parts lists and ordering instructions.
8. Operational Manual:
   a. A simplified version of the standard manufacturers' software and system operations manual shall be prepared for this project.
   b. This manual shall provide basic instructions in the application of the system as required for dispatchers and operators in day-to-day operations.
9. Spare Parts List: The Technical Manual shall also include a list of recommended spare parts for all the equipment furnished under this section.
   a. The list shall include recommended quantities sufficient to maintain the furnished system for a period of 5 years.
   b. After final system acceptance, the list shall be annotated to indicate which items, if any, and quantity are furnished as part of this contract.
   c. The list shall also be furnished in accordance with the section entitled "Contractor Submittals."

U. Training Submittals: Training plan which includes:
   1. A submittal of the training plan overview along with prerequisites for the OWNER's personnel.
   2. Schedule of training courses including dates, durations, and locations of each class.
   3. Resumes of the instructors who will actually implement the plan.
   4. Course Outline.

V. Record Drawings:
   1. The ICSC shall keep current a set of complete loop and schematic diagrams which shall include all field and panel wiring, piping and tubing runs, routing, mounting details, point-to-point diagrams with cable, wire, tube, and termination numbers.
   2. These drawings shall include all instruments and instrument elements.
   3. Two hard copies shall be submitted after completion of all commissioning tasks but prior to performance testing.
   4. All such drawings shall be submitted for review prior to acceptance of the completed work by the OWNER.

1.06 QUALITY ASSURANCE

A. Responsibilities
   1. The CONTRACTOR, through the use of a qualified SYSTEM SUPPLIER and qualified ICSC, shall be responsible to the DISTRICT for the implementation of

the PCIS and the integration of the PCIS with other required instrumentation and control devices.

2. SYSTEM SUPPLIER: Due to the critical and complex technical requirements of this project, all the systems specified in Division 16 and Division 17 shall be furnished by a single SYSTEM SUPPLIER, who shall have single source responsibility for the process control and instrumentation systems, and the electrical power system.
   a. The SYSTEM SUPPLIER shall be a single firm, or corporation designated by the CONTRACTOR to assume full responsibility through the CONTRACTOR to perform all engineering to select, furnish, install, test, calibrate, and place into operation all instrumentation, PCMs, controls, RTUs, and control panels.
   b. Where devices are specified to be of a manufacturer other than that of the SYSTEM SUPPLIER, the SYSTEM SUPPLIER shall purchase these devices and support them as part of the overall system. Such support shall include documentation, spare parts and trained service personnel. The SYSTEM SUPPLIER must design, fabricate, and develop all interfacing software in-house and perform software updating procedures for future enhancements.
   c. Due to the complexities associated with the interfacing of numerous control system devices, it is the intent of these specifications that the SYSTEM SUPPLIER be responsible to the CONTRACTOR for the integration of the PCIS with existing devices and devices provided under other sections with the objective of providing a completely integrated control system free of signal incompatibilities.
   d. As a minimum, the SYSTEM SUPPLIER shall perform the following work:
      1) Prepare analog hardware submittals for field instrumentation and for the SCADA System.
      2) Design, develop, and draft loop drawings and control panel designs.
      3) Prepare the test plan, the training plan, and the spare parts submittals.
      4) Procure all hardware.
      5) Fabricate panels.
      6) Perform factory tests on panels.
      7) Perform bench calibration and verify calibration after installation.
      8) Oversee and certify installation of the PCIS system, the electrical power system, and instrumentation and control system.
      9) Oversee, document, and certify loop testing.
      10) Oversee, document, and certify system pre-commissioning.
      11) Conduct the performance tests.
      12) Prepare Technical Manuals.
      13) Conduct training classes.
      14) Prepare record drawings.
      15) Integrate the PCIS with instrumentation and control devices being provided under other sections.
         a) Develop all requisite loop drawings and record loop drawings associated with equipment provided under other Divisions of these Specifications and OWNER furnished and existing equipment.
         b) Resolve signal, power, or functional incompatibilities between the PCIS and interfacing devices.

16) Supervise the installation of the electrical power and control system and insure compatibility between the PCIS system and the electrical system being installed.

e. Any SYSTEM SUPPLIER responsibilities in addition to the list above are at the discretion of the CONTRACTOR.

3. A contractual relationship shall exist between the Electrical Contractor and the Instrumentation & Control System Contractor. The first tier contractor shall contract directly with the CONTRACTOR. The first tier contractor shall be either the Electrical Contractor or the Instrumentation & Control System Contractor, and shall be defined as the SYSTEM SUPPLIER. The second tier contractor shall be either a division of, a joint venture, or a sub-contractor to the first tier contractor. The SYSTEM SUPPLIER shall manage, direct, and supervise the work of its second tier contractor. As such, the SYSTEM SUPPLIER shall be solely responsible for the entire electrical and instrumentation system, including, but not limited to, all electrical, instrumentation, and process contract drawings, Division 16, and Division 17.
   a. Any additional conduit, wire, etc. needed by the SYSTEM SUPPLIER shall be installed by the Electrical Contractor, under the above outlined working agreement, at no additional cost to the OWNER.
4. The CONTRACTOR shall coordinate the work of the SYSTEM SUPPLIER for the installation, interconnection, testing, calibration, and operation of the instrumentation, control, telemetry, PCIS, and SCADA System equipment and the scheduling of the SYSTEM SUPPLIER's personnel.
   a. The SYSTEM SUPPLIER shall be solely responsible for providing instrumentation, control and SCADA equipment that properly meets the functional intent of the specifications. Substitutions for functions specified are not permitted.

B. System Responsibility:
   1. All SCADA system hardware furnished in accordance with the Contract Documents shall be done so by the SYSTEM SUPPLIER.
   2. The CONTRACTOR shall coordinate the work and scheduling of its personnel and the SYSTEM SUPPLIER's personnel for the installation, interconnection, testing, calibration, and operation of all SCADA system equipment.
   3. The SYSTEM SUPPLIER shall be responsible for providing equipment that properly meets the functional intent of the Contract Documents.
   4. Substitutions for SCADA system functions specified are not permitted.

C. Unless otherwise specified, each individual instrument shall have a minimum accuracy of ±0.5 percent of full scale and a minimum repeatability of ±0.25 percent of full scale.

D. Conduct Factory Acceptance Tests in accordance with paragraph 2.09 of this section.

E. Installation supervision in accordance with paragraph 3.04 of this section.

F. Calibration: The SYSTEM SUPPLIER shall furnish the services of trained technicians to perform a complete system field calibration of each instrument and device.

G. All equipment and software furnished as required for Division 16 and Division 17 shall be of latest or recent technology.

1.07 DELIVERY, STORAGE, AND PROTECTION

A. All equipment and materials delivered to the job site shall be stored in a location which will not interfere with the operations of the CONTRACTOR, other contractors on the site, or the OWNER.

B. Storage and handling will be performed in manners which will afford maximum protection to the equipment and materials.
   1. Instruments shall be stored in complete conformance with the manufacturer's recommendations.
   2. Any instruments stored in variance with the manufacturer's recommendations shall be replaced at the ENGINEER's discretion at no additional cost to the OWNER.

C. It is the SYSTEM SUPPLIER's joint responsibility, with the CONTRACTOR to assure proper handling and on-site storage of instrumentation and control equipment.

D. Shipping Precautions: After completion of shop assembly, factory test, and approval, all equipment, cabinets, panels, and consoles shall be packed in protective crates and enclosed in heavy duty polyethylene envelopes or secured sheeting to provide complete protection from damage, dust, and moisture.
   1. Dehumidifiers shall be placed inside the polyethylene coverings.
   2. The equipment shall then be skid-mounted for final transport.
   3. Lifting rings shall be provided for moving without removing protective covering.
   4. Boxed weight shall be shown on shipping tags together with instructions for unloading, transporting, storing, and handling at the job site.
   5. Equipment shall be shipped to the site on dedicated air ride vans that will require no re-handling of the equipment on route.

E. Special Instructions: Special instructions for proper field handling, storage, and installation required by the SYSTEM SUPPLIER shall be securely attached to each piece of equipment prior to packaging and shipment.

F. Tagging: Each component and/or instrument shall be tagged to identify its location, instrument tag number, and function in the system.
   1. A permanent stainless steel or other non-corrosive material tag firmly attached and permanently and indelibly marked with the instrument tag number, as given in the tabulation, shall be provided on each piece of equipment in the PCIS.
   2. Instruments shall be tagged immediately upon receipt in the field.
   3. Identification shall be prominently displayed on the outside of the package.
   4. Tags shall utilize the Tag and Loop Number identifications shown of the P&IDs.

G. Storage:
   1. Equipment shall not be stored outdoors.
   2. Equipment shall be stored in dry permanent shelters, including in-line equipment, and shall be adequately protected against mechanical injury.

3. If any apparatus has been damaged, such apparatus shall be replaced and/or repaired at no additional cost to the OWNER.
4. If any apparatus has been subject to possible injury by water, it shall be thoroughly dried out and put through tests as directed by the ENGINEER.
   a. Such tests shall be at no additional cost to the OWNER, and if the equipment fails the tests, it shall be replaced at no additional cost to the OWNER.

H. Calibration:
1. General requirements for testing, calibration, precommissioning and start-up are as described in Section 17950.

1.08 PROJECT / SITE CONDITIONS

A. The PCIS system including, but not limited to the, instrumentation, controls, and SCADA Systems shall be designed and constructed for satisfactory operation and long, low maintenance service under the following environmental conditions:
1. Central Computer System and in plant PCMs, etc.:
   a. Temperature range: 10EC through 32EC (50EF through 90EF).
   b. Thermal shock: 0.55EC (1.0EF) per minute maximum.
   c. Relative humidity: 20 through 80 percent (non-condensing).
2. Remote Site Equipment, including RTUs, etc.:
   a. Ambient temperature range: -35EC through 27EC (-32EF through 90EF).
   b. Thermal shock: 1.0EC (1.8EF) per minute maximum.
   c. Relative humidity: 100 percent maximum.

1.09 SEQUENCING AND SCHEDULING

A. Factory Acceptance Test (FAT):
1. General requirements for testing, calibration, precommissioning and start-up are as described in Section 17950.

B. Loop Validation Test.
   a. General requirements for testing, calibration, precommissioning and start-up are as described in Section 17950.

C. Pre-commissioning Test.
1. General requirements for testing, calibration, precommissioning and start-up are as described in Section 17950.

D. Training.
1. Training shall be completed before the pre-commissioning phase of the project may start.
   a. The training sessions shall be scheduled a minimum of 3 weeks in advance of when the courses are to be initiated. The ENGINEER will review the course outline for suitability and provide comments that shall be incorporated.
2. Documentation:
   a. Training manuals shall be submitted to the ENGINEER a minimum of 10 working days prior to starting the training session.
   b. Within 10 days after the completion of each session the SYSTEM SUPPLIER shall submit through the CONTRACTOR the following:
      1) A list of all OWNER personnel that attended the session.

2) A copy of the training materials utilized during the lesson with all notes, diagrams, and comments.

E. All special tools and spare parts shall be submitted before performance testing commences, suitably wrapped and identified.

F. Performance Testing.
1. Pre-commissioning test must be completed a minimum of 5 working days prior to the performance test.

G. After pre-commissioning tests have been completed, the PCIS system will be given a final 90-day performance test.
1. Acceptance: General requirements for testing, calibration, precommissioning and start-up are as described in Section 17950.

1.10 WARRANTY

A. The SYSTEM SUPPLIER shall guarantee the performance and the hardware of all the instrumentation, control, telemetry and SCADA equipment and associated software and installation, as specified herein, for a period of 2 years following the date of completion and formal acceptance of the Work.
1. To fulfill this obligation, the SYSTEM SUPPLIER shall utilize technical service personnel designated by the SYSTEM SUPPLIER.
2. Services shall be performed within 3 calendar days after notification by the OWNER.

B. Equipment, software, and materials which do not achieve design requirements after installation shall be replaced or modified by the SYSTEM SUPPLIER to attain compliance, at no additional cost to the OWNER.
1. Following replacement or modification, the SYSTEM SUPPLIER shall retest the system and perform any additional procedures needed to place the complete system in satisfactory operation and attain design compliance approval from the ENGINEER.

C. All parts, material, labor, travel, subsistence, or other expenses incurred in providing all the services and service visits during the warranty period shall be borne by the SYSTEM SUPPLIER under the guarantee.

D. The warranty period shall start upon final acceptance of the complete PCIS work and successful completion of the performance test.

E. Equipment, and materials which do not achieve design requirements after installation shall be replaced or modified by the SYSTEM SUPPLIER to attain compliance, at no additional cost to the OWNER.
1. Following replacement or modification, the SYSTEM SUPPLIER shall retest the system and perform any additional procedures needed to place the complete SCADA system in satisfactory operation and attain design compliance approval from the ENGINEER.

F. The SYSTEM SUPPLIER through the CONTRACTOR warrants the materials and workmanship used for the SCADA system equipment and materials furnished under the Contract, and further guarantees the materials and workmanship used for any equipment and materials produced and furnished hereunder as a part of the work of

this Contract to be as herein specified and agreed upon, free from injurious defects, and in all respects satisfactory for the service required.

G. The SYSTEM SUPPLIER through the CONTRACTOR shall warrant/guarantee the satisfactory performance of the equipment and materials under operating conditions.
   1. In the event that tests and inspections disclose latent defects or failure to meet the specified requirements, the SYSTEM SUPPLIER upon notification by the ENGINEER shall proceed at once to correct or repair any such defects or non-conformance or to furnish, at the delivery point named in the Contract, such new equipment or parts as may be necessary for conformity to the specified requirements, and shall receive no additional compensation therefore.
   2. In case of any required repairs or other corrective or remedial work covered under warranty, the warranties on all such corrections, repairs, new equipment, or parts shall be extended for an additional 12 months from the date of final acceptance or 12 months from the date of completion of any such corrections, repairs, new equipment, or parts, whichever date is later.

H. The CONTRACTOR shall guarantee that the completed system shall perform all of the data acquisition, control, and reporting functions as shown and specified.

1.11 MAINTENANCE

A. In addition to the CONTRACTOR proposed special tools and excluded from the $10,000 spare parts allocation, the CONTRACTOR shall furnish the following:
   1. One steel pipe spool for each flow meter, sized to match the flow meter, labeled for meter tag number.
   2. Three spare I/O cards for each and every type used in the system.
   3. A fuse for fuse replacement for each and every fuse used in the system.
   4. Spare communications card for each and every type used in the system, to include but not be limited to remote I/O adapters, basic cards, etc.

B. All special tools and spare parts shall be submitted before performance testing commences, suitably wrapped, and identified.

C. System capacity requirements.
   1. All control system equipment furnished under this contract shall be capable of accommodating a future three fold expansion in the number of points including:
      a. PLCs.
      b. Memory requirements.
      c. Graphic displays.
      d. Database.
      e. Reporting packages.
      f. Hard disks.
      g. Magnetic tapes.
      h. Etc.
   2. All control system hardware furnished under this contract shall be provided with all the resources required for this project plus an additional 25 percent such that the entire 25 percent project growth is incorporated into the Contract without any additional cost to the OWNER.

a. This requirement includes all equipment and resources including, but not limited to:
   1) PLC Memory.
   2) PLC I/O cards.
   3) PLC power supplies.
   4) UPS.
b. The 25 percent spare resources requirement applies to the individual PLC/RTU/RIO level and not to the system wide configuration.

D. Each PLC and RIO location shall have a minimum of 25 percent or 3 empty I/O module slots, whichever is greater for to be used as spares.

PART 2 PRODUCTS

2.01 MATERIALS

A. All materials and equipment furnished under this contract shall be new, free from defects, and shall be standard products produced by manufacturers regularly engaged in the manufacturer of these products.

B. Where there is more than one item of similar equipment being furnished under this contract, all such similar equipment shall be the product of a singular manufacturer.

C. All meters, instruments, and other components shall be 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.

D. Signal Levels:
   1. Analog measurements and control signals shall be as indicated herein, and unless otherwise indicated, shall vary in direct linear proportion to the measured variable.
   2. Electrical signals outside control panels shall be 4-20 mA DC except as indicated.
   3. Signals within enclosures may be 1-5 volts DC.
   4. All electric signals shall be electrically or optically isolated from other signals.
   5. All pneumatic signals shall be 3 to 15 psig with 3 psig equal to 0 percent and 15 psig equal to 100 percent.
   6. Discrete input signal shall be 120 VAC, unless otherwise noted.
   7. Discrete output signals shall be:
      a. 120 VAC dry contact or TRIAC output as needed to coordinate with the field device, unless otherwise noted.
      b. Pilot lights within PCMs may be 24 VDC and driven by 24 VDC discrete outputs or 120 VAC and driven by 120 VAC discrete outputs.
      c. All discrete outputs without exception shall be routed through an external terminal block mounted fuse with blown fuse indication.

E. All instrumentation shall be suitable for operation, in the ambient conditions at the equipment installation locations.
   1. Heating, cooling, and dehumidifying devices shall be incorporated with the outdoor and/or indoor instrumentation in order to maintain it within its rated environmental operating ranges.

2. The SYSTEM SUPPLIER by virtue of its combined role with the Electrical SYSTEM SUPPLIER shall furnish and install all power wiring for these devices (e.g., heaters, fans, etc.), whether or not shown on the plans, at no additional cost to the OWNER.
3. All enclosures shall match the area classifications as detailed in Section 16050.

F. Instrument Air: Dry, filtered control air at 30 psig nominal pressure shall be piped to all field instruments and instrument panels requiring air.
1. Each field instrument shall be provided with an integral, non-adjustable filter/regulator assembly to provide regulated air.
2. Each instrument panel requiring air shall be provided with an adjustable filter/regulator assembly with gauge and an air manifold to provide air to pneumatic instruments.
3. All air shall be filtered to 5 micron maximum particle size.
4. Pressure reducers and regulators shall be furnished with additional instrumentation as required, at no additional cost to the OWNER.

G. Alternative Equipment and Methods: Equipment or methods requiring redesign of any project details are not acceptable without prior written approval of the ENGINEER through the "or equal" process as defined in these Contract Documents.
1. Any proposal for approval of alternative equipment or methods shall include evidence of improved performance, operational advantage and maintenance enhancement over the equipment or method indicated, or shall include evidence that an indicated component is not available.

2.02 SOURCE QUALITY CONTROL

A. The CONTRACTOR shall arrange with all Manufacturers of the equipment and fabricators of panels and cabinets, supplied under this project to allow the OWNER and ENGINEER to inspect and witness the testing of the equipment at the site of fabrication.
1. Equipment shall include the cabinets, special control systems, flow measuring devices, and other pertinent systems and devices.
2. A minimum of 15 working days notification shall be provided to the ENGINEER prior to testing.
3. No shipments shall be made without the ENGINEER's approval.

PART 3 EXECUTION

3.01 EXAMINATION

A. The CONTRACTOR and SYSTEM SUPPLIER shall 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.

B. The SYSTEM SUPPLIER, as defined by being solely responsible for the electrical and instrumentation construction project, shall install all extra conduits, cables, interfaces, as may be necessary in order to provide and complete and operating system, at no additional cost to the OWNER.

3.02 INSTALLATION

A. General: Under the supervision of the SYSTEM SUPPLIER and as part of its role as Electrical Contractor and in accordance with the manufacturer's instructions, and in coordination with the ENGINEER and the OWNER, all systems specified and/or required shall be:
   1. Installed.
   2. Connected.
   3. Calibrated.
   4. Tested.
   5. Started to place the system in operation.
   6. This shall include final calibration in concert with equipment specified elsewhere in these Contract Documents.

B. It is the intent of these specifications that the SYSTEM SUPPLIER shall accomplish the physical installation of all elements, instruments, accessories or assemblies specified in these contract documents.
   1. The SYSTEM SUPPLIER shall employ installers who are skilled and experienced in the installation and connection of all elements, instruments, accessories and assemblies.
   2. Electrical work shall be performed as specified in the applicable sections of Division 16.

C. The monitoring and control system configurations are diagrammatic.
   1. The locations of equipment are approximate unless dimensioned.
   2. The exact locations and routing of wiring and cables shall be governed by structural conditions and physical interferences and by the location of electrical terminations on equipment.
   3. Where job conditions require reasonable changes in approximated locations and arrangements, the SYSTEM SUPPLIER shall make such changes without extra cost to the OWNER, in accordance with the requirements of Division 16.

D. All equipment shall be located and installed so that it will be readily accessible for operation and maintenance.
   1. The OWNER reserves the right to require minor changes in location of equipment prior to roughing in without incurring any additional costs or charges.

E. Installation and Connection: The SYSTEM SUPPLIER shall install and connect all field-mounted components and assemblies under the criteria imposed by these specifications.
   1. The installation personnel shall be provided with a final reviewed copy of the shop drawings and data.

F. The instrument process sensing lines and air signal tubing shall, in general, be installed in a similar manner to the installation of conduit specified under Division 16.
   1. Individual tubes shall be run parallel and/or perpendicular to and near the surfaces from which they are supported.
   2. Supports for rigid tubing shall be used at intervals of not more than 3 feet.
   3. Horizontal runs of instrument tubing shall be sloped at a minimum of 1/16th inch per foot to allow for draining of any condensate.

4. Bends shall be formed with the proper tool and to uniform radii and shall be made without deforming or thinning the walls of the tubing.
    a. Ends of tubing shall be square-cut and cleaned before being inserted in the fittings.
    b. Bulkhead fittings shall be provided at all panels requiring pipe and/or tubing entries.
5. All piping shall be shard piped from the air header using copper metallic tubing, unless the area or material incompatibilities exist which would require the use of stainless steel tubing or other compatible materials.
    a. Flexible connection may be used only on moving equipment and under the constraint that the length shall be less than 1.5 times to maximum travel of the equipment.

G. Conduit, Cables, and Field Wiring:
1. All conduit shall be provided under Division 16 without delay to the work of Division 17.
2. All 4-20 mA signal circuits, process equipment control wiring, signal wiring to field instruments, PLC input and output wiring and other field wiring and cables shall be provided under Division 16.
3. All SCADA System equipment cables, and process LAN communication networks shall be provided under Division 17.
4. All terminations and wire identification at PCIS equipment furnished under this or any other Division shall be provided as identified in Division 16.

H. Equipment Tie-Downs:
1. All instruments, control panels, and equipment shall be anchored by methods which comply with seismic and wind bracing requirements which apply to the site.
2. All control panels, PCMs, VCPs, LCPs, RTUs, etc., must be permanently mounted and tied down to structures in accordance with Section 16190.

I. Existing Instrumentation: Each existing instrument to be reused and/or removed and reinstalled shall be cleaned, reconditioned and re-calibrated by an authorized service facility of the instrument Manufacturer.
1. The SYSTEM SUPPLIER shall provide certification of this work prior to reinstallation of each instrument.

J. The ENGINEER has based the drawings and design on non-certified information furnished by various equipment manufacturers. It is incumbent on the part of the CONTRACTOR to include in the bid all material and labor needed to install the actual equipment furnished.
1. The instrument equipment specifications, ladder logic diagrams, and installation details are based on non-certified vendor information and indicate minimum Scope of Supply from the equipment manufacturer.
2. The SYSTEM SUPPLIER shall include all costs in its bid to add additional instruments, wiring, computer inputs/outputs, controls, conduit, interlocks, electrical hardware, etc., into the design based on the equipment manufacturer's final certified vendor drawings.
3. The SYSTEM SUPPLIER shall revise or produce new loop diagrams to meet the equipment manufacturer's wiring requirements.
4. Such changes to instrumentation and electrical work shall be incorporated into the Scope of Work at no additional cost to the OWNER in light of the

CONTRACTOR's knowledge that non-certified vendor information has been used in the design.

5. The CONTRACTOR and SYSTEM SUPPLIER shall be responsible for providing any additional or different type connections as required by the instruments and specific installation requirements at no additional cost to the OWNER.
6. All such additions and all such changes, including the proposed method of installation, shall be submitted to the ENGINEER for approval prior to commencing the work.
7. Such changes shall not be a basis of claims for extra work or delay.

K. Installation Criteria and Validation: All field-mounted components and assemblies shall be installed and connected according to the requirements below:
1. Installation personnel have been instructed on installation requirements of the Contract Documents.
2. Technical assistance is available to installation personnel at least by telephone.
3. Installation personnel have at least one copy of the approved shop drawings and data.
4. All differential pressure elements shall have three valve manifolds.
5. All flexible cables and capillary tubing shall be installed in flexible conduits. The lengths shall be sufficient to withdraw the element for periodic maintenance.
6. All power and signal wires have been properly terminated.
7. All connectors shall be, as a minimum, water tight.
8. All wires shall be mounted clearly with an identification tag that is of a permanent and reusable nature.
9. All wire and cable shall be arranged in a neat manner and securely supported in cable groups and connected from terminal to terminal without splices unless specifically approved by the ENGINEER. All wiring shall be protected from sharp edges and corners.
10. All mounting stands and bracket materials and workmanship shall comply with requirements of the Contract Documents.
11. Verify the correctness of each installation, including polarity of electric power and signal connections, and making sure all process connections are free of leaks. The SYSTEM SUPPLIER shall certify in writing that for each loop or system, all discrepancies have been corrected.
12. The OWNER will not be responsible for any additional cost of rework attributable to actions of the CONTRACTOR or the SYSTEM SUPPLIER.

3.03 FIELD QUALITY CONTROL

A. General requirements for testing, calibration, precommissioning and start-up are as described in Section 17950.

3.04 ADJUSTING

A. At no separate additional cost to the OWNER, the SYSTEM SUPPLIER shall include the following services of qualified technical representatives of the SYSTEM SUPPLIER, and the Electrical Contractor.
1. Make all necessary adjustments, calibrations, and tests.

3.05 CLEANING

A. All control panels and enclosures shall be vacuumed clean prior to start-up and again after final completion of the project.

B. All panel surfaces shall be cleaned, any scratches and/or defects shall be repaired to “new” condition.
   1. If in the ENGINEER’s opinion the panel repairs do not constitute “new” condition, they shall be replaced with new panels at no additional cost to the OWNER.

C. All instrument faces and enclosures shall be wiped and/or vacuumed clean.

D. Removal of Abandoned Equipment: All existing instrumentation and control equipment that is no longer required after the new system has been put into service shall be removed and delivered to the OWNER by the CONTRACTOR.

3.06 DEMONSTRATION

A. General requirements for testing, calibration, precommissioning and start-up are as described in Section 17950.

3.07 SCHEDULES

A. The following schedules are provided as a guide general checklist for major portions of the project. They are not intended to be all-inclusive. It is the responsibility of the CONTRACTOR and SYSTEM SUPPLIER to study all of the Contract Documents and furnish all specified materials, documentation, and services.

B. Documentation Schedule.
   1. All drawings shall be generated utilizing AutoCAD 14 or later, and shall be delivered on CDs, as well as hard copies on 11-inch by 17-inch plain bond paper.
   2. All manuals shall be written specifically for this project shall be generated utilizing Microsoft Word 2000 or later and shall be delivered on CDs, as well as hard copies on 8.5-inch by 11-inch plain bond paper.
   3. Technical Manuals shall be supplied for the OWNER in accordance with the Section entitled "Contractor Submittals" as a condition of Substantial Completion.
   4. Calibration sheets for all instruments that have been completed and signed off and all calibration tags attached.
   5. All loop validation sheets completed and signed off and loop certifications issued.
   6. Pre-commissioning certification report and validation sheets.
   7. Training plan overview along with prerequisites for the OWNER's personnel.
   8. Training materials:
      a. Resume for the proposed instructors.
      b. Training manuals.
   9. Warranty Certificate.
   10. Recommended and priced spare parts lists.
   11. Certification of completion of performance tests.

C. Spare Parts and Tools Schedule.

1. Spare parts and tools as identified in paragraph 1.11 of all sections constituting Division 17.
2. SYSTEM SUPPLIER has furnished the spare parts/tools on site at an inventory level sufficient to minimize downtime and reduce the liability of the SYSTEM SUPPLIER for operations up to and through the guarantee period.
   a. All spare parts/tools stored on-site shall become the property of the OWNER upon completion of the guarantee period.

3.08 TRAINING

A. General: The SYSTEM SUPPLIER shall provide system maintenance and operator training courses by a qualified instructor for all the instrumentation, control, furnished for this project.
   1. All instruction, tools and training material shall be provided by the SYSTEM SUPPLIER.

B. Schedule:
   1. In conformance with the requirements of paragraph 1.09 of this section.

C. Agenda:
   1. The training shall include operation and maintenance procedures, trouble shooting with necessary test equipment, and changing setpoints, and calibration for that specific piece of equipment.

D. Maintenance Training.
   1. A maintenance training course shall be provided for up to 8 designated personnel of the OWNER.
   2. This course shall be designed to provide the operations, maintenance, and supervisory personnel with training in routine and preventive maintenance of all items in the instrumentation, and control systems.
   3. The training course shall include instruction on the use of all maintenance equipment and special tools provided under the contract.
   4. During the course, hands-on experience with the system equipment shall be provided.
   5. Course duration shall be a minimum of 1 days with a total of 16 hours of training.

E. Operator Training.
   1. An operator's training course shall be given for up to 8 designated personnel of the OWNER.
   2. This course shall be designed to teach operations, maintenance, and supervisory personnel how to operate the instrumentation, and control systems.
   3. The duration of this course shall be a minimum of 8 hours.
   4. In addition, the SYSTEM SUPPLIER shall provide 1 day of training to 2 people during the factory acceptance test.

F. Instruction.
   1. The operating and maintenance personnel shall be given hands-on instruction in the functions and operation of the system.
   2. They shall participate in the check out and be shown the various adjustable and setpoint features which may require readjustment, resetting or checking, re-calibration or maintenance by them from time to time.

END OF SECTION

SECTION 17100

CONTROL STRATEGIES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes requirements for:
   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 shown on the drawings.

B. Related Sections:
   1. The Contract Documents are a single integrated document, and as such all Divisions and Sections apply. It is the responsibility of the CONTRACTOR and its Sub-Contractors to review all sections to ensure a complete and coordinated project.

1.02 REFERENCES

A. Refer to Section 17050.

1.03 DEFINITIONS

A. Refer to 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.

1.04 SUBMITTALS

A. Refer to Section 17050.

PART 2 PRODUCTS

(NOT USED)

PART 3 EXECUTION

3.01 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 rollover to zero at an even decimal interval (1 followed by 4 or more zeros).
      d. Configure integrating functions to accumulate the maximum rate from the instrument for one year. Ensure that each incremental addition can be added while maintaining two significant digits of the incremental value at all times up to the reset value or 11 percent above the alarm value. Configure the integrated value to roll over to zero at an even decimal interval greater than one year's accumulation at full rate, or generate a reset alarm when the accumulated value reaches 90 percent of the maximum value that will allow accurate accumulation.
   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 one 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) Intrusion status on all enclosures equipped with intrusion switches.
      2) Enclosure temperature, with high and low alarm setpoints.
      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.
      6) Maintenance Bypass switch position.
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, PLC to RIO.
      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 hasn't 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 shown 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:
   1) Display total starts on PCIS screens, and provide a reset function.
   2) Where indicated, calculate number of starts for each day:
      a) Display current day and previous day starts on PCIS displays.
      b) Do not reset daily start count when overall count is reset.
      c) Archive starts for each day through SCADA.

5. Where run time accumulation is shown on the drawings, or required in this Section, integrate accumulated run time to the nearest 0.1 hours 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 hours.
        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.
7. For all analog input values used for process control, provide an over-ride function to allow an operator to manually enter a fixed value through the OIT or HMI:
    a. Maintain over-ride status and value in the PLC.
    b. Only allow access to over-ride selections and settings to operators with sufficient security.
    c. Use the over-ride value for all display and control functions instead of the actual analog input value.
    d. Generate an alarm whenever an over-ride value is in use.
8. 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 clamps to prevent operator-entered values (setpoints, etc.) that fall 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 ten times the normal expected scan or communication update.

9. Analog device override:
    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.
        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.
        3) Enter a value for the analog input from the PCIS system to the PLC.
    b. Provide the following functions in the PLC, with selections and value entry from the OIT and the local HMI for each and every analog output:
        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.
10. 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 vessel:
        1) Establish the maximum 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.
11. I/O filtering and processing:
    a. Analog Input Filtering:
        1) Provide PLC programming for each analog input to implement an adjustable first order filter, for the purpose of smoothing out spikes and other noise for analog transmitter input signals. By default, shall 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 21mA).

b) Under range - The input value is below the normal range (typically under 3mA, 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. By default, discrete inputs shall be configured with de-bounce timers set to zero seconds.

12. Instrument scaling:
a. Provide one 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 dropout values.

13. 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.

14. Display the current status of all operator selections (PCIS HAND/AUTO, PCIS START/STOP, etc.) on HMI and OIT.

15. 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:
        1) Where indicated, provide a selection to bypass software permissives for maintenance functions. This option shall only be selectable in PCIS Manual.
    b. Use hard-wired permissives for equipment protection where indicated.
16. 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 allow bumpless transfer between Manual and Automatic modes.
            i) Provide selectable slew rates with adjustable set points to allow the PID algorithm to slowly ramp to its final value to minimize system disturbance.
17. Equipment alternating and sequencing:
    a. Distribute number of starts and run time equally between identical equipment.

18. 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.
        4) For motors 200 HP and greater, provide software to prevent exceeding the manufacturer's recommended maximum starts per hour.
    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.
            b) 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 devices is reported to be running, start the "Control Activation" timer:
                (1) 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:
                    (a) Keep the RUN output off or the STOP output on.
                    (b) Place the device in a "Failed" state.
                    (c) Generate a "Failed to Respond" alarm.
            c) Re-establish PLC control of a device in a "Failed" state only after 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. Connect motor starter overload relays to stop the motor before de-energizing the motor starter coil.
h. Unless shown otherwise, power motor winding heaters from the starter control power transformer through a normally closed starter auxiliary contact.
i. 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.
j. 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.
k. 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 (60Hz) 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 speed of previously running equipment down 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 the new load running at the starting speed.
(3) Once the previously running equipment reaches the preset speed, resume the speed control algorithm for those equipment.
(4) Ramp the speed of the equipment that had just started until it reaches the speed of the previously running equipment.
(5) Operate all equipment at the same speed following the output of the speed control algorithm.

d) When tow 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.

19. 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 4-20mA 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 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.

20. Breaker status:
    a. Display the following data to the extent it is available from the specified device:
       1) Open.
       2) Closed.
       3) Tripped.
       4) Ground fault.
21. 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 a load sequence table on the OIT and HMI showing the major equipment and systems, and providing a “re-start” selection.
      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) Operator selection to 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) Once the operator has selected loads, and selected “re-start”:
         (1) Start the process loads in the order they were 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 and HMI 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.

3.02 DEMONSTRATION AND TRAINING

A. As specified in Section 17050.

END OF SECTION

SECTION 17101

SPECIFIC CONTROL STRATEGIES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes requirements for:
   1. Loop Descriptions:
      a. Specific control requirements and functional descriptions for individual control loops.

B. Related Sections:
   1. The Contract Documents are a single integrated document, and as such all Divisions and Sections apply. It is the responsibility of the CONTRACTOR and its Sub-Contractors to review all sections to ensure a complete and coordinated project.

1.02 REFERENCES

A. Refer to Section 17050.

1.03 DEFINITIONS

A. Refer to Section 17050.

PART 2 PRODUCTS

NOT USED

PART 3 EXECUTION

3.01 NORTH LIFT PUMP STATION SCREENING AND ODOR CONTROL - P&ID N-4

A. System Overview: The North Lift Pump Station Screening and Odor Control includes the components as described below:
   1. Rotating Mechanical Screen and integral Washer/Compactor, referred to as the Screening System.
   2. Packaged Odor Scrubber with Odor Scrubber Blower, referred to as Odor Scrubber System.
   3. Beacon and Alarm Horn and Other Instrumentation.

B. Equipment: Refer to the P&ID and electrical drawings for specific equipment, instruments, and devices included in this system.

C. Control System Overview: Refer to the P&ID and electrical drawings for specific instruments and devices located in the following locations:
   1. Field: LCPs, switches, sensors, and indicating transmitters.

2. MCC: 480V power.
3. Process Control System (PCS): Monitoring and control as indicated on the P&ID.

D. Screening Control System: Applies to the rotating mechanical screen **01-MS-200** and the washer/compactor **01-MS-201**:
   1. Field:
      a. LOCKOUT/STOP (LOS) switch: Shuts off power to the Screening System and prohibits the system from running in any mode of operation.
      b. LCP: At a minimum, the LCP shall be provided with the following controls:
         1) EMERGENCY STOP pushbutton: stops equipment in all operating modes.
         2) Screen REVERSE JOG pushbutton: shall run the screen in reverse until the pushbutton is released, when the HOA switch is in Hand.
         3) HAND-OFF-AUTO (HOA) selector switch:
            a) HAND: Enables the LCP START, STOP, and JOG switches.
            b) OFF: Screening System is off.
            c) AUTO: Enables the Screening System control strategy.
         4) Screening System control strategy:
            a) With the LCP HOA switch in the AUTO position, the screen shall automatically increase and decrease rotational speed based on the differential upstream and downstream water levels as measured by the ultrasonic level sensors or the Level Sensors Backup Timer.
            b) The incremental speed increase and decrease, run times, wait times and other control settings shall be readily accessible and adjustable by operator at the LCP.
            c) The LCP shall be equipped with a programmable Level Sensors Backup Timer. The Level Sensors Backup Timer shall start the screen if the ultrasonic sensors fail to start the screen within a preset interval of 0 to 999 minutes. The Level Sensors Backup Timer shall be disabled when the timer is set to zero.
            d) The spray water solenoid shall open and the washer/compactor and auger shall start in conjunction with the mechanical screen, following a time delay. The washer/compactor shall stop after a user-adjustable timer has elapsed and the spray water solenoid shall close after a time delay.
            e) All additional control devices/functions and HMI monitoring shall be as defined in Specification Section 11332B and as indicated on the Drawings.
   2. MCC: 480V power.
   3. Process Control System (PCS): Monitoring and Alarms: As indicated on the P&ID.

E. Odor Scrubber Control System: Applies to the Odor Scrubber **01-OS-202** and Odor Scrubber Blower **01-OS-203**:
   1. Field:
      a. LOCKOUT/STOP pushbutton: stops equipment in all operating modes.
      b. LCP: At a minimum, the following controls shall be provided:
         1) HAND-OFF-AUTOMATIC (H-O-A) selector switch at the LCP.
            a) HAND: Enables blower START S1/START S2 (S1-S2) switch at the LCP. This is normal operating mode.

b) OFF: Odor Scrubber Blower is off.
c) AUTOMATIC: None

2) START S1/START S2 (S1-S2) selector switch at the LCP.
a) START S1 : Start blower at S1 speed
b) START S2 : Start blower at S2 speed

3) EMERGENCY STOP pushbutton.

2. MCC: 480V power.
3. Process Control System (PCS): Monitoring and Alarms: As indicated on the P&ID

F. Beacon and Alarm Horn and Other Instrumentation:
1. Field:
a. 01-LSH-100: shall detect a high channel level and send an alarm to SCADA.
b. Beacon and Alarm Horn: Indicate and alarm common fail signal from the PLC.
c. 01-HS-200B - RESET pushbutton: Silences alarm horn. Beacon remains active.
2. MCC: None.
3. Process Control System (PCS):
a. Activate field beacon on any fail annunciation at the North Lift Pump Station PLC and alarm at HMI.
b. When any fail signal is annunciated at the PLC for the North Lift Pump Station, activate field horn only during normal working days and hours. The normal working days and hours shall be operator adjustable.
c. 01-HS-200B - RESET software switch: Silences alarm horn. Beacon remains active.
d. Monitoring and Alarms: As indicated on the P&ID.

G. Combustible Gas Detection
1. Field:
a. 01-AE/AIT-201: shall detect a high level combustible gas and send an alarm to SCADA.
b. Local status display on combustible gas.
c. Beacon and Alarm Horn: Indicate and alarm common fail signal
d. RESET pushbutton: Silences alarm horn and beacon.
2. MCC: None.
3. Process Control System (PCS): Monitoring and Alarms: As indicated on the P&ID.

H. Other Instrumentation:
1. Field:
a. 01-AE/AIT-101 measures and transmits wet well pH to SCADA.
b. 01-FE-101 measures pump discharge flow.
c. 01-FIT-101 indicates pump discharge flow and transmits signal to SCADA
2. MCC:
a. None
3. Process Control System (PCS):
a. Wet well level and pH indication and alarms.
b. Discharge flow and totalized flow indication.

3.02 DEMONSTRATION AND TRAINING

A. Refer to Section 17050.

END OF SECTION

SECTION 17201

LEVEL MEASUREMENT – SWITCHES AND FLOATS

PART 1 GENERAL

1.01 SUMMARY

A. Instruments for instrumentation and control systems that are to be permanently installed.

B. Level switches and floats used for level measurement.
   1. Tipping Float.
   2. Reed.

C. Related Sections
   1. Contract Documents are a single integrated document, and as such all Divisions and Sections apply. It is the responsibility of the CONTRACTOR and its Sub-Contractors to review all sections to insure a complete and coordinated project.

1.02 REFERENCES

A. All instruments shall comply with the latest edition and standards of the Instrumentation, Systems, and Automation Society.

1.03 DEFINITIONS

A. Definitions of terms and other electrical considerations as set forth in the:
   1. National Electrical Code.
   2. Institute of Electrical and Electronic Engineers.
   3. Instrumentation, Systems, and Automation Society.
   4. National Fire Protection Association.

1.04 SYSTEM DESCRIPTION

A. Furnish all instruments as identified on the P&IDs, instrument lists, and instrument data sheets.

B. Install and connect all instruments as per the manufacturer's recommendations for the particular installation.

C. Calibration of instruments will be performed by the Instrumentation and Control Systems Contractor.

1.05 SUBMITTALS

A. Product Data:
   1. Complete manufacturer's brochures identify instrument construction, accuracy, ranges, materials, and options.

2. Completed instrument data sheets including catalog number and source for determining catalog number.
3. Manufacturer's installation instructions.

B. Shop Drawings:
1. Mechanical connection diagrams.
2. Float switch mounting requirements with dimensions and elevations.
3. Electrical connection diagrams.

C. Operating Manuals:
1. Complete installation, calibration, and testing manuals.

1.06 QUALITY ASSURANCE

A. All instruments of similar type shall be furnished by a single manufacturer.

1.07 DELIVERY, STORAGE, AND HANDLING

A. Store all instruments in a dedicated van or structure with space conditioning to meet the recommended storage requirements provided by the manufacturer.
1. Any instruments that are not stored in strict conformance with the manufacturer's recommendation shall be replaced at no additional costs to the OWNER.

1.08 PROJECT/SITE CONDITIONS

A. All instruments must be compatible for the installed site conditions including but not limited to material compatibility, site altitude, installed temperature and humidity conditions.

B. Furnish instruments rated for installation in Class 1 Div. 1 and Div. 2 hazardous locations where indicated on the P&IDs and electrical plans.

1.09 SEQUENCING AND SCHEDULING

1.10 WARRANTY

A. Furnish manufacturer's standard warranty, modified to agree with the Contract Documents.

1.11 MAINTENANCE

A. Provide all necessary materials, fluids, etc. for calibration purposes.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Hardware Commonality:
1. Instruments performing similar functions shall be of the same type, model, or class, and shall be from a single manufacturer.

2.02 EQUIPMENT

A. Tipping Float:
   1. Float actuated switch shall be a dry contact type switch in a hermetically sealed polypropylene casing, suspended on a PVC coated cable.
   2. The number of floats per level system shall be as shown.
   3. The switch rating shall be at least 5 amps at 120 VAC.
   4. Switch setpoints shall be as shown on the drawings.
   5. Mercury switch type capsules are not allowed.
   6. As manufactured by:
      a. B/W Controls.
      b. Consolidated Electric, 9G.
      c. Or approved equal.
   7. Provide floats suitable for use in Class I Div 1 hazardous locations, with intrinsically safe relays.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine the complete set of plans, the process fluids, pressures, and temperatures and furnish instruments that are compatible with installed process condition.

3.02 PREPARATION

A. Coordinate the installation with all trades to insure that the mechanical system has all necessary appurtenances. weldolets, valves, upstream diameters, downstream diameters, etc. for proper installation of the instruments.

3.03 INSTALLATION

A. All instruments shall be installed in strict conformance with the manufacturer's recommendations.
   1. It is the Instrumentation and Control Systems Contractor's responsibility to install all instruments in conformance with manufacturer's recommendations.
   2. It is the Instrumentation and Control Systems Contractor's responsibility to notify the ENGINEER of any installation conditions that may be shown at variance with the manufacturer's recommendations.

3.04 FIELD QUALITY CONTROL

A. The Instrumentation and Control Systems Contractor shall calibrate all instruments in the field during the Calibration and Loop Validation Tests as identified in Section 17050.

3.05 ADJUSTING

A. All instruments shall be field calibrated to match the installed conditions.

3.06 CLEANING

A. All instruments shall be cleaned after calibration and before commissioning.

3.07 DEMONSTRATION

A. Performance of all instruments shall be demonstrated to the ENGINEER prior to commissioning.

B. All instrument calibration shall be witnessed by the OWNER's representative.

C. Each and every instrument shall be tested during the Loop Validation Tests and the OWNER's representative shall witness the response in the PLC control system and associated registers.

3.08 PROTECTION

A. All instruments shall be fully protected after installation and before commissioning. The CONTRACTOR shall replace any instruments damaged prior to commissioning.
   1. The ENGINEER shall be the sole party responsible for determining the corrective measures.

END OF SECTION

SECTION 17206

LEVEL MEASUREMENT – ULTRASONIC

PART 1 GENERAL

1.01 SUMMARY

A. Instruments for instrumentation and control systems that are to be permanently installed.

B. Related Sections
   1. Contract Documents are a single integrated document, and as such all Divisions and Sections apply. It is the responsibility of the CONTRACTOR and its Sub-Contractors to review all sections to insure a complete and coordinated project.

1.02 REFERENCES

A. All instruments shall comply with the latest edition and standards of the Instrumentation, Systems, and Automation Society.

1.03 DEFINITIONS

A. Definitions of terms and other electrical considerations as set forth in the:
   1. National Electrical Code.
   2. Institute of Electrical and Electronic Engineers.
   3. Instrumentation, Systems, and Automation Society.
   4. National Fire Protection Association.

1.04 SYSTEM DESCRIPTION

A. Furnish all instruments as identified on the P&IDs, instrument lists, and instrument data sheets.

B. Install and connect all instruments as per the manufacturer's recommendations for the particular installation.

C. Calibration of instruments will be performed by the Instrumentation and Control Systems Contractor.

1.05 SUBMITTALS

A. Product Data:
   1. Complete manufacturer's brochures identify instrument construction, accuracy, ranges, materials, and options.
   2. Completed instrument data sheets including catalog number and source for determining catalog number.
   3. Manufacturer's installation instructions.

B. Shop Drawings:
   1. Mechanical connection diagrams.
   2. Sensor transducer mounting requirements with dimensions and elevations.
   3. Electrical connection diagrams.

C. Test Reports:
   1. Certified factory and field calibration data sheets for instruments and devices that require set-up and calibration.
      a. Including factory calibration for each instrument with stated accuracy.

D. Operating Manuals:
   1. Certified factory and field calibration data sheets for instruments and devices that require set-up and calibration.
      a. Including factory calibration for each instrument with stated accuracy.
   2. Complete installation, calibration, and testing manuals.

E. Record Drawings:
   1. Complete field calibration sheets, including range, span, PLC I/O address, register, and scaling coefficients.

1.06 QUALITY ASSURANCE

A. All instruments of similar type shall be furnished by a single manufacturer.

1.07 DELIVERY, STORAGE, AND HANDLING

A. Store all instruments in a dedicated van or structure with space conditioning to meet the recommended storage requirements provided by the manufacturer.
   1. Any instruments that are not stored in strict conformance with the manufacturer's recommendation shall be replaced at no additional costs to the OWNER.

1.08 PROJECT/SITE CONDITIONS

A. All instruments must be compatible for the installed site conditions including but not limited to material compatibility, site altitude, installed temperature and humidity conditions.

B. Furnish instruments rated for installation in Class 1 Div. 1 and Div. 2 hazardous locations where indicated on the P&IDs and electrical plans.

1.09 SEQUENCING AND SCHEDULING

1.10 WARRANTY

A. Furnish manufacturer's standard warranty, modified to agree with the Contract Documents.

1.11 MAINTENANCE

A. Provide all necessary materials, fluids, etc. for calibration purposes.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Hardware Commonality:
   1. All instruments which utilize a common measurement principle, for example, d/p cells, pressure transmitters, level transmitters which monitor hydrostatic head, shall be furnished by a single manufacturer.
   2. All panel-mounted instruments shall have matching style and general appearance.
   3. Instruments performing similar functions shall be of the same type, model, or class, and shall be from a single manufacturer.

2.02 EQUIPMENT

A. Ultrasonic Level Transmitter:
   1. Shall be of the non-contact microprocessor based type for the continuous measurement of liquid levels.
   2. Components:
      a. A transducer with sufficient cable attached to the transducer for a complete, non-spliced, cable run from the transducer to the transmitter.
      b. A control transmitter unit which can be located up to 1,200 feet away from the sensor.
      c. A removable programming unit.
   3. Transmitter.
      a. The transmitter shall store the ultrasonic profile in the computer memory and moment by moment, analyze the profile to determine the actual liquid level.
      b. Unit shall alter the ultrasound profile to enhance the echo with every momentary variation in the vessel conditions.
      c. All program data shall be safeguarded internally in non-volatile EEPROM memory.
      d. Enclosure NEMA 4X enclosure with an integral front panel mounted meter indicating in scaled engineering units.
      e. Shall provide an isolated 4-20 mA analog output signal directly proportional to level.
      f. The unit shall be capable of displaying by software selection either:
         1) Distance to liquid surface from transmitter.
         2) Distance from bottom of tank to liquid surface.
         3) Remaining volume in tank.
      g. Shall contain up to five relays for use as programmable alarm points.
      h. Power requirements shall be 120 VAC.
      i. Shall be short circuit proof with respect to transducer connections.
   4. Transducer.
      a. Shall be encapsulated.
      b. Operating temperature range -20 degrees to 60 degrees Celsius with an accuracy of ± 0.25 percent of range.
      c. Measuring range 50 feet.
      d. Provided for flange mounting.
      e. Integral temperature compensation.
      f. Manufacturer to furnish sufficient cable attached to the transducer for a complete, non-spliced, cable run from the transducer to the transmitter.

5. Programming Unit.
   a. Shall be a separate transportable unit that shall be capable of being removed from the control transmitter after programming and configuring the controller.
6. Performance requirements:
   a. Ranges: Refer to instrument schedule.
      1) Select transducer to provide full range measurement from surface of transducer to bottom of vessel.
   b. Accuracy: 0.25 percent or range or 0.24 inches whichever is greater.
   c. Resolution: 0.1 percent or range or 0.08 inches whichever is greater.
   d. Electronics Ambient Temperature: -5 degrees Fahrenheit to 122 degrees Fahrenheit (-20 degrees Celsius to 50 degrees Celsius).
   e. Transducer Process Temperature: -40 degrees Fahrenheit to 300 degrees Fahrenheit (-40 degrees Celsius to 150 degrees Celsius).
   f. Power Supply:
      1) 115 VAC.
      2) 60 Hz.
7. Furnish transducer rated for use in Class I Division I hazardous locations as indicated on the electrical plans and P&IDs, with intrinsic safety barriers as required.

B. Manufacturers:
   1. Milltronics Hydroranger 200.
   2. No other manufacturer will be accepted. This item is being sole-sourced per NRS 338.140 to match equipment in use at the project site either completed or in the course of completion.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine the complete set of plans, the process fluids, pressures, and temperatures and furnish instruments that are compatible with installed process condition.

3.02 PREPARATION

A. Coordinate the installation with all trades to insure that the mechanical system has all necessary appurtenances, weldolets, valves, upstream diameters, downstream diameters, etc. for proper installation of the instruments.

3.03 INSTALLATION

A. All instruments shall be installed in strict conformance with the manufacturer's recommendations.
   1. It is the Instrumentation and Control Systems Contractor's responsibility to install all instruments in conformance with manufacturer's recommendations.
   2. It is the Instrumentation and Control Systems Contractor's responsibility to notify the ENGINEER of any installation conditions that may be shown at variance with the manufacturer's recommendations

3.04 FIELD QUALITY CONTROL

A. The Instrumentation and Control Systems Contractor shall calibrate all instruments in the field during the Calibration and Loop Validation Tests as identified in Section 17050.

3.05 ADJUSTING

A. All instruments shall be field calibrated to match the installed conditions.

3.06 CLEANING

A. All instrument enclosures shall be vacuumed clean after calibration and before commissioning.

3.07 DEMONSTRATION

A. Performance of all instruments shall be demonstrated to the ENGINEER prior to commissioning.

B. All instrument calibration shall be witnessed by the OWNER's representative.

C. Each and every instrument shall be tested during the Loop Validation Tests and the OWNER's representative shall witness the response in the PLC control system and associated registers.

3.08 PROTECTION

A. All instruments shall be fully protected after installation and before commissioning. The CONTRACTOR shall replace any instruments damaged prior to commissioning.
   1. The ENGINEER shall be the sole party responsible for determining the corrective measures.

3.09 SCHEDULES

A. The Instrumentation and Control System Contractor shall supply complete instrument data sheets for each and every instrument and submit this information in accordance with paragraph 1.05 of this Section.
   1. Instrument data sheets shall be furnished in both hard copy and electronic format.

END OF SECTION

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SECTION 17302

FLOW MEASUREMENT – MAGNETIC TUBES

PART 1 GENERAL

1.01 SUMMARY

A. Instruments for instrumentation and control systems that are to be permanently installed.

B. Related Sections
   1. Contract Documents are a single integrated document, and as such all Divisions and Sections apply. It is the responsibility of the CONTRACTOR and its Sub-Contractors to review all sections to insure a complete and coordinated project.

1.02 REFERENCES

A. All instruments shall comply with the latest edition and standards of the Instrumentation, Systems, and Automation Society.

1.03 DEFINITIONS

A. Definitions of terms and other electrical considerations as set forth in the:
   1. National Electrical Code.
   2. Institute of Electrical and Electronic Engineers.
   3. Instrumentation, Systems, and Automation Society.
   4. National Fire Protection Association.

1.04 SYSTEM DESCRIPTION

A. Furnish all instruments as identified on the P&IDs, instrument lists, and instrument data sheets.

B. Install and connect all instruments as per the manufacturer's recommendations for the particular installation.

C. Calibration of instruments will be performed by the Instrumentation and Control Systems Contractor.

1.05 SUBMITTALS

A. Product Data:
   1. Complete manufacturer's brochures identify instrument construction, accuracy, ranges, materials, and options.
   2. Completed instrument data sheets including catalog number and source for determining catalog number.
   3. Manufacturer's installation instructions.

B. Shop Drawings:
   1. Mechanical connection diagrams.
   2. Magnetic tube and magnetic transmitter mounting requirements with dimensions and elevations.
   3. Electrical connection diagrams.

C. Test Reports:
   1. Certified factory and field calibration data sheets for instruments and devices that require set-up and calibration.
      a. Including factory calibration for each instrument with stated accuracy.

D. Operating Manuals:
   1. Certified factory and field calibration data sheets for instruments and devices that require set-up and calibration.
      a. Including factory calibration for each instrument with stated accuracy.
   2. Complete installation, calibration, and testing manuals.

E. Record Drawings:
   1. Complete field calibration sheets, including range, span, PLC I/O address, register, and scaling coefficients.

1.06 QUALITY ASSURANCE

A. All instruments of similar type shall be furnished by a single manufacturer.

1.07 DELIVERY, STORAGE, AND HANDLING

A. Store all instruments in a dedicated van or structure with space conditioning to meet the recommended storage requirements provided by the manufacturer.
   1. Any instruments that are not stored in strict conformance with the manufacturer's recommendation shall be replaced at no additional cost to the OWNER.

1.08 PROJECT/SITE CONDITIONS

A. All instruments must be compatible for the installed site conditions including but not limited to material compatibility, site altitude, installed temperature and humidity conditions.

B. Furnish instruments rated for installation in Class 1 Div. 1 and Div. 2 hazardous locations where indicated on the P&IDs and electrical plans.

1.09 SEQUENCING AND SCHEDULING

A. See Section 01140 - Work Restrictions.

1.10 WARRANTY

A. The CONTRACTOR shall provide a manufacturer's of at least 1 year from final acceptance by the ENGINEER.

1.11 MAINTENANCE

A. Provide all necessary materials, fluids, etc. for calibration purposes.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Hardware Commonality:
   1. All instruments which utilize a common measurement principle, for example, d/p cells, pressure transmitters, level transmitters which monitor hydrostatic head, shall be furnished by a single manufacturer.
   2. Instruments performing similar functions shall be of the same type, model, or class, and shall be from a single manufacturer.

2.02 MAGNETIC FLOW METERS

A. General:
   1. Magnetic flowmeter systems shall be of the low frequency electromagnetic induction type and produce a DC pulsed linear signal, which is directly proportional to the liquid flow rate.
   2. Complete zero stability shall be an inherent characteristic of the flowmeter system.
   3. Magnetic flow metering system shall include:
      a. A metering tube.
      b. Signal cable.
      c. Remote transmitter.
      d. Flow meter grounding rings.

B. Source quality control:
   1. Shall be 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.

C. Metering tube:
   1. Constructed of Type 304 stainless steel, with Type 304 stainless steel flanged connections.
   2. Utilize a minimum of 2 bullet-nosed, self-cleaning electrodes.
   3. Liner in conformance with:
      a. Manufacturer’s recommendation for the intended service.
   4. Electrodes: 316Ti stainless steel electrodes.
   5. Meter housing NEMA 6.
   6. Coated carbon steel housing with aluminum terminal box.
   7. FM approved.
   8. Meter coating consisting of epoxy painted finish.
   9. Suitable cable length to signal converter/transmitter.
   10. Two grounding rings:
      a. Which are in conformance with the manufacturer’s bore and material recommendation for the meter’s intended service.
      b. Designed to protect and shield from abrasion the liner’s edge interface at the meter’s end.

D. Transmitter:
   1. Microprocessor-based signal converter/transmitter.
   2. Utilize DC pulse technique to drive flux-producing coils.
   3. Convert DC pulse signal from the tube to a standard 4-20 mA signal.
   4. Contain a 6-digit display for flow rate, percent of span, and totalizer.
   5. Operator interface consisting of keypads, which respond to English text entry.
   6. Integral zero return to provide a consistent zero output signal in response to an external dry contact closure.
   7. Integral low flow cut-off zero return.
   8. Automatic range change.
   9. Programmable parameters including:
      a. Meter size.
      b. Full-scale flow rate.
      c. Magnetic field frequency.
      d. Time constant.
   10. Data retention for a minimum of 5 years without auxiliary main or battery power.
   11. Self-diagnostics and automatic data checking.
   12. Protected terminals and fuses in a separate compartment which isolates field connection from electronics.
   13. Ambient operating temperature limits of -29 to 60 degrees Celsius (-20 to 140 degrees Fahrenheit).
   14. Intrinsically safe transmitter.

E. Performance requirements:
   1. Range:
      a. Refer to instrument schedule.
   2. Accuracy:
      a. 0.50 percent of flow rate from 10 to 100 percent of full scale for velocities over 3 feet per second.
   3. Repeatability:
      a. 0.25 percent of full scale.
   4. Isolation:
      a. Galvanic or.
      b. Optical.
   5. Power supply:
      a. 120 VAC ± 10 percent.
      b. 60 Hz.

F. Factory testing:
   1. Each flow metering system shall be hydraulically calibrated at a facility which is traceable to the Nation Institute of Testing Standards.
   2. The calibration procedure shall conform to the requirements of MIL-STD-45662A.
   3. A real-time computer generated printout of the actual calibration data indicating apparent and actual flows at 20 percent, 40 percent, 60 percent, 80 percent, and 100 percent of the calibrated range shall be submitted to the ENGINEER at least 30 days prior to shipment of the meters to the project site.

G. Manufacturer:
   1. Foxboro 9100A series Magnetic Flowtubes with an IMT25 magnetic flow transmitter.

2. No other manufacturer will be accepted. This item is being sole-sourced per NRS 338.140 to match equipment in use at the project site either completed or in the course of completion.

2.03 SOURCE QUALITY CONTROL

A. All instruments and/or representative instruments shall be calibrated to in facilities and with instruments traceable to the National Bureau of Standards.
   1. Provide complete documentation covering the traceability of all calibration instruments.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine the complete set of plans, the process fluids, pressures, and temperatures and furnish instruments that are compatible with installed process condition.

3.02 PREPARATION

A. Coordinate the installation with all trades to insure that the mechanical system has all necessary appurtenances, weldolets, valves, upstream diameters, downstream diameters, etc. for proper installation of the instruments.

3.03 INSTALLATION

A. All instruments shall be installed in strict conformance with the manufacturer's recommendations.
   1. It is the Instrumentation and Control Systems Contractor's responsibility to install all instruments in conformance with manufacturer's recommendations.
   2. It is the Instrumentation and Control Systems Contractor's responsibility to notify the ENGINEER of any installation conditions that may be shown at variance with the manufacturer's recommendations

3.04 FIELD QUALITY CONTROL

A. The Instrumentation and Control Systems Contractor shall calibrate all instruments in the field during the Calibration and Loop Validation Tests as identified in Section 17050.

3.05 ADJUSTING

A. All instruments shall be field calibrated to match the installed conditions.

3.06 CLEANING

A. All instrument enclosures shall be vacuumed clean after calibration and before commissioning.

3.07 DEMONSTRATION

A. Performance of all instruments shall be demonstrated to the ENGINEER prior to commissioning.

B. All instrument calibration shall be witnessed by the OWNER's representative.

C. Each and every instrument shall be tested during the Loop Validation Tests and the OWNER's representative shall witness the response in the PLC control system and associated registers.

3.08 PROTECTION

A. All instruments shall be fully protected after installation and before commissioning. The CONTRACTOR shall replace any instruments damaged prior to commissioning.
   1. The ENGINEER shall be the sole party responsible for determining the corrective measures.

3.09 SCHEDULES

A. The Instrumentation and Control System Contractor shall supply complete instrument data sheets for each and every instrument and submit this information in accordance with paragraph 1.05 of this section.
   1. Instrument data sheets shall be furnished in both hard copy and electronic format.

END OF SECTION

SECTION 17401

PRESSURE/VACUUM MEASUREMENT – DIAPHRAGM SEALS

PART 1 GENERAL

1.01 SUMMARY

A. Instruments for instrumentation and control systems that are to be permanently installed.

B. Seals used for pressure measurement.
   1. Diaphragm.

C. Related Sections
   1. Contract Documents are a single integrated document, and as such all Divisions and Sections apply. It is the responsibility of the CONTRACTOR and its Sub-Contractors to review all sections to insure a complete and coordinated project.

1.02 REFERENCES

A. All instruments shall comply with the latest edition and standards of the Instrumentation, Systems, and Automation Society.

1.03 DEFINITIONS

A. Definitions of terms and other electrical considerations as set forth in the:
   1. Instrumentation, Systems, and Automation Society.

1.04 SYSTEM DESCRIPTION

A. Furnish all instruments as identified on the P&IDs, instrument lists, and instrument data sheets.

B. Install and connect all instruments as per the manufacturer's recommendations for the particular installation.

1.05 SUBMITTALS

A. Product Data:
   1. Complete manufacturer's brochures identify instrument construction, materials, and options.
   2. Manufacturer's installation instructions.

B. Shop Drawings:
   1. Mechanical connection diagrams.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Store all instruments in a dedicated van or structure with space conditioning to meet the recommended storage requirements provided by the manufacturer.
   1. Any instruments that are not stored in strict conformance with the manufacturer's recommendation shall be replaced at no additional costs to the OWNER.

1.07 PROJECT/SITE CONDITIONS

A. All instruments must be compatible for the installed site conditions including but not limited to material compatibility, site altitude, installed temperature, and humidity conditions.

1.08 WARRANTY

A. Furnish manufacturer's standard warranty, modified to agree with the Contract Documents.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Hardware Commonality:
   1. Instruments performing similar functions shall be of the same type, model, or class, and shall be from a single manufacturer.

2.02 EQUIPMENT

A. Diaphragm seals.
   1. Pressure gauges shall be provided with diaphragm seals where shown.
   2. Pressure gauges and diaphragm seals shall be assembled and oil filled at the factory prior to shipment.
   3. For sludge, liquids containing solids, pulsating flow:
      1) Seals of all Type 316 stainless steel diaphragm for pressures over 15 psi.
      2) Elastomer diaphragm for pressures of 15 psi and below.
      3) Type 316 stainless steel nuts and bolts, fill connection and valved flush port size of 1/4 inch NPT, capable of disassembly without loss of filler fluid.
      4) As manufactured by:
         a) Aschcroft Model 101.
         b) U.S. Gauge (Ametek), SG.
         c) Marshalltown, Series 225-01.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine the complete set of plans, the process fluids, pressures, and temperatures and furnish instruments that are compatible with installed process condition.

3.02 PREPARATION

A. Coordinate the installation with all trades to insure that the mechanical system has all necessary appurtenances, weldolets, valves, upstream diameters, downstream diameters, etc. for proper installation of the instruments.

3.03 INSTALLATION

A. All instruments shall be installed in strict conformance with the manufacturer's recommendations.
   1. It is the Instrumentation and Control Systems Contractor's responsibility to install all instruments in conformance with manufacturer's recommendations.
   2. It is the Instrumentation and Control Systems Contractor's responsibility to notify the ENGINEER of any installation conditions that may be shown at variance with the manufacturer's recommendations.

3.04 CLEANING

A. All instrument enclosures shall be vacuumed clean before commissioning.

3.05 DEMONSTRATION

A. Performance of all instruments shall be demonstrated to the ENGINEER prior to commissioning.

3.06 PROTECTION

A. All instruments shall be fully protected after installation and before commissioning. The CONTRACTOR shall replace any instruments damaged prior to commissioning.
   1. The ENGINEER shall be the sole party responsible for determining the corrective measures.

END OF SECTION

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SECTION 17404

PRESSURE/VACUUM MEASUREMENT – GAUGES

PART 1 GENERAL

1.01 SUMMARY

A. Instruments for instrumentation and control systems that are to be permanently installed.

B. Related Sections
   1. Contract Documents are a single integrated document, and as such all Divisions and Sections apply. It is the responsibility of the CONTRACTOR and its Subcontractors to review all sections to insure a complete and coordinated project.

1.02 REFERENCES

A. All instruments shall comply with the latest edition and standards of the Instrumentation, Systems, and Automation Society.

1.03 DEFINITIONS

A. Definitions of terms as set forth in the:
   1. Instrumentation, Systems, and Automation Society.

1.04 SYSTEM DESCRIPTION

A. Furnish all instruments as identified on the P&IDs, instrument lists, and instrument data sheets.

B. Install and connect all instruments as per the manufacturer's recommendations for the particular installation.

C. Calibration of instruments will be performed by the Instrumentation and Control Systems Contractor.

1.05 SUBMITTALS

A. Product Data:
   1. Complete manufacturer's brochures identify instrument construction, accuracy, ranges, materials, and options.
   2. Completed instrument data sheets including catalog number and source for determining catalog number.
   3. Manufacturer's installation instructions.

B. Shop Drawings:
   1. Mechanical connection diagrams.

C. Test Reports:
   1. Certified factory and field calibration data sheets for instruments and devices that require set-up and calibration.
      a. Including factory calibration for each instrument with stated accuracy.

D. Operating Manuals:
   1. Certified factory and field calibration data sheets for instruments and devices that require set-up and calibration.
      a. Including factory calibration for each instrument with stated accuracy.
   2. Complete installation, calibration, and testing manuals.

E. Record Drawings:
   1. Complete field calibration sheets, including range, span, register, and scaling coefficients.

1.06 QUALITY ASSURANCE

A. All gauges shall be by a single manufacturer.

1.07 DELIVERY, STORAGE, AND HANDLING

A. Store all instruments in a dedicated van or structure with space conditioning to meet the recommended storage requirements provided by the manufacturer.
   1. Any instruments that are not stored in strict conformance with the manufacturer's recommendation shall be replaced at no additional costs to the OWNER.

1.08 PROJECT/SITE CONDITIONS

A. All instruments must be compatible for the installed site conditions including but not limited to material compatibility, site altitude, installed temperature, and humidity conditions.

1.09 WARRANTY

A. Furnish manufacturer's standard warranty, modified to agree with the Contract Documents.

1.10 MAINTENANCE

A. Provide all necessary materials, fluids, etc. for calibration purposes.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Hardware Commonality:
   1. Instruments performing similar functions shall be of the same type, model, or class, and shall be from a single manufacturer.

2.02 EQUIPMENT

A. General:
   1. Furnish and install pressure and vacuum gauges as specified, complete, including all fittings, snubbers, connections, gaskets, supports, and accessories in the locations shown or specified, in accordance with the Contract Documents.
   2. Pressure gauges shall be provided as shown shown on the plans:
      a. On suction and discharge connection to all pumps.
      b. On discharge connection from blowers and compressors.
      c. On each side of pressure reducing valves.
      d. In other locations as shown on the P&IDs and/or mechanical plans.

B. Construction:
   1. Gauges shall be industrial quality type with Type 316 stainless steel movement.
   2. Phenolic case.
   3. Liquid filled.
   4. Unless otherwise shown or specified, gauges shall have:
      a. A 4-1/2 inch dial.
      b. 1/4-inch threaded connection.
      c. Type 316 stainless steel pulsation dampener adapter.
         1) Pulsation Dampener as manufactured by:
            a) Ashcroft.
            b) Or equal.
   5. A shut-off valve.
   6. Gauges shall be calibrated to read in applicable engineering units.
   7. Accuracy of ± 0.5 percent to 150 percent of the working pressure or vacuum of the pipe or vessel to which they are connected.
   8. All gauges shall be vibration and shock resistant.
   9. Ranges:
      a. As shown on the instrument schedule.

C. Diaphragm seals:
   1. Gauges attached to system involving chemical solutions, corrosive fluids, sludge, sewage, or other liquids containing solids shall be equipped with diaphragm seals.
   2. In addition, diaphragm seals shall be provided and included at the locations shown.

D. Installation.
   1. All gauges shall be installed with the face in the vertical position.
   2. In strict accordance with the manufacturers printed instructions.
   3. At the locations shown on the drawings, when so shown.
   4. Care shall be taken to minimize the effect of water hammer or vibrations on the gauges.
   5. In extreme cases, and with the approval of the ENGINEER, gauges may be mounted independently, with flexible connectors.

E. Gauges general as manufactured by:
   1. Ashcroft Industrial Instruments (Dresser).
   2. Marsh Instruments Co.

3. Marshalltown Instruments, Inc.
4. U.S. Gauge Div. of Ametek.

2.03 SOURCE QUALITY CONTROL

A. All instruments and/or representative instruments shall be calibrated to in facilities and with instruments traceable to the National Bureau of Standards.
   1. Provide complete documentation covering the traceability of all calibration instruments.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine the complete set of plans, the process fluids, pressures, and temperatures and furnish instruments that are compatible with installed process condition.

3.02 PREPARATION

A. Coordinate the installation with all trades to insure that the mechanical system has all necessary appurtenances, weldolets, valves, upstream diameters, downstream diameters, etc. for proper installation of the instruments.

3.03 INSTALLATION

A. All instruments shall be installed in strict conformance with the manufacture's recommendations.
   1. It is the Instrumentation and Control Systems Contractor's responsibility to install all instruments in conformance with manufacturer's recommendations.
   2. It is the Instrumentation and Control Systems Contractor's responsibility to notify the ENGINEER of any installation conditions that may be shown at variance with the manufacturer's recommendations.

3.04 FIELD QUALITY CONTROL

A. The Instrumentation and Control Systems Contractor shall calibrate all instruments in the field during the Calibration and Loop Validation Tests as identified in Section 17050.

3.05 ADJUSTING

A. All instruments shall be field calibrated to match the installed conditions.

3.06 CLEANING

A. All instruments shall be cleaned after calibration and before commissioning.

3.07 DEMONSTRATION

A. Performance of all instruments shall be demonstrated to the ENGINEER prior to commissioning.

B. All instrument calibration shall be witnessed by the OWNER's representative.

C. Each and every instrument shall be tested during the Loop Validation Tests and the OWNER's representative shall witness the response in the PLC control system and associated registers.

3.08 PROTECTION

A. All instruments shall be fully protected after installation and before commissioning. The CONTRACTOR shall replace any instruments damaged prior to commissioning.
   1. The ENGINEER shall be the sole party responsible for determining the corrective measures.

3.09 SCHEDULES

A. The Instrumentation and Control System Contractor shall supply complete instrument data sheets for each and every instrument and submit this information in accordance with paragraph 1.05 of this section.
   1. Instrument data sheets shall be furnished in both hard copy and electronic format.

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SECTION 17501

ANALYTICAL INSTRUMENTS

PART 1 GENERAL

1.01 SUMMARY

A. Instruments for instrumentation and control systems that are to be permanently installed.

B. Related Sections:
   1. Contract Documents are a single integrated document, and as such all Divisions and Sections apply. It is the responsibility of the CONTRACTOR and its subcontractors to review all sections to insure a complete and coordinated project.

1.02 REFERENCES

A. All instruments shall comply with the latest edition and standards of the Instrumentation, Systems, and Automation Society.

1.03 DEFINITIONS

A. Definitions of terms and other electrical considerations as set forth in the:
   1. National Electrical Code.
   2. Institute of Electrical and Electronic Engineers.
   3. Instrumentation, Systems, and Automation Society.
   4. National Fire Protection Association.

1.04 SYSTEM DESCRIPTION

A. Furnish all instruments as identified on the P&IDs, instrument lists, and instrument data sheets.

B. Install and connect all instruments as per the manufacturer's recommendations for the particular installation.

C. Calibration of instruments will be performed by the Instrumentation and Control Systems Contractor.

1.05 SUBMITTALS

A. Product Data:
   1. Complete manufacturer's brochures identify instrument construction, accuracy, ranges, materials, and options.
   2. Completed instrument data sheets including catalog number and source for determining catalog number.
   3. Manufacturer's installation instructions.
   4. Calibration accessories with a comprehensive list of all buffers, reagents and accessories needed for routine calibration.

B. Shop Drawings:
   1. Mechanical connection diagrams.
   2. Sensor transducer mounting requirements with dimensions and elevations.
   3. Electrical connection diagrams.

C. Test Reports:
   1. Certified factory and field calibration data sheets for instruments and devices that require set-up and calibration.
      a. Including factory calibration for each instrument with stated accuracy.

D. Operating Manuals:
   1. Certified factory and field calibration data sheets for instruments and devices that require set-up and calibration.
      a. Including factory calibration for each instrument with stated accuracy.
   2. Complete installation, calibration, and testing manuals.

E. Record Drawings:
   1. Complete field calibration sheets, including range, span, PLC I/O address, register, and scaling coefficients.

1.06 QUALITY ASSURANCE

A. All instruments of similar type shall be by a single manufacturer.

1.07 DELIVERY, STORAGE, AND HANDLING

A. Store all instruments in a dedicated van or structure with space conditioning to meet the recommended storage requirements provided by the manufacturer.
   1. Any instruments that are not stored in strict conformance with the manufacturer's recommendation shall be replaced at no additional cost to the OWNER.

1.08 ENVIRONMENTAL CONDITIONS

A. Site/Operating Conditions:
   1. Outdoor, corrosive, wet weather installation in a wastewater plant serving residential, commercial, and industrial waste.
   2. Wastewater will be composed of soft biological flocs, sand/grit, stringy material, hair, bits of plastic and paper, and grease from screened sewage and may contain minor concentrations of industrial solvents and petroleum products.
   3. Ambient Air Temperatures:
      a. Maximum: 120°F.
      b. Minimum: 0°F.
   4. Wastewater Characteristics:
      a. Water pH: 5 to 9.
      b. Mixed liquor suspended solids (MLSS) concentrations will vary between 1,000 and 5,000 mg/L:
      c. Temperatures:
         1) Maximum: 90°F.
         2) Minimum: 50°F.
   5. Humidity Range: 0 to 100%.
   6. Site Elevation: Approximately 4,630 feet above mean sea level.

1.09 SEQUENCING AND SCHEDULING

A. See Section 01140.

1.10 WARRANTY

A. The CONTRACTOR shall provide a manufacturer's of at least 1 year from final acceptance by the ENGINEER.

1.11 MAINTENANCE

A. Extra materials:
   1. Maintenance kit for each analyzer sensor assembly with a minimum of one spare probe/sensor for every three probes/sensors installed.
   2. At least one set of other manufacturer spare parts.
   3. Calibration kit with calibration media sufficient for initial testing and at least 12 months of operation when required by manufacturer'

B. Provide all necessary materials, fluids, etc. for calibration purposes.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Hardware Commonality:
   1. All analytical instruments which utilize a common measurement principle.
   2. All panel mounted analytical instruments shall have matching style and general appearance.
   3. Analytical instruments performing similar functions shall be of the same type, model, or class, and shall be from a single manufacturer.

B. Manufacturers of pH Sensor, Analyzer/Transmitter shall be:
   1. Hach, GLI pH sensor with si792x P pH/ORP 2-wire transmitter.
   2. Or Equal.

2.02 pH ANALYZER/TRANSMITTER

A. Each pH analyzer/transmitter system shall consist of:
   1. A remote indicating analyzer/transmitter.
   2. Preamplifier.
   3. pH probe assembly.
   4. Mounting hardware.
   5. Interconnecting cables.

B. The pH analyzer/transmitter shall continuously measure and indicate the pH of an aqueous solution.
   1. The analyzer shall produce a 4-20 mA DC output signal that is linearly proportional to the measured pH from 0 to 14 units and be capable of delivering this output signal into a minimum load of 600 ohms.

C. The pH indicating transmitter shall be:
   1. Equipped with a Liquid Crystal Display (LCD) to simultaneously show measurements, sensor status, and alarms.
   2. Equipped with cable of required length to connect transmitter to sensor.
   3. Able to accept a signal from a pH/ORP sensor.
   4. Able to transmit a 4-20 mA signal, with HART communication.
   5. Powered by a 24 VDC power source.
   6. Provided with self-diagnostic functions with display of error messages.
   7. Provided with panel mounting hardware.

D. The pH preamplifier shall be integral to a watertight pH probe assembly.

E. The pH probe assembly shall include:
   1. A pH-measuring process electrode.
   2. Option for 1-point or 2-point calibration.
   3. An automatic temperature-compensation circuit from 0 to 50 degrees Celsius.
   4. pH probe assembly suitable for full submersion up to 20 feet.
      a. The probe assembly shall be constructed of non-corrosive materials.
      b. It shall be supplied with Type 316 stainless steel mounting hardware and interconnecting cable of suitable length for proper installation and servicing of the probe assembly.
   5. A threaded polypropylene body for maximum chemical resistance and completely sealed to eliminate process fluid intrusion.
   6. Wetted materials: Polypropylene, EPDM, Titanium, glass/platinum.
   7. Rated for Class I Division 1 hazardous location.

F. Each pH analyzer system shall be furnished with any additional chemicals, solutions, and maintenance materials that are required for sustaining the system in continuous operation for one year.

2.03 CALIBRATION KITS AND ACCESSORIES

A. The CONTRACTOR shall provide a minimum of one complete calibration kit for each type of analytical instrument.

B. The calibration kit shall include all buffer solutions, reagents, and accessories required for routine calibration of the instrument for a period of at least one year.

2.04 SOURCE QUALITY CONTROL

A. All instruments and/or representative instruments shall be calibrated to in facilities and with instruments traceable to the National Bureau of Standards.
   1. Provide complete documentation covering the traceability of all calibration instruments.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine the complete set of plans, the process fluids, pressures, and temperatures and furnish instruments that are compatible with installed process condition.

3.02 PREPARATION

A. Coordinate the installation with all trades to insure that the mechanical system has all necessary appurtenances, weldolets, valves, upstream diameters, downstream diameters, etc. for proper installation of the instruments.

3.03 INSTALLATION

A. All instruments shall be installed in strict conformance with the manufacturer's recommendations.
   1. It is the CONTRACTOR's responsibility to install all instruments in conformance with manufacturer's recommendations.
   2. It is the CONTRACTOR's responsibility to notify the ENGINEER of any installation conditions that may be shown at variance with the manufacturer's recommendations.

3.04 FIELD QUALITY CONTROL

A. The CONTRACTOR shall calibrate all instruments in the field during the Calibration and Loop Validation Tests as identified in Section 17050.

3.05 ADJUSTING

A. All instruments shall be field calibrated to match the installed conditions.

3.06 CLEANING

A. All instrument enclosures shall be vacuumed clean after calibration and before commissioning.

3.07 DEMONSTRATION

A. Performance of all instruments shall be demonstrated to the ENGINEER prior to commissioning.

B. All instrument calibration shall be witnessed by the OWNER's representative or ENGINEER.

C. Each and every instrument shall be tested during the Loop Validation Tests and the OWNER's representative shall witness the response in the PLC control system and associated registers.

3.08 TRAINING

A. The CONTRACTOR shall provide the services of a manufacturer's representative to conduct an onsite training session of not less than 4 hours for each type of instrument.

B. The manufacturer's representative shall be a factory-trained technician with sufficient experience and background with the respective equipment.

C. The training session shall include a detailed presentation of the measurement principle(s), adjusting setpoints, control screens where applicable, troubleshooting, calibration and maintenance procedures.

3.09 PROTECTION

A. All instruments shall be fully protected after installation and before commissioning. The CONTRACTOR shall replace any instruments damaged prior to commissioning.
   1. The ENGINEER shall be the sole party responsible for determining the corrective measures.

3.10 SCHEDULES

A. The CONTRACTOR shall supply complete instrument data sheets for each instrument and submit this information in accordance with paragraph 1.05 of this section.
   1. Instrument data sheets shall be furnished in both hard copy and electronic format.

END OF SECTION

SECTION 17504

ANALYZERS- GAS MONITORS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes requirements for:
   1. Combustible and toxic gas monitors.

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 - Process Control and Instrumentation Systems General Requirements.

C. Provide all instruments identified in the Contract Documents.

1.02 REFERENCES

A. Refer to Section 17050.

1.03 DEFINITIONS

A. Refer to Section 17050.

B. Specific definitions:
   1. LEL: Lower Explosive Limit is the lowest concentration of vapor in air, which will burn or explode upon contact with a source of ignition.
   2. Multi-Channel Gas Monitor: A multi-channel gas monitor facilitates monitoring of 2 or more sensor modules.
   3. Sensor Module: A module formed using the combination of a sensor and a transmitter is called a sensor module.
   4. Single-Channel Gas Monitor: A single-channel gas monitor is used to monitor a single type of gas.
   5. STEL: Short Term Exposure Limit is the maximum permissible concentration of a material for duration of 15 minutes.
   6. TWA: Time-Weighted-Average Concentration is the average concentration of a chemical to which it is permissible to expose a worker for a period of 8 hours.
   7. Wet Stack Sensor: A sensor designed for monitoring reactive gas concentrations in moisture saturated air streams.

1.04 SUBMITTALS

A. Furnish submittals in accordance with Sections Section 01330 and 17050.

1.05 QUALITY ASSURANCE

A. Refer to 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. Refer to Section 17050.

1.07 PROJECT OR SITE CONDITIONS

A. Refer to Section 17050.

1.08 WARRANTY

A. Refer to Section 17050.

1.09 MAINTENANCE

A. Refer to Section 17050.

B. Furnish the following spare parts:
   1. Duct Mount Fitting with Calibration Gas Delivery Fitting.
   2. Pump repair kit includes: 1 diaphragm, 2 valves, and o-rings.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. One of the following.
   1. Single-Channel Gas Monitor:
      a. MSA: Ultima X Series Single Channel Gas Monitors.
      b. ATI: Series 12 Gas Transmitter.
      c. SMC: Series 4000/5100 Gas Sensor-Transmitter Modules/Single Channel Monitor.
   2. Multi-Channel Gas Monitor:
      a. MSA: Quad Gas Multi-Channel Gas Monitors.

b. ATI: Series 14 Multi-Channel Gas Alarm Module.
c. SMC: Series 5000 Multi-Channel Gas Monitor/Controller.

3. Sample Flow System:
   a. MSA : Ultima X Series

2.02 MANUFACTURED UNITS

A. Single-Channel Gas Monitor:
   1. General:
      a. Single channel gas monitors:
         1) Monitor a single type of gas and produce 4-20mA DC output, which is directly proportional to the gas concentration.
   2. Performance requirements:
      a. Repeatability: ±1 percent of full scale or 2 ppm.
      b. Linearity:
         1) Combustibles: ±2 percent of full scale.
         2) Toxic Gas: ±10 percent of full scale or 2 ppm.
      c. Range:
         1) Combustible Gas: 0 to 99 percent LEL.
         2) Hydrogen Sulfide: 0 to 100 PPM.
         3) Oxygen: 0 to 25 percent.
         4) Carbon Monoxide: 500 PPM.
         5) Chlorine: 10 PPM.
         6) Hydrogen: 1000 PPM.
         7) Sulfur Dioxide: 100 PPM.
         8) Nitrogen Dioxide: 20 PPM.
         9) Nitric Oxide: 20 PPM.
         10) Hydrogen Chloride: 20 PPM.
         11) Hydrogen Cyanide: 20 PPM.
         12) Ammonia: 0 to 50 PPM.
   3. Sensor:
      a. Integral or remote as indicated on the Drawings.
      b. Gas type:
         1) Combustible Gas (Methane).
      c. Sensor Type:
         1) Toxic Gas: Electrochemical.
         2) Combustible Gas: Infrared.
      d. Corrosion resistant.
      e. Humidity: 15 to 95 percent relative humidity, non-condensing.
      f. Temperature Range:
         1) Operating: -40 degrees Fahrenheit to 131 degrees Fahrenheit.
   4. Transmitter:
      a. Wiring Requirements:
         1) Toxic Gas: 2 or 3-wire.
         2) Combustible Gas: 3-wire.
      b. LCD or LED Display.
      c. Programming and Setup:
         1) Non-Intrusive.
      d. Enclosure:
         1) NEMA 7 Class 1 Division 1 Groups B, C, D.
      e. Power supply:
         1) 24 VDC.

2) Power consumption: 11 VA maximum.
f. Outputs:
1) Isolated 4-20mA DC with HART communication protocol.
2) Relay outputs:
a) 3 Form C contact

B. Multi-Channel Gas Monitor:
1. General:
a. The multi-channel gas monitors facilitate monitoring of two or more single channel gas monitors.
2. Performance Requirements:
a. Range:
1) Min: 0-10 PPM.
2) Max: 0-100 PPM.
b. Accuracy: ±0.2 PPM.
c. Electronic Repeatability: ±1 percent of span/
d. Electronic Linearity: ±0.5 percent of span.
3. Sensor:
a. Integral or remote as indicated on the Drawings.
b. Gas type:
1) Combustible Gas (Methane).
c. Sensor Type:
1) Toxic Gas: Electrochemical.
2) Combustible Gas: Infrared.
d. Corrosion resistant.
e. Humidity: 15 to 95 percent relative humidity, non-condensing.
f. Temperature Range:
1) Operating: -40 degrees Fahrenheit to 131 degrees Fahrenheit.
4. Transmitter:
a. Minimum Number of Channels:
1) 8.
b. Enclosure: rated NEMA 4X
c. Temperature Range:
1) Operating: 32 degrees Fahrenheit to 130 degrees Fahrenheit.
d. Input:
1) One 4-20mA DC input per Sensor Module.
e. Integral LCD or LED display.
f. Power supply:
1) 120 VAC.
2) Power consumption: 30 VA maximum.
g. Outputs:
1) Isolated 4-20mA DC with HART communication protocol.
2) Relay outputs:
a) Form C contact(s).
b) Rated 5 amps at 120 VAC.
c) Programmable.
5. Components
a. Mounting: Instrument Rack/Chassis Mount Panel/Wall Mount.

C. Sample Flow System:
1. General: consist of gas monitor, gas sample draw pump with sample flow sensor and a flow fault indication relay: gas sensor/transmitters for

combustible gas (methane) or toxic (hydrogen Sulfide); flow caps for sample tubing and sensor calibration; sample draw tuning; water impermeable end of line filter; gas sensor calibration.

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2. Performance requirements:
   a. Repeatability: ±1 percent of full scale or 2 ppm.
   b. Linearity:
      1) Combustibles: ±2 percent of full scale.
      2) Toxic Gas: ±10 percent of full scale or 2 ppm.
3. Sensor:
   a. Sensor is either integral with the transmitter or could be in a remote location.
   b. Humidity: 15 to 95 percent relative humidity, non-condensing.
   c. Temperature Range:
      1) Operating: 32 degrees Fahrenheit to 122 degrees Fahrenheit.
4. Transmitter:
   a. LCD Display.
   b. Power supply:
      1) 120 VAC or 24VDC
      2) Power consumption: 3 VA maximum.
   c. Outputs:
      1) Relay outputs:
         a) Form C contact(s).
         b) Rated 5 amps at 120 VAC.
         c) Programmable.
5. Sensor/transmitter Gas sampling systems
   a. DC pump Gas Sampling for the Gas Sensor/transmitter
   b. Physical requirements
      1) The Gas Sampling system must be in a separate enclosure than the gas sensor mounted no more than 18 inches from the gas sensor.
      2) The interconnect wiring from the gas sensor to the gas sampling system shall be 3 wire cable and supplied by the manufacturer.
      3) The Gas Sampling system will be capable of supplying a gas sample for up to three gas sensors.
   c. Operating parameters
      1) Signal - To eliminate radio frequency interference (RFI) and Electromagnetic interference (EMI), the signal to the sensor from the Gas Sampling system will be in digital format or frequency format.
   d. Operating Voltage - The Gas Sampling system will be able to operate on voltage from 7 up to 30 VDC at less than 5 Watts of power.
   e. The Gas Sampling system will have a flow sensor which will activate a relay when the gas sample falls below the acceptable flow rate to the gas sensor. There also will be an indication of the loss of gas flow on the front panel of the unit.
   f. Introduction of the calibration gas to the gas sensor will be via an integral push button valve on the Gas Sampling system. This push button valve must return the Gas Sampling system to monitoring the sampled area when released.
   g. The Gas Sampling system will be able to pull a gas sample from up to 100 feet.
6. Enclosure Type
   a. The enclosure shall be NEMA 4X stainless steel type.

b. Access to the inside of the enclosure, monitor front panel and wiring connections shall be through a front facing, full length door. The door shall have a shatterproof window of sufficient size to allow the viewing of the meters and indicator lights.
c. The enclosure shall not be mounted in a hazardous location as defined by the NEC (National Electrical Code).

7. Monitor Unit Requirements
   a. Readout Displays - A four-digit LED readout shall be provided for the purpose of displaying the gas value from sensor and point number being displayed. The readout must also be able to be configured to read any value between 0-999 or 0.00-9.99 or 00.0-99.9.
   b. Visual Alarm Indicators - The monitor shall have a separate indicating light for warning, alarm and trouble for each gas sensor. The lights shall be color-coded. Blue and White shall not be used.
   c. Alarm Set Point Levels - Two separate alarm set point levels shall be provided for each sensor. The set points shall be independently adjustable for any value in the readout range. The set points shall provide drive signals to user interface relays. Alarm set points shall have the capability of providing the user a selection of latching or non-latching mode.
   d. Relay Outputs - The alarm set point drive signals shall activate user relays.
   e. Number of Relays - Common relay for alarm, horn, and trouble and discrete for warning shall be provided.
   f. Contact Rating - All relays shall be Form C, single pole, double throw minimum. Contacts shall be rated for 10 amps resistive at 125 VAC minimum.
   g. Contact Selection - The contacts shall be capable of being selected normally open or normally closed and normally energized or normally de-energized.
   h. Malfunction Indication - System trouble indication shall be provided as follows:-
      1) System power loss
      2) Signal loss from any sensor
      3) Sensor not connected
   i. Audible Alarm - An audible horn, buzzer or tone shall be provided when an alarm condition occurs. The audible horn, buzzer or tone should be settable to solid on or variable per sensor point.
   j. Controls - Controls shall be provided as follows:-
      1) Operating Modes and Parameters Selection - The selections listed in this paragraph shall be accomplished by the use of keypads, jumpers or other means that does not involve the use of tools.
         a) Display range value
         b) Latching or non-latching mode for all alarm set point drivers
         c) Increasing or decreasing alarm action for all alarm set points.
      2) Front Panel Controls - The functions listed in this paragraph shall be accomplished using push button type controls readily accessible.
         a) Display of alarm set point level on the readout display described.
         b) Resetting any alarm set point.
         c) Select channel to display.
         d) Resetting any latching relay if alarm condition is cleared

k. Sensor Input Signal - The sensor-input signal shall be a 4 to 20 milliampere type.
l. System will have a minimum 30-sec. delay on start-up or power loses to prevent false alarms.
   1) System Power Requirements - The system shall operate on 115 VAC, 60 Hz. Power shall not exceed 100 VA.

2.03 ACCESSORIES

A. Calibration Equipment:
   1. Provide calibration kit including appropriate gas with all necessary hardware to calibrate the gas monitoring/indication units for a 2 years period.
   2. Furnish carrying case.

B. Sun shield for outdoor Multi-channel Controllers, Sensor Flow Cap and Rainshield.

2.04 SOURCE QUALITY CONTROL

A. Factory calibrate each gas monitoring system before shipment.

PART 3 EXECUTION

3.01 INSTALLATION

A. Refer to 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. Refer to 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. Refer to Section 17050.

3.05 DEMONSTRATION AND TRAINING

A. Refer to Section 17050.

B. Demonstrate performance of all instruments to the ENGINEER before commissioning.

3.06 PROTECTION

A. Refer to 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 shown on the Drawings, in the Specifications or both.

END OF SECTION

A/E:	Carollo Engineers			COMBUSTIBLE GAS MONITORS						
								Spec. No.		Rev.
Contractor:				No	By	Date	Revision			
Project:								Contract		Date
Customer:										
Plant:								Req.		P.O.
Location:										
BOM No.:								By	Chk	App
File:										

G	1	Tag No. / Sample Unit / Transmitter	AE/AIT-	
E	2	Service		
N	3	P&ID		
S	4	Type		
M	5	Enclosure		
P	6	Sampling Method		
L	7	Operating Temperature Range		
	8	Operating Humidity		
U	9	Manufacturer		
N	10	Model No.		
I	11	Other		
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	
T	19	Enclosure		
R	20	Mounting		
A	21	Accuracy		
N	22	Range		
S	23	Power Requirements	115 VAC, 60 HZ	
M	24	Display		
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:

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SECTION 17710

CONTROL SYSTEMS - PANELS, ENCLOSURES, AND PANEL COMPONENTS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes requirements for:
   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 PLC/PCM/RTU cabinets, LCPs, Instrument Junction Boxes (IJBs), and Power Junction Boxes (PJBs).
      b. Control panels furnished as part of equipment systems specified in other Divisions, such as vendor control panels (VCP) and chemical feed panels.
      c. Control components.
      d. Control panel installation.

B. Related Sections:
   1. The Contract Documents are a single integrated document, and as such all Divisions and Sections apply. It is the responsibility of the CONTRACTOR and its Subcontractors to review all sections to ensure a complete and coordinated project.

1.02 REFERENCES

A. Refer to Section 17050.

B. Specific References:
   1. National Electrical Manufacturer's Association (NEMA):
      a. NEMA 250 - Enclosures for Electrical Equipment (1,000 Volts Maximum).
      b. NEMA ICS 6 - Enclosures for Industrial Control and Systems.
   2. Underwriters Laboratories Inc. (UL):
      a. UL 50 - Enclosures for Electrical Equipment.
      b. UL 508 - Industrial Control Equipment.
      c. UL 508A - Standard for Industrial Control Panels.

1.03 DEFINITIONS

A. Refer to Section 17050.

B. 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 (±3 inches in any dimension) from the sizes shown 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 indicated in Section 16050. Enclosures and internal equipment shall be braced to prevent damage from specified forces.

1.05 SUBMITTALS

A. Provide submittals in accordance with 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 of 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 at the project site. 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. Refer to 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 Underwriters Laboratories to assemble and certify UL-labeled control panels:
   1. Provide all components and equipment with UL508 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 UL508A labeling.
   3. Provide fuses for all equipment that is not UL or UR listed.

1.07 DELIVERY, STORAGE AND HANDLING

A. Refer to Section 17050.

B. Crate all panels for shipment using a heavy framework and skids:
   1. Provide factory-wrapped waterproof flexible barrier material for covering materials, where applicable, to protect against physical damage in transit.
   2. Provide suitable shipping stops and cushioning material for all instruments shipped with the panel to prevent damage due to mechanical shock during shipment.
   3. Provide each separate panel unit with removable lifting lugs to facilitate handling.

C. Ship all panels by dedicated air ride van, unless otherwise specified or approved.

1.08 PROJECT OR SITE CONDITIONS

A. Refer to Section 17050.

B. Provide enclosures suitable for the location and environmental conditions in which they are located, and in the NEMA types in accordance with Section 16050, unless otherwise indicated.

1.09 WARRANTY

A. Refer to Section 17050.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. As listed below in the individual component paragraphs.

B. Provide instruments and other components performing similar functions of the same type, model, or class, and from one Manufacturer.

2.02 EXISTING PRODUCTS

A. Provide labor and materials for complete modifications to existing panels as required.

B. Field cut and refinish existing panel faces to original condition to accommodate installation of new instruments, removal of existing instruments and fitting of blanks to suit new layouts. New instrument supports shall be provided as required for complete installation.

2.03 MATERIALS

A. Construct and finish enclosures using materials capable of withstanding the mechanical, electrical, and thermal stresses, as well as the effects of humidity and corrosion that are likely to be encountered in normal service:
   1. Enclosures shall have the following properties:
      a. NEMA 1: Steel.
      b. NEMA 4: Steel with gasketed door, rain tight.
      c. NEMA 4X: Stainless steel 316 (unless indicated 304 on the drawings)
      d. NEMA 4X: Polycarbonate or fiberglass reinforced polyester (FRP) in corrosive areas where stainless steel is incompatible.
      e. NEMA 12: Steel with gasketed door, dust-tight.
      f. NEMA 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:
      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 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 12, 4 and 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 the same.
      3) For large type NEMA 4 and NEMA 4X cabinets, not available with 3-point latching hardware, provide multiple clips and padlock hasps.

4) Provide quick release latches for all NEMA 4 and 4X enclosures.

g. Panel cut-outs:
   1) Cut, punch, or drill cutouts for instruments, devices, and windows. Smoothly finish with rounded edges.
   2) Allow a minimum of 3-inch envelope around all displays, controllers, and monitors.
   3) Reinforce around cut-outs with steel angles or flat bars for the following:
      a) Large panel cutouts; for example, openings for local operator interfaces.
      b) Pilot device groupings, where the removed metal exceeds 50 percent of the available metal.

3. In addition to the requirements specified above, the following requirements for NEMA 4X powder coated stainless steel enclosures apply:
   a. Minimum 14 gauge, Type 304
   b. Captive stainless steel cover screws threaded into sealed wells.
   c. Finish: white polyester powder coating.
   d. Specifically designed for use with flange-mounted disconnect handles where required or as indicated on the Drawings.
   e. NEMA 4X powder coated stainless steel enclosures are not an acceptable substitute for stainless steel unless indicated on the Drawings.
4. Outdoor Panels. Supplementary requirements for panels located outdoors are as follows:
   a. 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 iron 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.

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 in accordance with 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 fuse with 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 loop for each 4-20mA 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. Fuse holders:

a. Modular type:

1) DIN rail mounting on 35mm 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) In accordance with Section 16075.

c. Manufacturer: One of the following:

1) Phoenix Contact.

2) Allen Bradley 1492-FB Series B.

6. Control Circuit Breakers:

a. DIN rail mounting on 35mm rail.

b. Manual OPEN-CLOSE toggle switch.

c. Rated 250 VAC.

d. Interrupting Rating: 10kA 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) In accordance with Section 16075.

g. Manufacturer: One of the following:

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: 600V type MTW.
c. Minimum Sizes:
1) Primary power distribution: 12 AWG.
2) Secondary power distribution: 14 AWG.
3) Control: 16 AWG.
d. Color:
1) AC power (line and load): BLACK.
2) AC power (neutral): WHITE.
3) AC control: RED.
4) DC power and control: BLUE.
5) Ground: GREEN.
2. Signal Cables:
a. Materials: Stranded, soft annealed copper.
b. Insulation: 600V, PVC outer jacket.
c. Minimum Size: 16 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 all conductors and cables with wire markers in accordance with 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. Where the electrical power supply voltage to the control panel is more than 120 VAC, provide the panel with a flange mounted disconnect and control power transformer. 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 cannot be closed until all doors are closed.
a. Provide means to defeat this interlock.

4. Control panels supplied with 120 VAC:
    a. Provide an internal breaker with the line side terminals covered by a barrier.
    b. 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.
5. Provide a nameplate on the cover of the control panel identifying all sources of power supply and foreign voltages within the control panel.
6. Provide transformers, protective devices, and power supplies required to convert the supply voltage to the needed utilization voltage.
7. Provide surge protection device on input supply power.
8. 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.
9. 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.
10. The free ends of cable ties shall be cut flush after final adjustment and fastening.
11. Provide supports at the ends of cables to prevent mechanical stresses at the termination of conductors.
12. Support panel conductors where necessary to keep them in place.
13. Wiring to rear terminals on panel-mount instruments shall be run in nonmetallic duct secured to horizontal brackets run adjacent to the instruments.
14. 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.
15. 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 and both mounted in the control panel and remotely connected to the control panel.

2.05 COMPONENTS

A. Thermal Management:
    1. Enclosure Temperature Sensor:
        a. Provide wall mount RTD transmitter to measure internal cabinet temperature, in all enclosures containing electrical components such as PLCs, RTUs, RIO, and VFDs.
        b. Platinum RTD.
        c. 4-20 mA output.
        d. Sensor and electronic enclosure.

e. Accuracy: ±2.0 degrees Fahrenheit.
f. Manufacturer: One of the following:
1) Omega, EWS series.
2) TCS Basys Controls, TS Series.

B. Panel Meters:
1. Digital process indicators:
a. General:
1) Integral provisions for scaling.
2) Scale to process engineering units.
3) Switch programmable decimal points.
4) NEMA 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: ± (0.1 percent of reading + 2 digit).
b) DC current: 4 - 20mA: ± (0.1 percent of reading + 1 digit).
c) DC voltage: 0 - 10V: ± (0.1 percent of reading + 1 digit).
c. Operating voltage: 120 VAC.
d. Operating temperature: 0 degrees Celsius to 60 degrees Celsius.
1) Manufacturer: One of the following:
a) Red Lion.
b) Action Instruments Visipak.

C. Pilot Devices:
1. General:
a. Provide operator pushbuttons, switches, and pilot lights, from a single manufacturer.
b. Size:
1) 30.5mm.
c. Heavy duty.
d. Pushbuttons:
1) Contacts rated:
a) NEMA A600.
2) Furnish one spare normally open and normally closed contact with each switch.
e. Selector switches:
1) Contacts rated:
a) NEMA A600.
b) Knob type:
2) Furnish one spare normally open contact and normally closed contact with each switch.
3) Provisions for locking in the OFF position where lockout provisions are indicated on the Drawings.
f. Pilot lights:
1) Type:
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: White.
f) Opened: Amber.
g) Closed: Blue.
h) Failure: Red.

2. Indoor and Outdoor Areas:
   a. NEMA type 4/13.
   b. Manufacturer: One of the following:
      1) Allen Bradley Type 800T.
      2) Square D Class 9001 Type K.
      3) General Electric Type CR104P.
      4) IDEC TWTD.
3. Corrosive Areas:
   a. NEMA 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:
      1) Cutler Hammer Type E34.
      2) Square D Class 9001 Type SK.
      3) Allen Bradley Type 800H.
      4) IDEC TWTD.
4. Hazardous (Classified) Areas/Class I Division 2:
   a. NEMA 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:
      1) Cutler Hammer Type E34.
      2) Allen Bradley Type 800H.

D. Signal isolators and converters:
   1. Furnish signal isolators that provide complete isolation of input, output, and power input:
      a. Minimum isolation level: 1.5 kV AC/50 Hz for at least 1 minute.
      b. Adjustable span and zero.
      c. Accuracy: ±1.0 percent of span.
      d. Ambient temperature range: -20 degrees Celsius to +65 degrees Celsius.
   2. Manufacturer: One of the following:
      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.

E. Relays:
   1. General:
      a. For all types of 120 VAC relays, provide transient 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 A300 rated:
         1) 300 Volts.
         2) 10 Amps continuous.
         3) 7,200 VA make.
         4) 720 VA break.
      c. Plug-in type.
      d. LED indication for relay energized.
      e. Coil voltages: As required for the application.
      f. Minimum poles: 2PDT.
      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 shown 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 35mm rail.
      m. Ice Cube type relays shall be provided with retainer clips to secure relay in socket.
      n. Integrated label holder for device labeling.
      o. Manufacturer: One of the following:
         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 B300 rated:
         1) 300 Volts.
         2) 10 Amps continuous.
         3) 3,600 VA make.
         4) 320 VA break.
      c. Plug-in type.
      d. DIN rail mounting on 35mm 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 VA make.
      4) 360 VA 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:
      1) Idec GT3 series.
      2) Agastat type Series 7000 series (pneumatic).
      3) Allen Bradley type 700HR Series.

F. Terminal blocks:
   1. Din rail mounting on 35mm 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:
      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: One of the following:
   1) Panduit.

15. Fuses (holders) and circuit breakers:
    a. Fuse holders:
       1) Modular type:
          a) DIN rail mounting on 35mm rail.
          b) Touch safe design: All connection terminals to be protected against accidental touch.
          c) Incorporates blown fuse indicator.
       2) Provide nameplate identifying each fuse:
          a) In accordance with Section 16075.
       3) Manufacturer: One of the following:
          a) Phoenix Contact.
          b) Allen Bradley 1492-FB Series B.

G. Transient/Surge Protection Devices:
   1. Provide Surge Protection Device (SPD) for 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 8/20µs waveform according to ANSI/IEEE C62.41.1-2002 Category C Area.
      b. Provide both normal mode noise protection (between current carrying conductors) and common mode (between current carrying conductor and neutral) surge protection.
      c. DIN rail mounting.
      d. 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.
      e. Visual status indication of MOV status on the input and output circuits.
      f. Dry contact rated for at least 250 VAC, 1 Amp for remote status indication.
      g. Meeting the following requirements:
         1) Response time: ≤100 ns.
         2) Attenuation: ≥ -40dB at 100 kHz as determined by a standard 50 ohms insertion test.
         3) Safety approvals:
            a) UL 1283 (EMI/RFI Filter).
            b) UL 1449 2nd Edition.
      h. Manufacturer: One of the following:
         1) Phoenix Contact type SFP TVSS/Filter.
         2) Liebert Accuvar series.
         3) Islatrol.
   3. Data and Signal Line Protectors – Panel Mounted:

a. Surge protection minimum requirements: Withstand a 10 kA test current of a 8/20µs waveform in accordance with ANSI/IEEE C62.41.1-2002 Category C Area.
b. DIN rail mounting on 35mm rail (except field mounted SPDs).
c. SPD's consisting of 2 parts:
1) A base terminal block.
2) A plug protection module:
a) Replacing a plug does 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:
1) Phoenix Contact Plugtrab Series.
2) Bournes Series 1800.

4. Data and Signal Line Protectors – Field Mounted:
a. Surge protection minimum requirements: Withstand a minimum 10 kA test current of a 8/20µs waveform in accordance with ANSI/IEEE C62.41.1-2002 Category C Area.
b. Manufacturer: One of the following:
1) Phoenix Contact Pipetrab.
2) Joslyn JMD Series.

H. Beacons:
1. Manufacturer:
a. One of the following, or equal:
1) Federal Signal Corp Starfire Series.
2) Allen Bradley 855 B *-* 10 Series.
3) Edwards Model: Model 102.

I. Horns:
1. Electronic:
a. Manufacturer:
1) One of the following:
a) Federal Signal 300GCX or 300X Series
b) Allen Bradley 855H or 855XH Series.
c) Edwards 5530M or 5533MD Series.
2. Rated 80 dB minimum at 10 feet.

J. 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 configures 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. UL508C 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: ±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 35mm 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:
    a. Phoenix Contact Quint series.
    b. IDEC PS5R series.
    c. Sola.
    d. Acopian.

K. 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 35mm DIN rail.
    g. Approvals:
        1) FM.
        2) UL 913 & 1604.
2. Types:
    a. Switch Isolators:
        1) Designed and approved for use with discrete inputs.
        2) Supply Power: 20-30VDC.
        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 4-20 mA signals without Hart® communications capability:
        1) Designed and approved for use with 4-20 mA 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: 20-30VDC.
    c. Transmitter and converters for use with 4-20 mA signals with Hart® communications capability:
        1) Designed and approved for use with 4-20 mA 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: 20-30VDC.

3. Manufacturer: One of the following:
   a. Phoenix Contact ME Series.
   b. Pepperl + Fuchs.

L. Starters:
1. Magnetic Motor Starters:
   a. In conformance with the requirements of Section 16422.
2. Integral Self-Protected Starters:
   a. In conformance with the requirements of Section 16422.

M. Limit Switches:
1. NEMA-4X.
2. AC contact rating 120V, 10A.
3. DC contact rating 125V, 0.4A.
4. Provide robust actuation mechanism not prone to degradation.
5. Provide complete actuator mechanism with all required hardware.
6. Allows for contact opening even during contact weld condition.
7. UL approved.
8. Operating Temperature Range: -18 degrees to +110 degrees Celsius (0 degrees to 230 degrees Fahrenheit).
9. Manufacturer:
   a. Allen Bradley 802.
   b. Honeywell HDLS.
   c. Omron D4.
   d. Eaton E47, E49, E50.
   e. ABB equal.

2.06 ACCESSORIES

A. Refer to 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 in accordance with 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. 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 less than 30 inches wide.
      d. Provide 40-watt fluorescent lamp for enclosures larger than 30 inches wide:
         1) Provide additional fixtures for every 36 inches of width.
      e. Provide 40-watt incandescent lamp for exterior enclosures:
         1) Provide additional fixtures for every 36 inches of width.

H. Receptacles:
   1. Provide one duplex receptacle located every 4 feet of enclosure width, spaced evenly along the back mounting panels.
   2. GFCI, 125-volt, single-phase, 15-ampere.

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 PLC or RTU racks (remote or local) processor racks, and conductive enclosures of power supplies and connect to the equipment grounding circuit.

2.07 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. One coat of zinc phosphate shall be applied per the manufacturer's recommended dry film thickness, and allowed to dry before applying the finish coat.
      c. Finish coat shall be a baked polyester urethane powder, aliphatic air-dry polyurethane, or epoxy enamel to meet NEMA rating specified application.
      d. Exterior of enclosures located outdoors shall be UV resistant polyester powder coating. Total dry film thickness shall be 3 mils, minimum.
   2. Stainless Steel:
      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.

2.08 SOURCE QUALITY CONTROL

A. Refer to Section 17050.

PART 3 EXECUTION

3.01 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.

3.02 FIELD QUALITY CONTROL

A. Refer to Section 17050.

3.03 CLEANING

A. Refer to Section 17050.

3.04 PROTECTION

A. Refer to Section 17050.

END OF SECTION

SECTION 17720

PROGRAMMABLE LOGIC CONTROLLER SYSTEM

PART 1 GENERAL

1.01 SUMMARY

A. This Section includes:
   1. PLC based control systems hardware and software.

B. Related Sections:
   1. The Contract Documents are a single integrated document, and as such all Divisions and Sections apply. It is the responsibility of the CONTRACTOR and its Sub-Contractors to review all sections to insure a complete and coordinated project.
   2. In particular the following sections should be used in conjunction with this section:
      a. Section 17050, Process Control and Instrumentation Systems General.

1.02 REFERENCES

A. In accordance with Section 17050, Process Control and Instrumentation Systems General.

1.03 DEFINITIONS

A. In accordance with Section 17050, Process Control and Instrumentation Systems General.

1.04 SYSTEM DESCRIPTION

A. General:
   1. The CONTRACTOR, through the use of a qualified System Supplier and ICSC, shall furnish, supervise installation, assemble, configure, program, and place into service the PLC based control system.

B. Scope of Work:
   1. The ICSC shall furnish and install the PLC based control system as specified within these Contract Documents.
   2. The ICSC shall be responsible for all:
      a. Equipment selection and supply.
      b. Hardware and software submittal preparation.
      c. Installation.
      d. Testing.
      e. Training.
      f. Start-up.
      g. Implementation activities for the complete control system.

3. The PLC based control system hardware and software furnished under this Contract shall be a standardized system, which utilizes off-the-shelf commercially available configurations of hardware and software modules.
4. The System Supplier and its ICSC shall provide all installation, all labor supervision and all engineering required to assure the proper installation and operation of the complete control system.
5. The following work, equipment and services shall be included in this Contract but not be limited to:
   a. Prepare and submit for approval complete control system hardware shop drawings.
   b. Furnish and install complete and operational control systems, including all peripherals and other equipment specified herein.
   c. Perform all control system tests, adjustments, and calibrations.
   d. Furnish qualified labor to perform the complete control system installation and start-up.
   e. Furnish qualified instructors to provide complete control system instruction and training.
   f. Furnish all required control system tools, test equipment, spare parts, supplies, technical manuals, reproducible "As-Built" drawings, and program listings as specified herein.
   g. The System Supplier shall install a complete PLC LAN between all PCMs, etc. as depicted in the SCADA Network Diagram.
6. The ICSC shall be responsible for selecting, configuring, and verifying correct operation of compatible hardware to provide a complete and functional control system.
7. The control system shall consist of the systems as depicted on the SCADA Network Diagram.

C. General System Requirements.
   1. The control system shall be in conformance with the following key system criteria:
      a. All PLCs provided for the control system shall exhibit 100 percent interchangeability of parts.
      b. All process Local Area Network (LAN) communications shall conform to public domain protocols to preserve a non-proprietary system infrastructure.

1.05 SUBMITTALS

A. In accordance with Section 17050, Process Control and Instrumentation Systems General.

1.06 QUALITY ASSURANCE

A. In accordance with Section 17050, Process Control and Instrumentation Systems General.

1.07 DELIVERY, STORAGE, AND HANDLING

A. All equipment and materials delivered to the job site shall be stored in a location, which shall not interfere with the operations of the OWNER's personnel or interfere with construction.

B. Storage and handling shall be performed in manners, which shall afford maximum protection to the equipment and materials.

C. It is the system supplier's responsibility to assure proper handling and on-site storage.

D. In accordance with Section 17050, Process Control and Instrumentation Systems General.

1.08 PROJECT/SITE CONDITIONS

A. In accordance with Section 17050, Process Control and Instrumentation Systems General.

1.09 SEQUENCING AND SCHEDULING

A. In accordance with Section 17050, Process Control and Instrumentation Systems General.

B. The System Supplier's attention is directed to the construction sequencing requirements contained within the Contract Documents.

C. The System Supplier through its ICSC shall provide on-loan, any and all control system equipment required for partial start-up of a process area or system.

D. Factory Acceptance Test:
   1. In accordance with Section 17050, Process Control and Instrumentation Systems General.

E. Training:
   1. In accordance with Section 17050, Process Control and Instrumentation Systems General.
   2. The training as required by paragraph 3.10 of this section shall be scheduled concurrent with the calibration, equipment testing, and process system testing phases of the project.
   3. Operator and Maintenance Training:
      a. Training submittal shall be submitted to the ENGINEER at least 30 days in advance of when the lesson is to be given.
      b. Within 10 days after the completion of each class the system supplier through the CONTRACTOR shall present to the ENGINEER a completion report in accordance with paragraph 3.10 of this section.

1.10 WARRANTY

A. In accordance with Section 17050, Process Control and Instrumentation Systems General.

1.11 MAINTENANCE

A. In accordance with Section 17050, Process Control and Instrumentation Systems General.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. All PLC hardware, CPUs, I/O devices, and communication devices shall be new, free from defects, of first quality, and produced by manufacturers regularly engaged in the manufacture of these products.

B. Where there is more than one item of similar equipment being furnished under this Contract, all such similar equipment shall be the product of a singular manufacturer.

C. PLC: SCADAPack 357 as indicated on Drawings, no equal.
   1. Programming software: Concept by Schneider Electric, latest edition.

2.02 EQUIPMENT

A. PLC Processor:
   1. Processor: Self contained unit within the enclosure, which accommodates logic, memory, and processor support modules; capable of performing logic control functions based upon the program stored in memory and the status of I/O.
   2. Upon processor shutdown, outputs shall de-energize and go into a safe shutdown mode.
   3. Embedded Modbus Plus Port, for peer-to-peer communications.

B. PLC I/O:
   1. Analog:
      a. Input: 4-20mA isolated.
      b. Output: 4-20mA isolated.
   2. Discrete:
      a. Input: 120Vac individually isolated.
      b. Output: N.O. relay output individually isolated.

2.03 ACCESSORIES

A. Field Wiring Connectors, Terminal Blocks and Communication Cabling:
   1. I/O Connectors: Attached directly to I/O housing so modules can be quickly and easily removed without disturbing or flexing the field wiring; with screw terminals.
   2. Low and High Density Connectors: Capable of holding two 14 to 22 AWG wires or one 12 AWG wire.
   3. Modbus Plus Trunk Cable, p/n 490NAA2710x:
      a. Use continuous runs between taps. Do not splice cables.
      b. Provide spares.
   4. Modbus Plus Drop Cable, p/n 990NAD211x0:
      a. Provide with 9-pin D connectors.
      b. Provide spares.
   5. Modbus Plus Tap, p/n 990NAD23000:
      a. Provide with terminating resistor and grounding screw.
      b. Provide spares.

B. Network Bridge Plus:
   1. Modicon, p/n NW-BP85-000.

2. Provide as shown on SCADA Block Diagram to bridge networks.

2.04 SOURCE QUALITY CONTROL

A. Factory Acceptance Test: See Section 17950.

PART 3 EXECUTION

3.01 INSTALLATION

A. The ICSC shall utilize personnel to accomplish, or supervise the physical installation of all elements, components, accessories, or assemblies, which it furnishes.
   1. The ICSC shall employ installers who are skilled and experienced in the installation and connection of all elements, components, accessories, and assemblies it furnishes.

B. All components of the control system including all LAN cables shall be the installation responsibility ICSC unless specifically noted otherwise.
   1. Grounding shall be shown on submittal drawings.
   2. After installation of the entire control system is completed, the installation shall be inspected jointly by the ICSC, system supplier, and the equipment manufacturer's representatives.

C. In accordance with Section 17050, Process Control and Instrumentation Systems.

3.02 FIELD QUALITY CONTROL

A. Testing:
   1. All analog inputs and outputs of the control system shall have their calibration checked at a minimum of 3 points to verify consistency with the balance of the analog loop.
      a. This calibration check shall be done in conjunction with the analog loop tests specified in Section 17050.
   2. Testing:
      a. After the control system installation has been certified and the analog points have been calibrated, the entire control system shall be tested to verify that all discrete inputs and outputs of the PLCs are correct.
      b. As much as possible, points shall be checked "end-to-end."
         1) For example, valve status inputs shall be checked by stroking the valve and a pump start output shall be checked by using it to start the pump.
      c. Simulated testing shall be allowed only when no practical alternative exists.
      d. An I/O checklist shall be used to record test results and a copy provided to the ENGINEER upon completion.
   3. System Testing:
      a. After the entire control system installation has been certified and analog loop calibration and discrete I/O testing have been completed, system testing shall be performed in accordance with the approved test procedures.

1) System testing shall operate the various process systems of the facility to verify compliance with all functional requirements specified, including the automatic control modes and control system interlocks.
2) Tests, which fail to demonstrate the required operation, shall be repeated in their entirety or continued after corrective action has been completed at the discretion of the ENGINEER.

b. The ICSC shall submit to the ENGINEER a system testing completion report in conformance with paragraph 3.09 of this section.

4. Plant Pre-commissioning and Start-Up Test:
   a. In accordance with paragraph 1.09 of Section 17050.
   b. The System Supplier and CONTRACTOR shall provide start-up support to include the CONTRACTOR's and system supplier's personnel, ICSC and electrical personnel, and the PLC and SCADA software system manufacturer's representative as required during the testing period to produce a fully operational facility.
      1) This support shall be provided at no additional cost to the DISTRICT.
      2) Pre-commissioning and Start-Up Test shall be conducted in accordance with the requirements of Section 17050.
5. Acceptance Test:
   a. In accordance with Section 17050.
   b. During the test, the entire control system shall be continuously operated and maintained, 7 days per week, 24 hours per day, during the test period with zero downtime resulting from system failures.
      1) If a system failure occurs, the test shall be considered a failure and not acceptable.
      2) The ICSC shall repeat the test.
      3) The entire control system shall be acceptable only after all equipment and software has satisfied the performance test requirements.
   c. Downtime resulting from the following shall be considered system failures:
      1) If a component failure cannot be repaired/replaced within 2 hours.
      2) Downtime of any component, exclusive of I/O, whose failure results in the inability of the Operator to monitor and manipulate control loops from the associated workstations using standard workstation interface procedures.
      3) Downtime resulting from concurrent failure of any CRT, keyboard, or mouse, which is associated with the workstation.
      4) Downtime in excess of 2 hours resulting from any I/O component failure.
      5) Downtime resulting from concurrent failure of 2 or more I/O components in a single PLC.
      6) Downtime of any component/peripheral associated with the LAN if the failed component:
         a) Results in a disabling of the historical functions.
         b) The failed component is not repaired or replaced within 8 hours.
   d. The ICSC through the CONTRACTOR shall submit a final acceptance test completion report in accordance with paragraph 3.09 of this section.
   e. Final acceptance, in writing, of the entire control system shall be provided by the ENGINEER if the results of all of the performance tests are acceptable.

B. In accordance with Section 17050.

3.03 CLEANING

A. In accordance with Section 17050.

3.04 DEMONSTRATION

A. In accordance with Section 17050.

3.05 SCHEDULES

A. In accordance with Section 17050.

B. Documentation Schedule:
   1. When the installation is complete, a written certification of the installation shall be delivered to the ENGINEER.
      a. The certification shall state that all PLCs communication and I/O modules, modems, system grounds, LAN, communication network, workstations, printers, and all other components of the control system have been inspected and are installed in accordance with the manufacturer's guidelines.
   2. The System Supplier through its ICSC shall submit to the ENGINEER a system testing completion report when each process system have been successfully tested as described herein.
      a. The report shall note any problems encountered and what action was required to correct them.
      b. It shall include a clear and unequivocal statement that the process systems have been thoroughly tested and are complete and functional in accordance with all specification requirements.
   3. The ICSC through the CONTRACTOR shall submit a final acceptance test completion report which shall state that all contract requirements have been met and which shall include:
      a. A listing of all PLC system equipment maintenance/repair activities conducted during testing.
      b. A listing of all components, which were unable to operate successfully.
   4. Operator & Maintenance Training:
      a. Furnish a completion report which shall include:
         1) A list of all OWNER personnel that attended the class.
         2) An evaluation of OWNER personnel that attended the class via written testing or equivalent evaluation.
         3) A copy of the hard copy text utilized during the class with all notes, diagrams, and comments.

3.06 TRAINING

A. In addition to the training identified in Section 17050, Process Instruments and Controls General, the ICSC shall provide training for the purpose of familiarizing the OWNER's maintenance and operating personnel with the use, maintenance, calibration, and repair of all components of the control system.

B. The training shall be scheduled in accordance with paragraph 1.09 of the Section.

C. Training shall be specifically tailored to this project and reflect the entire control system installation and configuration.

END OF SECTION

SECTION 17733

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. Patch panels and other data network hardware.
      c. Related accessories.

B. Related Sections: The Contract Documents are a single integrated document, and as such all Divisions and Sections apply. It is the responsibility of the CONTRACTOR and its Sub-Contractors to review all sections to ensure a complete and coordinated project.

1.02 REFERENCES

A. Refer to 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. Refer to Section 17050.

1.04 SYSTEM DESCRIPTION

A. Provide all network equipment identified in the Contract Documents.

1.05 SUBMITTALS

A. Furnish submittals in accordance with 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. Construction drawings for all equipment cabinets, including dimensions, identification of all components, preparation and finish data, nameplates
e. Electrical connection diagrams.
f. 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 described 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 described in Section 17050.

F. Record Drawings:
1. As described 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. Refer to Section 17050.

1.07 DELIVERY, STORAGE, AND HANDLING

A. Refer to Section 17050.

1.08 PROJECT OR SITE CONDITIONS

A. Refer to Section 17050.

1.09 WARRANTY

A. Refer to 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. Manufacturers:
         1) Hewlett Packard, Procurve Switch 4200vl.
      b. 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 microsecond.
            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 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) 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: SC.
            b) Copper: RJ-45.

7) Modules:
   a) 10/100-Base-TX:
      (1) Protocol: IEEE 802.3 Type 10Base-T; 802.3u Type 100Base-TX.
      (2) Auto-sensing.
      (3) 24 ports per module.
   b) Fiber optic 100-Base-FX:
      (1) Protocol: IEEE 802.3u Type 100Base-FX.
      (2) Full Duplex.
      (3) 6 ports per module.
   c) 100/1000-Base-T:
      (1) Protocol: IEEE 802.3u Type 100Base-TX; 802.3ab Type 1000Base-T.
      (2) Auto-sensing.
      (3) 1 port per module.
   d) Fiber Gigabit-SX:
      (1) Protocol: IEEE 802.3z Type 1000Base-SX.
      (2) Full duplex.
   e) 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.
   f) Transceiver Module:
      (1) Provide transceiver module to interface with single port transceivers as required.
      (2) Transceiver modules capable of connecting 3 single port transceivers.
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. Manufacturers:
      1) GarrettCom, Magnum 6KQ.
   b. Properties:
      1) Hardware:
         a) Power supply:
            (1) Provide redundant power supplies.
            (2) 12VDC, 50 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) Connector type:
   a) Fiber: SC.
   b) 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.
6) Mounting:
   a) Provide hardware for Din-Rail or panel mounting as indicated on the Drawings.

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 SC 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. Category 5e Patch Panels:
   a. Manufacturers - One of the following:
      1) Hubbell Speedgain.
      2) Siemon HD.
      3) Lucent Systemax.
      4) Approved equal.
   b. Patch Panels and Connectors shall meet the following (minimum) requirements:
      1) Category 5e, T569A/B.
      2) RJ-45 patch cord termination: S110 UTP-STP cable termination.
      3) Capacity: 48 ports (minimum).
      4) Mounting: 19-inch rack mount.
      5) Accessories: Rear cable management bracket, individual port labels.
   c. Provide patch cables as required to support all network devices.
   d. Provide 4 spare straight through patch cables.
   e. Provide 1 spare cross over cable.
6. Category 6 Patch Panels:
   a. Manufacturers - One of the following:
      1) Hubbell Nextspeed.
      2) Siemon HD.
      3) Lucent Systemax.
      4) Approved equal.
   b. Patch Panels and Connectors shall meet the following (minimum) requirements:
      1) Category 6, T569A/B.
      2) RJ-45 patch cord termination: S110 UTP-STP cable termination.
      3) Capacity: 48 ports (minimum).
      4) Mounting: 19-inch rack mount.
      5) Accessories: Rear cable management bracket, individual port labels.

c. Provide patch cables as required to support all network devices. Provide four spare straight through patch cables. Provide one spare cross over cable.

7. Fiber Patch Panels:
   a. Wall Mounted Interconnect:
      1) Application: Use for the termination of a single cable outside of cabinets, in small enclosures or as indicated on the plans.
      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 plans, minimum 6 connections.
      5) Accessories:
         a) Door lock.
         b) Blanks for unused connector panels.
      6) Manufacturers:
         a) Corning Cable Systems, Wall-Mountable Interconnect Center.
         b) Or equal.
   b. 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.
      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 or 23-inch rack mounting, as required.
      4) Capacity: As shown in the Contract Documents.
      5) Manufacturers:
         a) Corning Cable Systems, Connector Module Housing.
         b) Or equal.

C. Network racks:
   1. Networking cabinets:
      a. Manufacturers:
         1) Belkin, 24U Premium Enclosure RK1002.
      b. Properties:
         1) 19-inch rack mount.
         2) Side rail cable management.
         3) Constructed of premium steel.
         4) Maximum airflow design.
         5) Velcro cable wraps.
         6) 20-amp surge protected power strip.

2.02 ACCESSORIES

A. Provide duplex patch cords to connect the interface cards provided with the associated patch panels.

B. Furnish accessories as indicated Section 17730.

PART 3 EXECUTION

3.01 INSTALLATION

A. Refer to Section 17050.

B. All racks shall be level and plumb.

C. Install Velcro wrap on all cable bundles within the network rack/enclosure.

D. 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.

E. Install cables a minimum of 40 inches away from electrical motors and transformers.

F. Install cables a minimum of 12 inches away from fluorescent lighting.

G. Individual pairs will be untwisted less than 1/2 inch at termination points.

H. All cables and terminations shall be labeled with cable designations as described in the Division 16 specifications.

I. 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.

J. 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. Refer to 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

Tag No.	Description	Range	Setpoint	Service	P&ID	Remarks
ANALYTICAL FIELD INSTRUMENTS						
01-AE/AIT-101	pH Analyzer w/ Remote Transmitter	1 - 12 pH	N/A	North Lift Pump Station Wet Well	N-4	Class 1 Div. 1 sensor
FLOW FIELD INSTRUMENTS						
01-FE/FIT-101	24" Flowmeter w/ Remote Transmitter	1 - 14 MGD	N/A	NLPS Raw Wastewater Discharge	N-4	Class 1 Div. 1 flow element
LEVEL FIELD INSTRUMENTS						
01-LE/LIT-100	Ultrasonic w/ Remote Transmitter	0 - 15 ft	12 ft	Rotating Fine Screen Upstream	N-4	Class 1 Div. 1 transducer
01-LE/LIT-101	Ultrasonic w/ Remote Transmitter	0 - 15 ft	11.5 ft	Rotating Fine Screen Downstream	N-4	Class 1 Div. 1 transducer
01-LSH-100	Hi Float Level Switch		12 ft	North Lift Pump Station Screening	N-4	Class 1 Div. 1
GAS MONITORS						
01-AE/AIT-201	Combustible Gas Detection	0 - 99% LEL	10% LEL	Odor Scrubber	N-4	Calss 1, Div. 1
	Sample Flow Panel					

Tag No.	Description	Range	Setpoint	Service	P&ID	Remarks
ANALYTICAL FIELD INSTRUMENTS						
01-AE/AIT-101	pH Analyzer w/ Remote Transmitter	1 - 12 pH	N/A	North Lift Pump Station Wet Well	N-4	Class 1 Div. 1 sensor
FLOW FIELD INSTRUMENTS						
01-FE/FIT-101	24" Flowmeter w/ Remote Transmitter	1 - 14 MGD	N/A	NLPS Raw Wastewater Discharge	N-4	Class 1 Div. 1 flow element
LEVEL FIELD INSTRUMENTS						
01-LE/LIT-100	Ultrasonic w/ Remote Transmitter	0 - 15 ft	12 ft	Rotating Fine Screen Upstream	N-4	Class 1 Div. 1 transducer
01-LE/LIT-101	Ultrasonic w/ Remote Transmitter	0 - 15 ft	11.5 ft	Rotating Fine Screen Downstream	N-4	Class 1 Div. 1 transducer
01-LSH-100	Hi Float Level Switch		12 ft	North Lift Pump Station Screening	N-4	Class 1 Div. 1
GAS MONITORS						
01-AE/AIT-201	Combustible Gas Detection	0 - 99% LEL	10% LEL	Odor Scrubber	N-4	Calss 1, Div. 1
	Sample Flow Panel					

Note : A=Analog D=Digital

Tag No.	Description	Signal Type	Data Field 1 A-Signal Range D-Close Status	Data Field 2 A-Eng. Range D-Open Status	PLC / RIO
N-4 NORTH LIFT PUMP STATION/METER VAULT SCREENING & ODOR CONTOL P&ID					
01-LI-100	Screening Channel Upstream Level	AI	4-20 mA		PLC-01
01-LI-101	Wet Well (Downstream) Level	AI	4-20 mA		PLC-01
01-LAH-100	Screening Channel Upstream Hi Level Alarm	DI	High Level	Normal	PLC-01
01-XL-200	Screening System Run Status	DI	Screen System Run	System Stopped	PLC-01
01-YA-200	Screening System Fail Alarm	DI	Screen System Fail	Normal	PLC-01
01-HS-200A	North Lift Pump Station Failure Switch (24-hour)	DO	Activate Beacon	Normal	PLC-01
01-HS-200D	North Lift Pump Station Failure Switch (Work hour)	DO	Activate Horn	Normal	PLC-01
01-AI-101	North Lift Pump Station Wet Well pH	AI	4-20 mA		PLC-01
01-FI-101	Raw Wastewater Pumps Discharge Flow (Alternate Bid A)	AI	4-20 mA		PLC-01
01-AAH-201	Combustible Gas Hi Level Alarm	DI	HI Level		PLC-01
01-AI-201	Combustible Gas Level	AI	4-20 mA	Normal	PLC-01
01-YA-203	Odor Scrubber Blower Fail Alarm	DI	Blower Fail	System Stopped	PLC-01
01-XL-203	Odor Scrubber Blower Run Status	DI	Blower Run	Normal	PLC-01

Note : A=Analog D=Digital

Tag No.	Description	Signal Type	Data Field 1 A-Signal Range D-Close Status	Data Field 2 A-Eng. Range D-Open Status	PLC / RIO
N-4 NORTH LIFT PUMP STATION/METER VAULT SCREENING & ODOR CONTOL P&ID					
01-LI-100	Screening Channel Upstream Level	AI	4-20 mA		PLC-01
01-LI-101	Wet Well (Downstream) Level	AI	4-20 mA		PLC-01
01-LAH-100	Screening Channel Upstream Hi Level Alarm	DI	High Level	Normal	PLC-01
01-XL-200	Screening System Run Status	DI	Screen System Run	System Stopped	PLC-01
01-YA-200	Screening System Fail Alarm	DI	Screen System Fail	Normal	PLC-01
01-HS-200A	North Lift Pump Station Failure Switch (24-hour)	DO	Activate Beacon	Normal	PLC-01
01-HS-200D	North Lift Pump Station Failure Switch (Work hour)	DO	Activate Horn	Normal	PLC-01
01-AI-101	North Lift Pump Station Wet Well pH	AI	4-20 mA		PLC-01
01-FI-101	Raw Wastewater Pumps Discharge Flow (Alternate Bid A)	AI	4-20 mA		PLC-01
01-AAH-201	Combustible Gas Hi Level Alarm	DI	HI Level		PLC-01
01-AI-201	Combustible Gas Level	AI	4-20 mA	Normal	PLC-01
01-YA-203	Odor Scrubber Blower Fail Alarm	DI	Blower Fail	System Stopped	PLC-01
01-XL-203	Odor Scrubber Blower Run Status	DI	Blower Run	Normal	PLC-01

SECTION 17950

TESTING, CALIBRATION, AND COMMISSIONING

PART 1 GENERAL

1.01 SUMMARY

A. General requirements that apply to all process control and instrumentation systems for the entire project.

B. Related Sections:
   1. In addition to the responsibilities listed below, the SYSTEM SUPPLIER shall be responsible for all requirements of Division 13, Division 16, and Division 17.
   2. The Contract Documents are a single integrated document, and as such all Divisions and Sections apply. It is the responsibility of the CONTRACTOR and its Sub-Contractors to review all sections to insure a complete and coordinated project.
   3. Items involving electrical, control, and instrumentation construction may be shown on drawings or referred to in specifications that do not apply specifically to electrical, control and instrumentation systems. Since the Contract Documents are a single integrated document, it is the responsibility of the CONTRACTOR and its Sub-Contractors to review all sections to insure a complete and coordinated project.
   4. Items not involving electrical, control, and instrumentation construction may be shown on drawings or referred to in specifications that do apply specifically to electrical, control and instrumentation systems. Since the Contract Documents are a single integrated document, it is the responsibility of the CONTRACTOR and its Sub-Contractors to review all sections to insure a complete and coordinated project.

1.02 REFERENCES

A. In accordance with Section 17050, Process Control and Instrumentation Systems General.

1.03 DEFINITIONS

A. In accordance with Section 17050, Process Control and Instrumentation Systems General.

1.04 SUBMITTALS

A. System Test Procedures additional minimum requirements:
   1. System test and start-up procedures and sequences shall be developed by the SYSTEM SUPPLIER and its ICSC in conjunction with the CONTRACTOR and other requirements as identified in these Contract Documents, and shall be submitted to the ENGINEER for review.
      a. An approved submittal shall be required prior to the commencement of system testing.

2. Procedures shall be prepared for each process system:
   a. The procedures shall, in narrative form, describe sequentially the operational steps to be followed in verifying the correct operation of each process system, including all features described in the control strategies contained in Specifications Section 17101, and those reflected in the P&IDs.
   b. All equipment, constituting the complete control system and its various displays, which function together to form a complete process system shall be tested together, including interlocks between devices. Test procedures for all process-orientated systems shall be developed and performed.

B. Factory Test Procedure additional minimal requirements:
   1. General requirements for factory testing are as described in Section 17050.
   2. The ICSC shall prepare and submit a factory test procedure which incorporates:
      a. Test sequences.
      b. Test forms.
      c. Estimated test duration which comply with the requirements of the factory test specified herein.

C. Testing, Calibration, and Start-up Submittal.
   1. Test Procedure Submittals:
      a. Submit the proposed procedures to be followed during tests of the PCIS and its components.
      b. Preliminary Submittal: Outlines of the specific proposed tests and examples of proposed forms and checklists.
      c. Detailed Submittal: After approval of the Preliminary Submittal, submit the proposed detailed test procedures, forms, and checklists. This submittal shall include a statement of test objectives with the test procedures.
   2. Provide certified and witnessed test and calibration checklists for each of the following tests:
      a. Calibration, adjustment and test details for all components and systems.
      b. Factory Acceptance Tests.
      c. Loop Validation Tests.
      d. Pre-commissioning Test.
      e. Performance Test.

1.05 DELIVERY, STORAGE, AND PROTECTION

A. Calibration:
   1. As instruments are received in the field that must be immediately inspected to assure that they conform to the approved submittals.
   2. They must be calibrated before going into storage in order to insure that proper functional instruments are on site and to reduce the risk of instrument failure impacting the construction schedule.

1.06 SEQUENCING AND SCHEDULING

A. Factory Acceptance Test (FAT):
   1. Prior to the delivery and installation of the SCADA system at the job site, but after the procurement, assembly, and configuration of all components, the SYSTEM SUPPLIER shall conduct a factory test.

2. The CONTRACTOR shall schedule the factory test after receiving approval of the factory test procedures submittal.
3. A copy of the test procedures shall be submitted to the ENGINEER at least 21 working days before the scheduled test date.
4. Notify the ENGINEER of scheduled tests a minimum of 15 working days prior to the date of the test.
5. Transmit completed PLC I/O Test Checklist forms 5 working days prior to the FAT.

B. Loop Validation Test:
1. The CONTRACTOR shall notify the ENGINEER of scheduled tests a minimum of 30 working days prior to the estimated completion date of installation and wiring of the PCIS.
2. Testing shall be completed 5 working days prior to the pre-commissioning phase of the project.
3. Loop Validation Certifications.
   a. After the field device loop tests have been successfully completed for all individual instruments, all separate analog control networks, all valves, all motors, all local operator interface panels, all motor control centers, etc. a certified copy of all test forms signed by the Instrumentation and Control System Contractor and the OWNER's representative as a witness, with test data entered, shall be submitted to the ENGINEER together with a clear and unequivocal statement that all instrumentation has been successfully calibrated, inspected, and tested.

C. Pre-commissioning Test:
1. The CONTRACTOR through the SYSTEM SUPPLIER and Instrumentation and Control System Contractor shall furnish the services of an on-site commissioning engineer to supervise and coordinate installation, adjustment, testing, pre-commissioning and start-up of the PCIS.
2. The commissioning engineer shall be present during the total period required to effect a complete operating system.
3. A team supplied by the Instrumentation and Control System Contractor shall be on site for a minimum of 40 hours to check all equipment, perform the tests indicated, and furnish startup services.
4. Shall commence after acceptance of all training, wire test, calibration tests and loop validation tests, and all inspections have demonstrated that the instrumentation and control system complies with all Contract requirements.
5. Acceptance of the PCIS pre-commissioning testing must be provided in writing by the ENGINEER before the performance testing may begin.

D. Performance Testing:
1. Pre-commissioning test must be completed a minimum of 5 working days prior to the performance test.

E. After pre-commissioning tests have been completed, the PCIS system will be given a final 90-day performance test.

F. Acceptance: For the purpose of this project, the following conditions shall be fulfilled before the WORK is considered substantially 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 and expendable supplies and test equipment have been delivered to the ENGINEER.
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 and are in like-new condition.

PART 2 PRODUCTS

2.01 SOURCE QUALITY CONTROL

A. Factory Acceptance Tests (FAT): Prior to shipment, the complete PCIS system including all PCMs, PLCs, RTUs, LCPs, and other equipment, shall be assembled, connected, and all software loaded for a full functional test of the integrated system.
   1. Test procedures shall be developed and submitted by the Instrumentation and Control System Contractor to show that the integrated system hardware and software is fully operational and in compliance with the requirements of the Contract Documents.
   2. All hardware test procedures shall follow the guidelines of the applicable portions of Sections 3 through 8 in ISA's recommended practice ANSI/ ISA RP.1-1975 (R1983).
   3. A copy of the test procedures shall be submitted to the ENGINEER in conformance with paragraph 1.09 of this section.
   4. The factory test will be witnessed by the OWNER and ENGINEER.
   5. The factory test shall make use of hardware simulators that contain switches, pilot lights, variable analog signal generators, and analog signal level displays, that shall be connected to the I/O points within the PCIS. All inputs and outputs shall be simulated and proper control system operation shall be validated. Each switch, pilot light, display, etc. shall be labeled in accordance with the P&IDs so that a timely and thorough test of the complete system can be conducted.
      a. The use of jumper wires, terminal block mounted pilot lights, and loose meters to act as or supply the functionality of a simulator will not be allowed.
      b. The hardware simulator may consist of a PLC, operating under a SCADA software package, that has its I/O points hardwired to the PCIS PLC's I/O points. The SCADA software operating on a PC may then act as the switches, pilot lights, variable analog signal generators, and analog signal level displays.
      c. For systems that contain RTUs or remote communications with other devices the complete communications system must be factory tested, including actual interfacing with telephone company equipment and/or the actual radios used for radio based telemetry systems.
   6. Factory Acceptance Test:
      a. PLC I/O Test:
         1) Test shall be conducted prior to the arrival of the OWNER and ENGINEER for the witness FAT.
         2) ENGINEER and OWNER shall review the test checklists.
         3) ENGINEER and OWNER shall at random pick points to be tested.

a) If any of the randomly selected points fail the test the entire FAT shall be considered failed and all costs for the re-test, including ENGINEER's and OWNER's time and travel expenses shall be borne by the CONTRACTOR.

4) PLC I/O Test Checklist Form:
   a) Forms shall be organized by:
      (1) PLC or PCM number.
      (2) I/O type.
   b) Test methodology:
      (1) Discrete inputs: Apply appropriate input and panel terminal, observe input card indicator, observe data value at each indicated data address.
      (2) Discrete outputs: Toggle bit in output buffer, observe data point, output card indicator light and measure response at field wiring terminals.
      (3) Analog inputs: Apply appropriate analog input signal at panel terminals, observe data value at each indicated data address.
      (4) Analog outputs: Enter scaled values in the output buffer file, observe the output data file value, and measure appropriate response at panel wiring terminals.
   c) Test form shall identify:
      (1) Panel: PCM number.
      (2) I/O Type.
      (3) I/O tag name.
      (4) Panel terminal block number.
      (5) I/O file:
      (6) Initial of individual performing test.
      (7) Date test was performed.

PART 3 EXECUTION

3.01 INSTALLATION

A. In accordance with Section 17050, Process Control and Instrumentation Systems.

3.02 FIELD QUALITY CONTROL

A. Manufacturer Services:
   1. The CONTRACTOR shall furnish the following Manufacturer's services for the instrumentation listed below:
      a. Perform bench calibration.
      b. Oversee installation.
      c. Verify installation of installed instrument.
      d. Certify installation and reconfirm manufacturer's accuracy statement.
      e. Oversee loop testing, prepare loop validation certificates.
      f. Oversee pre-commissioning, prepare pre-commissioning validation sheets, and certify pre-commissioning.
      g. Train the OWNER's personnel.
   2. Manufacturer's services shall be furnished for the following equipment:
      a. All process analyzers.

B. Installation Supervision: The Instrumentation and Control System Contractor shall insure that the instrumentation and PCIS system equipment is installed in a proper and satisfactory manner. These services shall include, but not be limited to:
   1. Providing the installing contractor with information and direction prior to commencement of the installation work.
   2. Periodic inspections during the construction period.
   3. Answering of all questions regarding the installation and hook-up.
   4. A complete check of the completed installation to insure that it is in conformance with the requirements of the equipment manufacturer and the Contract Documents.
   5. Field calibration and/or verification of all instruments.

C. Loop Validation: All instruments, devices, valves, feeders, and systems shall be calibrated and adjusted after installation, in conformance with the component manufacturer's instructions.
   1. Those components having adjustable features are to be set carefully for the specific conditions and applications of this installation, and that the components and/or systems are within the specified limits of accuracy.
   2. Defective elements which cannot achieve proper calibration or accuracy, either individually or within a system, shall be replaced.
   3. The calibration work shall be accomplished by the technical field representatives of the Instrumentation and Control System Contractor whom the CONTRACTOR shall require to certify in writing that for each loop or system all calibrations have been made and that all instruments and field devices are ready to operate.
      a. The CONTRACTOR shall provide the services of device manufacturers, ie valve, feeder, drive, etc. to assist the Instrumentation and Control System Contractor with the loop validation tests.
   4. All devices provided under Division 13 and Division 17 shall be calibrated according to the manufacturer's recommended procedures to verify operational readiness and ability to meet the indicated functional and tolerance requirements.
   5. Calibration Points: Each instrument shall be calibrated at 20, 40, 60, 80, and 100 percent of span using test instruments to simulate inputs. The test instruments shall have accuracies traceable to National Institute of Testing Standards.
   6. Factory Calibration: Instruments which have been factory-calibrated shall have their calibration verified in the field to determine whether any of the calibrations are in need of adjustment. Any instrument not requiring re-adjustment shall be confirmed by the ENGINEER.
   7. Field Calibration: All existing and new instruments which have not been factory calibrated shall be calibrated in the field to insure proper operation in accordance with the instrument loop diagrams or specification data sheets unless specifically waived by the ENGINEER.
   8. Analyzer Calibration: Each analyzer system shall be calibrated and tested as a workable system after installation. Testing procedures shall be directed by the manufacturers' technical representatives. All samples, sample gases, etc. shall be furnished by the manufacturer.
   9. Loop Validation Test:
      a. Each instrument and/or analyzer shall be field verified and/or calibrated by the Instrumentation and Control System Contractor.

1) During the calibration procedure the instrument loop shall be validated. The output from the instrument shall be varied and the associated PLC register, HMI display, and/or SCADA screen value shall be observed to confirm output value, scale, range, and units from the device through the final PCIS element.
2) Instrument and Instrument Component Validation: Each instrument shall be field tested, inspected, and adjusted to its indicated performance requirement in accordance its manufacturer's specifications and instructions.
3) Any instrument which fails to meet any Contract requirement, or, in the absence of a Contract requirement, any published manufacturer performance specification for functional and operational parameters, shall be repaired or replaced, at the discretion of the ENGINEER at no additional cost to the OWNER.

b. All control loops shall be checked under simulated operating conditions by impressing 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. Actual signals shall be used wherever available.
c. Following any necessary corrections, the loops shall be retested.
d. Specified accuracy tolerances for each analog network are defined as the root-mean-square-summation of individual component accuracy requirements.
e. Individual component accuracy requirements shall be as indicated by Contract requirements or by published manufacturer accuracy specifications, whenever Contract accuracy requirements are not indicated.
f. Each analog network shall be tested by applying simulated analog or discrete inputs to the first element of an analog network.
g. For networks which incorporate analog elements, simulated sensor inputs corresponding to 20, 40, 60, 80, and 100 percent of span shall be applied, and the resulting element outputs monitored to verify compliance to calculated root-mean-square-summation accuracy tolerance requirements.
h. Continuously variable analog inputs shall be applied to verify the proper operation and setting of discrete devices.
i. Provisional settings shall be made on controllers and alarms during analog loop tests.
j. All analog loop test data shall be recorded on test forms which include calculated root-mean-square-summation system accuracy tolerance requirements for each output.
k. Each field device requiring an analog output shall be exercised through the PCIS.
    1) During this validation process the output from the PLC shall be varied and the end device position, speed, etc. shall be measured to confirm the proper operation of the device for the supplied analog signal from the PCIS.
l. Each field device providing a discrete input to the PCIS shall be exercised in the field and the proper operation shall be observed at the PCIS.
    1) Limit switches shall be tested and limits set mechanically and then proper operation shall be observed as reported to the PCIS.

2) Starters, relay contacts, switch contacts shall be exercised and proper operation shall be observed as reported to the PCIS.
3) Instrument supplying discrete inputs to the PCIS shall be calibrated and tested, and the proper operation shall be observed as reported to the PCIS.

m. Each field device accepting a discrete output signal from the PCS shall be exercised in the field and proper operation shall be confirmed by correlating the PCIS signal with the actual response in the field.
1) Valves shall be stroked through outputs from the PCIS, and proper directional operation shall be field confirmed, as well as limits, and reports back the PCIS.
2) Motors starters shall be exercised from the PCIS and proper operation verified through direct field observation.
3) Solenoids, and other field devices shall be exercised from the PCIS and proper operation verified through direct field observation.

n. Instrument calibration sheets shall be completed for each and every field instrument and/or analyzer that provide the following information and a space for sign-off on individual items and on the completed unit:
1) Project name.
2) Loop number.
3) Tag number.
4) Manufacturer.
5) Model number.
6) Serial number.
7) Analog input devices:
a) Calibration range.
b) Calibration data: Input, output, and error at 10, 50, and 90 percent of span.
c) Analog input associated PLC register address.
d) Value in PLC register at 0, 10, 50, 90, and 100 percent of span.
e) Value in SCADA database at 0, 10, 50, 90, and 100 percent of span.
8) Analog output devices:
a) Calibration range.
b) Calibration data: Input, output, and error at 10, 50, and 90 percent of span as driven from the PLC.
c) Analog output associated PLC register address.
d) Control variable value at field device at 0, 10, 50, 90, and 100 percent of span.
e) Physical device response 0, 10, 50, 90, and 100 percent of span.
(1) Response to be actual valve position, or motor speed, etc.
9) Discrete instrument input devices:
a) Switch setting, contact action, and dead band.
b) Valve position switches:
(1) Response in the PLC as the valve is stroked from the PLC.
(2) Field observed actual valve position, and valve indicator position as the valve is stroked from the PLC.
c) Operator interface switches and associated response.
d) Starter and drive auxiliary device contact response.
e) Response of all other discrete inputs to the PLC.
10) Discrete output devices:

a) Documented observed response of field device to the discrete output from the PLC.
b) Observe the proper operation of Open, Close, Start, Stop, On, Off, etc.

11) Utilize the Factory Acceptance Test, PLC I/O Test form format modified to become the Loop Validation Test Checklist.
12) Space for sign-off by Instrumentation and Control System Contractor and date.
13) Test equipment used and associated serial numbers.

o. Calibration Tags:
1) A calibration and testing tag shall be attached to each instrument, piece of equipment, or system.
2) The Instrumentation and Control System Contractor sign the tag when calibration is complete.
3) The OWNER's representative will sign the tag when the calibration and testing has been accepted.

D. Pre-commissioning Test:
1. General:
a. Pre-commissioning test shall commence as specified in paragraph 1.09 of this section.
b. Pre-commissioning shall demonstrate proper operation of all systems with process equipment operating over full operating ranges under conditions as closely resembling actual operating conditions as possible.
2. Pre-commissioning Procedures and Documentation:
a. All pre-commissioning and test activities shall follow detailed test procedures and check lists accepted by the ENGINEER.
b. All test data shall be acquired using equipment as required and shall be recorded on test forms accepted by the ENGINEER, which include calculated tolerance limits for each step.
c. Completion of all system pre-commissioning and test activities shall be documented by a certified report, including all test forms with test data entered, delivered to the ENGINEER with a clear and unequivocal statement that all system pre-commissioning and test requirements have been satisfied.
3. Operational Validation:
a. Where feasible, system pre-commissioning activities shall include the use of water or air as applicable to establish service conditions that simulate, to the greatest extent possible the normal final control element operating conditions in terms of applied process loads, operating ranges, and environmental conditions.
b. Final control elements, control panels, and ancillary equipment shall be tested under start-up and steady-state operating conditions to verify that proper and stable control is achieved using motor control center and local field mounted control circuits.
c. All hardwired and software control circuit interlocks and alarms shall be operational.
d. The control of final control elements and ancillary equipment shall be tested using both manual and automatic control circuits.
e. The stable steady-state operation of final control elements running under the control of field mounted automatic analog controllers or software

based controllers shall be assured by adjusting the controllers as required to eliminate oscillatory final control element operation.

f. The transient stability of final control elements operating under the control of field mounted, and software based automatic analog controllers shall be verified 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.

4. Loop Tuning:
   a. All electronic control stations incorporating proportional, integral or derivative control circuits shall be optimally tuned, experimentally, by applying control signal disturbances and adjusting the gain, reset, or rate settings as required to achieve a proper response.
      1) If excessive oscillations or system instability, as determined by the ENGINEER, occur the Instrumentation and Control System Contractor, in conjunction with the ENGINEER, shall develop and implement any additional control algorithms needed to achieve an optimal control loop operation, at no additional cost to the OWNER.
   b. Measured final control element variable position/speed setpoint settings shall be compared to measured final control element position/speed values at 20, 40, 60, 80, and 100 percent of span and the results checked against indicated accuracy tolerances.
5. Pre-commissioning Validation Sheets:
   a. Pre-commissioning shall be documented on one of two types of test forms as follows:
   b. For functions which can be demonstrated on a loop-by-loop basis, the form shall include:
      1) Project name.
      2) Loop number.
      3) Loop description.
      4) Tag number, description, manufacturer, and data sheet number for each component.
      5) Space for sign-off and date by both the ICSC and ENGINEER.
      6) Use the FAT Loop Test Checklist forms modified to meet these specific testing conditions.
   c. For functions which cannot be demonstrated on a loop-by-loop basis, the test form shall be a listing of the specific tests to be conducted. With each test description the following information shall be included:
      1) Specification page and paragraph of function demonstrated.
      2) Description of function.
      3) Space for sign-off and date by both the ICSC and ENGINEER.
      4) Use the FAT Loop Test Checklist forms modified to meet these specific testing conditions.
6. Functional Performance:
   a. General:
      1) The complete PCIS system including all SCADA screens, reports, trends, etc. shall be functional throughout the pre-commissioning test.
      2) The complete PCIS shall perform all specified functions within the time frames listed below, based on the ultimate system expansion. Tests or calculations shall be developed to extrapolate from the initial

system measured performance to the expanded system performance.

b. Data Update Times:
   1) Data received from PCMs, and RIOs, shall be displayed on the operator's console within 1 second of receipt of such data at the CCS, regardless of originating PCM, RIO, state of the data received, and the number of stations that require the data.
   2) Alarm printouts, when required, shall be initiated within the same 1-second time frame.

c. Screen Displays:
   1) Any specified screen display, except trend displays, shall be drawn complete on any furnished CRT, including all real-time data, within 3 seconds from an operator request for the displays.

d. Trend Displays:
   1) Any specified trend display containing up to three trend lines and any time interval, both real-time and historical, shall be drawn complete on any furnished CRT within 10 seconds from an operator request for the trend display.

e. Reports:
   1) Any specified report shall be compiled and printing initiated on any furnished printer within 30 seconds from an operator request for the report.

7. Pre-commissioning Certification:
   a. The Instrumentation and Control System Contractor shall submit an instrumentation and control system pre-commissioning completion report which shall state that all Contract requirements have been met and shall include a listing of all instrumentation and control system maintenance and repair activities conducted during the pre-commissioning testing.

E. Proof of Conformance: The burden of proof of conformance to specified accuracy and performance is on the Instrumentation and Control System Contractor.
   1. The Instrumentation and Control System Contractor shall supply necessary test equipment and technical personnel if called upon to prove accuracy and/or performance, at no separate additional cost to the OWNER, wherever reasonable doubt or evidence of malfunction or poor performance may appear.

F. Testing: All systems shall be exercised through functional and operational tests in the presence of the OWNER's representative in order to demonstrate achievement of the specified performance.
   1. Operational tests depend upon completion of work specified elsewhere in these Contract Documents.
   2. The scheduling of tests shall be coordinated by the CONTRACTOR among all parties involved so that the tests may proceed without delays or disruption by uncompleted work.

3.03 DEMONSTRATION

A. Performance Test:
   1. After successful completion of the pre-commissioning test as accepted by the ENGINEER and OWNER, the performance test and system startup by the OWNER'S operating personnel can follow.

2. System startup, calibration, and training and instruction of the OWNER's personnel must be completed in conformance with paragraph 1.09 of this section.
3. General:
    a. Completed in conformance with paragraph 1.09 of this section.
    b. The performance test is part of the work that must be completed as a condition of substantial completion for the entire project.
    c. The complete PLC control and SCADA system must run continuously for the duration of the performance test.
        1) During this period, all system functions shall be exercised, and any system interruption and accompanying component, subsystem, or program failure shall be logged for cause of failure, as well as time of occurrence and duration of each failure.
        2) The SYSTEM SUPPLIER and Instrumentation and Control System Contractor shall provide a competently trained technician 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 shall be within 24 hours of a major failure.
4. Process Control System Testing:
    a. The entire process control system shall be tested and used under standard operating conditions.
5. Failures:
    a. Failures shall be classified as either major or minor.
    b. A minor failure would be a small and noncritical component failure or software problem which can be corrected by the OWNER's operators.
        1) This occurrence shall be logged but shall not be reason enough for stopping the test and shall not be grounds for non-acceptance.
        2) Should the same or similar component failure occur repeatedly, this may be considered as grounds for non-acceptance.
        3) Failure of one printer, or CRT display shall be considered a minor failure providing all functions can be provided by backup equipment, ie. alternate printers and CRT's, and repairs can be made and equipment returned to service within 3 working days.
    c. A major failure shall be 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.
        1) A major failure shall cause termination of the performance test.
        2) When the causes of a major failure have been corrected, a new acceptance test shall be started.
        3) Failure of a control loop to maintain stability or function properly resulting in a process disturbance.
        4) Failure of any control system that results in an overflow, underflow, overdose, or underdose condition shall be considered as a major failure.
6. Technician Report:
    a. Each time a technician is required to respond to a system malfunction he or she must complete a report which shall include details concerning the nature of the complaint or malfunction and the resulting repair action required and taken.

b. If a malfunction occurs which clears itself or which the operator on duty is able to correct, no report shall be required or logged as specified above.
c. If a technician has performed work but no report is written, then a major failure shall be considered to have occurred.
d. Each report shall be submitted within 24 hours to the ENGINEER or its representative, and the OWNER.

3.04 SCHEDULES

A. Documentation Schedule:
1. Calibration sheets for all instruments that have been completed and signed off and all calibration tags attached.
2. All loop validation sheets completed and signed off and loop certifications issued.
3. Pre-commissioning certification report and validation sheets.
4. Training plan overview along with prerequisites for the OWNER's personnel.
5. Training materials:
   a. Resume for the proposed instructors.
   b. Training manuals.
   c. A copy of the SCADA OPERATION MANUAL shall be provided to each operator during training on the workstation operations.
6. Warranty Certificate.
7. Recommended and priced spare parts lists.
8. Certification of completion of performance tests.

B. Spare Parts and Tools Schedule:
1. Spare parts and tools as identified in paragraph 1.11 of all sections constituting Division 17.
2. Instrumentation and Control System Contractor has furnished the spare parts/tools on site at an inventory level sufficient to minimize downtime and reduce the liability of the Instrumentation and Control System Contractor for operations up to and through the guarantee period.
   a. All spare parts/tools stored on-site shall become the property of the OWNER upon completion of the guarantee period.

END OF SECTION

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