Section 13110
PROTECTION FOR PIPELINES

PART 1 - GENERAL

1-1. SCOPE. This section covers the material and construction specifications to furnish, install, and test the corrosion protection system for the following:

   Steel pipe cathodic protection with galvanic anodes.
   Ductile iron pipe polyethylene encasement.

The items specified in this section include materials and installation procedures for carbon steel pipe galvanic cathodic protection and ductile iron pipe polyethylene encasement.


1-3. GENERAL REQUIREMENTS. The Contractor shall be responsible for all specified testing and the furnishing and proper installation of all materials and equipment, as specified herein and as indicated on the Drawings.

The Contractor shall obtain the services of a NACE certified corrosion or cathodic protection specialist to review installation procedures and supervise the testing. The corrosion or cathodic protection specialist shall be acceptable to the Owner and the Engineer. The Cathodic Protection Specialist shall test and certify that the corrosion control facilities for this project are constructed properly and as specified, and are fully functional. The final testing and commissioning will be performed by the Certified Cathodic Protection Specialist, hired by the Contractor. All work shall be performed in accordance with federal and local safety regulations.

1-4. SUBMITTALS. Complete specifications, data, and catalog information or drawings covering the items furnished under this section shall be submitted in accordance with the Submittals section.
Submittals shall include the following:

Experience record for the proposed NACE certified corrosion or cathodic protection specialist.

Drawings and data shall include the following items:

Drawings which indicate the location of each anode, underground reference electrode, buried insulated flange, and field test station complete with a description of piping connected are indicated.

Drawings with sufficient information that each underground galvanic anode and underground reference electrode can be exactly excavated or replaced.

Operations and maintenance manual for the cathodic protection system.

Tabulated reports of the following, where the reports are relevant to the specified cathodic protection systems:

- Underground reference electrode tests.
- Insulated flange tests.
- Anode current measurements of each test station connected galvanic anode.
- Pipe system potential measurements.

Test reports shall be submitted 15 days after completion of the cathodic protection tests.

1-5. DELIVERY, STORAGE, AND HANDLING. Shipping shall be in accordance with the Shipping section. Handling and storage shall be in accordance with the Handling and Storage section.

PART 2 - PRODUCTS

2-1. MAGNESIUM GALVANIC ANODES. Magnesium galvanic anodes shall be high potential magnesium anodes furnished as a packaged assembly with insulated lead wire. The packaged assembly shall consist of a permeable cloth
bag containing the anode and special compacted backfill. The anode shall be centered in the bag and completely surrounded by the backfill.

High potential magnesium anode alloy shall be Grade M1C, UNS alloy M15102, complying with ASTM B843, and shall have the following composition in percent by weight:

<table>
<thead>
<tr>
<th>Element</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aluminum</td>
<td>0.010 maximum</td>
</tr>
<tr>
<td>Manganese</td>
<td>0.50 to 1.30</td>
</tr>
<tr>
<td>Silicon</td>
<td>0.05 maximum</td>
</tr>
<tr>
<td>Copper</td>
<td>0.02 maximum</td>
</tr>
<tr>
<td>Nickel</td>
<td>0.001 maximum</td>
</tr>
<tr>
<td>Iron</td>
<td>0.03 maximum</td>
</tr>
<tr>
<td>Other</td>
<td>0.05 each and 0.30 maximum total</td>
</tr>
<tr>
<td>Magnesium</td>
<td>Remainder</td>
</tr>
</tbody>
</table>

Backfill surrounding the anode shall have the following composition in percent by weight:

<table>
<thead>
<tr>
<th>Material</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ground hydrated gypsum</td>
<td>75</td>
</tr>
<tr>
<td>Powdered bentonite</td>
<td>20</td>
</tr>
<tr>
<td>Anhydrous sodium sulfate</td>
<td>5</td>
</tr>
</tbody>
</table>

Packaged anode component specifics shall be as follows:

- Bare anode dimensions: 3x3x60 in.
- Bare anode weight: 40 lbs
- Lead wire type and size: Type TW insulated, 12 AWG solid copper
- Lead wire length: feet
- Approximate packaged weight: 105 lbs
High potential magnesium anodes shall be as manufactured by Mesa Products, Inc.; Stuart Steel Protection Company; Farwest Corrosion Control Company; or acceptable equal. High potential Winca (formerly Dow) magnesium anodes shall be as manufactured Norton Corrosion, Allied Corrosion, or equal.

2-2. ZINC REFERENCE ELECTRODES. Not used.

2-3. WIRE AND CABLE ACCESSORIES.

2-3.01. Cathodic Protection Cable. All cable, sizes 12 AWG and larger, where specified herein or on the Drawings to be cable Type CP, shall be stranded copper cathodic protection cable with low density high molecular weight polyethylene (HMWPE) insulation as supplied by the Kris-Tech Wire Company, Inc.; Energy Economics, Inc.; or Mesa Products, Inc. Provide color coding as indicated on the Drawings.

2-3.02. Wire and Cable Markers. Markers for wire and cable circuits shall be of an opaque nylon material consisting of a marker board, non-releasing holding device, and cable fastening tail. The holding device shall be designed to allow the fastening tail to pass around the cable and through the holding device, so the cable marker can not be removed except by cutting it loose from the cable. The marker board shall not be less than 3/8 inch wide, 3/4 inch long, and 25 mils thick with one side roughened to hold ink from a marking pen.

Cable markers shall be "TY-RAP" identification cable ties, "Part Number TY551M" as manufactured by Thomas & Betts; or "PAN-TY" marker ties, "Type PLF" as manufactured by Panduit Corporation, or equal.

As an alternative 1 inch diameter brass tags with 3/16 inch minimum stamped identification for anode, referenced electrode, or identified pipe test lead connected to cable with nylon wire ties is acceptable.

2-3.03. Marking Pens. Marking pen ink shall be suitable for marking on nylon and shall be black, permanent, and waterproof. Marking pens shall be "TY-RAP, Part Number WT163M-1" as manufactured by Thomas & Betts, or "Part Number PFX-0" as manufactured by Panduit Corporation, or equal.

2-3.04. Compressed Ring-Tongue Terminals. Compression ring tongue terminals shall be single hole, uninsulated, compression type terminal lugs made of corrosion-resistant copper, bronze, or nickel-plated brass. Compression ring tongue terminal part numbers shall be as indicated in the table below:
<table>
<thead>
<tr>
<th>Wire Size</th>
<th>Stud Size (inch)</th>
<th>Ring-Tongue Terminal Part No.</th>
<th>Manufacturer</th>
</tr>
</thead>
<tbody>
<tr>
<td>14 AWG Stranded</td>
<td>1/4</td>
<td>YAV12-G3</td>
<td>Burndy Corporation</td>
</tr>
<tr>
<td>12 AWG or 10 AWG Stranded or Solid</td>
<td>1/4</td>
<td>YAV10-T3</td>
<td>Burndy Corporation</td>
</tr>
</tbody>
</table>

2-3.05. **Exothermal Connections.** Welding charge formulation, equipment selection, and welding procedures shall be as recommended by the manufacturer of the exothermal weld materials for the size, shape, and composition of the materials being welded. Where the manufacturer offers a choice of exothermal weld materials, the recommended materials for cast iron pipe shall be used for ductile iron pipe. Materials shall be Cadweld as manufactured by Erico Products, Inc., or Thermoweld, a Division of Continental Industries, or equal.

2-3.06. **Oxidation Inhibiting Compound.** Oxidation inhibiting compound shall be an electrically conductive paste material, compatible with both steel and copper, and shall be Contax "Type CT" as manufactured by Thomas & Betts; "Kopr-Shield" as manufactured by Jet-Lube, Inc.; Dostex Type AP as manufactured by Dossert Corporation, "Ox-Gard" as manufactured by Gardner Bender, Inc.; "DEOX Oxide Inhibitor" as manufactured by Ilsco; or equal.

2-3.07. **Solder Connections.** All soldering shall be with 50/50 tin/lead hollow core solder with non-acid flux.

2-4. **ABOVEGROUND FIELD TEST STATIONS.** "Cott Big Fink" above ground type test station with orange color enclosure and a minimum of eight terminals. Test stations shall be installed in protected locations and shall not interfere with normal use of the area. Above grade test stations shall be as manufactured by Cott Manufacturing Co., or equal.

2-5. **FLUSH MOUNTED TERMINAL FIELD TEST STATIONS.** Flush mounted test stations should be installed in areas that above grade test stations are not suitable. Flush mounted field test stations shall consist of a traffic valve box, complete with a terminal block and cast iron locking cover. The cover shall be painted yellow and cast with the inscription "CP TEST". Each terminal block shall be furnished with a minimum of eight terminals as indicated on the Drawings. Flush mounted field test stations shall be "NM-Corrosion Control" terminal boxes, as manufactured by C.P. Test Services, Cott Manufacturing Co., or equal.
2-6. **UNDERGROUND REFERENCE ELECTRODES.** Underground reference electrodes shall be of the saturated, gelled, copper-copper sulfate type, packaged in a special backfill and complete with 75 feet of 14 AWG stranded copper lead wire with high molecular weight polyethylene insulation. Underground reference electrodes shall have a 1 year minimum design life. Underground reference electrodes shall be "Stealth SRE-007-CUY" as manufactured by Borin Manufacturing, Inc., "Model UL-CUG" as manufactured by Electrochemical Devices, Inc., or equal.

2-7. **FLANGE INSULATING KITS.** The flange insulating materials and special gasket diameters specified in this article may not be stock items and shall be ordered early to allow time for manufacture. Ordering information should include:

- Type E retainer.
- Double washers.
- Retainer material.
- Sealing element material.
- Insulating washer material.
- Insulating sleeve material.
- Nominal flange size.
- ANSI pressure class.

Each insulated flange kit shall include the following:

One Type "E", full-faced insulating and sealing flange gasket, consisting of a 1/8 inch thick retainer with special ring seal. The inside diameter shall be 1/8 inch less than the inside diameter of the flange in which it is to be installed and shall be PSI Linebacker, or acceptable equal.

One full length bolt insulating sleeve, 1/32 inch thick, for each flange bolt.

Two flat insulating washers, 1/8 inch thick, for each flange bolt.

Two flat steel backing washers, 1/8 inch thick, for each flange bolt. The backing washer outside diameter shall not be larger than the outside diameter of the insulating washer.
Insulating material selection shall be based on the application as indicated in the following table:

<table>
<thead>
<tr>
<th>Fluid</th>
<th>Sleeves</th>
<th>Insulating Washers</th>
<th>Gasket / Retainer</th>
<th>Seal Element</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water</td>
<td>G-10</td>
<td>G-10</td>
<td>G-10</td>
<td>Nitrile or EPDM</td>
</tr>
</tbody>
</table>

2-8. SHRINK SLEEVES FOR BURIED INSULATED FLANGES. Shrink sleeves shall be used where indicated on the Drawings to coat buried insulated flanges and shall conform to the requirements of ANSI/AWWA C216. Shrink sleeves shall be of the wraparound type for all pipe sizes for which they are available. Widths shall be as recommended by the manufacturer for the flange size being coated. Flange shrink sleeves shall be "Type Raychem FCWS-F/FLANGESEAL" as manufactured by Berry Plastics, Corrosion Protection Group, or "Aqua-Shield Flange Protection Kit, Type AQW-FPK", as manufactured by Canusa-CPS.

2-9. WAX TAPE COATING FOR BURIED INSULATED PIPE FLANGES. The wax-tape coating shall be used where indicated on the Drawings and shall conform to the requirements of ANSI/AWWA C217, and shall consist of three parts: surface primer, wax-tape and outer covering. The primer shall be a blend of petrolatum, plasticizer and corrosion inhibitors having a paste like consistency such as Trenton Wax-Tape Primer. The wax-tape shall be a plastic-fiber felt tape, 50 to 70 mils thick, and saturated with a blend of petrolatum, plasticizer, and corrosion inhibitors that is easily formed over irregular surfaces such as Trenton #1 wax-tape. The outer covering shall be a plastic wrapper consisting of three each 50 gauge, clear polyvinylidene chloride, high cling membranes wound together as a single sheet such as Trenton Poly-Ply.

2-10. MONOLITHIC INSULATING FITTINGS. Not used.

2-11. PIPE COATING REPAIR MATERIALS AT CABLE CONNECTIONS. Materials used to repair pipe coating at lead wire or joint bond connections shall be Thermit Weld Caps" and "Thermit Weld Mastic" as manufactured by Mesa Products Incorporated; "Royston Handy Caps" as manufactured by Royston Laboratories, Inc., or equal.

2-12. NONDETECTABLE UNDERGROUND MARKING TAPE. Underground, nondetectable marking tape shall be a minimum 3 inches in width, red in color, with "Caution Electric Line Buried Below", "Caution Cathodic Protection Cable
Buried Below”, or similar words printed in black. Nondetectable underground marking tape shall be "Shieldtec" as manufactured by Empire Level Manufacturing Company and as supplied by Hoff Company, Inc., or equal.

2-13. POLYETHYLENE ENCASEMENT MATERIALS FOR DUCTILE IRON PIPE. Polyethylene film for encasement pipe shall be a linear low density (LLD) or high density cross laminated (HDCL) material conforming to the applicable requirements of ANSI/AWWA-C105/A21.5, and as specified in this article.

Under no circumstance shall a co-extruded product be considered for this project. Material shall conform to the definitions as called for in ANSI/AWWA C105/A21.5. The polyethylene sleeve shall be as manufactured by Fulton Enterprises, Birmingham, Alabama, or equal.

The film supplied shall be clearly marked at a minimum of every 2 feet along its length, as stated in the ANSI/AWWA C105/A21.5.

At the discretion of the Owner, material delivered to the job site may be sampled and tested at the Owner’s expense to determine adherence to these specifications.

Polyethylene encasement materials shall meet the following minimum requirements:

<table>
<thead>
<tr>
<th>Item</th>
<th>LLDPE – 8 mil/HDCLPE – 4 mil</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tensile Strength, psi</td>
<td>3,600/6,300</td>
</tr>
<tr>
<td>Elongation, percent</td>
<td>800/100</td>
</tr>
<tr>
<td>Dielectric Strength, V/mil</td>
<td>800</td>
</tr>
<tr>
<td>Tear Resistance, gf</td>
<td>2,550/250</td>
</tr>
<tr>
<td>Impact Resistance, g</td>
<td>600/800</td>
</tr>
</tbody>
</table>

Joint tape shall be PVC or polyethylene, self-sticking type, 10 mils thick. Joint tape shall be Chase "Chasekote 750," Kendall "Polyken 900," or 3M "Scotchrap 50."

Strapping shall be the nonmetallic, water resistant type, conforming to Fed Spec PPP-S-760, Type II.

2-14. CORROSION COUPLONS. IR-free cathodic protection coupon with green THHN insulation, No. 12 AWG stranded wire, as manufactured by M.C. Miller Company, Sebastian, Florida.
PART 3 - EXECUTION

3-1. INSTALLATION. An insulated type joint shall be provided at each connection through a structure wall, and where indicated on the Drawings.

Field test stations shall be provided at each buried insulated joint.

Underground reference electrodes shall be provided where indicated on the Drawings.

Galvanic anodes shall be installed where indicated on the Drawings.

3-1.01. **Galvanic Anodes.** The burial depth of galvanic anodes and distance from the pipe shall be as indicated on the Drawings.

When installing anodes, penetration of layers of brick, concrete, or other debris may be required to properly place the anodes. It is not intended that anodes be installed at locations where penetration of solid reinforced concrete or rock is necessary.

If solid rock or reinforced concrete is encountered at the location and burial depth indicated on the Drawings for an anode, and prevents vertical installation of the anode, an investigation of the immediate area shall be made to determine a suitable location for vertical installation of the anode at the specified burial depth. If the Contractor is unable to find a suitable location in the immediate area of the specified anode location, the anode shall be installed vertically closer to the surface with a minimum earth cover of 5 feet. If a minimum earth cover of 5 feet cannot be maintained, the Engineer will direct the Contractor how to proceed.

After placement of packaged galvanic anodes, at least 5 gallons of water shall be poured over and around packaged anodes before backfilling.

Packaged galvanic anodes shall be backfilled with clean earth, free from rocks and debris. Anodes shall not be backfilled with sand.

3-1.02. **Zinc Reference Electrode/Anodes.** Not used.
3-1.03. **Wire, Cable, and Cable Accessories.**

3-1.03.01. **Routing.** Unless otherwise indicated on the Drawings, lead wire and cable shall be installed at a minimum of 3 feet below grade. Where lead wire is connected to pipe or to field test stations, a minimum of 18 inches of slack shall be left in the lead wire to permit settling of the backfill without stressing the electrical connection.

3-1.03.02. **Pipe Lead Wires.** Pipe lead wires shall be connected to the pipe at each field test station location as indicated on the Drawings. Pipe lead wires shall be two Type CP cables, size 12 AWG.

Connection of the lead wires to the pipe shall be as specified in the Cable Connections to Pipe article. To the extent practical, pipe lead wires shall be attached to the pipe on the top center line and separated a minimum distance of 6 inches.

Pipe lead wires shall not be spliced.

Pipe lead wires shall be clearly identified by and indication of the pipe they are connected to. Identification shall be made at installation using the specified permanent cable markers. The Contractor shall maintain the identification markings throughout construction to ensure that each pipe lead wire is clearly and correctly marked when terminated in the field test stations.

3-1.03.03. **Field Test Station Terminations.** Terminations shall be arranged on the field test station terminal boards as indicated on the Drawings.

Terminations at field test stations shall be made with single hole compression type terminal lugs of corrosion-resistant copper, bronze, or nickel-plated brass. A calibrated crimping tool designed to crimp the connector shall be used for all compression connections. The connector shall not release from the conductor when pulled or twisted.

All terminals, terminal lugs, jumpers, link bars, and any other terminal board metal parts or hardware installed in flush mounted field test stations shall be coated with a conductive oxidation inhibiting compound as specified in the article titled Oxidation Inhibiting Compound.

Solid conductors shall additionally be soldered in the terminal lug before terminating the lug in the field test station.
Permanent, legible identification markers shall be attached to each lead wire in each field test station. Each lead wire shall be identified as described on the drawings.

3-1.03.04. **Cable Connections to Pipe.** Except for stainless steel pipe, cables shall be exothermally welded to pipe. Cable connections to stainless steel pipe shall be made with silver brazing.

No connection to pipe shall be coated or covered until it has been inspected by the Engineer. The Engineer may reject any connection if it fails when the cable is pulled, breaks loose from the pipe when struck at an angle with a hammer, or does not appear to be a complete, properly shaped and made connection. Inspection by the Engineer in no way relieves the Contractor of responsibility for the performance of the connection.

After the connection has been inspected by the Engineer, the exposed part of the wire and the connection shall be coated as specified in the article titled Coating Electrical Connections to Pipe.

3-1.03.05. **Splices.** Splices in solid wires shall be made by twisting the conductors together and soldering with 50-50 solid solder and non-acid flux. Splices in stranded wires shall be performed using a properly sized uninsulated butt splice compression connector and a calibrated crimping tool designed to crimp the connector. The connector shall not release from the conductor when pulled or twisted. Acceptable butt splice connectors for the various cable sizes shall be as follows.

<table>
<thead>
<tr>
<th>Stranded Cable Size</th>
<th>Connector Type</th>
<th>Manufacturer</th>
</tr>
</thead>
<tbody>
<tr>
<td>14-10 AWG</td>
<td>Hylink, Type YSV Box</td>
<td>Burndy</td>
</tr>
<tr>
<td>8 AWG</td>
<td>Pan-Term Splice-Type SCS</td>
<td>Panduit</td>
</tr>
<tr>
<td>6 AWG and larger</td>
<td>Copper Hylink, Type YS</td>
<td>Burndy</td>
</tr>
</tbody>
</table>

A compression connection installed underground shall additionally be soldered before insulation and burial. After inspection by the Engineer, splices shall be insulated with one half-lapped layer of varnished cambric tape covered by two half-lapped layers of rubber tape elongated not more than 20 percent. Two half-lapped layers of vinyl electrical tape shall be applied over the rubber tape. At each end of each splice the vinyl tape shall overlap the rubber tape onto the undamaged cable insulation a minimum of two cable diameters.
3-1.03.06. **Exothermal Welds.** This article covers requirements for exothermal welding, including but not restricted to, cable-to-cable, cable-to-rod, cable-to-pipe, and cable-to-steel structure connections.

Exothermal welds shall be made using molds, sleeves, and cartridges sized in accordance with the welding equipment manufacturer's recommendations for the particular application.

Completed welds shall be capable of withstanding moderate hammer blows. Porous or deformed welds will not be acceptable. Damaged or worn molds shall not be used and shall be removed from site.

The inspection of, and responsibility of the Contractor for, exothermal welds shall be as described in the article titled Cable Connections to Pipe.

3-1.03.07. **Joint Bonds.** Ductile iron pipe shall be made electrically continuous by joint bonding. No joint bonding is required at joints where corrosion monitoring test stations are installed.

Non-insulated flanges and mechanical pipe couplings shall be joint bonded as detailed on the Drawings.

The method of attaching joint bond cables to pipe or to pipe fittings shall be as described in the article titled Cable Connection to Pipe.

Joint bonding cable connections on either side of a joint shall be separated as indicated on the drawings. Except where indicated otherwise, joint bonding cables shall be made with two #8 AWG Type CP cables. Joint bond cables shall contain at least 6 inches of slack wire to compensate for pipe movement and backfill settlement.

3-1.04. **Underground Reference Electrodes.** Underground reference electrodes shall be installed at the locations indicated on the Drawings.

Underground reference electrodes shall be stored and maintained in a dry environment, above freezing temperatures, until activation and installation. Underground reference electrodes shall be activated by complete immersion in clean, fresh water for approximately 8-12 hours prior to installation.

Except as indicated otherwise on the Drawings, the packaged underground reference electrode shall be installed horizontally below the frost line, in permanently moist soil, with a minimum of 6 inches of clean earthfill between the electrode package and any surrounding rock.
Activated reference electrodes shall be tested for proper operation in accordance with applicable articles of the subsection titled Testing, after placement and before backfilling.

3-1.05. Insulated Flanges. Flange insulating kits shall be installed in pipe flanges where indicated on the Drawings and as specified herein. After installation, protective coatings shall be provided around the joint as specified herein.

Bolting at insulated flanges shall consist of studs and nuts with sufficient stud length to allow at least one full stud thread protruding through each nut. Sleeves shall extend into the insulating washers.

Flange gasket seating surfaces shall be free from tool marks, scratches, pits, deposits, and other defects. Stud tensioning shall be performed using a torque wrench or other tensioning device such as a hydraulic wrench. Torque settings shall not exceed the maximum value specified by the insulated flange kit manufacturer.

Insulated flange kits shall be installed as follows:

a. Inspect the gasket kits. Verify that the material is as specified and provided in a new and undamaged condition.

b. Clean the bolting materials. Apply lubricant or antiseizing compound to all threads required for engagement with nuts and nut facings.

c. Align flange faces so that they are parallel and concentric with each other within 0.010 inch without external loading or springing.

d. Line up bolt holes by driving two tapered drift pins in opposite directions to each other into two diametrically opposite bolt holes.

e. Insert insulating sleeves into the bolt holes. If they do not slide in easily, the flanges are not lined up properly. Do not force sleeves into bolt holes as sleeve damage may result.

f. Assemble the studs (or bolts) as follows:

(1) Run one nut on each stud so that two full threads are showing beyond the nut.

(2) Slide a steel washer onto stud and insert into bolt hole. (If the flange requires two sided insulation, add an insulating washer after the steel washer.)
(3) From the opposite end of the stud, place an insulating washer, a steel washer, and then a nut. Hand tighten.

g. Torque studs to a maximum of 30 percent of the final torque value specified. Replace the two drift pins with stud assemblies. Torque the remaining studs to 30 percent of the final torque value in a star pattern sequence.

h. Repeat steps in g., increasing the torque to approximately 60 percent to 80 percent of the final torque value.

i. Continue torquing all studs in the sequence using the specified torque setting (100 percent) until there is no further rotation of nuts.

After installation, all insulated fittings shall be tested as specified in the paragraph entitled Insulated Fitting Tests.

3-1.05.01. Buried Insulated Flange Coating. Coat buried insulated pipe flanges with an external wax-tape coating in accordance with ANSI/AWWA C217. Do not apply the wax-tape coating until the insulated pipe flanges have been tested and approved by the Owner. The wax-tape coating shall consist of a surface primer, wax-tape and an outer covering. The wax tape coating system shall extend over the adjacent pipe coating by a minimum 12 inches or 18 inches away from the flange surface, whichever is greater.

The surfaces to receive the wax tape coating shall be clean and free of all dirt, grease, and other foreign material. Apply the primer by gloved hand or brush onto all exposed metal surfaces. Apply the wax tape immediately after the primer application. Cut strips of wax tape and apply them by gloved hand around all bolts, nuts, and other irregular shapes so that there are no voids or spaces under the tape. Apply a sufficient amount of tape to completely encapsulate all exposed metal surfaces with a minimum wax tape thickness of 140 mils. Apply by hand two layers of polyvinylidene chloride, high cling membrane sheet over the wax tape coating by tightly wrapping it around the pipe such that it adheres and conforms to the wax tape. Secure the plastic wrap to the pipe with adhesive tape.

3-1.06. Polyethylene Encasement. Provide polyethylene tube protection in accordance with ANSI/AWWA-C105/A21.5, Method A or Method C as specified in this article.
Preparation of the pipe shall include, but is not limited to, removing lumps of clay, mud, cinders, etc., prior to installation. Prior to installing the polyethylene tube, all irregular or sharp surfaces which could damage the polyethylene shall be covered with a minimum of two layers of the specified joint tape.

All polyethylene tube material shall be held firmly against the pipe with the specified strapping material installed on two-foot spacings.

The terms polyethylene tube protection and polyethylene encasement are equivalent and are used interchangeably in these Contract Documents.

Unless otherwise acceptable to the Engineer, a double wrap of polyethylene tube protection shall be provided at the following locations and as indicated on the Drawings:

| Ductile Iron Pipe | All blow off and vent piping, bends, tees, adapters, closure pieces, valves, and other fittings or specials. |

3-1.07. Field Test Stations. Field test stations shall be at locations indicated on the Drawings. Where it is not practical to locate field test stations directly over the pipe it is connected to because of interference with the normal use of the area, field test stations shall be located nearby. Test station locations shall be in protected locations, such as in fence rows or adjacent to manholes, or similar structures where they will experience minimum chance of damage and provide minimum interference with normal use of the area in which they are installed.

3-1.08. Coating Electrical Connections to Pipe. Electrical connections to pipe having a dielectric coating system shall be coated immediately following inspection of the connection. Coating shall be with the materials specified in the article titled Pipe Coating Repair Materials at Cable Connections, and shall be as recommended by the coating repair material manufacturer and as specified in this article.

All slag, splatter, and scale shall be removed from welded connections. Sharp edges or burrs shall be removed by grinding or filing. Connections shall be allowed to cool to handling temperature. All moisture shall be removed from
surfaces prior to application of the coating materials. The coating material shall be firmly pressed into place, forcing the mastic material to completely cover the exposed connection area and to conform around the wire, and the undamaged pipe coating.

3-2. **TESTING.** Testing to verify acceptable installation and performance of the cathodic protection system and associated equipment and materials shall be performed by the Contractor as specified in this section.

The Contractor shall ensure that all necessary safety precautions are taken, and shall provide all necessary equipment, materials, and labor for the performance of tests. If defects are discovered, the Contractor shall perform additional tests as are required to establish the nature of the defects.

If tests indicate that defects exist in materials, equipment, or installations which are the sole responsibility of the Contractor, these defects shall be immediately corrected. Tests and repairs shall continue until the materials, equipment, and installations are in accordance with the specification requirements. Corrective action shall include the restoration of all other construction and facilities disturbed by the repair work.

3-2.01. **Test Equipment.** Required test equipment to be used for the specified testing shall include the following:

a. Eight inch saturated copper-copper sulfate solution portable reference electrode, M.C. Miller "Model RE7", available from the M.C. Miller Co., Inc.; or Tinker and Rasor "Model 8A", available from Agra Equipment Company; or equal. The reference electrode copper rod shall be clean and filled with a fresh copper-sulfate and distilled water saturated solution within 30 days of testing time.

b. Flexible test leads as required.

c. High input impedance dc voltmeter with millivolt scale and built-in ohmmeter, "Wavetek Model HD110", available from Mesa Products; "Fluke Model 87" hand-held multimeter available from John Fluke Mfg. Co.; or equal.

d. Insulation checker, "Gas Electronics Model 601" available from M.C. Miller Company.

e. Six volt lantern battery or 12 volt automotive battery.
3-2.02. Test Procedures. The Contractor shall record and submit test data for each test performed.

3-2.02.01. Joint Bond Continuity Tests. The Contractor shall not permanently cover any joint bonded pipe with soil, concrete, or other backfill until the pipe continuity is tested. The pipe joint or joints shall be tested for continuity using low-resistance dc ohm-meter as follows:

a. A helical spring point test lead shall be placed in contact with the pipe adjacent to continuity bond wire exothermal weld on each side of the pipe joint being tested.

b. The electrical resistance across the mechanical joint under test shall be measured directly using the low-resistance ohm-meter. The electrical resistance of the pipe joint shall be less than 250 micro-ohms.

c. Discontinuities shall be repaired and testing repeated to verify successful repair.

3-2.02.02. Underground Reference Electrodes. After each underground reference electrode is installed, a minimum of 5 gallons of water shall be poured over and around the electrode. After the surrounding soil and underground reference electrode is saturated with water, place a mild steel stake or rod in firm contact with the soil, several feet from the reference electrode package. Connect the negative test lead of the specified dc voltmeter to the reference electrode lead wire. Firmly connect the voltmeter positive test lead to the mild steel stake or rod. Measure and record the dc voltage on the voltmeter.

For copper-copper sulfate type underground reference electrodes, the reading shall be stable between -0.4 and -0.8 volts. For zinc type underground reference electrodes, the reading shall be stable between +0.3 and +0.7 volts.

3-2.02.03. Insulated Fitting Tests. Tests to verify acceptable insulated pipe fitting installations shall be performed after pipe installation is completed. Insulated flanges shall not be disassembled or reworked after the insulated fitting tests are complete. Underground insulated fittings shall not be backfilled until the insulation integrity is verified by the Engineer. If the tests indicate that
an insulating flange is not providing satisfactory isolation of connecting piping, the Contractor shall perform additional tests and work as required to locate and correct deficiencies.

Insulated flange testing shall be performed using the insulation checker. Prior to testing, the insulation checker shall be calibrated and zeroed as recommended by the manufacturer.

Firm metal-to-metal contact shall be established between each instrument probe and flange face across the insulator being tested. An effective insulator is indicated by a full scale reading on the instrument. Any deflection less than full scale indicates a shorted insulator.

Electrical insulation tests shall be performed at 6 inch intervals around the circumference of the insulated flange. Failure of the insulation test at any location around the circumference shall qualify as a failed insulator.

Defective components shall be identified and replaced. Testing shall be repeated to verify insulator effectiveness.

3-2.02.04. Cathodic Protection Tests. Electrical and mechanical connections to the underground piping systems shall be complete before testing. Underground piping shall be electrically isolated from above-ground piping during testing. Underground piping shall have been completely backfilled for at least one month before final testing, although prior tests may be made at the Contractor's option for his own information.

a. Pipe Lead Wire Continuity Testing. Prior to performing anode current measurement tests or pipe potential tests, electrical continuity of pipe lead wires terminated in field test stations shall be verified.

The measurements shall be made as follows:

At the field test station, pipe lead wire or wires shall be disconnected from any anodes or shunts. The voltmeter shall be connected between the two pipe lead wires, and potential measurements recorded.

If no potential exists between the pipe lead wires, the resistance between the two pipe lead wires shall be measured. This resistance reading should be a relative reading to nullify the resistance of the meter lead wires or the lead
wire resistance shall be subtracted from the reading to calculate the resistance of the pipe lead wires. The resistance reading shall be stable and less than 0.1 ohm.

If a potential exists, if the reading is unstable, or if there is a high resistance between the pipe lead wires, one or both of the pipe lead wires may be damaged. To determine if either of the pipe lead wires is satisfactorily connected to the pipe, the following tests shall be performed after satisfactory results have been obtained for the anode open circuit potential test:

The current flowing from a pipe lead wire to an anode shall be measured and recorded. The above procedure shall be repeated using the spare pipe lead wire. Low current flow through pipe lead wires indicates a discontinuity. Pipe lead wires with discontinuities shall be repaired or appropriately marked in the test station as determined by the Engineer.

Pipe lead wires shall be reconnected to the test station terminal board in their original positions.

b. **Pipe Connected Anode Current Measurements**. After the piping and galvanic anodes have been backfilled for a minimum of 30 days, and connecting above-grade piping has been isolated, galvanic anode current shall be measured as follows:

At each field test station, the positive terminal multimeter test lead wire shall be connected to the Pipe Lead Wire 1 lug in the test station terminal block and the negative terminal multimeter test lead wire to the anode lead wire lug in the test station terminal block. The current shall be measure using the multimeter mA scale and recorded. The current polarity shall be confirmed to be positive.

c. **Pipe System Potential Measurements**. After satisfactory current measurements have been obtained for all test station connected anodes, pipe potentials shall be measured.

The measurements shall be made as follows:

At each field test station, the negative terminal of the voltmeter shall be connected to the portable reference electrode and the positive terminal connected directly to a pipe lead wire. The portable reference electrode shall be placed in moist soil, free of vegetation, on the surface directly over the pipe. The potential measurement and the
location where the reference electrode was placed shall be recorded. The potential polarity shall be confirmed to be negative.

At locations where underground reference electrodes are installed, measurements shall be made as follows:

The negative terminal of the voltmeter shall be connected to the underground reference electrode lead wire and the positive terminal connected directly to a pipe lead wire. The potential shall be recorded and polarity of the measurement confirmed to be negative.

Corrosion coupons can be used as a reference for pipe polarized potential. One second after disconnecting the coupon from the pipe, measure the potential with the positive terminal of the meter connected to the coupon and negating terminal connected to the copper sulfate reference electrode. The potential and the polarity shall be recorded.

3-2.03. Test Reports and Acceptance. Within 15 calendar days after completion of the cathodic protection tests, a complete report of the test results shall be submitted to the Engineer. The Engineer will interpret the results and advise the Contractor whether or not the system is acceptable.

For the system to be acceptable, tests results shall indicate that a protective anode current output of 0.03 milliamperes per square foot of coated pipe surface will produce potentials which are more negative than -0.90 volts at any location.

If the indicated protective current outputs are in excess of 0.03 milliamperes per square foot of coated pipe surface, the system will not be acceptable and the Contractor shall locate and repair defective coating and/or locate and remove grounds on the system.

If the galvanic system anode current output is less than 0.03 milliampere per square foot of coated pipe surface and potentials do not indicate protection has been achieved, the Engineer will advise the Contractor how to proceed.

The test reports shall include the following items:

Drawings upon which the location of each test station, underground reference electrode, galvanic anode, and insulated fitting is indicated.
Drawings with sufficient information that each underground galvanic anode can be exactly excavated or replaced.

Drawings showing the location of each field test station complete with a description of pipe lead wire connections.

Records of all anode installation details.

Tabulated reports shall include the following:

Final anode current measurements of each test station connected galvanic anode.

Final insulated fitting test measurements, with the test method indicated.

Final pipe system potential measurements.

Underground reference electrode tests.

End of Section
PART 1 - GENERAL

1-1. SCOPE. This section covers the furnishing and installation of an instrumentation and control system designated as the Supervisory Control and Data Acquisition (SCADA) System.

The control system will consist of field instrumentation, communications devices, and the following major control panels:

- Interconnect Pump Station PLC (PLC-10).

The System Supplier shall also modify the Centennial WSD Well D-17 Control Panel as described herein. Programming of the Well D-17 RTU shall be by the Centennial WSD. The System Supplier shall coordinate testing of the Well D-17 RTU hardware and software modifications with CWSD staff.

The system shall be furnished as specified, complete with all software, operator interface terminal (OIT) hardware, input/output hardware, instrumentation, and all devices, accessories, appurtenances, testing, and training necessary for proper operation.

1-1.01. Associated Projects. Under the pipeline construction project, PLC-10 will be connected to four remote IO stations, a Dechlorination Facility, and to the existing SACDA system at Well A-7. Communications between remote sites will be over single mode fiber optic cable. The pipeline project System Supplier shall be responsible for reprogramming PLC-10, and for updating the existing Genesis HMI software at the Castle Pines North WTP to incorporate the new sites, including the Pump Station. The PLC at Well A-7 shall be modified to transfer data between the existing and new systems. If the pipeline project is constructed concurrently with this project, the System Supplier shall coordinate the programming of PLC-10 with the pipeline project System Supplier.

1-1.02. Associated Sections. This section also includes the equipment and services specified in the following sections:

Section 13530 PROGRAMMABLE LOGIC CONTROLLERS
Section 13561 PANEL MOUNTED INSTRUMENTS
1-2. **GENERAL.** Equipment furnished and installed under this section shall be fabricated, assembled, erected, and placed in proper operating condition in full conformity with the drawings, specifications, engineering data, instructions, and recommendations of the equipment manufacturer, unless exceptions are noted by Engineer.

1-2.01. **General Equipment Stipulations.** The General Equipment Stipulations shall apply to all equipment and materials furnished under this section. If requirements in this specification differ from those in the General Equipment Stipulations, the requirements specified herein shall take precedence.

1-2.02. **Drawings.** The drawings indicate locations and arrangements of equipment and may include installation details and block and one-line diagrams showing connections and interfaces with other equipment. The input/output (I/O) lists are attached as an appendix to the Programmable Logic Controllers section.

Principal components of the instrumentation systems shall be as indicated on the P&ID drawings and instrument device schedule, Appendix 1-13500, attached to this section.

1-2.03. **Codes, Permits and Agency Approvals.** All work performed and all materials used shall be in accordance with the National Electrical Code, and with applicable local regulations and ordinances. Where mandated by codes, panels, assemblies, materials, and equipment shall be listed by Underwriters' Laboratories. Contractor shall, as part of their work, arrange for and obtain all necessary permits, inspections, and approvals by the authorities having local jurisdiction of such work. This shall include any third-party inspections and testing of panels and equipment.

1-2.04. **Supplier's Qualifications.** Equipment and software furnished under this section and under other related sections listed in the Scope paragraph above shall be designed, coordinated, and supplied by a single manufacturer or supplier, hereinafter referred to as the System Supplier. The System Supplier shall be regularly engaged in the business of supplying computer-based
monitoring, control, and data acquisition systems. The Contractor shall utilize the services of the System Supplier to coordinate all control system related items, to check-out and calibrate instruments, and to perform all testing, training, and startup activities specified to be provided.

The System Supplier shall have the following minimum qualifications:

- The supplier shall maintain a design office staffed with qualified technical design personnel.
- The supplier shall maintain competent and experienced service personnel to service the hardware and software furnished for this project.
- The intended supplier shall furnish the information requested in the Instrumentation and Control System Supplier Questionnaire bound elsewhere in the Documents. References including contact names, telephone numbers, and general project description shall be included in the questionnaire. The users and project lists shall be for similar control equipment, software, and type of projects.

1-2.05. **Coordination.** Systems supplied under this section shall be designed and coordinated by System Supplier for proper operation with related equipment and materials furnished by other suppliers under other sections of these specifications, under other contracts, and, where applicable, with related existing equipment. All equipment shall be designed and installed in full conformity with the drawings, specifications, engineering data, instructions, and recommendations of the manufacturer, and the manufacturer of the related equipment.

1-2.06. **Related Equipment and Materials.** Related equipment and materials may include, but will not be limited to, instrumentation, motor controllers, valve actuators, chemical feeders, analytical measuring devices, conduit, cable, and piping as described in other sections or furnished under other contracts.

1-2.07. **Device Tag Numbering System.** All devices shall be provided with permanent identification tags. The tag numbers shall agree with System Supplier's equipment drawings and shall be as close as practical to the tag numbers used on the project drawings and device schedules. All field-mounted transmitters and devices shall have stamped stainless steel identification tags. Panel, subpanel, and rack-mounted devices shall have laminated phenolic identification tags securely fastened to the device. Hand-lettered or tape labels will not be acceptable.
1-3. GENERAL REQUIREMENTS. The drawings and specifications indicate the extent and general arrangement of the systems. If any departures from the drawings or specifications are deemed necessary by System Supplier, details of such departures and the reasons shall be submitted to Engineer for review with or before the first stage submittal. No departures shall be made without prior written acceptance.

The specifications describe the minimum requirements for hardware and software. Where System Supplier's standard configuration includes additional items of equipment or software features not specifically described herein, such equipment or features shall be furnished as a part of the system and shall be warranted as specified herein.

1-3.01. Governing Standards. Equipment furnished under this section shall be designed, constructed, and tested in accordance with IEEE 519, ANSI C37.90, FCC Part 15 - Class A, and NEMA ICS-1-109.60.

1-3.02. Dimensional Restrictions. Layout dimensions will vary between manufacturers and the layout area indicated on the drawings is based on typical values. The System Supplier shall review the contract drawings, the manufacturer's layout drawings and installation requirements, and make any modifications requisite for proper installation subject to acceptance by Engineer. At least three feet of clear access space shall be provided in front of all instrumentation and control system components.

1-3.03. Workmanship and Materials. System Supplier shall guarantee all equipment against faulty or inadequate design, improper assembly or erection, defective workmanship or materials, and leakage, breakage, or other failure. Materials shall be suitable for service conditions.

All equipment shall be designed, fabricated, and assembled in accordance with recognized and acceptable engineering and shop practice. Individual parts shall be manufactured to standard sizes and thicknesses so that repair parts, furnished at any time, can be installed in the field. Like parts of duplicate units shall be interchangeable. Equipment shall not have been in service at any time prior to delivery, except for testing.

1-3.04. Corrosive Fluids. All parts, which are exposed to corrosive conditions, shall be made from corrosion resistant materials. System Supplier shall submit certification that the instrument manufacturer approves the selection of materials of primary elements that are in contact with the specified process fluid to be inert to the effects of the process fluid.
1-3.05. **Appurtenances.** Signal converters, signal boosters, amplifiers, special power supplies, special cable, special grounding, and isolation devices shall be furnished as needed for proper performance of the equipment.

1-3.06. **Programming Devices.** A programming or system-configuring device shall be provided for systems that contain any equipment that requires such a device for routine calibration, maintenance, and troubleshooting. The programming device shall be complete, newly purchased for this project, and shall be in like-new condition when turned over to Owner at completion of startup.

1-4. **SUBMITTALS.** Complete dimensional, assembly, and installation drawings, wiring and schematic diagrams; and details, specifications, and data covering the materials used and the parts, devices and accessories forming a part of the system furnished, shall be submitted in accordance with the Submittals section. Submittal data shall be grouped and submitted in three separate stages. The submittal for each stage shall be substantially complete. Individual drawings and data sheets submitted at random intervals will not be accepted for review. Equipment tag numbers or identifications used on the drawings shall be referenced where applicable.

1-4.01. **First Stage Submittal.** The first stage submittal shall include the following items:

   a. A detailed list of any exceptions, functional differences, or discrepancies between the system proposed by System Supplier and this specification.

   b. Product catalog cut sheets on all hardware and software items, clearly marked to show the model number, optional features, and intended service of each device.

   c. A brief, concise description of the proposed system, including major hardware and software components and personnel training.

   d. Standard field termination drawings for all process input/output equipment, showing typical terminations for each type of point available in the system.

   e. Outline for training classes.

   f. Additional Requirements identified in other Division 13 sections.

1-4.02. **Second Stage Submittal.** Before any equipment is released for shipment to the site and before factory testing is scheduled, the following data shall be submitted.


cpnmdd
INTERCONNECT PUMP STATION
16758.0200
10/29/10
At System Supplier's option, the first and second stage submittals may be combined.

a. Detailed functional descriptions of all software modules specified and furnished as part of System Supplier's standard system. The descriptions shall be identified with the applicable specification paragraph.

b. Complete panel fabrication drawings and details of panel wiring, piping, and painting. Panel and subpanel drawings shall be to scale and shall include overall dimensions, metal thickness, door swing, mounting details, weight, and front of panel arrangement to show general appearance, with spacing and mounting height of instruments and control devices.

c. Wiring and installation drawings for all interconnecting wiring between components of the system and between related equipment and the equipment furnished under this section. Wiring diagrams shall show complete circuits and indicate all connections. If panel terminal designations, interdevice connections, device features and options, or other features are modified during the fabrication or factory testing, revised drawings shall be submitted before shipment of the equipment to the site.

d. Review of drawings submitted prior to the final determination of related equipment shall not relieve System Supplier from supplying systems in full compliance with the specific requirements of the related equipment.

e. Input/output listings showing point names, numbers, and addresses. Input/output identification numbers from the contract documents shall be cross-referenced in this submittal.

f. Proposed lesson plans or outlines for all training courses specified herein, including schedule, instructors' qualifications and experience, and recommended prerequisites.

g. Standard system engineering and user manuals describing the use of the system and application programming techniques for creating reports, graphics, database, historical records, and adding new process I/O nodes to the system.

h. Additional Requirements identified in other Division 13 sections.

1-4.03. Third Stage Submittal. Complete system documentation, in the form of Operation and Maintenance Manuals, shall be submitted before the commencement of field acceptance testing. Operation and Maintenance Manuals shall include complete instruction books for each item of equipment and software.
furnished. Where instruction booklets cover more than one specific model or range of device, product data sheets shall be included which indicate the device model number and other special features. A complete set of "as-built" wiring, fabrication, and interconnection drawings shall be included with the manuals. If field-wiring modifications are made after these drawings are submitted, the affected drawings shall be revised and resubmitted. Additional requirements are identified in other Division 13 specification sections.

1-5. PREPARATION FOR SHIPMENT. All electronic equipment and instruments shall be suitably packaged to facilitate handling and to protect against damage during transit and storage. All equipment shall be boxed, crated, or otherwise completely enclosed and protected during shipment, handling, and storage. All equipment shall be protected from exposure to the elements, shall be kept dry at all times, and shall not be exposed to adverse ambient conditions.

Painted surfaces shall be protected against impact, abrasion, discoloration, and other damage. Painted surfaces that are damaged prior to acceptance of equipment shall be repainted to the satisfaction of Engineer.

Each shipment shall include an appropriate shipping list that indicates the contents of the package, including the specific instrument tags. The shipping list shall be accessible without exposing the instruments to the atmosphere. The shipping list shall also contain any cautionary notes regarding storage of the instruments, including requirements to protect the instrument from static discharge, desensitizing chemicals (solvents, paints, etc.), or ambient atmospheric conditions.

Individual instruments shall be appropriately tagged or labeled to positively identify the device. All identification shall be visible without the need to unpack the instrument from its protective packaging.

Instrument shipment and storage requirements shall be coordinated with Engineer or Owner prior to shipment. System Supplier shall provide adequate storage and be ready to accept the shipment before shipping any equipment to the site. Additional shipping and storage requirements shall be as detailed in the individual instrument specifications.

Components which are shipped loose due to transportation limitations shall be assembled and disassembled by the manufacturer prior to shipment to assure that all components fit together and are adequately supported.
1-6. **DELIVERY, STORAGE, AND SHIPPING.** Shipping shall be in accordance with the Shipping section. Handling and storage shall be in accordance with the Handling and Storage section.

1-7. **SPARE PARTS.** Spare parts and consumable items are specified in other sections.

1-7.01. **Packaging.** All spare parts shall be delivered to Owner before final acceptance of the system. Packaging of spare parts shall provide protection against dust and moisture and shall be suitable for storage. Circuit boards and other electronic parts shall be enclosed in anti-static material. All packages shall be clearly marked with the manufacturer’s name, part number or other identification, date of manufacture, and approximate shelf life.

1-7.02. **Replacement.** System Supplier may utilize spare parts and supplies during system installation, de-bugging, startup, or training, but shall restore all such materials and supplies to the specified quantities before final acceptance of the systems.

**PART 2 - PRODUCTS**

2-1. **GENERAL REQUIREMENTS.** All equipment furnished under each section referenced in SCOPE is a part of this section and shall be selected by System Supplier for its superior quality and intended performance. Equipment and materials used shall be subject to review.

2-1.01. **Standard Products.** The systems furnished shall be standard products. Where two or more units of the same type of equipment are supplied, they shall be the products of the same manufacturer; however, all components of the systems furnished hereunder need not be the products of one manufacturer unless specified herein.

To the extent possible, instruments used for similar types of functions and services shall be of the same brand and model line. Similar components of different instruments shall be the products of the same manufacturer to facilitate maintenance and stocking of repair parts. Whenever possible, identical units shall be furnished.

2-2. **PERFORMANCE AND DESIGN REQUIREMENTS.** The design of the systems furnished hereunder shall utilize concepts, techniques and features that provide maximum reliability and ease of maintenance and repair. The systems
shall include board-level devices such as light emitting diodes or other indicators to facilitate quick diagnosis and repair. Diagnostic software shall be furnished to facilitate system-level troubleshooting.

Where redundant hardware is provided, the system shall be capable of performing all specified functions, without reconfiguring hardware or software, with only one device of each category in service.

2-2.01. Factory Assembly. Equipment shall be shipped completely factory assembled, except where its physical size, arrangement, configuration, or shipping and handling limitations make the shipment of completely assembled units impracticable.

2-2.02. Expandability. Not used.

2-3. POWER SUPPLY AND INSTRUMENT SIGNAL. Power supply to all control system equipment will be 120 volts, 60 Hz, single phase. System Supplier shall be responsible for distribution of power among enclosures, consoles, peripherals, and other components of the system from the power supply receptacles and junction boxes indicated on the drawings. Power distribution hardware shall include cables and branch circuit overcurrent protection installed in accordance with the Electrical section.

Unless otherwise indicated, power supply to the instrumentation will be unregulated 120 volts ac. Unless otherwise indicated, all transmitted electronic analog instrument signals shall be 4-20 mA dc and shall be linear with the measured variable.

2-3.01. Facility Distribution System. Equipment not indicated to be powered from an uninterruptible power source shall be suitable for being supplied from the facility distribution system and shall be capable of withstanding voltage variations of ±10 percent and harmonics up to the limits of IEEE 519 without affecting operation. System Supplier shall provide voltage conditioning or filtering equipment if necessary to meet the requirements specified.

2-3.02. Power Supplies. Power supplies for voltages other than those listed above shall be an integral part of the equipment furnished. Internal power supplies shall be regulated, current limiting, and self-protected.

2-3.03. Surge Withstand. All equipment shall meet all surge withstand capability tests as defined in ANSI C37.90 without damage to the equipment.
2-3.04.  **Uninterruptible Power Supply.** An uninterruptible power supply (UPS) shall be furnished hereunder to power the control and communications at the Interconnect Pump Station. Each UPS shall be sized to provide 90 minutes of backup power. System Supplier shall be responsible for coordinating the size of the UPS unit with the equipment furnished hereunder, and shall advise Engineer if a unit of higher capacity is necessary.

2-4.  **SERVICE CONDITIONS AND ENVIRONMENTAL REQUIREMENTS.** The equipment provided for the instrumentation and control system shall be suitable for the service conditions specified in the attached equipment sections.

All equipment shall be designed and selected to operate without degradation in performance throughout the environmental extremes specified. Equipment shall be designed to prevent the generation of electromagnetic and radio frequency interference and shall be in compliance with FCC Rules and Regulations, Part 15, for Class A computing devices.

2-4.01.  **Ambient Temperature and Elevation.** All system equipment located in air conditioned rooms shall be suitable for operation in ambient temperatures from 10°C to 35°C and a relative humidity of 10 to 80 percent, noncondensing. All equipment located in non air conditioned indoor areas shall be suitable for an ambient temperature range of 0°C to 50°C and a relative humidity of 10 to 95 percent, noncondensing. All equipment located outdoors shall be suitable for operation in an ambient temperature range 0°C to 60°C and a relative humidity of 5 to 100 percent. Heaters and air conditioning/cooling equipment shall be provided where essential to maintain equipment within its manufacturer-recommended operating ranges.

All equipment and instruments shall be designed to operate at the site elevation of 6500 ft.

2-4.02.  **Deleterious Effects.** All system equipment will be installed in areas without anti-static floor construction and without any provisions for control of particulates or corrosive gases other than ordinary office-type HVAC filtering. System Supplier shall furnish any additional air cleaning equipment, anti-static chair pads, or other protective measures necessary for proper operation of the system.

All input/output hardware shall meet or exceed, without false operation, all requirements of NEMA ICS-1-109.60, Electrical Noise Tests.
2-4.03. **Noise Level.** The equivalent "A" weighted sound level for any system equipment located in the control room, except printers, shall not exceed 35 dBA. The sound level for printers shall not exceed 65 dBA. Sound reduction enclosures shall be provided where necessary to comply with these limits.

2-4.04. **Lightning Protection.** In addition to other environmental protection specified herein, the entire system shall be provided with lightning protection. Lightning protection measures shall include the following.

2-4.04.01. **Grounding.** All major components of the system shall have a low resistance ground connection. Grounding system provisions indicated on the drawings shall be modified as recommended by System Supplier.

2-4.04.02. **Surge Suppressors.** Surge and lightning suppressors shall be non-faulting, non-interrupting, and shall protect against line-to-line and line-to-ground surges. Devices shall be solid-state metal oxide varistor (MOV) or silicon junction type, with a response time of less than 50 nanoseconds. Surge protective devices shall be applied for the following:

a. All 120 VAC power connections to RTUs, PLCs, DCUs, instruments and control room equipment. Surge arresters shall be Transtector "ACP-100-HW Series", Power Integrity Corporation "ZTA Series", Phoenix Contact "Mains PlugTrab", or MCG Surge Protection "400 Series".

b. All analog signal circuits where any part of the circuit is outside of the building envelope. Circuits shall be protected at both the transmitter and the control system end of the circuit. Surge protection devices shall not impede or interfere with the use of smart transmitter calibration/communication. Protection devices located near the transmitter shall be Telematic "TP48". Protection devices in control panels shall be Transtector "PDS Series or FSP Series", Telematic "SD Series", Phoenix Contact "PipeTrab Series", or Citel "BP1-24".

c. All metallic pair (twisted and untwisted) conductor local area network and data highway termination points, where any part of the data highway cable is routed outside of the building envelope. Single-port protective devices shall be Phoenix Contact "PlugTrab Series", Transtector "FSP Series", or Telematic "NP Series".

2-5. **SOFTWARE DOCUMENTATION.** System Supplier shall furnish complete documentation on all software supplied with the systems specified herein. Operating systems, compilers, assemblers, and utility and diagnostic programs
that are standard commercial products of third parties need not be included in the optical media backup. Software documentation shall consist of the following principal items:

a. One backup set of any integrated circuit or solid-state memory-based plug-in firmware used.

b. One complete back up copy of system and application software in executable format on optical media compatible with the system furnished.

c. One set of printed user reference manuals for all standard system and application software.

d. One set of user reference manuals for all operating system software.

e. Two sets of printed as-built reference documentation for any special software provided specifically for this contract.

f. For each licensed software product, all documentation provided by the product manufacturer shall be provided. This includes all reference manuals and any other documents that were provided by the manufacturer. One set of this documentation shall be supplied for each and every piece of equipment provided. Multiple pieces of similar equipment or software require multiple copies of this documentation.

2-6. SOFTWARE LICENSE. All software programs supplied as a standard part of System Supplier's products for this project shall be licensed to Owner for use on the system specified herein. Such license shall not restrict Owner from using the software on the system provided hereunder or its replacement. Owner shall have the right to make copies of the software for use on the system provided. Specific requirements of System Supplier's software license are subject to review and approval by Owner and Engineer.

2-7. INSTALLATION TEST EQUIPMENT. All necessary testing equipment for calibration and checking of system components shall be provided by System Supplier. System Supplier shall also furnish calibration and maintenance records for all testing and calibration equipment used on the site if requested by Engineer.
2-8. PROGRAMMING SOFTWARE. The following programming software shall be provided for the instruments specified in other sections:

<table>
<thead>
<tr>
<th>Instruments Requiring Programming Software</th>
<th>Number of Copies of Programming Software</th>
</tr>
</thead>
<tbody>
<tr>
<td>Panel mounted instruments</td>
<td>1</td>
</tr>
</tbody>
</table>

PART 3 - EXECUTION

3-1. INSTALLATION REQUIREMENTS. The installation of equipment furnished hereunder shall be by the Contractor or their assigned subcontractors.

3-1.01. Field Wiring. Field wiring materials and installation shall be in accordance with the Electrical section.

3-1.02. Instrument Installation. Instruments shall be mounted so that they can be easily read and serviced and so that all appurtenant devices can be easily operated. Installation details for some instruments are indicated on the drawings.

All outdoor instrumentation shall be protected from direct sun exposure. Instruments shall be placed in locations to limit south and west sun exposure. Sunshades shall be provided on instruments that are subject to the direct sun exposure. Sunshades shall be located so the opening faces north or east where possible.

3-1.03. Salvage of Existing Equipment. Existing equipment and materials removed or replaced under this contract shall be delivered to Owner at a location designated by Owner, or shall be properly disposed of at Owner’s discretion. Care shall be taken to avoid damage to equipment delivered to Owner.

Any mounting brackets, enclosures, stilling wells, piping, conduits, wiring, or openings that remain after removal of equipment and support hardware shall be removed or repaired in a manner acceptable to Owner and Engineer. Transmitters or switches containing mercury shall be removed and disposed of by personnel trained in the handling of hazardous materials and using approved procedures.

3-2. SYSTEM SOFTWARE CONFIGURATION. System software shall be configured by the System Supplier. Configuration services shall consist of the creation of the system database, report formats, operator interface graphic and tabular display screen formats, password and security implementation, and
programming of control units to provide a fully functioning system. The System Supplier shall fully configure the system using data provided herein or supplied by the Engineer and/or the Owner after award of the contract.

The system that is delivered to the field for installation, checkout, and startup shall have all files, or databases, that are configurable in size, sized in a manner in which there will be 50 percent space available for future work after the completion of this project. This sizing should include the addition of memory modules, disk drives, or any other device to ensure the 50 percent spare space availability.

3-2.01. Control System Database. The control system database shall be developed and configured by the System Supplier. The System Supplier shall enter information obtainable from the Contract Documents into the database prior to soliciting input from the Engineer and the Owner. The System Supplier shall determine the need for any "pseudo" database points and shall ascertain and enter all information needed to define these points. The System Supplier is responsible for entering all information associated with each point. This includes but is not limited to, descriptions, engineering units, associated displays, areas, security, etc. All fields associated with each database point must be completely filled out accurately.

3-2.02. Graphic Screen Displays. The System Supplier shall be responsible for developing and configuring the custom graphic displays for new processes and equipment. Each piece of major process equipment that is monitored by the control system shall be displayed on one or more graphic screen. Graphic screens shall be representations of the equipment and piping. The screens must accurately show all devices and equipment that is part of the control loops. Alarm and/or event displays shall also be provided and proven functional prior to acceptance of the system. The following screens shall be provided, as a minimum:

- Overview of Interconnect Pump Station
- Alarm Summary
- Event Summary

3-2.03. Report Formats. Not used.
3-2.04. Configuration Standards and Conventions. The System Supplier shall review the Owner's current SCADA system, and shall configure new logic and graphic displays to be seamless with the existing system.

3-2.05. Configuration Review Meetings. Proposed graphic screens and report formats shall be reviewed with the Owner and Engineer throughout the configuration process. The System Supplier's programming personnel shall attend the initial review meeting. A second review meeting shall be held at approximately 50 percent completion. Both meetings shall be held at the Owner's facilities.

3-2.06. Software Functional Requirements. General functional requirements for system configuration are indicated on the drawings and described in the specifications. The information presented herein and indicated on the drawings illustrates the general functional intent of the system, and may not be sufficient to fully configure the system. The System Supplier shall be responsible for determining what additional information may be required to complete the configuration tasks, and for obtaining this information from the Engineer or the Owner.

3-3. SYSTEMS CHECK. System Supplier shall provide the services of a trained and experienced field supervisor to assist the installation contractor during installation, and to calibrate, test, and advise others of the procedures for installation, adjustment, and operation.

3-3.01. Field Manager. System Supplier shall appoint a field services manager who shall be responsible for the coordination of all system check-out and startup activities, and who shall be immediately available to Engineer and Owner by phone or on site for the duration of this project.

3-3.02. Field Inspection at Delivery. The field supervisor shall inspect major equipment items within five working days of delivery, to assure that the equipment was not damaged during shipment and shall supervise or assist with unpacking, initial placement, and initial wiring of the system.

3-3.03. Field Calibration of Instruments. After each instrument has been installed, a technical representative of System Supplier shall calibrate each instrument and shall provide a written calibration report for each instrument, indicating the results and final settings. The adjustments of calibrated instruments shall be sealed or marked, insofar as possible, to discourage
tampering. Instrument calibration shall be done before checkout of the system operation. A typical instrument calibration report is attached to the end of this section.

3-3.04. **Training for Installation Personnel.** Not used.

3-3.05. **Field Inspection Prior to Startup.** After installation and wiring connections are complete, the field supervisor, with additional System Supplier's personnel shall verify that each external connection to the system is correctly wired and field process components and devices are functioning as intended. A minimum of one working days shall be included for this task, but System Supplier shall be responsible for completing the following scope of work.

3-3.05.01. **Analog Signals.** Analog input signals shall be simulated at the transmitting source, and verified to be received at the proper register address in the control system. Analog outputs shall be generated at the control system, and verified to be received with the correct polarity, at the respective receiving device.

3-3.05.02. **Discrete Signals.** Discrete input and output signals shall be simulated and verified that they are received at the respective receiving device, and at the proper voltage.

3-3.05.03. **Devices by Other Suppliers.** If interrelated devices furnished by other suppliers, under other contracts, or by Owner, such as valve actuators, motor controls, chemical feeders, and instruments, do not perform properly at the time of system checkout, the field supervisor shall use suitable test equipment to introduce simulated signals to and/or measure signals from these devices to locate the sources of trouble or malfunction.

3-3.05.04. **System Check Out Report.** The System Supplier shall submit a written report on the results of such tests to Engineer. Additional documentation shall be furnished as requested by Engineer to establish responsibility for corrective measures. System Supplier shall verify, in writing, to Engineer or Owner that System Supplier has successfully completed the external connection check before beginning system startup or field acceptance testing.

3-3.06. **Start Up Assistance.** Not used.

3-4. **TESTING.** The system shall be tested at the factory and acceptance tested on site.
System Supplier shall prepare a testing procedure to be approved by Owner and Engineer that shall demonstrate that the system conforms to the specifications. The testing procedure shall be submitted at least 14 days in advance of testing. The site acceptance testing shall be conducted by System Supplier and witnessed by Owner and/or Engineer.

System Supplier shall notify Engineer and Owner in writing at least 14 days before the proposed testing date.

3-4.01. **Factory Testing.** After system assembly and debugging at System Supplier’s facility, the system shall be tested before the system is shipped to the site.

3-4.02. **Site Acceptance Testing.** After installation and checkout by System Supplier's personnel, the system shall be subjected to an acceptance test.

Site acceptance testing shall be scheduled after receipt of the System Check Out Report and System Supplier shall verify that all field signal changes are reflected in the proper address locations in the system database.

The site acceptance testing shall demonstrate all functional and graphical requirements described herein. The system shall operate without loss of basic functions. The number of working days of continuous operation for the test shall be 7. The operational demonstration shall confirm that the status, alarm, and process variable signals are valid and are being updated appropriately, and that the discrete and analog output signals from the control system are being correctly transmitted and implemented. Any errors or abnormal occurrences shall be recorded by System Supplier's field representative. System Supplier's field representative need not be continuously present during the site acceptance testing, but shall be available to respond to the site within one hour of notification. The representative shall inspect the system for faults at least once every 24 hours and shall log or record any noted problems. The log shall include a description of the problem, its apparent cause, and any corrective action taken.

3-4.02.01. **Failure of Redundant Equipment.** Failure of redundant equipment shall not be considered downtime provided that automatic failover occurs as specified and, in the opinion of Engineer, the failure was not caused by deficiency in design or installation. In the event of repeated failure of any hardware component or software module, the acceptance test shall be terminated and restarted.
3-4.02.02. Completion of Test. Successful completion of the site acceptance test, including the operational demonstration, is prerequisite to Substantial Completion as specified in the Supplementary Conditions.

3-5. TRAINING. System Supplier shall conduct training courses for personnel selected by Owner. Five categories of training, instrument, control system maintenance, operator (post-installation), networking, and supplemental shall be provided. Training shall be conducted by experienced instructors who are familiar with the specific system supplied.

3-5.01. General Training Requirements. In general, System Supplier's standard training courses may be used to meet the training objectives specified. Where standard courses do not meet these objectives, additional coursework shall be developed. Clock hour requirements for each level of training shall be as listed. A "clock hour" is defined as one hour of instruction or supervised training exercise. Training hour requirements are the number of hours of training to be provided for each student. Additional training time shall be provided if considered necessary to meet the training objectives.

3-5.01.01. Training Costs. All costs associated with the training program; excluding travel, lodging, and per diem expenses for Owner's and Engineer's personnel to attend off-site training programs; shall be the responsibility of System Supplier and shall be included in the contract price.

3-5.01.02. Lessons. Training lesson plans and other information for the second stage submittal as defined herein shall be submitted at least 30 days prior to the start of training.

3-5.01.03. Video Recording. Not used.

3-5.02. Instrument Training. Training on the calibration, maintenance, troubleshooting, and repair for the instrument devices provided under this project shall be provided. Training shall also be provided for any hand-held or computer-based calibration devices and their associated software. Two hours of training for four students shall be provided at the System Supplier's facility.

3-5.03. Control System Maintenance Training. System maintenance training shall be provided to enable Owner's personnel to perform routine and preventive maintenance, troubleshoot, and repair all hardware furnished with the system, except equipment provided by the HMI computer manufacturer. Maintenance
and repair instruction shall assume that Owner’s personnel will repair equipment by replacing circuit boards and modules, and shall not include instruction on circuit board level repair.

3-5.03.01. **Classes.** All maintenance training shall be conducted at Owner’s facilities. Each session shall consist one hour of training for four of the Owner’s personnel.

3-5.03.02. **Content of Classes.** The training shall cover at least the following topics:

a. Preventive, scheduled maintenance for all equipment.
b. Function and normal operation of circuit boards and modules.
c. Diagnosis of hardware failures to the faulted board or module.
d. Removal and replacement of removable circuit boards and modules.
e. Emergency maintenance and restoration procedures.

The maintenance training program shall be developed for personnel who have experience in electronics maintenance and repair and a general knowledge of computer systems, but not necessarily any familiarity with the specific hardware furnished.

3-5.04. **Operator Training.** Owner’s personnel will utilize the system for day-to-day monitoring and/or control of the facilities. The training program shall provide operators with sufficient knowledge to move from screen to screen within the system, understand the contents of group and detailed point displays, react to and acknowledge alarms, adjust control set points and alarm limits, configure and print shift reports, print preconfigured reports on demand, control equipment connected to the system, and react to and resolve minor system errors.

3-5.04.01. **Classes.** Operator training shall include sessions as specified below.

3-5.04.01.01. **Pre-installation Session.** Not used.

3-5.04.01.02. **Post-installation Session.** The post-installation training shall include two separate, but identical, sessions for two shifts of personnel and shall be conducted at Owner’s facilities. Each class shall consist of four hours of instruction using the lesson plan submitted and approved for use. The training shall take place at the Interconnect Pump Station. The post-installation sessions
may have to be conducted outside normal working hours to accommodate the working schedule of Owner's personnel. The post-installation training sessions shall be conducted for four of the Owner’s operating personnel.

3-5.04.02. **Content of Classes.** Each session shall cover at least the following topics:

- a. Power-up, "bootstrapping", and shutdown of all hardware devices.
- b. Logging on and off the system and the use of passwords.
- c. Access and interpretation of standard displays and diagnostics.
- d. Moving from screen to screen within the graphic display environment.
- e. Interpretation of preconfigured group and detailed point or database displays.
- f. Response to and acknowledgment of alarms.
- g. Adjustment of control set points and alarm limits.
- h. Control of field equipment and devices connected to the system.
- i. Manual entries to database points.
- j. Generation of current (real-time) and historical custom and predefined reports and trend displays.
- k. Appropriate responses to software and hardware errors.
- l. Enabling and disabling individual inputs and outputs.

The operator-training program shall be developed for personnel with no prior experience with the hardware and software provided as part of the project.

3-5.05. **Programmer Training (HMI Software).** Not used.

3-5.06. **Programmer Training (PLC Software).** Not used.

3-5.07. **Network Training.** System Supplier shall provide training on network equipment provided. Network training shall be conducted in one session at Owner's facilities using the hardware and software installed for this project.

- a. Course shall provide an overall description of the network and how it operates.
- b. A course describing the flow of communications, and how to bypass failed/out-of-service components.
The training shall provide instruction for up to five Owner-selected students.

3-5.08. Supplemental Training. System Supplier shall provide additional training to Owner's personnel on topics of Owner's choosing. Supplemental training shall be conducted in one session at Owner's facilities using the hardware and software installed for this project. The training shall consist of two hours of instruction for four students.

End of Section
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<th>Actual Output</th>
<th>Desired Output</th>
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Proportional Band:

Reset:

Position of switches, jumpers, etc.

Comments:

Date of Calibration:

Calibrated By:

Black & Veatch  | Instrument Calibration Report  | Figure 1-13500
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<thead>
<tr>
<th>Tag</th>
<th>Loop</th>
<th>Service Description</th>
<th>Device Type</th>
<th>Spec</th>
<th>Size</th>
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<td>102</td>
<td>IPS wetwell influent flow</td>
<td>Digital indicator</td>
<td>13561</td>
<td></td>
<td>0-5 mgd</td>
<td>4-WIRE</td>
<td>PI-2</td>
<td>Mount on CWSD well panel</td>
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<tr>
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<td>Flow from CWSD tank to IPS wetwell</td>
<td>Magnetic flowmeter</td>
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<td>18&quot;</td>
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<td>PI-2</td>
<td>HART compatible</td>
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<tr>
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<td>102</td>
<td>IPS wetwell influent flow</td>
<td>HART-to-Modbus converter</td>
<td>13561</td>
<td></td>
<td>4-WIRE</td>
<td></td>
<td>PI-2</td>
<td>Mount in CWSD well panel</td>
</tr>
<tr>
<td>LT</td>
<td>105</td>
<td>IPS wetwell level</td>
<td>Submersible level transmitter</td>
<td>13563</td>
<td></td>
<td>0-40 ft</td>
<td></td>
<td>PI-2</td>
<td>0 = el 6020.0 ft</td>
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<tr>
<td>LSHH</td>
<td>106</td>
<td>Wetwell high level alarm</td>
<td>Fixed-mount Float Switch</td>
<td>13563</td>
<td></td>
<td></td>
<td></td>
<td>PI-2</td>
<td>EI 6057.0 rising</td>
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<tr>
<td>LSSL</td>
<td>106</td>
<td>Wetwell low level shutdown</td>
<td>Fixed-mount Float Switch</td>
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<td></td>
<td></td>
<td></td>
<td>PI-2</td>
<td>EI 6026.46 falling</td>
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<td>107</td>
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<td>2 position selector switch</td>
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<td></td>
<td>PI-2</td>
<td>ENABLE/DISABLE</td>
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<td>IPS Pump No. 1 discharge pressure</td>
<td>Pressure switch</td>
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<td></td>
<td>PI-2</td>
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<td>PSHH</td>
<td>112</td>
<td>IPS Pump No. 2 discharge pressure</td>
<td>Pressure switch</td>
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<td></td>
<td>PI-2</td>
<td>350 psig rising</td>
</tr>
<tr>
<td>PSHH</td>
<td>113</td>
<td>IPS Pump No. 3 discharge pressure</td>
<td>Pressure switch</td>
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<td></td>
<td></td>
<td>PI-2</td>
<td>350 psig rising</td>
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<tr>
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<td>Magnetic flowmeter</td>
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<td>4-WIRE</td>
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<tr>
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<td>Pressure transmitter</td>
<td>13563</td>
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<td>0-500 psig</td>
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<td>PI-2</td>
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<tr>
<td>PSHH</td>
<td>122</td>
<td>IPS discharge pressure shutdown</td>
<td>Pressure switch</td>
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<td></td>
<td></td>
<td>PI-2</td>
<td>400 psig rising</td>
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<tr>
<td>FY</td>
<td>122</td>
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<td>Time delay relay</td>
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<td>PI-2</td>
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<td>Float switch</td>
<td>11185</td>
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<td>PI-2</td>
<td>Furnished w/sump pumps</td>
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<td>140</td>
<td>Dry pit sump level</td>
<td>Float switch</td>
<td>11185</td>
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<td>PI-2</td>
<td>Furnished w/sump pumps</td>
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<tr>
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<td>140A</td>
<td>Dry pit sump level start lead pump</td>
<td>Float switch</td>
<td>11185</td>
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<td></td>
<td></td>
<td>PI-2</td>
<td>Furnished w/sump pumps</td>
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<tr>
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<td>140B</td>
<td>Dry pit sump level start lag pump</td>
<td>Float switch</td>
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<td>PI-2</td>
<td>Furnished w/sump pumps</td>
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<td>ZSO</td>
<td>147B</td>
<td>South entry door position</td>
<td>Door limit switch</td>
<td>13565</td>
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<tr>
<td>ZSO</td>
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<td>Flow switch</td>
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<td>Fire sprinkler system</td>
<td>Valve tamper switch</td>
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<tr>
<td>TS</td>
<td>151B</td>
<td>Fire sprinkler system</td>
<td>Valve tamper switch</td>
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<td>By others</td>
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<tr>
<td>TS</td>
<td>151C</td>
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<td>Valve tamper switch</td>
<td>13930</td>
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<td></td>
<td></td>
<td>PI-2</td>
<td>By others</td>
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PART 1 - GENERAL

1-1. SCOPE. This section covers programmable logic controllers (PLCs), including associated input/output hardware to control process equipment and serve as the interface to field devices.

1-1.01. Control System. The Instrumentation and Control System section shall apply to all equipment furnished under this section. Additional PLC software requirements are indicated in the Control Logic Descriptions, Appendix 2-13530 attached to this section.

1-2. GENERAL. Equipment furnished and installed under this section shall be fabricated, assembled, erected, and placed in proper operating condition in full conformity with the drawings, specifications, engineering data, instructions, and recommendations of the equipment manufacturer, unless exceptions are noted by Engineer.

1-2.01. General Equipment Stipulations. The General Equipment Stipulations shall apply to all equipment and materials furnished under this section. If requirements in this specification differ from those in the General Equipment Stipulations, the requirements specified herein shall take precedence.

1-2.02. Drawings. Supplementing this section, the drawings indicate the number and types of PLCs, locations of PLCs, and provide diagrams and schematics regarding connection and interaction with other equipment. All hardware, including power supplies, special cables, and other appurtenant equipment, shall be provided to meet the functional requirements described herein and indicated on the drawings.

1-2.03. I/O List. An input/output (I/O) field device signal listing is included as an appendix attached to this section.

1-3. SUBMITTALS. Submittals shall be as specified in the Instrumentation and Control System section.

1-4. DELIVERY, STORAGE, AND SHIPPING. Delivery, storage and shipping shall be as specified in the Instrumentation and Control System Section.
1-5. **SPARE PARTS.** Spare parts shall be furnished as follows:

<table>
<thead>
<tr>
<th>Spare Part</th>
<th>Quantity</th>
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<tr>
<td>Processor modules</td>
<td>1 of each type used</td>
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<tr>
<td>Power supply modules</td>
<td>1 of each type used</td>
</tr>
<tr>
<td>I/O modules</td>
<td>1 of each type used</td>
</tr>
<tr>
<td>Communications modules</td>
<td>1 of each type used</td>
</tr>
</tbody>
</table>

**PART 2 - PRODUCTS**

2-1. **GENERAL.** All equipment furnished under this section shall be expressly selected by System Supplier for its superior quality for the intended purpose and shall comply with the following requirements.

2-1.01. **Interchangeability.** All programmable logic controller systems shall be products of the same manufacturer and of the same series or product line. Processors, local and remote input/output hardware, communications modules, and specialty modules such as coprocessors and ASCII modules shall be interchangeable among all I/O panels and systems. PLC modules and hardware by other manufacturers will be acceptable only if the PLC manufacturer does not offer suitable modules and hardware for the same functions.

2-1.02. **Initial, Spare, and Future Memory (RAM).** System Supplier shall provide adequate memory for the amount of I/O, control algorithms, and communications in the initial system.

Each programmable logic controller shall include provisions for future expansion and shall have 100 percent spare memory capacity and 100 percent spare data capacity installed. The spare memory capacity shall be documented by submitting to Engineer, during factory testing, a statement indicating the amounts of memory of all types being utilized and the total amount available in each system. The statement shall include an estimate of the total program and data memory necessary, including spare memory, based on the I/O hardware for the system, and previous programming experience.

2-1.03. **Spare I/O.** Each PLC input/output enclosure shall be provided with at least 20 percent spare inputs and outputs of each type. Spare I/O shall be installed, wired, and interfaced properly to the terminal strip. The spare I/O shall be in addition to any I/O installed and reserved for future process signals as may be indicated on the I/O list. In addition, each PLC input/output enclosure shall be
capable of accommodating 20 percent of additional input/output capacity of each type as originally assembled, without the need for additional expansion racks, communication adapters, cables, or PLC power supplies.

2-1.04. **Expandability.** Each PLC processor and associated I/O shall have a future expandability of at least 50 percent of the provided system.

2-1.05. **Acceptable Manufacturers.** The PLCs shall be Bristol Babcock, without exception.

2-1.06. **Signal Power Supplies.** Regulated dc power supplies shall be provided in each PLC enclosure for analog inputs. Power supplies shall be suitable for an input voltage variation of ±10 percent, and the supply output shall be fused or protected against short-circuiting. Output voltage regulation shall be as required by the instrumentation equipment supplied under another section.

The loop power supply shall be separate from the power supply circuit for the processor and racks.

The power source for all digital inputs from field devices shall be separately fused for each digital input module. Unless otherwise noted, all field devices will be provided with dry contacts that close to provide an input to the PLC.

2-1.07. **Appurtenances.** The PLC processor and I/O hardware shall be provided as complete systems, as shown on the block diagram drawings. The PLCs shall include all necessary hardware and software for a complete working system. All special rack or panel mounted power supplies, special interconnecting and programming cables, special grounding hardware, or isolation devices shall be furnished for proper operation of the equipment. Signal converters, signal boosters, amplifiers, special power supplies, special cable, special grounding, intrinsically safe relays and current repeaters, surge suppression devices, and isolation devices shall be furnished and installed for proper operation of the equipment.

2-1.08. **PLC Arrangement.** The PLCs shall be distributed and arranged as indicated on the drawings.

2-1.09. **Service Conditions.** PLCs will be installed in non air conditioned rooms. PLCs shall be furnished with heated enclosures.

2-2. **LARGE PLC PROCESSOR.** Not used.
2-3. MINI PLC PROCESSOR. The programmable logic controller processor shall be an industrial type that utilizes battery-backed CMOS type or nonvolatile type memory. Battery-backed memory shall include integral batteries with sufficient capacity for at least 6 months’ memory retention without power to the processing unit. Standby and shelf life of the batteries shall be at least 5 years. PLCs shall be Bristol Babcock "ControlWave Micro", no exception.

2-3.01. Diagnostics. The processor shall utilize self-monitoring diagnostic techniques. Easily visible LEDs shall indicate "run" and "halt" status, as well as memory and input/output error conditions. Diagnostic codes shall also be available through the programming device to facilitate troubleshooting.

2-3.02. Programming Port. The processor shall include a programming port that is available for programming and monitoring on-line after the system is fully functional. Removal or disruption of network communications, remote I/O communications, or HMIs to permit programming and monitoring will not be acceptable.

2-3.03. Communications. The processor shall be programmed to operate autonomously, regardless of communications status with other units.

2-3.04. Environment. The processor shall be suitable for operation in the environments specified in another section. A key switch shall be provided on the processor to select the operating mode and as a security measure.

2-3.05. Programming. The processor shall be programmable using conventional relay ladder logic, or as required, and shall include the following functions and features.

- Contacts, coils, branching.
- Data comparisons.
- On-delay and off-delay timers.
- Counters with comparators.
- Floating Point Math and Logical instructions.
- Master control relay.
- Transitional or one-shot outputs.
- Standard and user-defined data tables for digital and analog value storage.
2-3.06. **Capabilities.** The processor shall include the following capabilities for programming, debug of programs, and troubleshooting.

- Off-line programming.
- On-line status of coils and registers.
- Input/output forcing.

2-3.07. **Configuration.** Processors shall be configured for standard rack mounting and shall be of plug-in printed circuit board construction. Each programmable logic controller shall include integral communications ports for the programming device, remote input/output, HMI device, or remote communications interfaces as required.

Programmable logic controller systems shall support the following types of input/output.

- 120 volt ac digital input and output.
- 24 volt dc digital input and output.
- 4-20 mA dc analog input and output.

2-3.08. **Input/Output Hardware.** Input/output hardware shall be supplied in standard modules of 4, 8, or 16 points each for assembly in local and remote input/output enclosures. Local I/O shall be base mounted in the rack with the processor.

Programmable logic controllers having fixed, non-removable input/output hardware are not acceptable.

All digital input/output hardware shall include isolation against surges of at least 1,500 volts. All output hardware connected to inductive loads shall be supplied with surge suppression devices as required and recommended by the PLC manufacturer to prevent damage to output hardware. Combination input/output modules will be acceptable if they meet all of the requirements in the following subparagraphs.

2-3.08.01. **Wiring Terminals.** All input/output modules shall utilize easily removable plug-in or hinged field wiring terminals to allow removal of modules without disconnecting individual wires. All IO points shall be wired to field termination terminals.
2-3.08.02. **I/O Circuit Power Supply.** Outputs for motor driven equipment will typically be powered from the driven equipment. Digital outputs for miscellaneous equipment shall be powered either from the controlled equipment or the PLC enclosure as indicated on the drawings or as coordinated with the controlled equipment supplier. Outputs that control process equipment specified under other sections or provided under other contracts shall be fully isolated or shall operate relay-type digital output modules or interposing relays in the PLC cabinet.

2-3.08.03. **Digital Input Modules.** Digital input modules shall sense voltages between 20 and 28 volts dc and shall have LED indicators for each point to display the status of the field contact. Each input module shall be suitable for being connected to a separate voltage source and return. Return voltage may be common to the entire input module.

2-3.08.04. **Digital Output Modules.** Digital output modules shall control voltages from 20 and 28 volts dc and shall be rated at least 1 ampere. Outputs shall be individually fused and shall have LED indicators to display output status. Each digital output connected to a device located outside of the PLC panel shall be provided with an interposing relay. Outputs shall withstand a surge of at least 80 amperes for one cycle and shall have an off-state leakage current not to exceed 2.0 mA.

2-3.08.05. **Relay Digital Output Modules.** Not used.

2-3.08.06. **Analog Input Modules.** Analog input modules shall accept linear 4-20 mA dc signals from field transmitters. Input circuitry shall be floating differential type designed to prevent loop grounding. Analog to digital conversion accuracy shall be at least 12 bit (0-4095 count) resolution. Where analog input signals are grounded outside of the PLC enclosure, isolation shall be provided for the associated analog input point either on the analog input module or through an I/I signal isolator provided in the PLC enclosure.

2-3.08.07. **Analog Output Modules.** Analog output modules shall transmit linear 4-20 mA dc signals to field devices. Loop power for all analog outputs shall be provided by regulated power supplies in each input/output enclosure and shall be capable of driving a 0 to 600 ohm load. Digital to analog conversion accuracy shall be at least 12 bit (0-4095 count) resolution.

2-3.08.08. **Panel Terminations.** All PLC input/output signals for field connections shall be terminated through panel enclosure terminal strips. Direct connection of field wiring to the I/O module terminals is not acceptable.
2-4. **COMMUNICATIONS.** Each programmable controller system shall be furnished complete with communication hardware modules for local input/output hardware, remote input/output hardware, and other programmable controllers.

Communication hardware shall be compatible with the cable, data highway, fiber optic, or radio communication media. Ethernet components and cable are specified in other specification sections.

2-4.01. **Addressability.** Each programmable logic controller shall be individually addressable so that only the selected controller responds when queried. IP addressing shall be used. Designation of a controller's network address may be either a software or hardware function.

2-4.02. **Communications Hardware.** System Supplier shall provide all necessary communications hardware. Hardware shall be included for, but not be limited to, remote I/O, data highway, host computer, fiber optics, Ethernet and radio.

2-4.02.01. **PLC to PLC Communications Hardware.** Each PLC shall communicate to other PLCs over an Ethernet data highway communications network. System Supplier shall include all rack mounted, enclosure mounted, or desktop mounted communications modules required for a complete working system.

2-4.02.02. **PLC to Remote Communications Hardware.** The master PLC shall communicate with the remote PLC rack over an Ethernet remote I/O communications network. System Supplier shall include all rack mounted, enclosure mounted, or desktop mounted communications modules required for a complete working system.

2-4.02.03. **PLC to Host Communications Hardware.** Not used.

2-4.03. **Communications Media.** System Supplier shall provide all necessary cabling for the PLC communications network and PLC remote I/O communications network. Communications cables shall meet the requirements of the manufacturers of the PLCs and communications modules. PLC communications media shall be as specified under the Network Systems section.

2-5. **MEDIA CONVERTERS.** Not used.

2-6. **TELEPHONE NETWORKS.** Not used.

2-7. **SERIAL NETWORKS.** Not used.
2-8. PROGRAMMING DEVICE HARDWARE. Not used.

2-9. PROGRAMMING SOFTWARE. System Supplier shall furnish one licensed copy of PLC programming software for the Owner. The software shall be suitable for running on a laptop computer running Windows XP operating system software. A full legal set of programming software documentation shall accompany each copy of the software. Each copy of the programming software shall include all necessary device drivers and add-on software packages.

2-9.01. Standard Product. The programming software shall be personal computer based and a standard product of the PLC manufacturer.

2-9.02. PLC Simulation. Not used.

2-9.03. Programming Software Features. The programming software shall allow off-line development of all PLC-related programming, including user annotation of the program, and creation and printing of application programs and I/O cross-reference lists. Special programming tasks originally provided by System Supplier shall also be included.

On-line features shall include IEC-1311 standards program modification, ladder-logic modification, program language modification, monitoring of real-time ladder-logic execution, monitoring of program execution, monitoring and manipulation of timer and counter preset and present values, monitoring and forcing of physical I/O, and monitoring and manipulation of analog (register) and bit (binary) data table values. PLC and I/O hardware diagnostic and status information shall be accessible using the software in on-line mode.

2-10. SYSTEM ENCLOSURES. Programmable logic controllers and input/output hardware shall be housed in shop-assembled panels as indicated on the drawings and as described in the Panels, Consoles, and Appurtenances section.

2-11. OPERATOR INTERFACE TERMINALS. Operator interface terminals (OIT) shall be microprocessor-based flat panel type. The unit shall have data entry capabilities and shall include a password security function. The unit shall be connected to the PLC and shall display status, alarm, and diagnostic information. The unit shall provide a minimum nominal diagonal display area dimension of 10 inches, with a minimum resolution of 800x600, 18 bit color, and a luminance of 300 cd/m². The OIT shall be furnished with a minimum of 8 MB of flash memory and 8 MB of system memory. The operator interface unit shall be
provided with an Ethernet port for communications, and one serial RS-232 or RS-485 port for programming. The OIT shall be rated NEMA 4X, suitable for panel face.

Terminals shall be powered from 120 V ac, 60 Hz, single phase, or 24 volts dc. Terminals shall be suitable for ambient temperatures of +32 to +130°F and a relative humidity of 5 to 95 percent.

One licensed copy of the OIT software used to create the screens shall be turned over to the Owner upon successful startup and commissioning of the system.

The operator interface unit shall be an Eaton" PanelMate Power Pro 3000", Allen-Bradley "PanelView Plus 1250", or equal.

OIT shall provide graphic screens that shall be used by the operators to access all functions and set points necessary for comprehensive control. The System Supplier shall be responsible for developing and configuring the custom graphic displays. Each piece of major process equipment that is monitored and controlled by the local PLC shall be displayed on the graphic screens. Graphic screens shall be representations of the equipment and piping. The screens must accurately show all devices and equipment that is part of the control loops. The System Supplier shall use the configuration standards and conventions to be established by direct coordination with the Owner that shall describe and define such items as proposed graphic display process line colors/representations; color standards for "on", "off", "opened", "closed", and "alarm" conditions; alarm handling conventions; how items will be selected for control; methods for navigation between displays; address usage/naming conventions; and security setup. Proposed displays shall be submitted to the Engineer and Owner for approval.

PART 3 - EXECUTION

3-1. INSTALLATION REQUIREMENTS. PLCs installation requirements are specified in Instrumentation and Control System section except as described herein.

Field check, testing, and training shall be as specified in the Instrumentation and Control System section.

3-2. CONFIGURATION.

3-2.01. PLC Programming and Configuration. Configuration services are specified in the Instrumentation and Control System section.
3-2.02. **Communications Configuration.** The communications shall be fully configured and installed by System Supplier. Communications shall be configured as shown on the drawings.

End of Section
## Appendix 1-13530

### Castle Pines North Metropolitan District

**CPNMD-CWSD Interconnect Pump Station**

### PLC IO List

<table>
<thead>
<tr>
<th>Tag</th>
<th>Loop</th>
<th>User Description</th>
<th>P&amp;ID</th>
<th>PLC</th>
<th>IO Type</th>
<th>Field Device</th>
<th>Analog Range</th>
<th>Analog Power</th>
<th>Digital Close State</th>
<th>Remarks</th>
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<td>TOBFV-4</td>
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<td>Valve fully closed</td>
<td>Future point</td>
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<tr>
<td>ZLO</td>
<td>114</td>
<td>IP-4 discharge valve position</td>
<td>PI-2</td>
<td>10</td>
<td>DI</td>
<td>TOBFV-4</td>
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<td></td>
<td>Valve fully open</td>
<td>Future point</td>
</tr>
<tr>
<td>QA</td>
<td>114</td>
<td>Air compressor running unloaded</td>
<td>PI-3</td>
<td>10</td>
<td>DI</td>
<td>CMP-101</td>
<td></td>
<td></td>
<td>Comp unloaded</td>
<td></td>
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<tr>
<td>QL</td>
<td>131</td>
<td>Air Comp No 1 run status</td>
<td>PI-3</td>
<td>10</td>
<td>DI</td>
<td>CMP-101</td>
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<td>Compressor running</td>
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<td>131</td>
<td>Air Comp No 1 alarm status</td>
<td>PI-3</td>
<td>10</td>
<td>DI</td>
<td>CMP-101</td>
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<td>Compressor alarm</td>
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<td>QA</td>
<td>132</td>
<td>Air compressor 2 running unloaded</td>
<td>PI-3</td>
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<td>QL</td>
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<td>Air Comp No 2 run status</td>
<td>PI-3</td>
<td>10</td>
<td>DI</td>
<td>CMP-102</td>
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<td>Compressor running</td>
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<td>132</td>
<td>Air Comp No 2 alarm status</td>
<td>PI-3</td>
<td>10</td>
<td>DI</td>
<td>CMP-102</td>
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<tr>
<td>PAL</td>
<td>134</td>
<td>Air receiver AR-101 pressure</td>
<td>PI-3</td>
<td>10</td>
<td>DI</td>
<td>AR-101</td>
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<td></td>
<td>Low pressure</td>
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<tr>
<td>PAL</td>
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<td>Air receiver AR-102 pressure</td>
<td>PI-3</td>
<td>10</td>
<td>DI</td>
<td>AR-102</td>
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<td>Low pressure</td>
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<td>LAH</td>
<td>137</td>
<td>Surge tank high water/low air volume</td>
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<td>DI</td>
<td>LSH-137</td>
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<td>High water level</td>
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<td>LAL</td>
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<td>Surge tank low water/high air volume</td>
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<td>Low water level</td>
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<td>Surge tank flush valve position</td>
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<td>DI</td>
<td>GV-2</td>
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<td>Valve fully open</td>
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<td>LAHH</td>
<td>140</td>
<td>Dry pit sump high level</td>
<td>PI-3</td>
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<td>LSHH-140</td>
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<td>Pump alarm</td>
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<td>QA</td>
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<td>Sump Pump No 2 alarm status</td>
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<td>PLC main power input status</td>
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<td>JA</td>
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<td>ZSO-147A</td>
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<td>South entry door position</td>
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<td>151</td>
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<td>PI-2</td>
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<td>FS-151</td>
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<td>Valve moved</td>
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<td>Analog Range</td>
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<td>Digital Close State</td>
<td>Remarks</td>
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<tr>
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<td>DI</td>
<td>PAC-101</td>
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<td>PAC alarm</td>
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<td>QL</td>
<td>152</td>
<td>PAC-101 run status</td>
<td>PI-2</td>
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<td>DI</td>
<td>PAC-101</td>
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<td>ZCC</td>
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<td>IPS inlet valve close command</td>
<td>PI-2</td>
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<td>DO</td>
<td>BFV-2</td>
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<td>Close valve</td>
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<tr>
<td>ZCO</td>
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<td>IPS inlet valve open command</td>
<td>PI-2</td>
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<td>DO</td>
<td>BFV-2</td>
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<td>Open valve</td>
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<tr>
<td>HS</td>
<td>111</td>
<td>Pump IP-1 run command</td>
<td>PI-2</td>
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<td>DO</td>
<td>IP-1</td>
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<td>Run pump</td>
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<tr>
<td>HS</td>
<td>112</td>
<td>Pump IP-2 run command</td>
<td>PI-2</td>
<td>10</td>
<td>DO</td>
<td>IP-2</td>
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<td></td>
<td>Run pump</td>
<td></td>
</tr>
<tr>
<td>HS</td>
<td>113</td>
<td>Pump IP-3 run command</td>
<td>PI-2</td>
<td>10</td>
<td>DO</td>
<td>IP-3</td>
<td></td>
<td></td>
<td>Run pump</td>
<td></td>
</tr>
<tr>
<td>HS</td>
<td>114</td>
<td>Pump IP-4 run command</td>
<td>PI-2</td>
<td>10</td>
<td>DO</td>
<td>IP-4</td>
<td></td>
<td></td>
<td>Run pump</td>
<td>Future point</td>
</tr>
</tbody>
</table>
### Control Logic and Display Requirements

<table>
<thead>
<tr>
<th>Loop Number</th>
<th>I/O Points</th>
<th>Control Logic</th>
<th>Operator Display Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Analog Signals</td>
<td>Analog process signals shall be trended. Flows shall be totalized on a daily and monthly basis. High and low alarm set points, with time delays, shall be provided where needed.</td>
<td>Display the following values: 1. CPN storage tank levels. 2. IPS discharge flow. Enter the following values from the display: 1. Flow set point. 2. Run order of pumps. 3. Enable pumps. 4. Tank shutdown and reset set points. 5. Time delay to start and stop pumps. 6. Shutdown reset push button. 7. Low flow shut down.</td>
<td></td>
</tr>
<tr>
<td>Discrete Values</td>
<td>Motor running signals shall be totalized. Process alarm signals shall have adjustable time delays to prevent nuisance alarms.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Interconnect Pump Station Pump Controller</td>
<td>The IPS will be controlled to furnish a constant flow to the interconnect pipeline. The operator enters the flow set point, the run order of the pumps, and enables the pumps. The lead pump starts and the speed is modulated to meet the flow set point. If the pump is at maximum speed for 5 minutes and the flow set point is not maintained, the next pump is started. Both pumps will run at the same speed. If two pumps are running at minimum speed but the flow exceeds the set point, the lag pump shall be stopped. If the lead pump fails, the lag pump shall be started. Due to the capacities of the pumps, the flow set point shall be limited to the range of 0.4-0.9 mgd if IP-1 is the lead, and 1.6-5.0 mgd if IP-2 or IP-3 is the lead. The levels for both CPN storage tanks shall be transferred to PLC-10 from the existing SCADA system. The higher level shall be used for control. The operator enters ‘high shutdown’ and ‘reset’ level set points. The tank level must be below the shutdown level for the pumps to start. Once running, the pumps will be stopped if the tank level exceeds the high shutdown level. The pumps will be re-enabled when the level falls below the ‘reset’ level. If the discharge flow, FI-120, falls below a set point, the pumps shall be disabled for a period of time, initially 15 minutes, and then restarted. High discharge pressure, low wetwell level, or a disable from Centennial WSD will shut down the pumps until they are reset at the pump station.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(CPNMD) (INTERCONNECT PUMP STATION) (167558.0200) (10/29/10) 2-13530 -1-
## Appendix 2-13530
### Castle Pines North Metropolitan District
**CPNMD-CWSD Interconnect Pump Station**
Control Logic and Display Requirements

<table>
<thead>
<tr>
<th>Loop Number</th>
<th>I/O Points</th>
<th>Control Logic</th>
<th>Operator Display Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>101</td>
<td>IPS Inlet Valve QA-101, ZCC-101, ZCO-101, ZLC-101, ZLO-101</td>
<td>The valve is manually opened and closed from the display.</td>
<td>Display the following values: 1. Valve position. 2. Valve alarms. Enter the following values from the display: 1. Valve open/close command.</td>
</tr>
<tr>
<td>102</td>
<td>IPS Inlet Flow FI-102</td>
<td>None. The HART/analog signal is sent to the CWSD Well D-17 panel where flow rate and total are read by the RTU through a HART/Modbus converter.</td>
<td>Display the following values: 1. Flow to IPS wetwell.</td>
</tr>
<tr>
<td>105</td>
<td>IPS Wetwell Level LI-105, LAHH-106, LALL-106</td>
<td>Low level in the wetwell, based on the level transmitter, will turn off the pumps until the level rises above the reset level. If the low level switch is tripped, the pumps are stopped, and cannot be started until manually reset by the operator.</td>
<td>Display the following values: 1. Wetwell level. 2. Wetwell high and low level alarms. Enter the following values from the display: 1. High and low alarm set points. 2. Low level shutdown reset.</td>
</tr>
<tr>
<td>107</td>
<td>CWSD Disable QA-107</td>
<td>This input from the CWSD Well D-17 panel will disable all of the pumps. The signal can be activated through the CWSD RTU, or from a switch on the control panel. The shutdown is hardwired to the pumps.</td>
<td>Display the following values: 1. CWSD pump disable signal status.</td>
</tr>
<tr>
<td>111</td>
<td>Interconnect Pump No. 1 SC-111, SI-111, QA-111, QL-111, YA-111, YL-111, ZLC-111, ZLO-111</td>
<td>If the drive is in the AUTO mode, the pump can be controlled manually or automatically. In the manual mode, the operator starts and stops the pump, and sets the speed. Wetwell level and discharge pressure shutdowns are active in the manual control mode. In the automatic mode, the pump is started and stopped, and its speed set by the IPS pump controller. The discharge valve control is hard wired through the drive.</td>
<td>Display the following values: 1. Drive AUTO status. 2. Pump run and alarm status. 3. Pump speed. 4. Discharge valve position. Enter the following values from the display: 1. Auto/manual control mode. 2. Pump start/stop command. 3. Pump speed command.</td>
</tr>
</tbody>
</table>
## Appendix 2-13530
### Castle Pines North Metropolitan District
#### CPNMD-CWSD Interconnect Pump Station
##### Control Logic and Display Requirements

<table>
<thead>
<tr>
<th>Loop Number</th>
<th>I/O Points</th>
<th>Control Logic</th>
<th>Operator Display Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>120</td>
<td>FI-120</td>
<td>The discharge is used by the IPS pump controller to modulate the speed of the pumps. If the flow exceeds a high flow set point, it is an indication of a possible line break, and an alarm is created. Low flow shuts off the pumps for a period of time.</td>
<td>Display the following values: 1. Pump station discharge flow. 2. High and low flow alarms. 3. Daily and monthly flow totals. Enter the following values from the display: 1. Flow alarm set points. 2. Time before restarting pumps on low flow shutdown.</td>
</tr>
<tr>
<td>121</td>
<td>PI-121</td>
<td>High discharge pressure as measured by the transmitter will shut down the pumps after a short delay.</td>
<td>Display the following values: 1. IPS discharge pressure. 2. High and low discharge pressure alarms. Enter the following values from the display: 1. High and low pressure alarm set points.</td>
</tr>
<tr>
<td>131</td>
<td>QA-131</td>
<td>None.</td>
<td>Display the following values: 1. CMP-101 run and alarm status. 2. CMP-101 running unloaded alarm.</td>
</tr>
<tr>
<td>134</td>
<td>PAL-134</td>
<td>None.</td>
<td>Display the following values: 1. AR-101 low pressure alarms.</td>
</tr>
<tr>
<td>137</td>
<td>LAH-137</td>
<td>If the flush valve is open for an extended period of time, initially 20 minutes, create an alarm.</td>
<td>Display the following values: 1. Surge tank high and low water level alarms. 2. Flush valve fail-to-close alarms. Enter the following values from the display: 1. Time delay for flush valve alarm.</td>
</tr>
<tr>
<td>140</td>
<td>LAHH-140</td>
<td>None.</td>
<td>Display the following values: 1. Sump high level alarms. 2. Sump pump alarms.</td>
</tr>
<tr>
<td>145</td>
<td>JA-145</td>
<td>None.</td>
<td>Display the following values: 1. PLC power alarms.</td>
</tr>
</tbody>
</table>

(CPNMD)  
(INTERCONNECT PUMP STATION)  
(167558.0200)  
(10/29/10)
<table>
<thead>
<tr>
<th>Loop Number</th>
<th>I/O Points</th>
<th>Control Logic</th>
<th>Operator Display Requirements</th>
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</thead>
<tbody>
<tr>
<td>147</td>
<td>Entry Door Alarms</td>
<td>ZLO-147A</td>
<td>None. Display the following values:</td>
</tr>
<tr>
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<td></td>
<td>ZLO-147B</td>
<td>1. IPS entry door open.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ZLO-147C</td>
<td></td>
</tr>
<tr>
<td>150</td>
<td>IPS Potable Water</td>
<td>FI-150</td>
<td>None. Display the following values:</td>
</tr>
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<td></td>
<td>FQ-150</td>
<td>1. Potable water flow rate.</td>
</tr>
<tr>
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<td></td>
<td></td>
<td>2. Daily and monthly potable water flow totals.</td>
</tr>
<tr>
<td>151</td>
<td>Fire Water System</td>
<td>FA-151</td>
<td>None. Display the following values:</td>
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<td>TA-151C</td>
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<td>152</td>
<td>Packaged Air</td>
<td>QA-152</td>
<td>Display the following values:</td>
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<td>Conditioner</td>
<td>QL-152</td>
<td>1. PAC-101 alarm and run status.</td>
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</tbody>
</table>
PART 1 - GENERAL.

1-1. SCOPE. This section covers the furnishing of all panel mounted instruments and accessories required for the Instrumentation and Control System as specified herein or as indicated on the Drawings.

Equipment and services provided under this section shall be subject to the Instrumentation and Control System section. This section shall be used and referenced only in conjunction with the Instrumentation and Control System section. Supplementing the Instrumentation and Control System section, instrument data, special requirements, and options are indicated on the Drawings or the Instrument Device Schedule.

When multiple instruments of a particular type are specified, and each requires different features, the required features are described on the drawings or the Instrument Device Schedule.

1-2. DESIGN CRITERIA. The instruments shall be installed to measure, monitor, or display the specified process at the ranges and service conditions indicated on the drawings or as indicated in the Instrument Device Schedule. The instruments shall be installed at the locations indicated on the drawings or the Instrument Device Schedule.

Where possible, each instrument shall be factory calibrated to the calibration ranges indicated on the drawings or in the Instrument Device Schedule. Transmitters or similar measurement instruments shall be calibrated using National Institute of Standards and Technology (NIST) approved bench calibration procedures, when such procedures exist for the instrument type. For "smart" devices, calibration data shall be stored digitally in each device, including the instrument tag designation indicated on the drawings and/or Instrument Device Schedule.

1-3. SUBMITTALS. Submittals shall be as specified in the Instrumentation and Control System section.
PART 2 - PRODUCTS

2-1. GENERAL. The following paragraphs describe minimum device stipulations. The drawings or Instrument Device Schedule shall be used to determine any additional instrument options, requirements, or service conditions.

2-1.01 Programming Device. For systems that require a dedicated programming device for calibration, maintenance, or troubleshooting, one such programming device shall be provided for each Owner facility (quantity required shall be as indicated in the Instrumentation and Control System section). The programming device shall include appropriate operation manuals and shall be included in the training stipulations. For systems that allow the programming device functions to be implemented in software, running on a laptop computer, the software shall be provided instead of the programming device.

2-1.02 Configuration Software/Serial Interface. Devices indicated as requiring a serial interface shall be provided with all accessories to properly communicate over the serial link. An appropriate cable shall be provided to allow the transmitter serial interface to be connected to a personal computer. One licensed copy of the diagnostic/interface software shall be provided for each Owner facility (quantity required shall be as indicated in the Instrumentation and Control System section). Software shall be capable of running under the Windows XP operating system. If the software furnished performs the same functions as the programming device, specified elsewhere, then the programming device shall not be furnished.

2-2. PANEL FRONT MOUNTED DEVICES.

2-2.01 Annunciators. Not used.

2-2.02 Totalizers. Not used.

2-2.03 Digital Panel Indicators. Digital indicators shall be designed for semi-flush mounting in a panel. The indicator shall be a 3-1/2 digit LED, LCD, or gas discharge type display, with digits at least 0.5 inch high. The indicator shall be easily read at a distance of 10 feet in varying control room lighting environments. Operating temperature range shall be 32°F to 140°F. Accuracy shall be ±0.1 percent. The indicator shall be scaled in engineering units, with the units engraved on the display face or on the associated nameplate. The indicator shall have a selectable decimal point and shall provide over-range indication. Digital indicators shall be manufactured by Eurotherm/Action Instruments, Newport Electronics, Precision Digital Corporation, or Red Lion Controls.
2-2.04. **Electronic Bar Graph Indicators**. Not used.

2-2.05. **Edgewise Panel Indicators**. Not used.

2-2.06. **Manual Loading Stations**. Not used.

2-2.07. **Ratio Stations**. Not used.

2-2.08. **1/4 DIN Single-Loop Control Stations**. Not used.

2-2.09. **1/4 DIN Manual/Auto Backup Stations**. Not used.

2-2.10. **Large Case Recorders**. Not used.

2-2.11. **Strip Chart Recorders**. Not used.


2-2.13. **Digital and Panel Clocks**. Not used.


2-2.14.01. **Selector Switches**. Selector switches shall be heavy-duty, oil-tight 30.5 mm type with gloved-hand or wing lever operators. Position legends shall be engraved on the switch faceplate. Switches for electric circuits shall have silver butting or sliding contacts, rated 10 amperes continuous at 120 V ac. Contact configuration shall be as indicated on the drawings or for the application. Switches used in electronic signal circuits shall have contacts suitable for that duty. Switches shall be Cutler-Hammer "Type T", General Electric "CR", Micro Switch "Type PT", or Allen-Bradley "800T".

2-2.14.02. **Indicating Lights**. Indicating lights shall be heavy-duty, oil-tight 30.5 mm type, with full voltage LED lamps. Legends shall be engraved on the lens or on a legend faceplate. Lights shall be push-to-test type. Indicating lights shall be Cutler Hammer "Type T", General Electric "CR", Micro Switch "Type PT", or Allen-Bradley "800T".

2-2.14.03. **Push Buttons**. Push buttons shall be heavy-duty, oil-tight 30.5 mm type. Legends shall be engraved on the push-button faceplate. Contacts shall be rated 10 amperes continuous at 120 V ac. Push buttons shall be Cutler-Hammer "Type T", General Electric "CR", Micro Switch "Type PT", or Allen-Bradley "800T".
2-2.15. **Alarm Horns.** Not used.

2-3. **PANEL INTERIOR MOUNTED DEVICES.**

2-3.01. **Integrators.** Not used.

2-3.02. **Power Supplies.** Regulated dc power supplies for instrument loops shall be designed and arranged so that loss of one supply does not affect more than one instrument loop or system. Power supplies shall be suitable for an input voltage variation of ±10 percent, and the supply output shall be fused or short-circuit protected. Output voltage regulation shall be by the instrumentation equipment supplied. Multiloop or multisystem power supplies will be acceptable if backup power supply units are provided which will automatically supply the load upon failure of the primary supply. The backup supply systems shall be designed so either the primary or the backup supply can be removed, repaired, and returned to service without disrupting the instrument system operation. Multiloop power supply connections shall be individually fused so a fault in one instrument loop will be isolated from the other loops being fed from the same supply. Fuses shall be clearly labeled and shall be located for easy access. Multiloop supply systems shall be oversized for an additional 10 percent future load. Failure of a multiloop supply shall be indicated on the respective instrument panel or enclosure.

Filter control systems may be designed so one power supply feeds all instrument loops common to one individual filter.

2-3.03. **Relays.** Relays indicated to be provided in panels, enclosures, or systems furnished under this section shall be of the plug-in socket base type with dustproof plastic enclosures unless noted otherwise. Relays shall be UL recognized and shall have not less than double-pole, double-throw contacts. Control circuit relays shall have silver cadmium oxide contacts rated 10 amperes at 120 V ac. Electronic switching-duty relays shall have gold-plated or gold alloy contacts suitable for use with low-level signals. Relays used for computer input, alarm input, or indicating light service shall have contacts rated at least 3 amperes. Time delay relays shall have dials or switch settings engraved in seconds and shall have timing repeatability of ±2 percent of setting. Latching and special purpose relays shall be for the specific application. Unless otherwise indicated, all relays shall have an integral pilot light that illuminates to indicate an energized condition. Relays shall be Eagle Signal "Series 22, 80"; IDEC "Series RR"; Potter & Brumfield "Series KRP, CB"; or Struthers-Dunn "Series A3, A4".

2-3.04. **Intrinsically Safe Relays.** Not used.
2-3.05. **Electronic Signal Booster/Isolators.** Electronic signal boosters and isolators shall have all solid-state circuitry and complete electrical isolation between the power supply and the input and output signals. Accuracy shall be ±0.15 percent of span. Isolators shall be manufactured by Acromag, Moore, Phoenix Contact, or R.I.S.

2-3.06. **Electronic Signal Selectors.** Not used.

2-3.07. **Electronic Signal Summers.** Not used.

2-3.08. **Fixed Deadband Signal Monitors.** Not used.

2-3.09. **Adjustable Deadband Signal Monitors.** Not used.

2-3.10. **Strip Heaters.** Electric strip heaters shall be provided as indicated on the drawings, as specified, and for the application. Strip heaters shall be sized to prevent condensation within the enclosure and to maintain the equipment above its minimum operating temperature. Strip heaters shall be located to avoid overheating electronic hardware or producing large temperature fluctuations. Strip heaters shall be controlled by adjustable thermostats with adjustment ranges of 30° to 90°F. A circuit disconnect switch shall be provided within the enclosure.

2-3.11. **Intrinsically Safe Barriers.** Not used.

2-3.12. **HART to Modbus Converters.** The converter shall connect to the current/HART output of a HART compatible transmitter and provide a Modbus output to a PLC communications channel. The converter shall not affect the 4-20 mA analog signal. The converter shall be DIN rail mounted, and require a 24 volt dc power source. The converter shall be Moore Industries "Model HCS" or equal.

**PART 3 - EXECUTION**

3-1 **FIELD SERVICES.** Manufacturer's field services shall be provided for installation, field calibration, startup, and training as specified in the Instrumentation and Control System section. Instruments shall not be shipped to the Work Site until two weeks prior to the scheduled installation. System Supplier shall be responsible for coordinating the installation schedule with the Installation
Contractor. Each shipment shall contain a listing of protective measures required to maintain sensor operation, including a listing of any common construction or cleaning chemicals that may affect instrument operation.

End of Section
PART 1 - GENERAL

1-1. SCOPE. This section covers the furnishing of flow instruments and accessories required for the Instrumentation and Control System as specified herein or as indicated on the drawings.

Equipment and services provided under this section shall be subject to the Instrumentation and Control System section. This section shall be used and referenced only in conjunction with the Instrumentation and Control System section. Supplementing the Instrumentation and Control System section, instrument data, special requirements, and options are indicated on the drawings or the Instrument Device Schedule.

When multiple instruments of a particular type are specified, and each requires different features, the required features are described on the drawings or the Instrument Device Schedule.

1-2. DESIGN CRITERIA. Each device shall be a pre-assembled, packaged unit. Upon delivery to the work site, each device or system shall be ready for installation with only minor piping and electrical connections required by Contractor.

Primary elements shall derive any required power from the transmitter, unless otherwise indicated.

The instruments shall be installed to measure, monitor, or display the specified process at the ranges and service conditions indicated on the drawings or as indicated in the Instrument Device Schedule. The instruments shall be installed at the locations indicated on the drawings or in the Instrument Device Schedule.

Where possible, each instrument shall be factory wet flow calibrated to the full scale flow range of the sensors or calibration ranges indicated on the drawings or in the Instrument Device Schedule. Transmitters or similar measurement instruments shall be calibrated using National Institute of Standards and Testing (NIST) approved bench calibration procedures, when such procedures exist for the instrument type. Calibration and configuration data shall be stored digitally in each device, including the instrument tag designation indicated on the drawings or Instrument Device Schedule.
1-3. **SUBMITTALS.** Submittals shall be made as specified in the Instrumentation and Control System section.

1-4. **SHIPMENT, PROTECTION, AND STORAGE.** Equipment provided under this section shall be shipped, protected, and stored as specified in the Instrumentation and Control System section. Identification of packaging shall be as specified in the Instrumentation and Control System section.

**PART 2 - PRODUCTS**

2-1. **GENERAL.** The following paragraphs provide minimum device requirements. The drawings or Instrument Device Schedule shall be used to determine any additional instrument options, requirements, or service conditions.

2-1.01. **Interconnecting Cable.** For instruments where the primary element and transmitter are physically separated, interconnecting cable from the element to the transmitter shall be provided. The cable shall be the type approved by the instrument manufacturer for the intended purpose of interfacing the element to the transmitter. Length of cable shall be a minimum of three meters or as indicated on the drawings or in the Instrument Device Schedule. The interconnecting cable shall be provided in the length necessary for installation. Splices shall not be allowed in the installed cable.

2-2. **FLOW INSTRUMENTATION.**

2-2.01. **Differential Pressure Flow Transmitters.** Not used.

2-2.02. **Magnetic Flowmeters, Signal Converters, and Accessories.**

2-2.02.01. **Magnetic Flowmeter.** The magnetic flowmeter shall be a completely obstructionless, in-line flowmeter with no constrictions in the flow of fluid through the meter. The meter shall consist of a metallic tube with flanged ends and with grounding rings or grounding electrodes as required by the application. Flange diameter and bolt drilling pattern shall comply with ANSI/ASME B16.5 for line sizes from one-half inch to 24 inches or AWWA C207 for line sizes larger than 24 inches. Flange class ratings and meter maximum pressure ratings shall be compatible with the adjoining piping. Flangeless wafer insert style meters may be used for pipe sizes up to 6 inches, where compatible with adjacent piping flanges. Self-cleaning electrodes shall be provided for all meters used for sludge metering. Electrode and liner materials shall be fully compatible with the process fluid as approved by the Engineer and shall comply with the requirements specified in the instrument device schedules. Each meter shall be factory wet flow
calibrated to the sensors full flow capacity, at a facility, which is traceable to NIST or other standard acceptable to Engineer, and a copy of the calibration, report shall be submitted as part of the operation and maintenance manual submittal.

The meter shall be capable of standing empty for extended periods of time without damage to any components.

The meter housing shall be of a splash-proof and drip-proof design, unless indicated on the drawings or in the Instrument Device Schedule to be submersible. Where required to be submersible, the meter housing shall withstand submersion in 30 feet of water for 48 hours without damage.

Meters shall be as manufactured by ABB, Endress + Hauser, Foxboro, Krohne, Rosemount, or Siemens.

2-2.02.02. Magnetic Flowmeter Signal Converters. Separately mounted, microprocessor-based signal converters shall be provided for the magnetic flowmeters. The signal converters shall include output damping, self-testing, built-in calibration capability, and an "empty pipe zero" contact input. The overall accuracy of the magnetic flowmeter transmitter and signal converter shall be ±0.5 percent of actual flow rate for full-scale settings of 3 to 30 fps. The meter manufacturer shall furnish the signal cable between the converter and the magnetic flowmeter. Signal cable shall be continuous and not spliced between the meter and the signal converter. The signal converter shall be housed in a corrosion-resistant, weatherproof NEMA Type 4X housing and shall be suitable for operation over an ambient temperature range of -30 to +140°F, and relative humidity of 10 to 100 percent. The converter shall have an analog output of 4-20 mA dc. Where indicated on the drawings or in the Instrument Device Schedule, the converter shall have a pulse output designed to operate a remote seven-digit totalizer and scaled so that the totalizer will operate for 60 days at 100 percent flow without repeating, and a HART digital output. Scaling factors shall be field adjustable and shall be selected to provide a totalizer multiplier of a power of 10. Transmitters shall contain a local indicator with a minimum four digit LCD type display, scaled to read in engineering units of flow.

Magnetic flowmeter systems shall provide zero flow stability by means of automatic zero adjustment of a DC excited metering circuit. Converters shall be capable of bi-directional flow measurement. Signal converters shall be of the same brand as the magnetic flowmeters.
Where indicate on the drawings or in the Instrument Device Schedule, the signal converter shall have a non-reset seven-digit totalizer on the face of the enclosure.

2-2.03. **Open Channel Ultrasonic Flowmeters.** Not used.

2-2.04. **Open Channel Admittance Probe Flowmeters.** Not used.

2-2.05. **Doppler Ultrasonic Flowmeters.** Not used.

2-2.06. **In-Line Type Ultrasonic Flowmeters (Single Path).** Not used.

2-2.07. **In-Line Type Ultrasonic Flowmeters (Multi-Path).** Not used.

2-2.08. **Averaging Pitot Type Flow Elements.** Not used.

2-2.09. **Thermal Dispersion Flowmeters.** Not used.

2-2.10. **Propeller Flowmeters.** Not used.

2-2.11. **Turbine Flowmeters.** Not used.

2-2.12. **Orifice Plates.** Not used.

2-2.13. **Differential Pressure Flow Indicators.** Not used.


2-2.15. **Liquid Service Rotameters.** Not used.

2-2.16. **Target-Type Flow Switches.** Not used.

2-2.17. **Coriolis Mass Flowmeters.** Not used.

**PART 3 - EXECUTION**

3-1. **FIELD SERVICES.** Manufacturer’s field services shall be provided for installation, field calibration, startup, and training as specified in the Instrumentation and Control System section.
Instruments shall not be shipped to the Work Site until two weeks prior to the scheduled installation. The System Supplier shall be responsible for coordinating the installation schedule with the Installation Contractor. Each shipment shall contain a listing of protective measures required to maintain sensor operation, including a listing of any common construction or cleaning chemicals that may affect instrument operation.

End of Section
PART 1 - GENERAL

1-1. **SCOPE.** This section covers the furnishing of pressure and level instruments and accessories required for the Instrumentation and Control System as specified herein or as indicated on the drawings.

Equipment and services provided under this section shall be subject to the Instrumentation and Control System section. This section shall be used and referenced only in conjunction with the Instrumentation and Control System section. Supplementing the Instrumentation and Control System section, instrument data, special requirements, and options are indicated on the drawings or the Instrument Device Schedule.

When multiple instruments of a particular type are specified, and each requires different features, the required features are described on the drawings or the Instrument Device Schedule.

1-2. **DESIGN CRITERIA.** Each device shall be a pre-assembled, packaged unit. Upon delivery to the work site, each device or system shall be ready for installation with only minor piping and electrical connections required by Contractor.

Primary elements shall derive any required power from the transmitter, unless otherwise indicated.

The instruments shall be installed to measure, monitor, or display the specified process at the ranges and service conditions indicated on the drawings or as indicated in the Instrument Device Schedule. The instruments shall be installed at the locations indicated on the drawings or in the Instrument Device Schedule.

Where possible, each instrument shall be factory calibrated to the calibration ranges indicated in the drawings or in the Instrument Device Schedule. Transmitters or similar measurement instruments shall be calibrated using National Institute of Standards and Technology (NIST) approved bench calibration procedures, when such procedures exist for the instrument type. Calibration data shall be stored digitally in each device, including the instrument tag designation indicated on the drawings and/or Instrument Device Schedule.
1-3. **SUBMITTALS.** Submittals shall be made as specified in the Instrumentation and Control System section.

1-4. **SHIPMENT, PROTECTION, AND STORAGE.** Equipment provided under this section shall be shipped, protected, and stored in accordance with the requirements of the Instrumentation and Control System section. Identification of packaging shall be as described in the Instrumentation and Control System section.

**PART 2 - PRODUCTS**

2-1. **GENERAL.** The following paragraphs provide minimum device stipulations. The drawings or Instrument Device Schedule shall be used to determine any additional instrument options, requirements, or service conditions.

2-1.01. **Interconnecting Cable.** For systems where the primary element and transmitter are physically separated, interconnecting cable from the element to the transmitter shall be provided. The cable shall be the type approved by the instrument manufacturer for the intended purpose of interfacing the element to the transmitter. Length of cable shall be a minimum of 3 meters or as indicated in the drawings or Instrument Device Schedule.

2-1.02. **Programming Device.** For systems that require a dedicated programming device for calibration, maintenance, or troubleshooting, one such programming device shall be provided for each Owner facility (quantity required shall be as indicated in the Instrumentation and Control System section.) The programming device shall include appropriate operation manuals and shall be included in the training requirements. For systems that allow the programming device functions to be implemented in software, running on a laptop computer, the software shall be provided instead of the programming device.

2-1.03. **Configuration Software/Serial Interface.** Devices indicated as requiring a serial interface shall be provided with all accessories required to properly communicate over the serial link. An appropriate cable shall be provided to allow the transmitter serial interface to be connected to a personal computer. One licensed copy of the diagnostic/Interface software shall be provided for each Owner facility (quantity required shall be as indicated in the Instrumentation and Control System section). Software shall be capable of running under Microsoft’s Windows XP operating system. If the software furnished performs the same functions as the programming device, specified elsewhere, then the programming device shall not be furnished.
2-2. PRESSURE AND LEVEL INSTRUMENTATION.

2-2.01. Pressure and Pressure Sensing Level Transmitters. Transmitters shall be an all solid state electronic two-wire device that does not require a direct power connection to the transmitter. Process fluid shall be isolated from the sensing elements by AISI Type 316 stainless steel, Hastelloy-C, ceramic, or cobalt-chromium-nickel alloy diaphragms, and the transducer may use a silicone oil fluid fill. Transmitters shall have self-diagnostics and electronically adjustable span, zero, and damping. Transmitters shall be enclosed in a NEMA Type 4X housing and shall be suitable for operation at temperatures from 0° to 180°F, and relative humidity of 5 to 100 percent. All parts shall be cadmium-plated carbon steel, stainless steel, or other corrosion-resistant materials. Transmitters shall have over-range protection to maximum line pressure. Accuracy of the transmitter shall be 0.075 percent of span, and transmitter output shall be 4-20 mA dc without the need for external load adjustment. Transmitters shall not be damaged by reverse polarity. Transmitters shall have an elevated or suppressed zero. For calibrated spans of less than 8 psig a differential pressure type transmitter with side vents shall be utilized. Transmitters shall be provided with brackets for wall and pipe-stand mounting.

Transmitters shall be factory calibrated to the required range and provided with the manufacturer's standard hand-held communications/calibration device. One device shall be furnished for all transmitters provided by a single manufacturer.

Transmitters shall be furnished with LCD type digital indicators.

Transmitters will have a turndown ratio of 30:1, or more.

Transmitters shall be ABB "Model 264GS", Endress & Hauser "Cerabar S", or "Deltabar S Series", Foxboro "Model IGP10-D", Rosemount "Model 1151", or Siemens "Sitrans P".

2-2.02. Premium Accuracy Pressure and Pressure Sensing Level Transmitters. Not used.

2-2.03. Differential Pressure Transmitters. Not used.


2-2.05. Flange-Mounted Pressure Sensing Level Transmitters. Not used.

2-2.06. Ultrasonic Level Transmitters. Not used.
2-2.07. **Admittance Probe Level Transmitters.** Not used.

2-2.08. **Submersible Pressure Sensing Level Transmitters.** The level transmitter system shall consist of a submersible pressure sensor/transmitter unit that is suitable for direct submersion into the liquid being measured. Sensor size shall not exceed 1-1/4 inch diameter by 9 inch length. The sensor shall be a solid-state variable capacitance or diffused silicon semiconductor type that shall provide an output signal directly proportional to the sensed pressure over a factory-calibrated range. The sensor assembly shall have a stainless steel or titanium housing and shall be supported by a polyethylene or urethane jacketed cable with a minimum 200 lb test strength. The sensor cable shall be of sufficient length so that no splice or connector is required in the wet or inaccessible area, and the vent tube termination point is located in an area protected from dirt and moisture.

The transmitter shall have a two-wire, Type 4-20 mA dc current output that is proportional to level. The output shall have surge protection, and shall not be damaged by reverse polarity. The transmitter shall be suitable for an operating temperature range of 0° to +50°C. Accuracy of the level transmitter shall be ±0.25 percent "best straight line", with an overall combined accuracy of ±1 percent over the entire operating temperature/pressure range.

Submersible pressure sensing level transmitters shall be Ametek Controls PMT Division "Model 575", Endress & Hauser "Waterpilot" or "Deltapilot" Series, Druck "Model PTX-1830", or Siemens "Sitrans P MPS".

2-2.09. **Bubbler System Components.** Not used.

2-2.10. **Fixed-Mount Float Type Level Switches.** Switches shall be of the floating ball type, with a nominal 5-1/2 inch diameter, coated stainless steel float ball that contains a sealed switch assembly. The float shall be supported with a flexible synthetic rubber hinge fastened to an adjustable mounting bracket. The hinge shall also act as a housing for the lead wires from the alarm switch. The lead wire shall be a waterproof cable of such length that no splice or junction box is required in the wet well. Stainless steel mounting accessories shall be furnished. The switch contacts shall be single-pole-double-throw rated 4 ampere at 250 V ac. Switches shall be Siemens/U.S. Filter Control Systems "9G-EF" or Contegra "FS90".

2-2.11. **Weighted Float Type Level Switches.** Not used.

2-2.12. **Adjustable Deadband Float Type Level Switches.** Not used.
2-2.13. **Electrode/Conductance Relay Level Switches.** Not used.

2-2.14. **Flange-Mounted Displacement Float Type Level Switches.** Not used.

2-2.15. **Pressure Switches.** Pressure switches shall be diaphragm actuated type switches. Switches shall be field adjustable type, with trip point repeatability better than 1 percent of actual pressure. Switches shall have over-range protection to maximum process line pressure. Switches mounted inside panels shall have NEMA Type1 housings. All other switches shall have weatherproof housings. Switches shall be differential type where indicated in the Instrument Device Schedule. Switch wetted parts shall be compatible with the process fluid. Where the process is not defined, all wetted parts shall be Teflon-coated or viton and the connection port shall be stainless steel.

Panel-mounted and surface-mounted switches shall be provided with 1/4 inch NPT connections. All stem-mounted switches shall be provided with 1/2 inch NPT connections.

All pressure switches shall be ranged in psi and all vacuum switches in inches of water. Unless otherwise indicated, switches shall have a fixed deadband and shall be auto-reset type. As a minimum, switches shall be SPDT, rated 10 ampere at 120 V ac.

Each switch shall be provided with a threaded end, ball-type shutoff valve. Shutoff valve materials shall be compatible with the process fluid. Where the process is not specified, valves shall have AISI Type 316 stainless steel wetted parts and Teflon seals. Multi-port valves shall have all unused ports plugged. Shutoff valve construction shall be as detailed in Section 13565.

Switches shall be installed at the locations indicated on the drawings, with installation conforming to the installation details. All switches, snubbers, and diaphragm seals shall be installed in the vertical, upright position. Thread sealer, suitable for use with the associated process, shall be used in the assembly of threaded connections. All connections shall be free from leaks. Lines shall be purged of trapped air at switch locations prior to installation of the switch or diaphragm seal.

Switches shall be manufactured by Ashcroft, Barksdale, NeoDyn, Mercoid Controls, or S.O.R.

2-2.16. **Flood Level Switches.** Not used.
2-2.17. **Ultrasonic Level Switches.** Not used.

2-2.18. **Field-Mount Pressure Gauges.** Pressure gauges shall be of the indicating dial type, with C-type phosphor bronze Bourdon tube; stainless steel rotary geared movement; phenolic or polypropylene open front turret case; adjustable pointer; stainless steel, phenolic, or polypropylene ring; and acrylic plastic or shatterproof glass window.

Gauge dial shall be 4-1/2 inch size, with white background and black markings. The units of measurement shall be indicated on the dial face. Subdivisions of the scale shall conform to the requirements of the governing standard. Pointer travel shall be not less than 200 degrees or more than 270 degrees of arc.

Surface-mounted gauges shall be provided with 1/4 inch NPT connections. All stem-mounted gauges shall be provided with 1/2 inch NPT connections. Where indicated in the drawings or on the Instrument Device Schedule, stem mounted gauges shall have an adjustable viewing angle to allow the gauge to be positioned for optimum viewing.

All pressure gauges shall measure in psi and all vacuum gauges in inches water. All gauges shall have a suitable range to give mid-scale readings under normal conditions. Gauge accuracy shall be 0.5 percent of scale range.

Each gauge shall be provided with a threaded end, ball-type gauge valve. Gauge valve materials shall be compatible with the measured process. Where the process is not defined, gauge valves shall have AISI Type 316 stainless steel wetted parts and Teflon seals. Multi-port gauge valves shall have all unused ports plugged. Gauge valve construction shall be as detailed in Section 13565.

Gauges shall be installed at the locations indicated on the drawings, with installation conforming to the installation details. All gauges, snubbers, and diaphragm seals shall be installed in the vertical, upright position. Thread sealer, suitable for use with the associated process, shall be used in the assembly of threaded connections. All connections shall be free from leaks. Lines shall be purged of trapped air at gauge locations prior to installation of the gauge or diaphragm seal.

Each gauge shall be provided with all required mounting hardware to securely mount the unit according to the mounting requirements indicated in the drawings or the Instrument Device Schedule.

(CPNMD)  
(INTERRUPT PUMP STATION)  
(167558.0200)  
(10/29/10)
Unless otherwise indicated, mounting and installation hardware shall be Type 316L stainless steel.

Pressure gauges shall be Ashcroft "1279 Duragauge", or equal.

2-2.19. **Annular Type Pressure Sensors.** Not used.

**PART 3 - EXECUTION**

3-1. **FIELD SERVICES.** Manufacturer's field services shall be provided for installation, field calibration, startup, and training as specified in the Instrumentation and Control System section.

Instruments shall not be shipped to the Work Site until two weeks prior to the scheduled installation. System Supplier shall be responsible for coordinating the installation schedule with the Installation Contractor. Each shipment shall contain a listing of protective measures required to maintain sensor operation, including a listing of any common construction or cleaning chemicals that may affect instrument operation.

End of Section
PART 1 - GENERAL

1-1. SCOPE. This section covers the furnishing of all miscellaneous instruments and accessories required for the Instrumentation and Control System as specified herein or as indicated on the drawings.

Equipment and services provided under this section shall be subject to the Instrumentation and Control System section. This section shall be used and referenced only in conjunction with the Instrumentation and Control System section. Supplementing the Instrumentation and Control System section, instrument data, special requirements, and options are indicated on the drawings or the Instrument Device Schedule.

When multiple miscellaneous instruments of a particular type are indicated, and each requires different selectable features, the required features are described on the drawings or in Instrument Device Schedule.

1-2. DESIGN CRITERIA. Each device shall be a pre-assembled, packaged unit. Upon delivery to the work site, each device or system shall be ready for installation with only minor piping and electrical connections required by System Supplier.

Primary elements shall derive any required power from the transmitter, unless otherwise indicated.

The instruments shall be installed to measure, monitor, or display the specified process at the ranges and service conditions indicated on the drawings or as indicated in the Instrument Device Schedule. The instruments shall be installed at the locations indicated on the drawings or the Instrument Device Schedule.

Where possible, each instrument shall be factory calibrated to the calibration ranges indicated in the Instrument Device Schedule. Transmitters or similar measurement instruments shall be calibrated using National Institute of Standards and Technology (NIST) approved bench calibration procedures, when such procedures exist for the instrument type. Calibration data shall be stored digitally in each device, including the instrument tag designation indicated on the Instrument Device Schedule.
1-3 **SUBMITTALS.** Submittals shall be made as specified in Instrumentation and Control System section.

1-4 **SHIPMENT, PROTECTION, AND STORAGE.** Equipment provided under this section shall be shipped, protected, and stored as specified in the Instrumentation and Control System section. Identification of packaging shall be as described in the Instrumentation and Control System section.

**PART 2 - PRODUCTS**

2-1. **GENERAL.** The following paragraphs provide minimum device stipulations. The Instrument Device Schedule shall be used to determine any additional instrument options, requirements, or service conditions.

2-1.01. **Interconnecting Cable.** For systems where the primary element and transmitter are physically separated, interconnecting cable from the element to the transmitter shall be provided. The cable shall be the type approved by the instrument manufacturer for the intended purpose of interfacing the element to the transmitter. Length of cable shall be a minimum of three meters or as indicated in the Instrument Device Schedule.

2-1.02. **Programming Device.** For instruments that require a dedicated programming device for calibration, maintenance, or troubleshooting, one such programming device shall be provided for each Owner facility (quantity required shall be as indicated in the Instrumentation and Control System section). The programming device shall include appropriate operation manuals and shall be included in the training requirements. For systems that allow the programming device functions to be implemented in software, running on a laptop computer, the software shall be provided instead of the programming device.

2-1.03. **Configuration Software/Serial Interface.** Devices indicated as requiring a serial interface shall be provided with all accessories required to properly communicate over the serial link. An appropriate cable shall be provided to allow the transmitter serial interface to be connected to a personal computer. One licensed copy of the diagnostic/interface software shall be provided for each Owner facility (quantity required shall be as indicated in the Instrumentation and Control System section). Software shall be capable of running under Microsoft's Windows XP operating system. If the software furnished performs the same functions as the programming device, specified elsewhere, then the programming device shall not be furnished.
2-2. **MISCELLANEOUS INSTRUMENTS.**

2-2.01. **Resistance Temperature Detectors.** Not used.

2-2.02. **Resistance Temperature Transmitters.** Not used.

2-2.03. **Temperature Switches.** Not used.

2-2.04. **Temperature Gauges.** Not used.

2-2.05. **Field-Mounted Process Indicators.** Not used.

2-2.06. **Milliamp Calibrator.** Not used.

2-2.07. **Pressure Calibrator.** Not used.

2-2.08. **Multi-function Instrument Calibrator.** Not used.

2-2.09. **Manometer.** Not used.

2-2.10. **Proximity (Door) Switches.** Proximity switches shall be magnetic proximity type, consisting of two sensors. One sensor shall be fixed to the door and the other to the door frame. The sensor mounted to the door shall have no electrical connections. Switches shall be provided with DPDT contacts rated 5 amperes at 120 V ac. All necessary mounting hardware shall be provided to allow both the sensors to be installed at the locations indicated on the drawings.

2-2.11. **Vibration Switches.** Not used.

2-2.12. **Instrument Shutoff Valves.** Instrument shutoff valves shall be provided for instruments as indicated on the drawings and as detailed in the specifications. The indicated shutoff valves shall be provided by System Supplier for all instruments furnished under the Panel Mounted Instruments section, Flow Instruments section, Pressure and Level Instruments section, Analytical Instruments section, and the Miscellaneous Instruments section. Shutoff valves shall be compatible with the measured process and shall be selected in accordance with the manufacturer's recommendations for the specified process. Unused ports of multi-port gauge valves shall be plugged. An instrument shutoff valve schedule shall be submitted indicating the quantity, material, size, and associated instrument. Permanent tagging of the instrument valves is not required. However, temporary hand-written tags or other means of identification shall be provided to ensure that the appropriate valve is installed for a given instrument.
Instrument shutoff valves shall be D/A Manufacturing, Anderson-Greenwood, or equal.

2-2.13. **Limit Switches.** Not used.

2-2.14. **Modulating Valve Positioners.** Not used.

2-2.15. **Current-to-Pressure Transducers.** Not used.

2-2.16. **Valve Position Transmitters.** Not used.

**PART 3 - EXECUTION**

3-1. **FIELD SERVICES.** Manufacturer's field services shall be provided for installation, field calibration, startup, and training as specified in the Instrumentation and Control System section.

Instruments shall not be shipped to the Work Site until two weeks prior to the scheduled installation. The System Supplier shall be responsible for coordinating the installation schedule with the Installation Contractor. Each shipment shall contain a listing of protective measures required to maintain sensor operation, including a listing of any common construction or cleaning chemicals that may affect instrument operation.

End of Section
PART 1 - GENERAL

1-1. SCOPE. This section covers the furnishing of panels, consoles, and appurtenances as indicated on the drawings.

1-1.01. Control System. The Instrumentation and Control System section shall apply to all equipment furnished under the Panels, Consoles and Appurtenances section.

1-2. GENERAL. Equipment furnished and installed under this section shall be fabricated and assembled in full conformity with the drawings, specifications, engineering data, instructions, and recommendations of the equipment manufacturer, unless exceptions are noted by Engineer.

1-2.01. General Equipment Stipulations. The General Equipment Stipulations shall apply to all equipment and materials provided under this section. If requirements in this specification differ from those in the General Equipment Stipulations, the requirements specified herein shall take precedence.

1-2.02. Drawings. General dimensions and arrangements are indicated on the drawings. System Supplier shall be responsible for coordinating the console and enclosure sizes and arrangements to accommodate the equipment provided.

1-3. SUBMITTALS. Submittals shall be made as specified in the Instrumentation and Control System section.

1-4. DELIVERY, STORAGE, AND SHIPPING. Delivery, storage and shipping shall be as per The Instrumentation and Control System section.

1-5. SPARE PARTS. Spare parts for each panel shall be provided as specified below.

<table>
<thead>
<tr>
<th>Spare Parts</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fuses</td>
<td>5 of each size used</td>
</tr>
<tr>
<td>1 m fiber optic patch cable</td>
<td>2</td>
</tr>
</tbody>
</table>
PART 2 - PRODUCTS

2-1. PANEL DESIGN AND FABRICATION FEATURES. All panels furnished shall conform to the stipulations of NEMA ICS-6-1993. Unless indicated otherwise on the drawings, the following paragraphs describe general fabrication specifications for the PLC cabinets, instrument panels, consoles, enclosures, and subpanels.

2-1.01. Piping. Not used.

2-1.02. Power Entrance. The power entrance to each panel shall be provided with a surge protection device. Refer to the Instrumentation and Controls section for surge suppression requirements.

2-1.03. Power Wiring. Power distribution wiring on the line side of panel fuses shall be minimum 12 AWG. Secondary power distribution wiring shall be minimum 14 AWG. Wiring for ac power distribution, dc power distribution, and control circuits shall have different colors and shall agree with the color-coding legend on System Supplier's panel wiring diagrams. With the exception of electronic circuits, all interconnecting wiring and wiring to terminals for external connection shall be stranded copper, insulated for not less than 300 volts, with a moisture resistant and flame retardant covering rated for not less than 90°C.

2-1.04. Instrument and Control Wiring. All internal panel wiring shall be type MTW stranded copper wiring rated not less than 300 volts. Electronic analog circuits shall be twisted and shielded pairs rated not less than 300 volts. Analog circuits shall be separated from ac power circuits. Wires within the panel shall conform to the minimum size as shown in the table below.

<table>
<thead>
<tr>
<th>Type</th>
<th>Minimum Wire Size</th>
<th>Color</th>
</tr>
</thead>
<tbody>
<tr>
<td>AC Control</td>
<td>16 AWG</td>
<td>Red</td>
</tr>
<tr>
<td>DC Control</td>
<td>16 AWG</td>
<td>Blue</td>
</tr>
<tr>
<td>Analog Circuits</td>
<td>18 AWG Twisted Pair</td>
<td></td>
</tr>
</tbody>
</table>

All wiring shall be grouped or cabled and firmly supported inside the panel. Each individual wire in power, control, and instrumentation circuits shall be provided with identification markers at each point of termination. The wire markers shall be positioned to be readily visible for inspection and the identification numbers shall match the identification on the supplier's panel wiring drawings. Wiring shall be bundled in groups and bound with nylon cable ties or routed in Panduit or similar nonmetallic slotted ducts. Ducts shall be readily accessible within the panel, with removable covers, and with space equal to at least 40 percent of the
Prefabricated wiring harnesses may be used to provide field terminals for PLC IO modules.

2-1.05. **Terminal Blocks.** Terminal blocks for external connections shall be suitable for 12 AWG wire and shall be rated 30 amperes at not less than 300 volts. Terminal blocks shall be fabricated complete with marking strip, covers, and pressure connectors. Terminals shall be labeled to agree with identification shown on the supplier's submittal drawings. A terminal shall be provided for each conductor of external circuits, plus one ground for each shielded cable. Not less than 8 inches of clearance shall be provided between the terminal strips and the base of vertical panels for conduit and wiring space. Not less than 25 percent spare terminals shall be provided. Each control loop or system shall be individually fused, and all fuses or circuit breakers shall be clearly labeled and located for easy maintenance.

2-1.06. **Device Tag Numbering System.** All devices shall be provided with permanent identification tags. The tag numbers shall agree with the Instrument Device Schedule and with the supplier's equipment drawings. All field-mounted transmitters and devices shall have stamped stainless steel identification tags. Panel, subpanel, and rack-mounted devices shall have laminated phenolic identification tags securely fastened to the device. Hand-lettered labels or tape labels will not be permitted.

2-1.07. **Nameplates.** Nameplates shall be provided on the face of the panel or on the individual device. Panel nameplates shall have approximate dimensions and legends, as indicated on the drawings, and shall be made of laminated phenolic material having engraved letters approximately 3/16 inch high extending through the black face into the white layer. Nameplates shall be secured firmly to the panel. Panel face nameplates do not replace the requirement for device identification tags as specified under the Device Tag Numbering System paragraph.

2-1.08. **Painting.** Interior and exterior surfaces of all panels shall be thoroughly cleaned and painted with rust inhibitive (universal) primer. The panel interior shall be painted white with the manufacturer's standard coating. All pits and blemishes in the exterior surface shall be filled. Exterior surfaces shall be painted with one or more finish coats of the manufacturer's standard coating.
Finish coats shall have a dry film thickness of at least 4 mils. Color samples shall be submitted to Engineer for color selection. One quart of paint shall be furnished with the panels for future touchup painting.

2-1.09. **Factory Test.** Panels shall be factory tested electrically and pneumatically by the panel fabricator before shipment.

2-2. **FREESTANDING VERTICAL PANELS.** The following paragraphs specify the freestanding vertical panels:

2-2.01. **Construction.** Panel construction shall be an indoor, dusttight, completely enclosed cubicle formed from steel structural members and steel plates. The base shall be formed of steel channels, with flanges extending upwards. The base shall be provided with 1/2 inch diameter holes at 12 inch centers so that the base can be bolted to the concrete equipment base. Welds, seams, and edges on all exposed surfaces shall be ground smooth. Suitable lifting facilities shall be provided for handling and shipment.

2-2.02. **Structure.** Panel structure shall be suitably braced and of sufficient strength to support all equipment mounted on or within, to withstand handling and shipment, to remain in proper alignment, and to be rigid and freestanding. Top, sides, and back shall be fabricated from USS 10 gage or heavier carbon steel sheets, with stationary back suitable for back to wall installation, or designed for rear access with hinged back doors. Doors shall not be greater than 24 inches wide or spaced not greater than 36 inches center to center. Rear access doors shall be fabricated from USS 14 gage or heavier carbon steel.

2-2.03. **Panel Front.** The front shall be a hinged door, or doors, with mounted instruments and control devices, fabricated from USS 10 gage carbon steel sheet and suitably braced and supported to maintain alignment. Panels with hinged fronts shall be of sufficient width to permit door opening without interference with rear projection of flush mounted instruments.

2-2.04. **Doors.** Doors shall be essentially full height, having turned back edges and additional bracing to ensure rigidity and prevent sagging. Doors shall be mounted with strong, continuous, piano type hinges. Positive lockable latches, acting from a common door handle, shall hold doors securely compressed at top, side, and bottom against rubber gaskets. All panels furnished as part of this project shall be keyed the same.

2-2.05. **Mounted Instruments.** Not used.
2-2.05.01. **Instrument Arrangement.** Panel instruments and control devices shall be arranged in a logical configuration for the plant operators. The center-line of recorders shall be within 3 feet and 5'-9" above the base of the panel for convenient reading and chart replacement. Control switches shall be within 6 feet and 2'-6" above the base of the panel. Indicators may be located within 2'-6" and 6'-6" above the base of the panels.

2-2.06. **Conduit Entrance.** The bottom shall be open, and components shall be arranged for external wiring conduit and piping to enter from below. The top shall be provided with nominal 1 inch and 2 inch capped conduit connectors at 6 inch intervals to accommodate external wiring to be installed from above.

2-2.07. **Size and Arrangement.** Not used.

2-2.08. **Interior Lighting.** Illumination of panel interiors shall be provided by ceiling mounted lamp fixtures spaced at approximately 2'-6" and near the door. Fixtures shall be fluorescent tube type, with a common "On-Off" switch that is activated when the door is opened. Duplex-grounded receptacles shall be provided for service and maintenance tools at spacing not greater than 5 feet throughout the length of a panel. The lighting and receptacle circuit shall be fused separately from the instrumentation systems.

2-2.09. **Interconnect Pump Station (IPS) PLC-10 Panel.** This panel shall be a NEMA 12 enclosure approximately 30" W x 72" H x 18" D. The cabinet shall house PLC-10, communications equipment, an uninterruptible power supply, and appurtenances required to control the Interconnect Pump Station, and to connect to the existing Castle Pines North SCADA system. An operator interface terminal (OIT) shall be mounted on the front of the panel to provide local control. All control and communication devices, including field instruments that require 120 V ac power, shall have backup power from the UPS.

2-2.09.01. **Pump Shutdown Circuit.** Each pump shall have a hard-wired shutdown contact in the control panel. The contact shall be a normally closed relay contact. The relay shall be energized on low wetwell level, high discharge pressure, or if activated by the Centennial WSD control system.

2-2.09.02. **Discharge Flow Signal.** The IPS inlet flowmeter, FIT-102, shall send a HART/4-20 mA flow signal to a HART/Modbus converter in the Centennial WSD Well D-17 Monitoring Panel. The analog signal shall continue to a new digital display in the panel and to PLC-10.

2-3. **FILTER CONSOLES.** Not used.
2-4. **WALL-MOUNTED CABINETS.** Not used.

2-5. **FIBER OPTIC TERMINATION CABINETS (FOTC).** Fiber optic termination cabinets (also commonly referred to as patch panels) shall be furnished to terminate fibers at the Fiber Optic Modules, and any other data highway attached equipment. The cabinets shall meet the following requirements:

a. The termination cabinet shall be the wall rack mounted type, having provisions for terminating all of the strands of all of the fiber optic cables that enter the cabinet. Splice trays, strain relief cable attachment points, fiber organizers and bend radius hardware shall be furnished with each termination cabinet.

b. Panel size shall be suited to the number of fibers to be terminated within the cabinet. Bayonet/flanged couplings shall be furnished and mounted for each fiber to be terminated.

c. Fiber terminations shall be spliced to pigtai cables (specified below) having SC connectors. The pigtails shall be terminated in an orderly method.

Fiber Optic Termination Cabinets shall be OFS Technologies "Fiber Interconnect Unit", Corning Cable Systems "WCH Series", or equal.

2-6. **FREE STANDING EIA 19-INCH RACK ENCLOSURES.** Not used.

2-7. **DATA SERVER ENCLOSURES.** Not used.

2-8. **WALL MOUNTED INSTRUMENT SUBPANELS.** Not used.

2-9. **CONTROL SYSTEM CONSOLES AND ENCLOSURES.** Not used.

2-10. **CONTROL SYSTEM FURNITURE.** Not used.

2-11. **MODIFICATION OF EXISTING PANELS.** The Centennial WSD Well D-17 Monitoring Panel will be modified as described below.

2-11.01. **Well D-17 Monitoring Panel Modifications.** This panel provide the connection point between the Centennial WSD SCADA system and the Castle Pines North SCADA system. This panel will receive an analog/HART signal from the IPS discharge flow transmitter, and send a dry contact "enable" signal to allow operation of the pumps.
A HART/Modbus converter shall be mounted in the panel and wired to a spare communications port on the CPU module. The analog signal will be wired to a new digital indicator mounted on the front of the panel as shown on the drawings. A new two-position "ENABLE-DISABLE" selector switch will also be mounted on the front of the panel and wired in parallel with a spare output in the RTU. If the selector switch is in the "DISABLE" position, or if the RTU output is activated, a closed contact signal will be sent to PLC-10 to disable the IPS pumps. Programming of the RTU will be by Centennial WSD staff and invoiced to CPNMD. The System Supplier shall coordinate with CWSD staff to assure proper transfer of signals.

PART 3 - EXECUTION

3-1. GENERAL INSTALLATION REQUIREMENTS. Installation requirements are specified in the Instrumentation and Control System section. In addition, equipment furnished under this section shall conform to the following manufacturing stipulations.

3-1.01. Piping. All tubing shall be run in horizontal and vertical planes and shall be rigidly supported to withstand handling and shipment. Flexible polyethylene tubing shall be used to connect devices mounted on hinged doors.

3-1.02. Wiring. All wiring shall be grouped or cabled and firmly supported inside the panel. Wiring shall be bundled in groups and routed in Panduit or similar nonmetallic slotted ducts. Ducts shall be readily accessible within the panel with removable covers and shall have a space of at least 40 percent of the depth of the duct available for future use after installation is complete and all field wiring installed. Sufficient space shall be provided between cable groups or ducts and terminal blocks for easy installation or removal of cables.

3-1.03. More than One Panel. Where signal or loop wiring must be routed to more than one panel or device, the required circuit routing shall be as indicated on the one-line diagrams. The panel fabricator shall provide such additional circuits as may be indicated on the electrical schematic drawings.

End of Section
1-1. **SCOPE.** This section covers the furnishing of all hardware and software for network systems for the Instrumentation and Control System. Principal components of the network systems shall be as indicated on the block diagram drawings and as described below.

System Supplier shall furnish all necessary equipment, interconnecting cables, accessories, and appurtenances for proper network operation and to meet the functional requirements indicated on the drawings and specified herein. Configuration of all hardware shall be provided by the System Supplier.

Equipment and services provided under the Networks section shall be subject to the general requirements specified in the Instrumentation and Control System section. Supplementing this section, network data, special requirements, and options may be indicated on the drawings.

1-1.01. **Control System.** The Instrumentation and Control System section shall apply to all systems described herein. All applicable requirements specified in the Instrumentation and Control System section shall apply to equipment and services provided herein.

1-1.02. **Network Functional Description.** The network system shall provide communications between the PLCs and the remote IO units.

1-2. **GENERAL.** System Supplier shall select the equipment for its superior quality and the intended performance. The System Supplier shall install all equipment in accordance with the manufacturer's instructions. Equipment and materials used shall be subject to review and shall comply with the following requirements.

1-2.01. **General Equipment Stipulations.** The General Equipment Stipulations shall apply to all equipment and materials provided under this section. If requirements in this specification differ from those in the General Equipment Stipulations, the requirements specified herein shall take precedence.
1-2.02. **Drawings.** Supplementing this section, the drawings indicate locations and arrangement of hardware and enclosures, provide mounting details, and may show other information regarding the connection and interaction with other equipment.

1-2.03. **Governing Standards.** Governing Standards for network systems shall be as specified in the Instrumentation and Control System section.

1-2.04. **Power and Instrument Signals.** Unless otherwise specified, electric power supply to the network equipment will be unregulated 24 volts dc or 120 volts ac.

1-2.05. **Appurtenances.** Special power supplies, special cable, special grounding, and isolation devices shall be furnished for proper performance of the equipment.

1-2.06. **Interchangeability and Appearance.** To the extent possible, components used for similar types of functions and services shall be the same brand and model line. Similar components of different network hardware shall be the products of the same manufacturer to facilitate maintenance and stocking of repair parts. Whenever possible, identical units shall be furnished.

1-2.07. **Programming Devices.** A programming or system-configuring device, or software required for programming, shall be provided for systems that contain any equipment that requires such a device or software for routine maintenance and troubleshooting. The programming device shall be complete, newly purchased for this project, and shall be in like-new condition when turned over to Owner at completion of startup. Programming software shall be licensed to the Owner.

1-3. **SUBMITTALS.** Submittals shall be made in accordance with the requirements of the Instrumentation and Control System section and as listed below.

The submittals shall include the following items for the Network Design submittal (to be provided with the First Stage Submittals):

a. A complete network topology diagram, detailing all hardware, cabling and the interconnections between all connected equipment. Interconnections to existing installed equipment and Owner-furnished equipment shall be included in the diagram.

b. A complete listing of IP addresses to be assigned to all equipment furnished under this contract shall be provided. The assignment of IP addresses shall be coordinated with the Owner.
All above documentation shall also be provided in the O&M manuals.

1-4. DELIVERY, SHIPMENT, PROTECTION, AND STORAGE. Equipment provided under this section shall be shipped, protected, and stored as specified in the Instrumentation and Control System section. Identification of packaging shall be as described in the Instrumentation and Control System section.

1-5. CONNECTION TO OWNER NETWORKS. Network hardware and software provided shall be compatible with the Owner's existing network systems wherever a system interconnection is provided. System Supplier shall verify existing systems to ensure compatibility.

All connections to the Owner's existing network shall be fully coordinated between the Owner and the System Supplier. Prior to connecting to the existing network, the System Supplier shall provide a written request to the Owner for an Owner's representative to be available when existing systems are disconnected and at the time of any new connections.

1-6. COORDINATION WITH OWNER. The System Supplier shall coordinate all demolitions, installations and rework on the existing networks with the Owner and the Engineer. No work shall be performed without the written consent of the Owner. The System Supplier shall submit a written request to perform work on the existing network, including date, time, scope of work, length of time, and any Owner's support that may be required.

PART 2 - PRODUCTS

2-1. GENERAL. The following paragraphs provide minimum Ethernet network device stipulations.

2-2. NETWORK CABLING SPECIFICATIONS. Individual network equipment and related devices shall be coordinated with items provided in the following sections:

    13591 Network Cable

2-3. ETHERNET NETWORK HARDWARE. Ethernet network hardware shall be provided as specified and/or as shown on the drawings. All specified functionality of provided Ethernet network equipment shall adhere to the
IEEE 802 standards. Ethernet Hubs will not be accepted for network systems. Ethernet switches shall be provided to connect multiple network segments together, selectively forwarding traffic between the segments.

2-3.01. **Ethernet Switches.** Not used.

2-3.02. **Industrial (Panel-Mounted) Ethernet Switches.** Each switch mounted in process areas shall include the following functionality:

a. Ports: Switch shall support the quantity of 10/100BaseTX ports and 100BaseFX fiber ports to meet the functionality indicated on the drawings, with a minimum of 20 percent spare auto-negotiating 10/100Base-T, RJ-45 ports, and two single mode fiber uplink ports. A minimum of four UTP ports and four single mode fiber ports shall be provided.

b. Each switch connection shall automatically sense the network speed of the devices to which it is connected.

c. Capable of ring-based media redundancy with 30 ms recovery time.


e. Prioritization: IEEE 802.1p QoS Support.

f. Network Segregation: Port VLAN.

g. Management: SNMPv3 and Browser-based management shall be supported.

h. IGMP snooping supported.

i. LED indication of the link activity for each port.

j. Environmental: Suitable for installation in industrial environments. Operating Temperature Range: 0 to 60°C. Optional -40 to 60°C rating availability.

k. Mounting: DIN-rail mounted suitable for panel installation.

I. All necessary memory upgrades, software feature sets, and cables needed for proper operation of these switches shall be furnished with each switch.

Switches shall be Phoenix Contact "SFN Series", Hirschmann "RS-20 series", Moxa "508A series", N-Tron "708FX series", or equal.

2-3.03. **Network Routers.** Not used.
2-3.04. **Network Firewall.** Not used.

2-3.05. **Ethernet Connectors.** Ethernet wiring connectors shall be RJ-45 male modular plug connectors.

2-3.05.01. **Standard RJ45 Connectors.** Standard connectors shall be polycarbonate, clear connectors. Connectors shall conform to RJ-45 and ISO 8877 standards. Contacts shall be gold plated with a 0.5A current rating and a -25° to 60°C temperature rating. Connectors shall accept unshielded Cat-5e or Cat-6, AWG 24, solid conductor cable.

2-3.05.02. **Industrial RJ45 Connectors.** Not used.

2-3.06. **Media Converters.** Not used.

2-3.07. **Frame Relay Routers.** Not used.

2-4. **ETHERNET NETWORKS SOFTWARE.** Not used.

2-5. **SPARE PARTS.** Spare parts shall be provided as specified below.

<table>
<thead>
<tr>
<th>Spare Parts</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Switches</td>
<td>1 of each type</td>
</tr>
<tr>
<td>Converters</td>
<td>1 of each type</td>
</tr>
</tbody>
</table>

**PART 3 - EXECUTION**

3-1. **NETWORK INSTALLATION REQUIREMENTS.** Additional network installation requirements are specified in the Instrumentation and Control System section. Networks shall be installed and tested in accordance with the following requirements.

3-2. **NETWORK CONFIGURATION.** The System Supplier shall fully configure all network devices. All device selections shall be fully coordinated with the Owner to ensure compatibility with existing systems and standards.

3-2.01. **Ethernet Switches.** Not used.

3-2.02. **Routers.** Not used.
3-2.03. **Firewalls.** Not used.

3-2.04. **Network Configuration Report.** The System Supplier shall provide a configuration report to the Owner detailing all connections, addresses, and port assignments.

3-2.05. **Management Software.** Not used.

3-3. **NETWORK TESTING.** After each network has been installed, a technical representative of System Supplier shall test the network and shall provide a written report for each test.

3-3.01. **Field Testing.** After each network has been installed, a technical representative of System Supplier shall test the network and shall provide a written report for each test. Specific testing requirements are described in the individual network specification sections.

3-3.02. **Systems Check.** A technical representative of System Supplier shall participate in the checkout of network systems. Systems check requirements shall be as specified in the Instrumentation and Control System section.

3-3.01. **Test Equipment.** Unless specified otherwise, all test equipment for the calibration and checking of system components shall be provided by System Supplier for the duration of the testing work and this test equipment will remain the property of System Supplier.

3-3.02.02. **Ethernet Network Minimum Test Requirements.** The following minimum tests are to be performed by the System Supplier:

   a. Verify Link Integrity Status LED is lit on both sides of each link.
   b. Verify proper operation and failover of each redundant component and redundant link.
   c. Verify alarming of each link failure.
   d. Verify bandwidth usage.

3-3.02.03. **Ethernet Network Test Reports.** Upon completion and testing of the installed Ethernet network, the System Supplier shall submit test reports to the Engineer in printed form. Test reports are to show all test results performed by the System Supplier for each port and piece of equipment. Date of calibration of the test equipment is also to be provided.
3-4. **NETWORK TROUBLESHOOTING.** It is the System Supplier's responsibility to provide trouble-free and reliable networks. The System Supplier shall employ any means necessary to ensure operational networks. The System Supplier shall obtain any needed test equipment, including but not limited to time-domain reflectometers, protocol analyzers and network sniffers, to troubleshoot any problems. The System Supplier shall utilize the services of a trained and certified Network Engineer that is regularly involved in troubleshooting network problems, in the event that operational or reliability problems exist. Acceptable certifications include Cisco CCNP, Cisco CCIE, or Network Professional Association Certified Network Professional (CNP).

3-5. **CUSTOMER TRAINING.** Training for networks is covered under Network Training in the Instrumentation and Control System section.

End of Section
PART 1 - GENERAL

1-1. SCOPE. This section covers the furnishing and installation of cable systems to provide communications for the Computer Control System as indicated on the drawings.

Accessories and appurtenances shall be provided as specified herein to provide a complete and properly operating system.

Equipment and services provided under this section shall be subject to the General Computer Control System Requirements specified in the Instrumentation and Control System Section and the Ethernet Networks section. Supplementing the Network Cable section, network data, special requirements, and options are indicated on the drawings.

1-2. SUBMITTALS. Submittals shall be made as specified in the Instrumentation and Control System section.

1-2.01. Qualifications. Not used.

1-2.02. Drawings and Data. All material and equipment documentation shall be submitted for review in accordance with the Submittals section. Each sheet of descriptive literature submitted shall be clearly marked to identify the material or equipment.

Product data shall include the following in the Submittals section:

a. Cut sheets and catalog literature for proposed fiber optic cable, and fiber optic cable accessories (pigtails, connectors, etc.)

b. Manufacturer specifications and data that clearly shows that the fiber optic cable meets all requirements specified herein.

c. Sample of the proposed cable.

d. Physical dimension drawings of all fiber optic accessories.

e. Proposed fiber identification sequence and labeling.
f. Provide off-line maintenance aids and on-line diagnostics to check the performance of the communication links and interfaces of devices on the data highway.

g. Provide a Recommended Spare Parts List (RSPL).

h. Provide a list of recommended special tools for fiber installation testing or maintenance.

1-2.03. **Operations and Maintenance Manuals.** Operation and Maintenance Manuals shall have the following items included in addition to those items specified in other sections:

   a. Description of all components.

   b. Methods of connection.

   c. Connection diagram.

   d. OTDR trace plots for all fibers.

1-3. **SHIPMENT, PROTECTION, AND STORAGE.** Equipment provided under this section shall be shipped, protected, and stored in accordance with the requirements of the Instrumentation and Control System section.

1-4. **QUALIFICATIONS.** Due to the specialized nature of installing, splicing, terminating, and testing optical fiber cable, the Contractor shall utilize personnel who are experienced in such practices. The installing Contractor or Sub-contractor shall have performed similar installation and testing work on at least three projects of similar size and complexity. The personnel assigned to the installation and testing shall also have experience on at least three projects of similar size and complexity.

PART 2 - PRODUCTS

2-1. **GENERAL.** All fiber optic cable, fiber optic hardware and accessories shall be designed, assembled and connected in accordance with the requirements of these specifications and the drawings.

2-2. **ETHERNET UNE-SHIELDED TWISTED PAIR (UTP) CABLE.** Ethernet cables and connectors shall be provided for a complete and working system, and/or as shown on the drawings. Cable for Ethernet wiring shall be UTP Cat-6 cable. Cable shall be Cat-6. Jacket color coding for cables shall be as follows:
2-2.01. **Category 5e UTP Cable.** Not used.

2-2.02. **Category 6 UTP Cable.** Cat-6 cable shall meet the following requirements:

- a. 24 AWG
- b. 4 pair solid strand FEP Teflon insulation
- c. 100 Ohm impedance
- d. 1-250 MHz frequency range
- e. Min attenuation 19.9 Db
- f. 100 Ohm impedance
- g. Min NEXT 44.3dB/100MHz
- h. Min PS-NEXT 42.3dB/100MHz
- i. Min ELFEXT 27.8dB/100MHz
- j. Min PS-ELFEXT 24.8dB/100MHz
- k. Min return loss 20.1 dB/100 MHz
- l. Max delay skew 45 ns
- m. Max propagation delay 540 ns

Plenum rated cable shall have FEP insulation jacketing and FEP insulation for conductors. Non-plenum rated cable shall have PVC insulation jacketing and polyethylene insulation for conductors. Cat-6 cable shall be Belden "1872" or equal.

2-2.03. **Ethernet Patch Cables.** Pre-wired and terminated patch cables with RJ-45 connectors and lever protecting boot shall be furnished for all connections to computers, network equipment, and controller equipment except where physical conditions (i.e., length over 12 feet or conduit size) require unterminated wire to be installed. Patch cables shall be Cat-6 and shall meet the requirements of Cat-6 cable specified in this section. Straight through cables shall be wired
using the T568-B standard for both connectors as shown in Section 3-1.01. Crossover cables shall be wired using the T568-A standard for one connector and the T568-B standard for the opposite end.

2-3. **FIBER OPTIC CABLE.** The fiber optic cable must meet all of the requirements of the following paragraphs:

a. The fiber optic cable must meet the following requirements of the National Electrical Code (NEC) Section 770.

b. Riser Applications – Applicable Flame Test UL 1666.

c. Finished cables shall conform to the applicable performance requirements of Table 8-6 and 8-7 in the Insulated Cable Engineers Association, Inc. (ICEA) Standard for Fiber Optic Premises Distribution Cable (ICEA S-83-596).

d. Every fiber in the cable must be usable and meet required specifications.

e. All optical fibers shall be sufficiently free of surface imperfections and inclusions to meet the optical, mechanical, and environmental requirements of this specification.

f. Each optical fiber shall consist of a doped silica core surrounded by a concentric glass cladding. The fiber shall be a matched clad design.

g. All optical fibers shall be proof tested by the fiber manufacturer at a minimum load of 100 kpsi.

h. All optical fibers shall be 100 percent attenuation tested. The attenuation shall be measured at 850 nm, and 1,300 nm for multimode fibers. The attenuation shall be measured at 1,310 nm and 1,550 nm for single-mode fibers. The manufacturer shall store these values for a minimum of 5 years. These values shall be available upon request.

i. The storage temperature range for the cable on the original shipping reel shall be -40°C to +70°C. The operating temperature range shall be -40°C to +70°C. Testing shall be in accordance with FOTP-3.

j. The attenuation specification shall be a maximum attenuation for each fiber at 23 ±5°C.

k. The attenuation of the cabled fiber shall be uniformly distributed throughout its length such that there are no discontinuities greater than 0.2 dB at 850 nm/1,300 nm (multimode) in any one kilometer length of fiber.
l. Required Fiber Grade: Maximum Fiber Attenuation at 850 nm shall be 3.5 dB/km.

m. Optical fibers shall be placed inside a loose buffer tube. The nominal outer diameter of the buffer tube shall be 3.0 mm.

n. The cable shall contain 24 fibers. Each buffer tube shall contain up to 12 fibers.

o. The fibers shall not adhere to the inside of the buffer tube.

p. Each fiber shall be distinguishable from others by means of color coding in accordance with TIA/EIA-598-A, "Optical Fiber Cable Color Coding".

q. The fibers shall be colored with ultraviolet (UV) curable inks.

r. Buffer tubes containing fibers shall also be color coded with distinct and recognizable colors in accordance with TIA/EIA-598-A, "Optical Fiber Cable Color Coding".

s. In buffer tubes containing multiple fibers, the colors shall be stable during temperature cycling and not subject to fading or smearing onto each other. Colors shall not cause fibers to stick together.

t. The buffer tubes shall be resistant to kinking.

u. The cable jacket color shall be black.

v. Fibers may be included in the cable core to lend symmetry to the cable cross-section where needed. Fibers shall be placed so that they do not interrupt the consecutive positions of the buffer tubes. In dual layer cables, any fillers shall be placed in the inner layer. Fillers shall be nominally 3.0 nm in outer diameter.

w. The jacket shall be continuous, free from pinholes, splits, blisters, or other imperfections. The jacket shall have a consistent, uniform thickness; jackets extruded under high pressure are not acceptable. The jacket shall be smooth, as consistent with the best commercial practice. The jacket shall provide the cable with a tough, flexible, protective coating, able to withstand the stresses expected in normal installation and service.

x. The outer cable jacket shall be marked with the manufacturer's name or UL file number, date of manufacture, fiber type, flame rating, UL symbol, and sequential length markings every 2 feet (e.g., "62.5/125 MICRON – TYPE OFNR – (UL) 00001 Feet"). The print color shall be white.

y. The cable shall be all-dielectric.
z. The cable shall be gel-free.

aa. The outside diameter of the cable shall not exceed 7 mm.

ab. Flammability: All cables shall comply with the requirements of the 1996 NEC Article 770. All cables shall pass UL 1666.

Fiber optic cable shall be as manufactured by Corning Cable Systems, Belden, BICCGeneral, AMP, or equal.

2-3.01. **Multimode Fiber.** Not used.

2-3.02. **Singlemode Fiber.** Single mode fiber optic cable shall meet the following requirements:

a. The dispersion unshifted single-mode fiber utilized in the cable specified herein shall conform to the specifications herein.

b. Cladding Diameter: 125.0 ± 1.0 μm.

c. Core-to-Cladding Offset: < 0.8 μm.

d. Cladding Non-Circuladty: < 1.0%.

e. Coating Diameter: 245 ± 10 μm.

f. Colored Fiber Diameter: Nominal 900 μm.

g. Attenuation Uniformity: No point discontinuity greater than 0.10 dB at either 1,310 nm or 1,550 nm.

h. Attenuation at the Water Peak: The attenuation at 1383 ± 3 nm shall not exceed 2.1 dB/km.

i. Cutoff Wavelength: The cabled fiber cutoff wavelength(λ_{ccf}) shall be < 1,260 nm.

j. Mode-Field Diameter: 9.30 ± 0.50 μm at 1,310 nm 10.50 ± 1.00 micrometers at 1,550 nm.

k. Zero Dispersion Wavelength (λ_o): 1,301.5 nm < λ_o < 1,321.5 nm.

l. Zero Dispersion Slope (So): < 0.092 ps/(nm^2 *km).

m. Fiber Polarization Mode Dispersion (PMD): < 0.5 ps/(sq. km).

2-3.03. **Fiber Optic Cable Connectors.** All optical fibers shall be terminated with connectors that are Type ST for multi-mode cable and Type SC for single mode cable.
2-3.03.01. **Epoxy Connectors.** Epoxy connectors shall be provided to terminate each fiber in the cable. Connector style, ST, SC, or other, shall be coordinated with the patch panels and field devices that will interface directly with the cable. Connectors shall be compatible with the supplied cable. Connector loss shall be no greater than 0.3 dB. Loss measurement shall be performed at the time of splicing and documentation shall be furnished for each termination. Connectors shall be Corning Cable Systems Connectors, or equal.

2-3.03.02. **Crimp Style Connectors.** Not used.

2-3.04. **Fiber Optic Jumper Cables.** Fiber optic jumper cables shall be furnished and installed for equipment interfacing and between termination cabinets. The jumpers shall meet the following requirements:

a. The jumpers shall be 9/125, single mode cables. They shall be tight-buffered and be protected by Kevlar-type strength material.

b. The jumpers shall be supplied with connectors on each end. Connector types (ST, SC, LC, etc.) shall be matched to the equipment provided. Jumpers shall be sized to provide a single connection between the fiber optic hardware being connected.

2-4. **PLC COMMUNICATIONS MEDIA.** Not used.

PART 3 - EXECUTION

3-1. **INSTALLATION.** The System Supplier shall be responsible for the coordination of the installation of all cable furnished hereunder. The System Supplier shall be responsible for the termination of all cable furnished hereunder.

3-1.01. **Cable Damage.** If the cable becomes damaged during installation, the Contractor shall stop work and notify the Engineer immediately. The Owner and Engineer will decide whether to replace the entire reel of cable or to install a splice at the damaged section. If the Owner decides to replace the entire reel of cable, the Contractor shall begin the installation at the last designated splice point. The damaged cable between these points shall be removed, coiled, tagged, and given to the Owner. Installation of new cable to replace damaged cable shall not be a basis of extra payment or contract completion time. In addition to installation of the new cable, the Contractor shall reimburse the Owner for the entire cost of the replacement reel of cable. This cost will be withheld from the contract price. If the Owner decides to install a splice at the
damaged point, and the cable is damaged a second time, the entire reel of damaged cable (and all subsequent damaged reels) shall be replaced with new reels at the Contractor's expense.

3-1.02. Ethernet Cable Installation. Straight through cables shall be wired using the T568-B standard for both connectors as shown in the table below (connector pin numbers are left to right with the clip down). Crossover cables shall be wired using the T568-A standard for one connector and the T568B standard for the opposite end as shown in the table below.

<table>
<thead>
<tr>
<th>Connector Pin</th>
<th>568A Wiring Conductor</th>
<th>568B Wiring Conductor</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>White/Green</td>
<td>White/Orange</td>
</tr>
<tr>
<td>2</td>
<td>Green</td>
<td>Orange</td>
</tr>
<tr>
<td>3</td>
<td>White/Orange</td>
<td>White/Green</td>
</tr>
<tr>
<td>6</td>
<td>Orange</td>
<td>Green</td>
</tr>
<tr>
<td>4</td>
<td>Blue</td>
<td>Blue</td>
</tr>
<tr>
<td>5</td>
<td>White/Blue</td>
<td>White/Blue</td>
</tr>
<tr>
<td>7</td>
<td>White/Brown</td>
<td>White/Brown</td>
</tr>
<tr>
<td>8</td>
<td>Brown</td>
<td>Brown</td>
</tr>
</tbody>
</table>

3-1.03. Fiber Optic Cable Installation. The cable manufacturer shall provide installation procedures and technical support concerning the items contained in this specification. Fiber optic cable installation shall meet the following requirements:

a. All fiber optic cable shall be installed, terminated, and tested by the System Supplier or his fiber subcontractor as specified above.

b. In pulling the cable, strain-release, or other tension limiting devices shall be used to limit the pull tension to less than 600 lbs.

c. Minimum bend radius restrictions shall be satisfied both during and after cable installation.

d. Horizontal, unsupported cable runs shall be supported at continuous distances of 5 feet or less.

e. All conduit and cabinet entrances shall be sealed with RTV or other re-enterable sealant material to prevent ingress of water, dust or other foreign materials.

f. Cable routing within occupied office areas shall conform to Federal, State, and local electrical and fire codes.
g. Any non-terminating (field) splices shall be documented as to the physical location and cable meter mark (prior to stripping). Field splices shall be OTDR-tested and documented prior to final cable acceptance testing.

h. Fiber optic cables shall be installed in accordance with NECA 301-2004, Installing and Testing Fiber Optic Cables.

3-2. CABLE TESTING. After the network cabling has been installed, each network cable shall be tested.

3-2.01. Test Equipment. Unless specified otherwise, all test equipment for the calibration and checking of system components shall be provided by System Supplier for the duration of the testing work and this test equipment will remain the property of System Supplier.

3-2.02. Ethernet UTP Cable Testing. The System Supplier shall utilize the previously specified test equipment, and additional tools as needed to validate the Ethernet UTP cable installation. All test equipment shall bear current calibration certification from a certified calibration laboratory, as appropriate. Each cable shall be tested for open pairs, shorted pairs, crossed pairs, reversed pairs and split pairs. A check-off sheet shall be utilized, shall be signed by the technician testing the cables, and shall be submitted for approval. Any identified faults shall be corrected at no additional cost.

3-2.03. Fiber Optic Cable Testing. Acceptance testing of the data highway (fiber and electronic equipment) shall be conducted as a part of integrated system field testing, as specified elsewhere. Prior to such tests, however, the fiber optic cable shall be tested as specified herein.

The System Supplier, or his fiber subcontractor, shall conduct fiber optic cable testing as specified below. All testing following field installation shall be witnessed by the Engineer. The Contractor shall bear the cost for factory witnessed testing in accordance with Section 01610 – General Equipment Stipulations. A test plan shall be submitted prior to the proposed test dates. The test plan and procedures shall be mutually agreed to prior to conducting the tests.

Each optical fiber of each fiber optic cable shall be OTDR (Optical Time Domain Reflectometer) tested on the reel at the factory, on the reel upon arrival at the jobsite, and after installation and termination. For each fiber, an OTDR (Optical Time Domain Reflectometer) trace soft/hardcopy is required to be provided to the Owner and Engineer. OTDR traces shall be provided for each test (at the factory, on the reel at the job-site, and after installation). A 100 foot launch
cable shall be spliced to each fiber for each fiber OTDR test, to ensure accurate results. This end-to-end trace shall be performed from BOTH ends of the fiber. Also for each fiber, an end-to-end power attenuation (insertion loss) test shall be performed. The attenuation test shall use a stabilized optical source and an optical power meter calibrated to the appropriate operating wavelength (1,300 nm).

For each installed fiber, the power attenuation shall not exceed the following, tested from connector to connector at the respective patch panels:

\[(0.0035)L + (0.25)N + 3.0 \text{ dB}\]

Where:

- \(L\) = The length of the fiber optic cable in meters and
- \(N\) = the number of splices in the fiber.

Any fiber optic cables containing one or more fibers not meeting this performance will not be accepted by the Owner, and shall be repaired or replaced at no additional cost.

Each fiber optic jumper cable shall be tested and must exhibit an end-to-end attenuation of less than 2.0 dB at 1300 nm. Any jumper exceeding this level shall be replaced at no additional cost to the Owner. Any damaged cable still on the reel shall be returned to the manufacturer for replacement at no additional cost to the Owner.

All fiber cable testing shall be documented on pre-approved test forms. Three copies of all documentation (including OTDR traces) shall be submitted to the Engineer upon successful completion of the testing.

End of Section
SECTION 13800
SURGE CONTROL SYSTEM

PART 1 - GENERAL

1-1. SCOPE. This section covers one 465 cubic feet steel pressure tank, nozzles, supports and accessories to be provided as indicated on the Drawings. The tank shall be used as an air chamber for controlling surge pressures in the 24 inch high service pump discharge transmission pipeline. The tank shall normally be partially filled with water with a pad of compressed air above the water level and will be located indoors.

1-2. GENERAL. Equipment furnished under this section shall be fabricated, assembled, erected, and placed in proper operating condition in full conformity with the Drawings, specifications, engineering data, instructions, unless exceptions are noted by the Engineer.

Each item shall be furnished complete with all accessories required for proper operation, all components indicated on the Drawings or specified, and all additional materials or construction required by the design of the tank.

The tank shall be provided complete with support legs, access manholes, flanged nozzles, and any additional materials or construction essential for proper installation and operation of the air chamber.

1-2.01. General Equipment Stipulations. The General Equipment Stipulations shall apply to all equipment furnished under this section.

1-2.02. Governing Standard. Except as modified or supplemented herein, design, materials, fabrication, erection, and testing of the pressure tank shall conform to all sections of ASME Boiler and Pressure Vessel Code for Unfired Pressure Vessels.

The tank shall bear the stamp of the National Board of Boiler and Pressure Vessel Inspectors and the manufacturer's number as registered with the National Board.

Welding procedures, welders, and welding operators shall be qualified in accordance with Section IX of the ASME Boiler and Pressure Vessel Code.
1-2.03. **Permanent Identification.** The tank shall be stamped with the following information.

- Manufacturer's name.
- Maximum allowable working pressure 450 psi at 100°F.
- Manufacturer's serial number.
- Date of manufacture.
- Thickness and tensile strength of shell steel.
- Thickness and tensile strength of head steel.

1-3. **SUBMITTALS.** Complete shop erection Drawings and specifications covering materials to be furnished, dimensions, sizes and thicknesses of plates and members, details of welded joints, fabrication and erection of steel work, fittings, and all accessories shall be submitted in accordance with the Submittals section.

**Welded Steel Air Chamber**

- Submit a general arrangement drawing showing all connection sizes and locations for acceptance.
- Name of manufacturer.
- Dimensions.
- Weight, empty and full of water.
- Anchor bolt locations and details.
- Reaction forces required for structural design of the tank foundation.
- Full information and details concerning field assembly and installation.
- Weld procedure specifications and procedure qualification records.
- Chart indicating volume of water in the tank for every 2 inches of sidewater depth.

**Manufacturer's Certificates**

- Functional Test Certification.
- Performance Test Reports.
Test results of the standard hydrostatic test performed upon the tank shall be submitted in accordance with the Submittals section.

If the design of the tank utilizes radiographic examination of welds, copies of the results of the examination shall be submitted in accordance with the Submittals section.

Data shall include all horizontal and vertical loadings, anchor bolt sizes and locations, and maximum loads imparted to the foundation by the tank.

PART 2 - PRODUCTS

2-1. DESCRIPTION AND DESIGN REQUIREMENTS. The tank shall be steel, electrically welded, vertical cylindrical, with skirted torispherical dished head of quality steel of 55,000 psi minimum tensile strength. Outlets shall be the sizes indicated and locations shown on the Drawings and as required for all instrumentation and control connection specified or otherwise required.

The tank shall be designed and rated as indicated below. The tank shall be provided with a 12 inch inlet/outlet connection. The inlet/outlet connection shall be provided with an acceptable anti vortex suppressor sized for a minimum velocity of 20 feet per second. The tank shall be provided with flanged openings on the top of the tank for instrumentation by others. Flange size shall be coordinated with level sensing probes provided. Flange size shall be nominal 6 inch.

<table>
<thead>
<tr>
<th>Number of air chambers</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air chamber volume</td>
<td>465 ft³</td>
</tr>
<tr>
<td>Air chamber orientation</td>
<td>Vertical</td>
</tr>
<tr>
<td>Inside diameter</td>
<td>7.5 ft</td>
</tr>
<tr>
<td>Approximate straight side length</td>
<td>12 ft</td>
</tr>
<tr>
<td>Design temperature</td>
<td>80 °F</td>
</tr>
<tr>
<td>Normal working pressure</td>
<td>375 psig</td>
</tr>
<tr>
<td>Internal test pressure</td>
<td>475 psig</td>
</tr>
<tr>
<td>Seismic Criteria</td>
<td>See Specification Section 01610</td>
</tr>
</tbody>
</table>
2-2. MATERIALS AND CONSTRUCTION. Fittings, manholes, and flanged pipe outlets shall be welded to the tank on both inside and out. All horizontal and circumferential welding of shell and the dished head shall be of the double welded butt joint type.

Welding on the interior of the tank shall be done in such a manner so as to not have any area that cannot be painted and tested. Couplings installed on the bottom side of the tank shall be installed flush with the bottom. Backing strips used during the construction of the tank shall be removed.

All slag, weld metal accumulation and splatters shall be removed by chipping and/or grinding. All sharp edges shall be peened or ground smooth. Basic materials shall be as follows:

- **Shell and Plate**
  - ASTM A36 or ASTM A285, Grade C or SA-516-70.

- **Nozzle and Piping**
  - ASTM A53, Grade B, seamless.

- **Flanges**
  - ASTM A105.

- **Structural Shapes**
  - ASTM A36.

- **Anchor Bolts, Nuts, Washers**
  - ASTM F1554, Grade 36 with compatible nuts; hot-dip galvanized, ASTM A153.
  - Washer ANSI B18.22.1.

- **Assembly Bolts and Nuts**
  - ASTM A193-B7/A194-2H.

- **Gaskets**
  - 1/16-inch thick neoprene.

- **Welding Electrodes**
  - Carbon steel of similar grade to the base metal (E70XX).

Certified mill test reports covering all plates and structural shapes to be used in work shall be furnished as evidence that such materials are new and in compliance with the governing specifications. Mill test reports shall be submitted.

2-2.01. **Anchor Bolts.** Anchor bolts with associated nuts and washers shall be furnished with the tank. Anchor bolts, together with templates or setting drawings, shall be delivered sufficiently early to permit setting the anchor bolts when the structural concrete is placed. The bolts shall be at least 3/4 inch in diameter.
2-3. **AIR CHAMBER CONSTRUCTION.** The air chamber manufacturer shall determine the tank wall, supports, and dished head wall thicknesses. The air chamber shall be designed and fabricated in accordance with the ASME Boiler and Pressure Vessel Code, Section VIII, for Unfired Pressure Vessels. The air chamber and appurtenances shall be fabricated from a minimum number of pieces, and longitudinal shell seams shall be staggered.

Welding seams shall be located to clear all nozzle openings. All flange faces shall be true to the centerline of the nozzles and bolt holes shall straddle center lines unless noted otherwise. All welding shall be done by electric arc process. All welding shall be full and continuous, of uniform size and free from slag, porosity, undercuts, and other defects. All welds shall be fully penetrated. The maintenance access opening flange shall be machined smooth for a gasket surface after welding.

Flame cut edges, including edges of handholes in tank skirts, shall be ground smooth.

Tank components shall be carefully fitted to form joints which are free of voids. Voids at joints filled with weld metal will not be acceptable.

2-4. **AIR CHAMBER ACCESSORIES.** Accessories shall be provided on the air chamber tank as indicated on the piping and instrumentation Drawings. The general arrangement of the tank, including the locations of piping, manholes, accessories, and other appurtenances, shall be as indicated on the piping and instrumentation Drawings and specified herein.

The number, locations, types, and sizes of the piping connections indicated are approximate and are subject to change. Submit a general arrangement drawing for acceptance by the Engineer.

2-4.01. **Lifting Lugs.** Lifting lugs shall be provided for air chamber lifting and placement.

2-4.02. **Maintenance Access Manhole.** One maintenance access manhole with an inside diameter of at least 24 inches shall be provided on the side of the air chamber. The maintenance access hole shall be flanged, fully gasketed, and furnished with a hinged steel blind flange suitable for the air chamber design pressure specified herein.
2-4.03. **Nozzles.** Nozzles for connecting piping and air chamber fittings shall be provided at the locations and in the sizes indicated on the Drawings. Blind flanges or plugs shall be provided for nozzles as indicated on the Drawings and shall be suitable for the tank design pressure.

2-4.04. **Vertical Support Legs.** The air chamber shall be provided with steel support legs. The combination of the length of the legs and the location of the inlet connection shall be such that the bottom of the horizontal connecting pipe is not less than 18-inches above finished floor and as indicated on the Drawings. Suitable steel mounting plate shall be provided for attaching the legs to a concrete base, as indicated on the Drawings. The vertical support legs shall be designed and coordinated with the foundation supports to provide the required clearance and to carry the air chamber loads into the foundation, including seismic forces.

2-4.05. **Connections.** The ends of butt welding nozzles shall be prepared by machining. The ends of butt welding nozzles shall be internally trimmed by machining where required to match connecting pipe.

Unless otherwise indicated on the Drawings, connections shall extend 6 inches from the tank.

Unless otherwise indicated on the Drawings, tank connections 2 inches and smaller shall be Class 3000 Bonney "Sockolets".

Unless otherwise indicated on the Drawings, internal and external tank piping 2 inches and smaller shall be not less than Schedule 80.

2-4.06. **Gaskets.** Two sets of permanent gaskets for all manholes, handholes, and blind flanges shall be furnished and shipped separately. All manhole covers, handhole covers, and blind flanges shall be fitted with temporary gaskets for use during shipment and erection. The permanent gaskets shall be shipped in wooden boxes identified by tank name. Gaskets containing asbestos are not acceptable.

2-4.07. **Sight Level Gauge.** The air chamber shall be provided with a sight gauge for visual level indication. The gauges shall be clear type or magnetic flag type with a chemical-resistant valve and gauge tube assembly mounted on the tank.
The gauge tube shall be fabricated of 1 inch diameter clear PVC, polycarbonate, or borosilicate glass each lined with clear PFA Teflon, as specified. An epoxy coated steel shield which does not obstruct the gauge shall be provided the full length of the gauge.

Alternatively, the gauge tube shall be fabricated of 1 inch diameter FEP (Fluorinated Ethylene Propylene) with flair through flange end connections. The FEP gauge tube shall have a wall thickness of 0.1 inch and the flanges shall be epoxy-coated ductile iron.

A graduation strip shall be mounted adjacent to or integral with the sight level gauge. The strip shall run the full length of the level gauge and shall be graduated in gallons with flags at each of the control levels indicated herein using 1 inch high black lettering over a range from zero gallons to the rated capacity of the tank.

The gauge tube assembly shall be Jogler, Inc. "Model ULSS"; Pureflex, Inc. "Model Puresite"; or equal.

The air chamber manufacturer shall provide a confirmation that the sight level gauge is included in the pressure testing of the air chamber and that the gauge can withstand the test pressures of the air chamber.

2-5. PROTECTIVE COATINGS.

2-5.01. Surface Preparation. All iron and steel surfaces that will receive a protective coating shall be cleaned and blasted in strict compliance with the paint manufacturer's recommendations. All mill scale, loose rust, and contaminants shall be removed before primer is applied. Surfaces shall be dry and free from grease, oil, dirt, dust, grit, rust, weld flux, slag, weld splatter, and other objectionable surfaces. The tank shall be cleaned by a high-speed power wire brushing or by blasting to the extent recommended by the coating manufacturer. Welds shall be scraped, chipped, and brushed to remove all weld splatter.

2-5.02. Interior Air Chamber Coating. Prepare the surface by sandblasting in accordance with Steel Structures Painting Council Specification No. 5. Immediately following the sandblasting, the interior surface shall be coated. The coating shall be approved for potable water with National Sanitation Foundation (NSF) Standard 61 certification. The coating shall be a surface primer with two additional layers of epoxy coating. All coatings shall be suitable for the interior tank environment and shall be NSF certified. Apply not less than 3 coatings in accordance with the manufacturer's printed instructions, with each coat having
a dry film thickness of 5 to 10 mils. The first coat, primer, shall be blue. All additional coatings shall be gray. One quart of primer coating and one quart of each finish coat coating shall be furnished for surface touchup in the field.

2-5.03. **Exterior Air Chamber Coating.** All exterior iron and steel surfaces shall be shop primed with a universal primer, Ameron "Amercoat 385 Epoxy", Carboline "Carboguard 888 Primer", or Tnemec "Series N27 S.T. Typoxy", and then given two shop coats of finish paint. The first finish coat shall be an epoxy enamel, Ameron "Amercoat 385 Epoxy", Carboline "Carboguard 890", or Tnemec "Series 69 Hi-Build Epoxoline II". The second finish coat shall be an aliphatic polyurethane, Ameron "Amercoat 450 HS", Carboline "Carbothane 134 HG", or Tnemec "Series 74 Endura-Shield". The shop coating, including primer, shall have a minimum dry film thickness of 10 mils. One quart of primer coating and one quart of each finish coat coating shall be furnished for surface touchup in the field.

2-6. **CONTROLS.**

2-6.01. **General.** Air chamber water level shall be controlled by adding or venting compressed air to maintain the water level within the preset limits.

The air chamber shall be provided with automatic controls to maintain the minimum air volume in the air chamber at 200 cubic feet. Automatic controls shall add compressed air to the air chamber when the total air chamber air volume is reduced to 180 cubic feet. The compressed air addition shall be shutoff once the total air chamber air volume reaches 200 cubic feet.

The air chamber shall be provided with automatic controls to release air out of the air chamber when the total air chamber air volume reaches or exceeds 230 cubic feet. Releasing air out of the air chamber shall be discontinued once the total air chamber air volume is reduced to 210 cubic feet.

2-6.02. **Control Panel.** All control components shall be provided in a free-standing NEMA 4 steel control panel, Hoffman or equal, mounted in the location indicated on the Drawings. The control panel shall be provided with a lockable front access door with a continuous piano-type hinge, operated from a 3-point latch mechanism.

The control panel shall also be provided with an externally operable disconnect switch that can be locked into the "Off" position. Size shall be selected to suit the piping and hardware contained inside of the panel.
The power supply will be 480 volts, 60Hz, 3 phase. Where control voltage lower than the power supply voltage is required, a suitable control power transformer shall be furnished by the surge control system supplier. A surge suppressor shall be provided to protect the panel from transient voltages.

Control components and indicating lights mounted through the panel front shall maintain the panel rating as specified. Interior control components shall be mounted on the back panel.

The panel shall be provided complete with labeled terminal strips for field wiring connections. All components shall be factory assembled and wired, requiring only the field connection of external circuitry and piping.

Install piping to route exhaust air from the control panel. A noise muffler shall be provided. Adequate noise attenuation shall be provided at exhaust outlet such that exhaust air does not produce noise levels in excess of 75 dB at 3 ft from the exhaust outlet.

2-6.03. Electrode/Conductance Relay Level Switches. Electrodes shall be rigid AISI Type 316 stainless steel solid rod type with a PVC outer sheath. Electrode lengths shall be cut to meet appropriate volume levels within the air chamber. Electrode holder shall be male external pipe threaded type, stainless steel, corrosion resistant, rated for minimum 400 psi and capable of housing desired electrodes.

Electrode relays shall be dual-coil or solid-state relay type with single-pole, double-throw output contacts rated not less than 5 amperes at 120 V ac. The relay primary power shall be 120 V ac, 60 Hz, single phase. Interconnecting cable from the electrodes to the relays shall be provided. Cable shall be approved by the electrode manufacturer.

Relays shall be housed in Surge Control System Control Panel as indicated on the Drawings. Electrodes and conductance relays shall be manufactured by B/W Controls, Warrick Controls or Engineer-approved equal. The electrodes shall be used as follows:

1. Low Air Volume Alarm (150 cubic feet)
2. Open Air In Solenoid Valve (180 cubic feet)
3. Close Air In Solenoid Valve (200 cubic feet)
4. Close Air Release Valve (210 cubic feet)
5. Open Air Release Valve (230 cubic feet)
6. High Air Volume Alarm (250 cubic feet)

The volumes indicated above are the volumes of air in the air chamber.

2-6.04. Control Switch. A HAND-OFF-AUTO selector switch shall be mounted on the control panel door for control of the air add and air release (exhaust) solenoid valves. In the AUTO position, the tank air volume shall be controlled as previously specified. In the HAND position, control shall be performed by a second ADD-RELEASE selector switch. In the ADD position, the add air solenoid shall be energized to increase the tank air volume. In the RELEASE position, the air release solenoid shall be energized to decrease the tank air volume.

2-6.05. Level Alarms and Indicating Lights. Separate high and low level alarms shall be provided when the air volume remains too low (Low Volume Alarm Level) or too high (High Volume Alarm Level) for 10 minutes or more. 120 V ac contacts from each timing relay shall be connected to the plant control system for remote indication of each condition. Indicating lights shall also be provided on the panel front for "HIGH LEVEL" and "LOW LEVEL". Six additional normally closed dry contacts which open for "LOW LEVEL" shall be provided to relay status to the pumps. Contacts shall be rated minimum 5 amperes at 120 V ac.

2-6.06. Air Release Valves. For emergency operation, an automatic air release valve shall be installed on the side of the air chamber at the High Air Volume Alarm Level to release air from the tank in the event the compressor fails to stop. The air release valve shall be sized to release at least as much air from the tank as the two compressors are capable of adding. Air release valve shall be designed for minimum 400 psi working pressure.

Air release valves shall be Apco/Valve and Primer "No. 200A", GA Industries "Figure 920H", Multiplex "Crispin Type PL", or Val-Matic "No. 38".

2-6.07. Pressure Relief Valve. A pressure relief valve set for 400 psig shall be provided on the top of the air chamber.

2-6.08. Solenoid Valves. Solenoid valves shall be provided for the surge control system as indicated on the Drawings. Valves SOLV-151 and SOLV-153 shall allow air into the appropriate tank when the air chamber air volume has reached the "Open Air in Level". Valves SOLV-152 and SOLV-154 shall allow air to vent from the tank when the air chamber air volume has reached the "Open Air Release Level".
2-6.09. **Check Valves.** A check valve shall be provided in the compressed air piping immediately upstream of the air chamber as indicated on the Drawings. Check valves shall be sized in accordance with the valve manufacturer's recommendations and shall be suitable for service at the maximum compressor discharge air temperature.

Check valves shall be disc and spring type designed for installation in the discharge piping from reciprocating compressors. Combination unloading devices/check valves will not be acceptable. Check valves shall be Hoerbiger or equal.

2-6.10. **Shutoff Valves.** All shutoff valves shall be ball valves. Valves in steel piping shall have carbon steel bodies, chrome plated or stainless steel balls, and reinforced teflon seals and seats. Shutoff valves in stainless steel tubing shall have AISI Type 316 stainless steel bodies and balls and reinforced Teflon seals and seats. Valves in the compressor discharge piping shall be suitable for the maximum compressor discharge air temperature.

2-6.11. **Automatic Tank Drain.** An automatic tank drain connection shall be provided to periodically flush the contents of the air chamber. The connection shall be provided on the air chamber at the same level as the "Open Air Release" electrode as indicated on the Drawings. The drain line shall be a 2 inch connection complete with a pressure reducing valve (set to 60 psig) and an electric motor actuated gate valve.

A continuous run timer for the electric motor actuated gate valve shall be provided in the surge tank control panel to open the gate valve. The timer shall be adjustable from one to seven days. A cycle timer shall be provided to keep the gate valve open for a preset period of time adjustable from 5 to 30 minutes. A limit switch shall be provided on the gate valve. An indicating light shall be provided by the limit switch to the plant PLC when the valve is completely open.

Gate valve construction shall be as specified in the Resilient Seated Gate Valves section. Valve actuators shall be as specified in Valve and Gate Actuators section.

2-6.12. **Pressure Reducing Valves.** Pressure reducing valves for water service shall be direct-acting or pilot-operated type.
Direct-acting valves shall be globe type with threaded connections and union assembly. The valves shall be provided with bronze body and cover, stainless steel trim, reinforced neoprene diaphragm, Buna N disc, and stainless steel strainer. Direct-acting pressure reducing valves shall be Cla Val "Model 990", Cash-Acme, or Watts.

Pilot-operated valves shall be globe type with flanged ends. The valves shall be provided with epoxy coated ductile iron body, bronze trim, and Buna-N rubber diaphragm and disc. The pilot regulating valve shall be bronze with stainless steel trim. Pilot-operated pressure reducing valves shall be Cla Val "Model 90 01", Watts, or OCV.

Pilot-operated valves shall be equipped with a low flow bypass. The low flow bypass shall consist of a direct-acting pressure reducing valve in parallel with the pilot-operated valve. The valves and required piping assembly shall be factory assembled and shall be Cla Val "Model 90 48", Watts, or OCV.

2-6.12. Miscellaneous Components. Miscellaneous components shall be provided as required by the surge control system supplier for a complete and satisfactory working system. Miscellaneous components may include, but not be limited to, pushbuttons, selector switches, control relays, terminal strips, time delay relays, and indicating lights.

2-6.13. Surge Suppressors. Surge and lightning suppressors shall be non-faulting, non-interrupting, and shall protect against line-to-line and line-to-ground surges. Devices shall be solid-state metal oxide varistor (MOV) or silicon junction type, with a response time of less than 50 nanoseconds. Surge protective devices shall be applied to the incoming power to the control panel.

PART 3 - EXECUTION

3-1. FABRICATION. The surge control system shall be completely shop fabricated; no fabrication will be allowed in the field. Fieldwork shall be limited to assembly of accessories, making piping and wiring interconnections, and testing and startup.

3-2. HYDROSTATIC PRESSURE TEST. Prior to painting, the air chamber shall be hydrostatically pressure tested as required by the ASME Boiler and Pressure Vessel Code. At a minimum testing shall be to 1.5 times working pressure for a
minimum of 2 hours and checked for leaks. During testing, connections shall be plugged outside the tank. Any leaks shall be repaired, and the air chamber shall be retested.

3-3. **PROTECTION DURING SHIPMENT.** Tank shall be thoroughly cleaned before shipment. All weld connections, flanged connections, and other openings shall be covered with tight-fitting heavy sheet metal closures, securely attached, to prevent entry of dirt and moisture and to protect the interior of the tank. Sheet metal closures tank openings shall be carefully sealed with an adhesive backed waterproof cloth tape. All exposed threads shall be greased and protected with metallic or other substantial type protectors.

3-4. **INSTALLATION.** Surge control system equipment installed under this section shall be erected and placed in proper operating condition in full conformity with Drawings, specifications, engineering data, instructions, and recommendations of the surge control system supplier, unless exceptions are noted by the Engineer.

Contractor shall coordinate with the surge control system supplier regarding field services provided by the surge control system supplier. Contractor shall give the Engineer and the District written notice at least 30 days prior to the need for field services furnished by others.

Equipment shall not be installed or operated except by, or with the guidance of, qualified personnel having the knowledge and experience necessary to obtain proper results as specified in Section 11060 – Equipment Installation.

Each equipment unit shall be leveled, aligned, and shimmed into position. Installation procedures shall be as recommended by the equipment manufacturer and as required herein. Shimming between machined surfaces will not be permitted.

The surge control system supplier shall provide installation supervision and installation checks as specified herein. For installation supervision, the supplier’s field representative will observe, instruct, guide, and direct the Contractor’s erection or installation procedures. For installation checks, the supplier’s field representative will inspect the equipment installation immediately following erection by the Contractor, and observe the tests indicated in Section 11060 – Equipment Installation.
3-5. **FIELD HYDROSTATIC PRESSURE TEST.** The surge control system shall undergo a field hydrostatic pressure test as a part of the pipeline hydrostatic pressure tests that are specified in Section 02704 – Pipeline Pressure and Leakage Testing.

3-6. **FUNCTIONAL AND PERFORMANCE TESTING.** Startup and Testing shall be conducted in accordance with Section 11060 – Equipment Installation. All requirements herein are in addition to the requirements of Section 11060 and shall be performed and properly coordinated during the startup and testing period. Functional and performance testing shall be performed on site.

3-6.01. **Functional Tests.** Verify all electrical circuitry continuity and control settings. Operate controls manually to verify automatic operation is properly set.

3-6.02. **Performance Test.** A dynamic test of the surge control system shall be performed in response to flow startup and stoppage. The number of pumps shall be increased, one at a time, with pump discharge pressure being recorded for each pump combination on a strip chart recorder or data logger. The pressure recorder shall be of the fast response type suitable for measuring transient pressures. The pressure recorder shall be located on the pump discharge header. This procedure shall be performed for both startup and shutdown of flow. The pump flow shutdown test shall simulate abrupt pump shutdown that would be caused by an electrical power outage. Take pressure readings for a sufficient period of time until the system pressures dampen.

Contractor shall provide to the Engineer a complete report of each test performed within 10 days after test completion. Reports shall include:

1. Date and time of all tests.
2. Description of method of testing, including pumping combinations, flows, pressures, method of collecting pressure records, and other pertinent data.
3. Summary of the results of pressure measurements and testing.

3-7. **CLEANING AND DISINFECTION.** After installation has been completed and all connections have been made, all tank surfaces, interior and exterior, shall be thoroughly cleaned and disinfected in accordance with Section 02704 – Pipeline Pressure and Leakage Testing.
3-8. FIELD PROTECTIVE COATING INSPECTION AND TESTING. Contractor shall perform a dry film thickness test for the interior and exterior surfaces of the surge tank.

Contractor shall perform holiday testing for the interior and exterior surfaces of the surge tank.

End of Section
Section 13930

FIRE PROTECTION SYSTEMS

PART 1 - GENERAL

1-1. SCOPE. This section covers the furnishing and installation of materials, equipment, and appurtenances associated with the standpipe systems. All labor, materials, tools, equipment, service and supervision required to design, install, test, and place the standpipe systems in service shall be provided.

Standpipe systems shall meet the design conditions and features and as indicated on the drawings. All required piping, valves and appurtenances are not indicated on the drawings but shall be provided for a complete system compliant with the requirements indicated herein.

1-2. GENERAL.

1-2.01. Coordination. Piping, equipment, and appurtenances furnished and installed under this section shall be designed, fabricated, assembled, erected, and placed in proper operating condition in full conformity with the drawings, specifications, engineering data, instructions, and recommendations furnished by the manufacturer unless exceptions are noted by Engineer.

Contractor shall verify that each component of the standpipe system is compatible with all other parts of the system; that all piping, equipment, and appurtenances are appropriate for the intended function; and that all devices necessary for a properly functioning system have been provided.

Equipment and appurtenances furnished under this section shall be the standard product of the manufacturer. Where two or more units of the same class of equipment are required, they shall be the products of a single manufacturer; however, all the component parts of the system need not be the products of one manufacturer.

Contractor shall coordinate with the electrical contractor to make certain that the field wiring associated with this section is complete in accordance with the requirements of the equipment specified herein. Contractor shall coordinate the wiring of alarm devices to the equipment furnished and installed.
Contractor shall become familiar with details of the work, shall verify dimensions in the field, and notify Engineer of any discrepancy before performing the work.

1-2.02. **General Equipment Stipulations.** The General Equipment Stipulations shall apply to all equipment furnished under this section. If requirements in this specification differ from those in the General Equipment Stipulations, the requirements specified herein shall take precedence.

1-2.03. **Governing Standards.** Except as modified or supplemented herein, all work covered by this section shall be performed in accordance with the applicable national, state, and local codes and ordinances, laws, regulations, and NFPA Standards which pertain to such work. In case of a conflict between these specifications and any applicable national, state, or local code, ordinance, law, regulation, or NFPA Standard, the latter shall govern.

1-3. **SUBMITTALS.**

1-3.01. **Drawings and Data.** Complete design calculations; assembly, and installation drawings; together with complete engineering data covering the materials used and the parts, devices, and accessories forming a part of the equipment and appurtenances furnished, shall be submitted in accordance with the Submittals section.

The submittal to Engineer shall be made after the local authorities having jurisdiction have approved the design.

The data and specifications submitted shall include, but not be limited to, the following:

**Design Documents**
- Complete working plans, hydraulic calculations, water supply data, and information required by NFPA Standards.
- Hydraulic design placard.

**Equipment, Piping, and Appurtenances**
- Name of manufacturer.
- Type and model.
- Construction materials, thickness, and finishes.
- Capacities.
- Pressure and temperature ratings.
Overall dimensions.
Piping connection type, size, and location.
Wiring diagrams.
Pressure loss data.
Net weight.

Test Reports
Test reports and certificates as described in NFPA Standard 14.

1-3.02. Operation and Maintenance Manuals. Adequate operation and maintenance information shall be supplied as required in the Submittals section. Operation and maintenance manuals shall be submitted in accordance with the Submittals section.

1-4. QUALITY ASSURANCE. All materials and work shall conform to the requirements of the National Fire Protection Association (NFPA), Factory Mutual (FM), and Underwriters' Laboratories (UL).

Manufacturer's providing equipment and appurtenances shall be listed by product name and manufacturer in the UL Fire Protection Equipment Directory and FM Approval Guide.

Standpipe system materials shall be permanently stamped or labeled with the listing and approval agency's identification.

Materials, installation, inspection, and testing of the standpipe system shall comply with the requirements of the local authorities having jurisdiction and Owner's insurance underwriter.

The standpipe system drawings and calculations shall be performed by an individual who has National Institute for Certification of Engineering Technologies (NICET) III certification in the subfield of automatic sprinkler and standpipe design and signed and sealed by a registered professional engineer licensed in the state in which the project is located.

The standpipe system shall be installed by a firm having previously installed a minimum of five systems similar in size and scope to this project.
1-5. PERFORMANCE AND DESIGN REQUIREMENTS. All piping, equipment, and appurtenances shall be designed to meet the performance and design conditions as specified herein and on the drawings. The system shall be designed as an automatic wet Class III standpipe system as indicated in Schedule 13930-S01

1-5.01. Flow Test. The standpipe system shall be designed using data from a water flow test performed by the Contractor.

The water flow test is to verify that adequate pressure is available at the required flow before the system is designed. If it is not possible to perform a flow test prior to designing the system, the test may be performed later, however, Contractor shall accept responsibility for any modifications required in the event that the flow tests indicate a lower available water supply than that on which the calculations were based.

The water supply information provided below is based on estimates, and does not include losses associated with any portion of the standpipe system. Contractor shall verify water supply data prior to designing the standpipe system.

Estimated water supply – static pressure 100 psig

1-5.02. Pipe Sizing. The standpipe system shall be hydraulically calculated, and shall include a safety factor of 5 psig at the design flow.

Pipe and accessory sizes indicated on the drawings are the minimum allowed, and shall be increased if determined necessary by hydraulic calculations.

1-6. DELIVERY, STORAGE, AND HANDLING. Shipping shall be in accordance with the Shipping section. Handling and storage shall be in accordance with the Handling and Storage section.

1-7. EXTRA MATERIALS. Not used.

PART 2 - PRODUCTS

2-1. SERVICE CONDITIONS. All components of the standpipe system shall be designed to meet the specified conditions.

2-2. ACCEPTABLE MANUFACTURERS. Acceptable manufacturers shall be as indicated in the respective product description paragraphs.
2-3. **MATERIALS.** All piping systems and related components shall be rated for at least 175 psig working pressure.

2-3.01. **Anchor Bolts and Expansion Anchors.** All anchor bolts, expansion anchors, nuts and washers shall comply with UL, FM, and NFPA requirements. Powder-driven anchor assemblies shall not be used.

2-3.02. **Piping Systems.** Piping on the supply side of the backflow prevention device shall be as specified in other sections for potable water use. Piping on the standpipe side of the backflow prevention device shall be black steel pipe as follows:

- **Standard Weight ASTM A53 with Threaded Malleable or Cast Iron Fittings.**
  - All 2 inch and smaller piping.

- **Standard Weight ASTM A53 with Flanged Fittings.**
  - All 2-1/2 inch and larger piping.

- **Standard Weight ASTM A53 with Grooved-End Fittings.**
  - All 2-1/2 inch and larger piping on the standpipe side of the backflow preventer. (optional)

Pipe shall be furnished complete with all fittings, jointing materials, supports and anchors, and other accessories required for a complete system.

Plain-end fittings with mechanical devices which grip into the pipe, and saddle type branch fittings shall not be used.

2-3.03. **Pipe Supports.** Pipe supports shall be suitable for the application, construction, and type and size of pipe used.

"C" type clamps shall be provided with retaining clips and shall not be used for piping larger than 3 inch size.

2-3.04. **Service Valves.** Service valves shall be UL-listed and FM approved, with 175 psig non-shock minimum working pressure rating.

2-3.04.01. **Gate Valves.** Gate valves in 2 inch and smaller sizes shall be cast-bronze with threaded ends, solid wedge disc, outside screw and yoke, and rising stem.
Gate valves in 2-1/2 inch and larger sizes shall be iron body, bronze mounted, with tapered solid wedge disc, outside screw and yoke, and rising stem. Valves shall be provided with replaceable bronze disc facing rings and flanged ends.

Gate valves in 4 inch and larger sizes for use with indicator posts shall be iron body, bronze mounted, with solid wedge disc, non-rising stem, operating nut, replaceable bronze disc facing rings, and bonnet cap for indicator post.

2-3.04.02. Butterfly Valves. Butterfly valves in 3 inch and larger sizes shall be provided with cast iron body, iron or aluminum/bronze disc, BUNA-N or EPDM seat sleeve. Valve body shall be lug or grooved type as determined by the piping system. Butterfly valves shall be provided with an integral indicator to show disc position. The indicator shall include a pre-wired single-circuit supervisory switch rated for 10 amperes ac.

2-3.04.03. Ball Valves. Ball valves in 2 inch and smaller sizes shall be brass ball and body with reinforced Teflon seat and threaded ends.

2-3.04.04. Check Valves. Swing check valves 2-1/2 inch and larger shall be cast-iron body with bolted cap, bronze disc or cast-iron disc with bronze disc ring, and flanged ends.

2-3.05. Specialty Valves. Specialty valves shall be UL-listed and FM approved, with 175 psig non-shock minimum working pressure rating.

2-3.05.01. Standpipe Hose Valves. Provide bronze hose valves with 2.5 inch NS male hose threads, and 2.5 inch NH female, 300 pound rated, with cap and chain.

2-3.05.02. Deluge-Pipe Valve. Not used.

2-3.05.03. Air Maintenance Device. Not used.

2-3.05.04. Dry-Pipe Valve. Not used.

2-3.05.05. Air Maintenance Device. Not used.

2-3.05.06. Ball Drip Valves. Ball drip valves shall be automatic drain type, 3/4 inch body size, with spring-loaded ball check device and threaded ends.

2-3.05.07. Backflow Preventer. The sprinkler system backflow preventer shall be a reduced pressure principle type. The unit body shall be epoxy-coated cast iron or stainless steel. Gate valves with flanged ends, outside screw and
yoke, rising stem, and resilient seats shall be factory installed at each end of the unit. Each gate valve shall be provided with a supervisory switch to alarm in the event that the valve is not in the full open position.

Backflow preventers shall be as manufactured by Febco, Watts Industries, Inc., or Ames.

2-3.06. Hose Racks. Provide hose rack assembly with a 300 pound rated brass angle valve with 100 feet of 1.5 inch hose and satin brass fog nozzle with rubber bumper. The rack shall be coated steel painted red and provided with instruction decal. Hose shall be single jacket lined 300 pound test polyflex.

2-3.07. Fire Department Connection. A sprinkler system fire department siamese connection shall be provided. The location and type of the connection shall be as indicated on the drawings or as approved by Engineer and the local authority having jurisdiction.

The siamese connection shall be a projecting wall-type, with cast-brass body; polished chrome plated finish; NH-standard thread inlets according to NFPA 1963 and matching local fire department threads; and threaded NPS outlet. Connection shall include lugged cap, gasket, and chain; lugged swivel connection and drop clappers for each hose connection inlet; and round wall escutcheon plate with marking "STANDPIPE". The connection shall be provided with two 2-1/2 inch inlets and one 4 inch back outlet.

2-3.08. Alarm Devices. Alarm devices shall be provided. Alarm device type and size shall be as needed to match piping and equipment connections.

Water flow indicators shall be electrical supervision vane type, rated to 250 psig, and shall comply with UL 346. The indicators shall be furnished with a pipe saddle and cast aluminum housing, and shall be suitable for horizontal or vertical installation. Two isolated spdt alarm contacts shall be provided. Contacts shall be rated for 7 ampere, 125 volts ac and 0.25 ampere, 24 volts ac. Water flow indicators shall be complete with factory-set, field-adjustable, instantly recycling pneumatic retard element to prevent false signals, and tamper-proof cover that alarms when cover is removed.

Supervisory (tamper) switches shall comply with UL 753, and shall be electrical supervision type, with spdt normally closed contacts. The switches shall be designed to signal when the controlled valve is in other than the fully open position and when the switch is removed or dismantled.
Water flow alarms shall be electric audible and visual type and shall be compliant with NFPA Standard 72 and UL Standard 1638. The alarm shall be weatherproof, and shall be suitable for a 120 volts ac or 24 volts dc power supply to be compatible with the fire alarm system. The alarm shall be initiated by the water flow switch.

2-3.09. **Air Compressor.** Not used.

2-3.10. **Pressure Gauges.** Pressure gauges shall comply with UL 393, and shall be provided with 3-1/2 inch to 4-1/2 inch diameter dial, and a dial range of 0-250 psig.

PART 3 - EXECUTION

3-1. **INSPECTION.** Contractor shall field verify all existing conditions prior to designing the system.

3-2. **INSTALLATION.** Piping, equipment, and appurtenances furnished under this section shall be installed in proper operating condition in full conformity with the drawings, specifications, engineering data, instructions, and recommendations of the equipment manufacturer, unless exceptions are noted by Engineer.

A metal placard with the hydraulic design information shall be attached with a stainless steel chain to each sprinkler riser. Each placard shall contain the system design information as required by NFPA 14.

3-2.01. **Standpipe Piping and Accessories.** Deviations from approved "working plans" for standpipe piping require recalculation and approval by authority with jurisdiction. Written approval shall be obtained from Engineer prior to deviating from approved "working plans".

Approved fittings shall be used to make changes in direction, branch takeoffs from mains, and reductions in pipe sizes. Unions shall be installed adjacent to each valve in pipes 2 inch and smaller. All piping shall be hidden from view in areas with finished ceilings, unless accepted by Engineer to be exposed.

"Inspector's Test Connections" shall be installed in standpipe piping, complete with shutoff valve, sized and located according to NFPA 14.
The standpipe piping shall be installed with drains for complete system drainage. Ball drip valves shall be installed to drain piping between fire department connections and check valves, and where indicated. Drains shall be routed to outside the building unless otherwise indicated on the drawings.

Hanger and support spacing and locations for steel piping joined with grooved mechanical couplings shall be in accordance with the manufacturer’s written instructions for rigid systems.

Metal roof decking shall not be used for the support of equipment or piping.

Piping shall be installed in accordance with NFPA 14 to protect from earthquake damage.

Pressure gauges shall be installed at each standpipe test connection and at top of each riser. Pressure gauges shall be provided with connections not less than 1/4 inch and with soft metal seated globe valve arranged for draining pipe between gage and valve. Gauges shall be installed to permit removal and shall not be installed where subject to freezing.

All alarm devices shall be connected to the plant control system.

The electric standpipe flow alarm shall be mounted outside on an exterior wall of the building at a location suitable to Engineer so personnel in the area will notified when an alarm is sounded.

3-2.02. Standpipe Valves. Fire standpipe valves shall be installed with all trim, fittings, controls, and specialties according to NFPA 14, manufacturer’s written instructions and the requirements of the authority having jurisdiction.

Service valves shall be supervised-open, and located to control sources of water supply except from fire department connections. Permanently marked identification signs indicating portion of system controlled by each valve shall be provided.

3-3. FIELD TESTING. Field testing of the standpipe systems shall conform to NFPA Standard 14 "System Acceptance" Chapter and to the requirements of the local Fire Department.

The Engineer and the local authority having jurisdiction will witness all tests. Contractor shall arrange the testing schedule with the local authority having jurisdiction and the Engineer; with at least 7 days' advance notice.
Contractor shall replace piping and components that do not pass the test procedures specified, and then retest to demonstrate compliance. The procedure shall be repeated until satisfactory results are obtained at no additional cost to Owner. Three copies of test reports shall be submitted in writing to Engineer and to the authority having jurisdiction.

Test certificates shall be executed and submitted prior to final inspection and acceptance in accordance with NFPA Standard 14. Three copies of each test certificate shall be furnished to Engineer and the authority having jurisdiction.

After installation and testing of the standpipe system, complete drawings, conforming to installation records, control valves, water supply connections, and wiring diagrams, shall be submitted to Engineer prior to final acceptance.

3-4. **ADJUSTING.** All alarm devices shall be adjusted for proper operation. All drains shall be checked for proper operation.

3-5. **CLEANING.** Immediately prior to the final inspection, equipment, piping and appurtenances shall be thoroughly cleaned. Dirt and debris shall be cleaned from the pipe.

3-6. **FINAL INSPECTION AND ACCEPTANCE.** A decision shall be reached during the inspection concerning the resolution of discrepancies and changes as recommended by the authorities having jurisdiction. All work determined to be the responsibility of Contractor, and included within the scope of the specifications, shall be promptly completed at no expense to Owner.

The final acceptance of the standpipe system shall be made after the completion of the corrective work resulting from the final testing and inspection and after receipt of a formal letter of acceptance from the authority having jurisdiction.

End of Section
Schedule 13930-S01
Standpipe System Schedule

Performance and Design Requirements

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<tr>
<th>Zone</th>
<th>Area or Rooms to be Protected</th>
<th>System Type</th>
<th>Hazard Classification</th>
<th>Sprinkler Density (gpm/sq ft)</th>
<th>Design Area (sq ft)</th>
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<td>Class III</td>
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End of Schedule